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The Feeding Value of Certain Duck Food Plants of the Bear River Migratory Bird Refuge As Determined By Chemical Analysis

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Introduction

The study of bird feeding problems has become a prominent factor in wild life management. This is true especially with respect to the evaluation of recently established migratory bird refuges. In 1929 the Federal Government assumed control of a large area of land located on the Bear River Bay of Great Salt Lake for the purpose of providing a sanctuary for water fowl. Dykes were built and the areas inside these dykes flooded with fresh water from Bear River. During subsequent years aquatic and marsh plants* developed abundantly and apparently have provided satisfactory feeding and nesting grounds for migratory birds. In an attempt at a partial evaluation of the Bear River Migratory Bird Refuge as a feeding area this study of the chemical composition of a few types of vegetation collected on the refuge was undertaken.

By the chemical analysis of these plants it was anticipated that information on the following points could be obtained: (1) variation in chemical composition of different food plants; (2) effect of season on the chemical composition; (3) effect of depth of water and the associated changes in pH, temperature, and turbidity on the chemical composition of food plants; (4) the feeding value of the most important food plants.

Source of Materials

The flooded area at the Bear River refuge is divided into five units by dykes as shown in Figure 1. Within these

* The term "marsh plants" as used, includes those plants that grow in wet soil, as well as those growing partially submerged.

