Scott, M. L. 1961. Professor of Animal Nutrition, Cornell University. Personal communication.
———— and E. R. Holm. 1961. Wild waterfowl starter, grower and breeder rations. Mimeographed material.

ESTIMATING CONSUMPTION OF FOOD BY WINTERING WATERFOWL POPULATIONS

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Wildlife food habits studies generally conclude that a series of foods make up certain percentage volumes and frequencies of the total consumption by the population of a species or group of species. These studies do not define the demand by the population on the food supply. With a few simple assumptions, and some additional knowledge of the food supply and the population, food habits studies can culminate in a more tangible expression of the amount of each food item consumed by the population, thereby permitting comparison of demand and supply.

This paper describes a method that was used to estimate the total food demand of the wintering waterfowl populations of Back Bay, Virginia, and Currituck Sound, North Carolina, from 1958 to 1962, to permit comparison with estimated standing crops of submerged aquatic plants. Potential errors that are avoided by this method of presenting food habits data by groups of waterfowl species are discussed.

The methods described in this paper were developed for application to data obtained from the cooperative study of Back Bay, Virginia, and Currituck Sound, North Carolina, by the Bureau of Sport Fisheries and Wildlife, the Virginia Commission of Game and Inland Fisheries, and the North Carolina Wildlife Resources Commission. The cooperation of all personnel assisting in collection of the data, used herein as examples of the methods described, is gratefully acknowledged. Donald W. Mayo, Virginia Commission of Game and Inland Fisheries, assisted the author in sorting and preliminary identification of items in the waterfowl gizzards.

To estimate the amounts of each food consumed by a waterfowl population, it is necessary to know the average amount of food consumed by each individual of each waterfowl species per day, the size of the population of each waterfowl species, its tenure in the area of concern, and the relative percentage of each food eaten by each major species in the population.

It was found that as a "rough rule of thumb" the average food consumption per bird per day could be estimated, in dry weight, as 10 percent of the wet body weight of each species. The average weights used for each waterfowl species were the average of the drake and hen weights presented by Kortright (1954), which presumably include both young of the year and older birds. Individual daily consumption might possibly have been calculated by other methods, such as estimating the percentage of the daily consumption reflected by the gizzard content. A correlation of $r = 0.964$ was obtained in comparing average body weight of 21 species of waterfowl with the average content of food in the gizzards of 765 individuals. However, a simplified, and perhaps superior, estimate of daily food consumption for each bird was obtained by using the 10 percent estimate of wet body weight as the amount in dry weight required. This method also permits estimates of total food demand by a population when only the size of the population is known.

The 10 percent estimate was an approximation based on unpublished data and the few reports in the literature of the daily consumption of food by different species of waterfowl.

Daily consumption (in dry weight) by mallards, was found by James B. DeWitt and Harold A. Doty of the Patuxent Wildlife Research Center, to be 8.4 percent of the wet body weight. Between October 24, 1961, and February 2, 1962, 40 young-of-the-year mallards at the Center consumed an average of 106 grams of commercial pellets per day which were approximately 95 percent dry weight. The average body weight of these birds was 1201 grams.

Mallards, blue-winged teal, and Canada geese were found by Jordan (1953) to have average daily intake of 0.20 pound, 0.06 pound, and 0.40 pound dry weight, respectively, when they were fed corn and small grains. The maximum intakes of corn by mallard drakes and Canada geese were 0.33 pound and 0.52 pound, respectively. The ratio of body weights between geese and mallards was 2.4 to 1 (7.20 pounds to 2.94 pounds), whereas the ratio of small grain intake during February was 2.6 to 1. Jordan concluded that, "The food intake of captive waterfowl seemed to be more or less directly related to body weight."

Groups of waterfowl consisting of 54 mallards, 8 redheads, 4 pintails, and 2 gadwalls had an average consumption of 1.94 pounds dry weight of food per duck per week, or 0.28 pound per day (Holm and Scott, 1954). A group of birds of this composition would have an average weight of 2.4 pounds per bird. The daily intake of food in dry weight thus approximated 11 percent of the wet body weight.

Active wild birds subjected to natural conditions, and feeding on foods that are probably less nutritious than commercial foods, may require greater amounts of food than pen-raised birds. It seems that a fair estimate of the average daily consumption of food (dry weight) for waterfowl is 10 percent of the wet body weight.

The populations of each species of waterfowl in Back Bay, Virginia, and Currituck Sound, North Carolina, and the tenure of each species in the area were obtained from 53 periodic aerial waterfowl inventories during the winters of 1958 through 1962. Waterfowl-days were calculated for each species for each winter by multiplying the average population of each species by the 203-day interval between the first survey in late September and the last survey in early April of each wintering period.

Table I presents the estimated average annual waterfowl utilization and estimated average annual food consumption by each waterfowl species during the 4-year period. Food consumption was calculated as the product of the estimated average daily consumption per bird and the number of waterfowl days. The average annual consumption of food by waterfowl during the 4-year period was 5,815 tons dry weight, or approximately 29 tons dry weight per day for the 203-day wintering period.