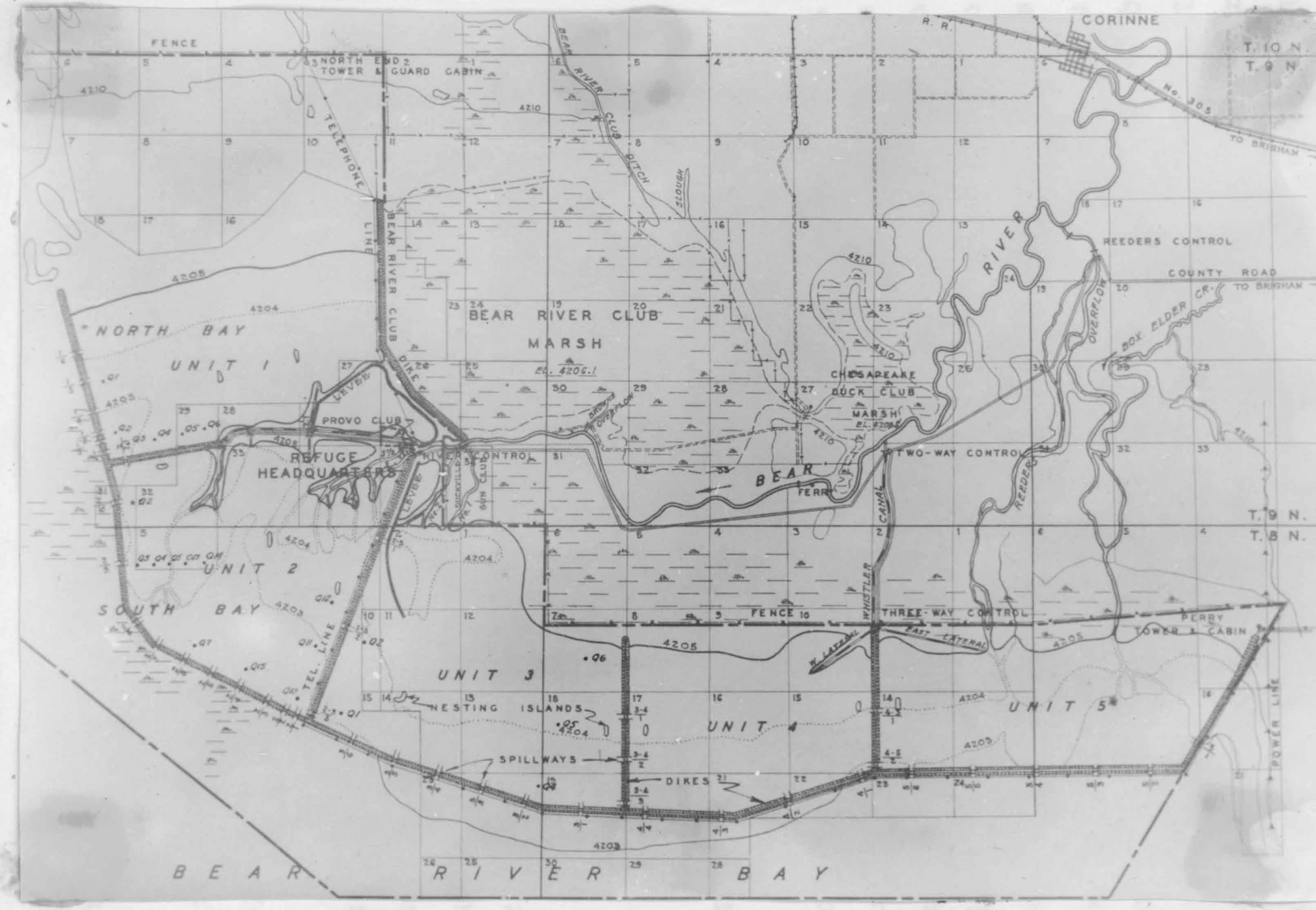

FIGURE I

The Bear River Migratory Bird Refuge

units numerous quadrates five meters square were established by the Wild Life Research Station in such a way as to include represenative vegetative samples of the larger units. The location of these numbered quadrates is indicated by the letter Q followed by a number, as shown in Figure 1. At intervals throughout the growing season plant samples were collected from areas of similar size adjacent to these numbered areas, the original quadrates being left as checks. These plant samples, collected as a part of the Wild Life Research Stations project, were made available for the studies reported in this paper. They were composed of various species of Potamogeton, Ruppia, and algae. Other plants used in this investigation were gathered on the refuge or from the near vicinity. In taking the samples from the flooded areas, an effort was made to include the roots and other under ground parts.

Methods of Chemical Analysis

The plant samples were thoroughly washed, and air dried at room temperature. They were carefully examined, for the removal of foreign matter and then ground to a fine powder. The ground material was dried at 100°C. previous to weighing out samples for analysis. The elements of composition determined were carbohydrates (starch), nitrogen, crude fat, crude fiber, total ash, and the following ash constituents, Ca, P, Mg, Na, K, and Cl.

The total nitrogen was determined by Kjeldahl-Gunning-Arnold method (1a)*. This value was multiplied by 6.25 to con-

* Numbers refer to the citations in the Bibliography, page 23

vert to crude protein. The crude fat was determined by ether extraction (1b), the crude fiber by alternate boiling with a solution of H_2SO_4 and NaoH, filtering, washing and weighing as outlined in the Methods of Association of Official Agricultural Chemist (1c).

The starch was determined by acid hydrolysis (2), and the glucose formed being determined by the method of Shaffer and Hartman (3). The value of the glucose determination was multiplied by .90 and reported as starch.

To determine the mineral elements a portion of the dried plant material was ashed. The ash, dissolved in dilute HNO_3 was made up to a definite volume. An aliquot of this solution was taken for the determination of the mineral constituents.

The calcium was precipitated as calcium oxalate and determined by subsequent titration with $KMnO_4$. The magnesium was determined by precipitation as the pyrophosphate, igniting and weighing as MgO; the phosphorus by precipitating as ammonium phosphomolybdate, and titrating with standard sodium hydroxide. The sodium and potassium were determined as perchlorates; the chlorine was estimated by precipitating as silver chloride, and titration of the excess silver nitrate with potassium thiocyanate.

All analyses were made in duplicate, calculated to the dry weight basis and the average value reported.

The Composition of the Most Important Food Plants Found at the Refuge

A chemical analysis was made of the important food plants found at the refuge, to determine the amount of carbohydrates, proteins, fats, and mineral elements they contained. The plants analyzed were Potamogeton pectinatus (sago pondweed), Scirpus paludosus (seeds)(bayonet grass), Salicornia spp. (samphire), Triglochin maritima (arrow grass), Ruppia maritima (widgeon grass) and Zannichellia palustris (horned pondweed).

Three of the plants-Potamogeton pectinatus, Ruppia and Zannichellia-are aquatic plants. Scirpus paludosus grows partially submerged, while Salicornia and Triglochin grow in wet soil. These plants appear to be well adapted to the environmental conditions at the refuge because of their ability to tolerate relatively high concentrations of soluble salts, either in the soil, as in the case of the marsh plants, or in the water, in the case of the aquatics.

The results of the crude fat, crude fiber, carbohydrate, protein, and ash analyses are shown in Table I, while the analyses of the constituents contained in the ash are reported in Table II. A table of analyses similar to those recorded in Table I is shown in Table III, in which analyses of some of the more common grasses and forage plants are given.

From Tables I and III it can be seen that except for the Scirpus seeds, the ash content of the refuge plants is unusually high, as compared with the forage plants. The crude fiber, representing the cellulose and other supporting structures, of the refuge plants is low as compared to the plants in Table III. In the aquatics this is probably due to the fact that the plants depend on the buoyancy of the water for support, while

Table I

Analyses of Some Food Plants Found at the Refuge

Plants	% ash	% crude fat	% crude fiber	% carbohydrate as starch	% crude protein
Potamogeton	43.8	3.7	13.8	1.84	8.7
Ruppia	44.5	2.1	14.4	1.90	5.25
Zannichellia	29.1	6.2	17.7	1.57	11.2
Scirpus (seeds)	5.35	5.35	20.2	1.18	
Salicornia	24.5	13	11.7	4.3	10.4
Triglochin	22.6	8.5	21.2	7.2	10.5

Table II

Analyses of Ash Constituents

Plants	% Na_2O	% K_2O	% CaO	% P_2O_5	% MgO	% Cl
Potamogeton	1.85	.13	27.8	1.13	1.84	.73
Ruppia	1.95	.40	30.2	.94	6.45	.56
Zannichellia	2.7	1.5	15.6	1.18	1.41	.79
Scirpus (seeds)	.75	.085	1.75	1.35	.40	.56
Salicornia	21.9	1.95	3.23	1.10	3.50	4.7
Triglochin	12.9	3.57	5.3	1.04	1.60	4.35

Table III

Average Proximate Analysis of the Dry Matter in Representative Forages*

Type of Forage	% protein	% ash	% crude fiber	% carbo-hydrates and fat
Corn fodder	8.57	7.14	29.8	54.4
Sorghum fodder	8.2	8.64	28.9	54.2
Kentuckey blue-grass	9.56	7.6	32.6	50.2
Timothy	7.0	5.5	33.7	53.7
Sudan grass	9.26	7.9	30.4	52.4
Prairie hay	8.55	8.2	32.6	50.3
Alfalfa hay	16.3	9.4	31.0	43.3
Cow-pea hay	21.4	12.96	24.9	40.5
Soy-bean hay	17.5	9.4	27.2	45.8

in Triglochin and Salicornia the succulent nature of their tissues and their high turgor pressures (4) support them in lieu of supporting structures.

The carbohydrate content of the refuge plants determined as starch seems to be quite low. It is possible that the carbohydrate reserves are stored in the form of hemicelluloses. In the case of Potamogeton it appears to be stored as starch in underground tubers as shown by qualitative tests. The crude fat and crude protein vary considerably, the aquatic plants in general, being lower in both. The high ash content of the

* From "Feeds and Feeding" by W.A. Henry and F.B. Morrison, The Henry-Morrison Company, Madison, Wis. (1923).

aquatics is due chiefly to a high calcium content. Calcium carbonate is deposited on the outside of the stems and leaves of some of the plants, particularly Ruppia, in quantities sufficient to make them rough to the touch.

Salicornia and Triglochin have a high sodium and chlorine content as compared with other plants, due probably to the high soluble salt content of the soil on which they were growing. The average chlorine content of the soil varies between one and two per cent. In the flooded areas silting has occurred, reducing somewhat the salt concentration of the immediate bottom soil. The concentration of chlorine in the bottom soil in these water covered areas varies from 0 to 1.8% the average being .98%, while in the water it varies from 0 to 1.9%, being low in the spring and the fall. The differences in chlorine content between the aquatic plants and Salicornia and Triglochin are shown in Table II.

Chemical Composition of Aquatic Plants in Relation to Change in Season

Aquatic plants were collected from the quadrates in Units 1, 2, 3, from August through November and analyzed to determine what changes in chemical composition occur during this period, which is the most important feeding time of the year. More birds are present during the months of September, October, and November than at any other time. The bird census of the refuge taken in September 1936 showed an average population of over one half million birds for the month. Most of these were ducks. This number may vary somewhat from year to year but it does indicate that a great number of birds feed on the refuge at this time of year.

No attempt was made to collect individual species at the different seasons. All of the samples were mixtures of Potamogeton spp. and Ruppia spp., with some algae. Between 7 and 10 samples were analyzed for each month. The dominant plant in the samples analyzed from the months of August and October was Potamogeton, while the dominant plant from the months of September and November was Ruppia. The results of all of the analyses for any one month were averaged together. These averages are compared in Tables IV and V.