Table II presents the food habits data for ruddy ducks and the method of using these data to estimate consumption of each food item. The estimate of the average annual consumption of each food item is the product of the percentage volume of food and the estimated total food consumption (from Table I). Similar estimates were made for each waterfowl species represented in the gizzard collections. Estimates of consumption of individual food items were based on data for all years combined rather than year by year, because the sampling was not representative enough for an annual comparison of each waterfowl species in all years. Calculations were carried to units, for the purpose of cross-checking, but from a practical standpoint the figures might well be rounded to hundreds or thousands of pounds.

The assumption has been made in these calculations that volume and dry weight are equivalent for all food items. Low and Bellrose (1944) presented the weight-volume ratio of approximately 20 waterfowl foods, and although the ratios ranged from 0.39 to 1.10, this amount of variation would not justify the time necessary for extensive elaboration of weight-volume ratios of each food item in the diet of each species, if consideration is given to numerous other variables involved in food habits work and in the estimates of expansion. The effect of the variation in the ratio between weight and volume among the various food items is certainly worth further consideration.

The total amounts of each food item consumed by each waterfowl group (such as dabbling ducks, diving ducks, total ducks, or total waterfowl) were obtained by adding the amounts of the item in the diet of each species within the group (from tables corresponding to Table II). Thus, food consumption presented for each group was weighted by the waterfowl days and the estimated

TABLE I
AVERAGE ANNUAL WATERFOWL USE OF BACK BAY-CURRITUCK SOUND AREA AND ESTIMATED FOOD CONSUMPTION, 1958-61 *

Waterfowl Species	*Rate of Consumption*†	*Avg. Wintering Waterfowl-Days*	*Consumed by Population (lb. per winter)*
Mallard	0.25	155,800	38,953
Black Duck	0.25	695,125	173,785
Gadwall	0.19	12,225	2,323
Pintail	0.20	574,400	114,880
Green-winged Teal	0.08	159,975	12,798
Blue-winged Teal	0.09	69,175	6,225
American Widgeon	0.16	1,679,775	268,762
Shoveler	0.14	3,750	520
Wood Duck	0.15	1,225	185
TOTAL DABBLERS		3,351,450	618,430
Redhead	0.24	203,150	48,755
Ring-necked Duck	0.16	1,012,525	162,012
Canvasback	0.27	575,175	155,298
Scaup	0.20	65,550	13,110
Common Goldeneye	0.20	250	50
Bufflehead	0.09	3,150	285
Old Squaw	0.15	225	38
Common Scoter	0.21	275	58
Ruddy Duck	0.12	697,575	83,708
TOTAL DIVERS		2,557,925	463,312
Mergansers	0.20	825	165
Unidentified Ducks	0.19	18,400	3,495
Fulvous Tree Duck	0.17	200	35
TOTAL DUCKS		5,928,800	1,085,437
Coot	0.12	3,971,900	476,627
Canada Goose	0.79	6,104,250	4,822,232
Snow Goose	0.68	3,726,750	2,534,185
Blue Goose	0.51	25	13
American Brant	0.40	20,225	8,090
Whistling Swan	1.47	1,839,900	2,704,652
TOTAL WATERFOWL		21,591,850	11,631,323

* Waterfowl use was estimated in terms of waterfowl-days; food consumed by the species was estimated as the product of pounds (dry weight) of food per bird per day and the number of waterfowl-days; food per bird per day was estimated as described in text.
† Pounds (dry weight) of food per bird per day.

daily consumption of each species in the group. This distinction is not generally made by waterfowl workers, who present food habits data for various groups of waterfowl, and either assume that the waterfowl gizzard collection is proportional to the population, or ignore the necessity of proportionally weighting the species within the group to make them conform to the population. A precise proportional sampling of all species in a wintering waterfowl population is virtually impossible. In the data presented in Table I, if 10 gizzards of common goldeneyes had been collected, a proportional sampling would have required 244,000 Canada goose gizzards. If gizzards of waterfowl species are collected from hunters, they will tend to approximate the composition of the overall kill, but because of shooting regulations, wariness of some species, tenure of the species in the area, desirability of the species, and other factors, the species composition of the kill may differ considerably from the species composition of the population. In attempting to relate total food demand of a wintering population to the food supply, all abundant species in the population should be represented in the collection of gizzards, because of their effect on the standing crop. By using the data from aerial waterfowl inventories to define the population and weight the food habits data, the researcher need not depend on his