The data show a definite increase in the ash content, an increase in the carbohydrates, and a decrease in nitrogen in the month of November as compared with the other months. There is a decrease in the per cent of sodium in the months of October and November from that reported for the months of August and September.

Table IV

Chemical Composition of Aquatic Plants in Relation to Season

Month	% ash	% crude fat	% crude fiber	% nitrogen	% carbohydrates
August	29.5	5.63	15.71	1.49	2.55
September	28.3	4.76	19.7	1.52	4.28
October	27.4	5.65	21.8	1.41	2.81
November	41.2	4.45	17.2	1.34	8.4

Table V

Ash Constituents of Aquatic Plants in Relation to Season

Month	% Na_2O	% K_2O	% CaO	% P_2O_5	% MgO
August	3.66	.86	14.02	.806	1.75
September	3.5	.686	13.5	.836	2.12
October	1.44	.47	17.2	.96	2.48
November	1.87	.74	15.0	.815	1.83

There are many factors that enter into the reasons for change in composition, so that it would be difficult to draw definite conclusions as to the cause of these changes. The fact that the dominent species in the same quadrate varies with the season is one factor which is probably important. Changes in depth and turbidity of the water during the season are other factors which may affect the chemical composition.

Concerning the ash and ash constituents it has been pointed out by Kostychev (5) that, "As yet we cannot determine how far the composition of the ash is conditioned by external ecological and internal physiological conditions."

As for the increase in carbohydrates it might be suggested that practically all plants increase their reserve carbohydrate content at the end of the season, probably at the expense of some of their protein.

Chemical Composition of the Aquatic Plants in Relation to Depths of Water

At the time the plants were collected from the quadrates, notes were taken as to the depth of water, temperature of the water at the bottom and at the surface, and the pH of the water at the bottom. The collections were sorted into four groups according to the depth of water at the quadrates. Chemical analysis were made of about eight plant samples for each depth reported*, and the values obtained in each group were averaged. The results are reported in Table VI. The average differences in temperature between the surface and the bottom water at the time the plants were gathered is also shown, the greatest difference being 1.6°C. at the depth of 19-25 inches. This comparison shows that on the average the temperature down to 12 inches in depth is only .5°C. less than at the surface, whereas there is more than three times that difference at 19-25 inches.

The pH values reported for the various depths are averages of the separate pH determinations. The pH averages as shown in Table VI decreased with the depth; however, this decrease is very slight and the differences are probably not significant.

The turbidity of the water in the units varies considerably, but during the greater portion of the growing season is high. The underlying mud in the units is so finely divided that even slight disturbances of the water cause considerable turbidity,

* Only three samples were analyzed for Na, K, P, and Mg in the 19-25 inch depth

especially in the shallower areas. After wind storms the turbidity persists for long periods of time and may be an important factor in the growth of the water plants. The turbidity values reported in Table VI are averages of determinations made on 46 samples of water collected from the quadrates at the time the plant collections were made. A photo electric cell was used in the determination. The values reported represent the percentages of light absorbed by the refuge waters as compared with pure water. The average of these determinations shows that only 3.5% to 4% of the light penetrates to a depth of 25 inches, taking the light at the surface as 100%.

Bourn (6) has shown that the growth of Potamogeton pecinatus declines rapidly in light intensities below 4% and that the limit for growth lies between 2.5% to3.5% of solar energy. Kostychev (5) states that the rate of photosynthesis varies directly with the amount of solar energy, when the amount of solar energy is below the maximum required. To illustrate what effect turbidity has on the growth of the aquatic plants on the refuge, the accompanying photograph (Figure 2) is presented. The depth of the water where there are no plants (center) is about 6 feet, while that where the plants are growing on the sides and foreground is approximately 2 feet. The amount of solar energy that can reach the bottom at a depth of 6 feet is very low, a fraction of one per cent. In such an area it would be impossible for growth of green plants to occur. As to whether the changes in chemical com-

TABLE VI

Variation in Composition with Depth

Depth of Water in Inches	% Ash	% Crude Fat	% Nitrogen	% Carbohydrate	% Crude Fiber	% Na_2O	% K_2O	% CaO	% P_2O_5	% MgO	Av. Temp. Diff.	Av. pH	Av.* Turbidity
1 to 4	26.5	5.02	1.35	4.38	19.7	3.61	0.845	12.1	0.83	1.69	0.5	8.7	9.6
4.5 to 8	30	5.2	1.37	3.22	20.1	3.7	0.52	14.4	0.78	1.70	0.5	8.7	23.8
10 to 12	30.6	4.94	1.55	3.28	18.1	3.63	0.87	20.5	0.79	1.66	0.5	8.5	42.4
19 to 25	27.4	5.45	1.66	2.04	21.0	1.45	0.47	17.2	1.02	2.24	1.6	8.3	96.2

*Values represent % of light absorbed, compared with 100% transmitted for pure water.

Figure 2

Effect of Turbidity on Plant Growth
(Explanation in Text)

position of the plants with increase in depth of water as reported in Table VI are due to turbidity, pH, temperature or other factors, such as oxygen supply, remains to be determined. It is known, however, that turbidity affects the rate of photosynthesis and therefore the rate of growth.

Refering to Table VI and Figure 3, it is shown that the total nitrogen content increases progressively with an increase in depth of water, while the carbohydrate content of the plants decreases. (Figure 4). The crude fat content is also highest in the deepest water. There is an increase of magnesium and phosphorus with a decrease in sodium and potassium in the 19-25 inch depth, but it is possible that with the analysis of more samples these differences might not be so great, as no wide