TABLE II

FOOD HABITS AND ESTIMATED FOOD CONSUMPTION OF RUDDY DUCKS *

Food Item	*No. of Occ.*	*Vol. (cc.)*	*% Vol. Food*	*Avg. Total Annual Food Consumption*† *(lb. dry wt.)*	*Annual Consump. in Lbs. Dry Wt. (col. 3 x 4)*
Ruppia maritima	37	14.31	34.5	(83,708)	28,879
Potamogeton pectinatus	13	9.92	23.9		20,006
Potamogeton perfoliatus	18	5.04	12.1		10,128
Chara sp.	1	2.85	6.9		5,775
Nymphaea odorata	2	1.02	2.5		2,093
Najas guadalupensis	7	0.61	1.5		1,256
Scirpus olneyi	2	0.61	1.5		1,256
Vallisneria americana	3	0.54	1.3		1,088
Scirpus americanus	2	0.38	0.9		753
Potamogeton pusillus	1	0.32	0.8		670
Eleocharis quadrangulata	3	0.21	0.5		419
Polygonum densiflorum	1	0.15	0.4		335
Myrica cerifera	1	0.09	0.2		167
Myrica pensylvanica	1	0.06	0.1		84
Unidentified vegetation	8	1.38	3.3		2,762
TOTAL VEGETATION	55	37.49	90.4		75,671
Amphipoda	9	3.91	9.4		7,869
Gastropoda	1	0.06	0.1		84
Odonata	1	0.04	0.1		84
Unidentified Animals	1	Trace	. .		. .
TOTAL ANIMAL	11	4.01	9.6		8,037
Total Food	55	41.50	(44.6)‡		83,708
Grit	55	51.50	(55.4)‡		
Lead Shot	0	. . . .	. . .		
Total Content	55	93.00	(100.0)		

* Food habits data from gizzard analyses of 55 ducks collected on Back Bay, Virginia, and Currituck Sound, North Carolina, during the winters of 1958 through 1961.
† Data for 1958-61 from Table I.
‡ Percentage of total content.

collection of gizzards being proportional to the species composition of the population, and he can confine the collection of gizzards of each species to the number considered necessary to reflect the average food habits of the population. The variability of the diet of each species of waterfowl would then be the criterion for determining the required number of gizzards of each species, rather than the size of the population of the species. Only waterfowl gizzards were used because of the difficulty of obtaining an adequate sample of gullets with food; however, the methods described in this paper could be applied to food habits studies from gullets, possibly with increased accuracy.

The following data are presented as an example of some of the comparisons that can be made with data on the standing crop of food and estimates of the food demand of the waterfowl population. Estimates of the dry weight of the standing crop of each species of submerged aquatics were obtained from transect surveys of Back Bay, Virginia, and Currituck Sound, North Carolina, and the standing crops were computed as the average of the fall and spring surveys. Detailed description of the methods of conducting these surveys and the data obtained will be presented in subsequent reports. The average percentage consumption of the standing crop of all submerged aquatics varied from 17.6 percent to 24.2 percent during the 4-year period and averaged 19.9 percent. It might be inferred that a five-fold increase in the waterfowl population, with relatively the same species composition, would denude the submerged aquatic vegetation. Also, a change in the composition of the waterfowl population in favor of those species that feed primarily on submerged aquatic vegetation could result in greater utilization of the standing crop.

Inadequate representation of swan gizzards in the sample prevented precise comparison of total food consumption by the waterfowl population with the standing crop of each species, for only one swan gizzard was included; if the assumption is made that virtually 100 percent of the swan diet consists of submerged aquatics, swans would consume over 50 percent of the total amount of submerged aquatics consumed by the waterfowl population. However, excluding swans in the comparison, it was estimated that the remaining waterfowl population consumed the following percentages of the standing crop of some of the major species: sago pondweed 9.2 percent; wildcelery 7.1 percent; southern naiad 13.8 percent; claspingleaf pondweed 5.8 percent; widgeongrass 8.3 percent; and muskgrasses (*Chara* and *Nitella*) 1.0 percent.

SUMMARY AND DISCUSSION

This paper proposes a method of estimating the total food demands of the wintering waterfowl population of an area. The average annual food consumption of each species of waterfowl using the Back Bay, Virginia-Currituck Sound, North Carolina, area was estimated during the period 1958-62, by multiplying the waterfowl days by the estimated daily food consumption of each species of waterfowl. Daily consumption, in pounds dry weight, was estimated from the literature to be approximately 10 percent of the average wet body weight of the species. The percentage volume of each food item in the diet of each species was multiplied by the estimated average annual food consumption by the population of that species to obtain an estimate of the quantity of each food item. An example is given to show how waterfowl food demand can be compared with food supply.

A more concrete understanding by waterfowl habitat managers who may endeavor to produce more waterfowl foods, or by waterfowl researchers who may seek to evaluate habitats could result from this mode of expressing waterfowl food demand. The use of waterfowl days utilization in weighting food habits data eliminates the necessity of attempting to achieve proportional sampling of waterfowl gizzards, which is virtually impossible. Potential refinement of estimating food demand consists of obtaining adequate stomach samples of each waterfowl species, improving the estimate of food consumption of each abundant waterfowl species, establishing dry weight-volume ratios of each food item, and evaluating their importance in further weighting the data.

LITERATURE CITED

Holm, E. R. and M. L. Scott. 1954. Studies on the nutrition of wild waterfowl. New York Fish and Game Journal, 1(2):171-187.

Jordan, James S. 1953. Consumption of cereal grains by migratory waterfowl. J. Wildl. Mgt., 17(2):120-123.

Kortright, F. H. 1943. The ducks, geese and swans of North America. Am. Wildl. Inst. 476 pp.

Low, J. B. and F. C. Bellrose, Jr. 1944. The seed and vegetative yield of waterfowl food plants in the Illinois River valley. J. Wildl. Mgt., 8(1):7-21.