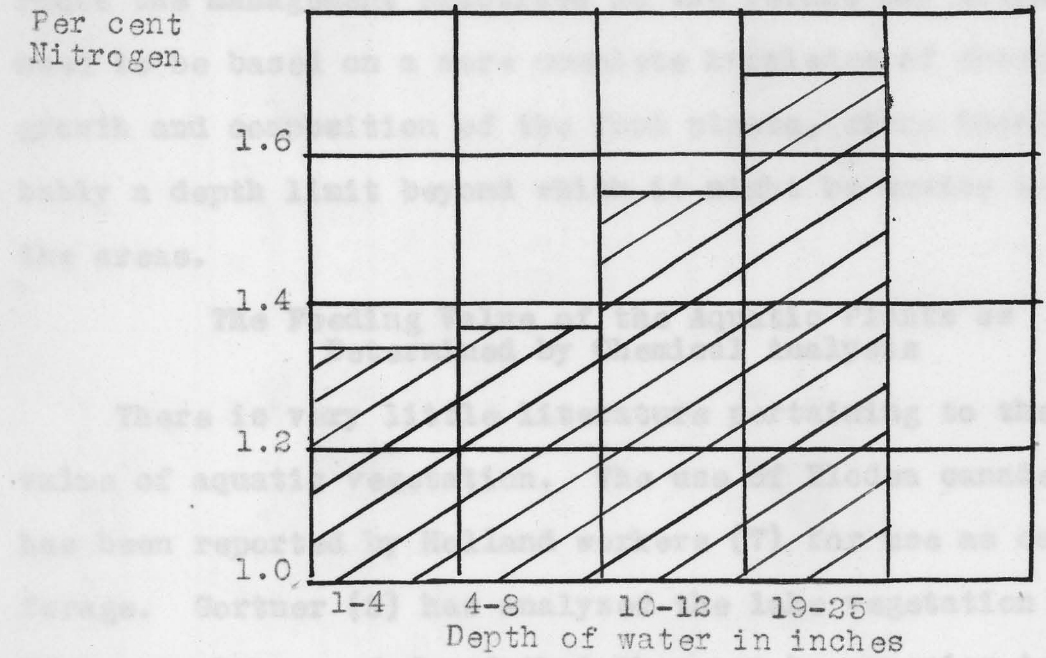

Figure 3

Per cent of Nitrogen plotted against Depth

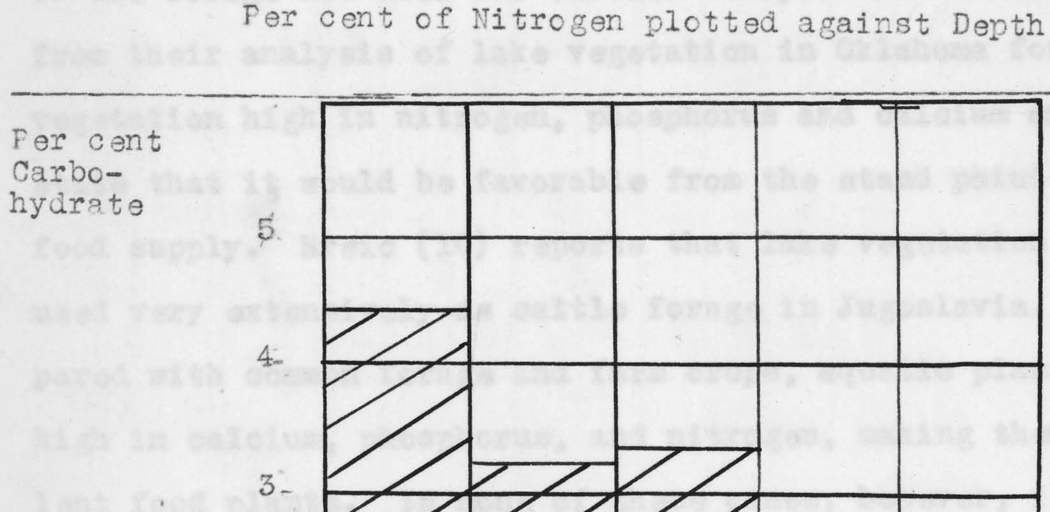

Figure 4

Per cent of Carbohydrate plotted against Depth variations are evident in the other depths. In view of these facts the management practices at the refuge may ultimately need to be based on a more complete knowledge of changes in growth and composition of the food plants, since there is probably a depth limit beyond which it might be unwise to flood the areas.

The Feeding Value of the Aquatic Plants as Determined by Chemical Analysis

There is very little literature pertaining to the feeding value of aquatic vegetation. The use of Elodea canadensis has been reported by Holland workers (7) for use as cattle forage. Gortner (8) has analyzed the lake vegetation from Minnesota lakes and found that they may be superior to much of the forage now used for cattle. Harper and Daniel (9) from their analysis of lake vegetation in Oklahoma found the vegetation high in nitrogen, phosphorus and calcium and state that it would be favorable from the stand point of food supply. Mrsic (10) reports that lake vegetation is used very extensively as cattle forage in Jugoslavia. Compared with common forage and farm crops, aquatic plants are high in calcium, phosphorus, and nitrogen, making them exellent food plants. In none of these cases, however, is mention made of the feeding value of water vegetation in relation to bird feeding. Wetmore (11) states that there are two plants present in great abundance at the Bear River Migratory Bird Refuge upon which ducks depend largely for their staple vegetable food. They are Potamogeton and Scirpus

Table VII
Analysis of Plant Samples from the Bear River Bird Refuge Showing Variations in Food Constituents

Plant	Calories per gram	% crude fat	% crude fiber	% carbo-hydrate	% CaO	% P_2O_5	% MgO	% crude protein	Nitrogen free extract
Potamogeton	905	3.7	13.8	1.84	27.8	1.13	1.84	8.7	30.0
Ruppia	566	2.1	14.4	1.9	30.2	0.94	6.45	5.25	33.75
Zannichellia	1266	6.2	17.7	1.57	15.6	1.18	1.41	11.20	35.8
Salicornia	2966	13.0	11.7	4.3	3.23	1.10	3.5	10.4	30.4
Triglochin	1524	8.5	21.2	7.2	3.30	1.04	1.6	10.5	37.2
Scirpus	547	5.35	20.2	1.18	1.75	1.35	0.40		
Unit 1	1084	4.04	20.1	5.30	15.36	0.88	1.45	8.75	59.33
Unit 2	1202	5.08	18.9	3.85	16.33	0.70	1.94	10.2	40.17
Unit 3	1119	5.08	18.6	2.70	6.47	0.79	1.56	7.8	38.12

paludosus.

The entire plant of Potamogeton is utilized for food: the stems, leaves, rhizomes, tubers and seeds. Of Scirpus, the seeds are the only part taken as food. In the late fall, winter, and early spring this latter plant is of great importance as a food supply because of the lack of other available food. Other plants also present in abundance and which furnish food for ducks and other game birds are Salicornia spp., Ruppia spp., Triglochin spp., and Zannichellia spp.

Potamogeton and Ruppia are particularly important, since they constitute the dominant aquatic vegetation of the units under consideration. Being unable to find any references to work done on food requirements of wild fowl, it is difficult to evaluate the results of the chemical analyses of the aquatic plants in terms of the food requirements of the birds. No experiments have been carried out to determine the amounts or kinds of nutrients necessary but, generally speaking, birds require a much greater amount of food than do other vertebrate animals. They are more active than other vertebrates and their body temperature and rate of respiration are higher because of their sustained flights and the speed at which some of them travel. It is therefore necessary that they have large quantities of easily digestable food.

Plants high in nitrogen, calcium, phosphorus and magnesium make excellent food. All the plants analyzed are high in these elements as will be observed by a comparison of Tables III, VII, and VIII.

Table VIII

Average Proximate Analysis of the Dry Matter in Representative Farm Crops

Plants	Protein	Fat	P_2O_5	CaO	MgO
Corn	11.5	4.3	1.77	.70	.66
Wheat	12.2	2.2	2.24	1.12	.68
Beans	30.4	12.6	2.50	2.92	.97
Clover	35.2	5.6	.92	2.10	.99

The soluble sugar and starch content of the plants analyzed is comparatively low. In the case of Potamogeton, qualitative tests on the tubers show a high percentage of starch, indicating that considerable starch is stored in them. If the carbohydrates are expressed as nitrogen free extract, which would include hemicellulosses and glucosides as well as sugars and starches, the percentage is increased considerably as shown in Table VII. The energy that can be derived as heat from the combined fat, protein,and carbohydrate constituents has been calculated,using the values given by Kostychev (5) for the number of calories of the heat yielded per gram of substance, as follows:

Substance	Heat in Calories
Fat	9320 cal.
Starch	4123 cal.
Protein	5576 cal.

The values are shown in Table VI. Although, as has been stated, there is no way of expressing these results in terms of bird feeding values, the results shows that the plants collected at the refuge have a high feeding value when compared with those forage and crop plants listed in Tables III and VIII.

Summary and Conclusions

1 - Plants growing at the Bear River Refuge are characterized by a high ash and low crude fiber content.

2 - The change in season seems to have no marked effect in altering the chemical composition of the plants, at least for the short period for which the samples were analyzed. There appears to be an increase in carbohydrate and in ash, and a decrease in sodium in those samples gathered in Nov.

3 - There is an increase in nitrogen and a decrease in carbohydrate content of the aquatic plants with an increase in the depth of water in which they are growing. Whether this is due to difference in temperature, pH or turbidity has not been determined.

4 - The turbidity of the water is undoubtedly an important factor in the growth of aquatic plants on the refuge and merits further detailed study.

5 - The chemical analyses of these plants show a high food value in comparison with other food plants.

6 - A great many more determinations on plants gathered over a considerably longer period of time would be necessary to obtain conclusive results and do justice to this problem.

Bibliography

1 - Association of Official Agriculture Chemists.
Official and Tentative Methods of Analysis.
Washington, D.C. Ed 4 (1935) (a) page 24,
(b) page 339 and 21, (c) page 340.

2 - Griffin, R.A.
Technical Methods of Analysis.
Ed. 2 (1927), McGraw Hill, New York.

3 - Shaffer, P.A. and Hartman, A.F.
Methods for the Determination of Reducing Sugars
in Blood, Urine, Milk, and other Solutions.
Jour. Biol. Chem. 45; 349-364, (1920).

4 - Harris J.A.
The Physic-chemical Properties of Plant Saps.
(1934) U. of Minnesota press, Minneapolis, Minn.

5 - Kostychev, S. (transalated by C.J. Lyon).
Kostychev's Chemical Plant Physiology.
(1931), page 227. Macmillan, New York.

6 - Bourn, W.S.
Ecological and Physiological Studies on Certain
Aquatic Angiosperms.
Contributions from Boyce Thompson.
Institute 4; 425 (1932).

7 - Jour. Board Agr. (London), 26:321-2.

8 - Gortner, Ross Aiken.
Lake vegetation as a Possible Source of Forage.
Science N.S., 77: 306-7, Mar. 24, 1933.

9 - Harper, H.J. and Daniel H.A.
Chemical Composition of Certain Aquatic Plants.
Bot. Gaz., 96: 186, 1934.

10 - Mrsic, Vilim.
Lake Vegetation as a possible Source of Forage.
Science N.S., 83: 391-2, Apr. 24, 1936.

11 - Wetmore, Alexander.
Wild Ducks and Ducks Foods of the Bear River
Marches, Utah.
U.S.D.A. Bulletin No. 936, May 31, 1921.

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D.C.C.