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FOOD HABITS OF REDHEADS AT THE HORICON MARSH, WISCONSIN

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Abstract.—Food habits of Redheads (*Aythya americana*) were investigated at the Horicon National Wildlife Refuge, Wisconsin, during 1983–1985. Prelaying females consumed plant material almost exclusively, primarily seeds of moist-soil plant species. The diet of laying and incubating females was dominated by seeds but also contained 16–17% animal matter. Consumption of animal matter during egg production was substantially lower than reported in other studies of food habits of Redheads. The diet of juvenile Redheads changed with age. Animal foods were nearly half of the diet of ducklings <4 wk of age, whereas older ducklings consumed primarily plant material. A diversity of flooding regimes may promote plant communities that produce important food resources for Redheads on the Horicon Marsh.

HABITOS ALIMENTICIOS DE *AYTHYA AMERICANA* EN LA CIÉNAGA HORICON, WISCONSIN

Sinopsis.—Se investigaron los hábitos alimenticios de *Aythya americana* en el Refugio Nacional de Vida Silvestre de Horicon, Wisconsin entre 1983 y 1985. Antes de poner, las hembras comieron casi exclusivamente materia vegetal, principalmente semillas de plantas de suelo húmedo. La dieta de hembras que ponian o incubaban fué dominada por semillas, pero también tenía de 16 a 17% de materia animal. El consumo de materia animal durante la producción de huevos fué sustancialmente menor que lo reportado en otros estudios de los hábitos alimenticios de *Aythya*. La dieta de los juveniles cambia con la edad. Comida animal fué casi la mitad de la dieta de crías de <4 semanas de edad, mientras que crías mayores consumieron materia vegetal principalmente. Una diversidad de regímenes de inundación pueden ser importantes para promover las comunidadees de plantas que producen recursos alimenticios importantes para *Aythya americana* en la ciénaga de Horicon.

Seasonal variation in diet of breeding waterfowl has been documented for several species and is believed influenced by food availability and nutritional demands (Krapu and Reinecke 1991). Plant foods rich in carbohydrates may provide an important nutritional source to some diving duck species upon arrival on breeding grounds (Austin et al. 1990, Hohman 1985, Noyes and Jarvis 1985, Woodin and Swanson 1989). Diets of females normally consist largely of animal matter during formation and

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laying of eggs (Hohman 1985, Noyes and Jarvis 1985, Woodin and Swanson 1989), when demands for protein and calcium are high.

Food resources high in nutrients and energy content seem to be critical for proper growth and development of young (Sugden 1973a). Diet varies with age of ducklings in several species (Chura 1961, Hohman 1985, Jarvis and Noyes 1986, Krapu and Swanson 1977, Sugden 1973a) and is presumed to reflect changing nutritional requirements. High consumption of protein, often noted in young ducklings, increases rate of growth in birds (Johnson 1971) and probably minimizes vulnerability to predators.

Food habits of Redheads on the Horicon National Wildlife Refuge, Wisconsin, one of the few important Redhead breeding areas east of the Mississippi River (Swanberg 1982, Weller 1964), have not been described. Redhead production was a primary objective of the refuge when the area was established. In 1983, a 3-yr study was initiated to gather information for water management of subimpoundments on the refuge to enhance conditions for Redheads. In this paper, we describe the diets of Redheads by breeding status of adults and age of juveniles and relate food resources to water regimes.

STUDY AREA

Horicon Marsh is located in east-central Wisconsin in Dodge and Fond du Lac counties (43°37′N, 88°38′W). The marsh is a palustrine wetland with persistent emergent vegetation and floating vascular aquatic beds (Cowardin et al. 1979). The Horicon NWR was established in 1941 and contains the northern two-thirds (8390 ha) of the 12,814 ha marsh. This portion of the marsh receives runoff from 530 km^2, mainly through the east branch of the Rock River and ground water. Land use in the watershed is primarily agricultural, largely dairying.

The study area consisted of nine impoundments (1460 ha) in the northern portion of the marsh. Two impoundments were managed for moist-soil plant production using seasonal drawdown. The remaining impoundments were continually inundated during the study period. Mean maximum pool depth of each impoundment was about 73 cm.

METHODS

We collected birds (Federal Scientific Collecting Permit No. PRT 2-8289-TW, Wisconsin Scientific Collecting Permit Nos. SCP-SO-83-10, SCP-SO-1984-18, and SCP-SO-1985-18) throughout the study area at various times of the day with a shotgun during April–August, 1983–1985. Before collection, we observed feeding adults for a minimum of 10 min and recorded pairing status and method of feeding (surface, tip-up, diving). Immediately upon retrieval of the birds, we removed the upper digestive tract, injected it with 100% ethanol, and later stored it in 70% ethanol (Siegfried 1973). Breeding status of females was determined from examination of ovaries and brood patches (Krapu 1974). Ducklings were collected after we observed them feeding for 10 min (we incidentally collected some ducklings [n = 15] at night and during the day from

dense emergent vegetation without the associated 10 min observation period). Ages of ducklings were determined by plumage development (Weller 1957).

Contents of esophagi and proventriculi were sorted by taxa. Plant items were identified according to Fassett (1957) and Martin and Barkley (1961); invertebrates were identified with keys of Pennak (1978) and Hilsenhoff (1981). Food items were oven dried to constant mass at 90 C for 24 h and weighed to the nearest 0.1 mg. Results are expressed as frequency of occurrence and aggregate percent dry weight (Swanson et al. 1974). Information about nutritional content of items consumed by Redheads was obtained from several sources and used to calculate crude protein intake (Anderson and Low 1976, Bardwell et al. 1962, Boyd 1970, Boyo 1968, Drobney 1977, Fredrickson and Taylor 1982, Gortner 1934, Hoffman 1983, Krapu and Swanson 1975, Reinecke and Owen 1980, Sugden 1973b). We used Mann-Whitney U-tests to compare percent animal, vegetative, and seed components of the diet and estimated crude protein content of the diets among breeding-status (prelaying, laying, incubating) and juvenile-age categories (0–3, 4–6, 7–11 weeks). We used a Wilcoxon paired-sample test to compare animal, vegetation and seed components, and mean crude protein levels of paired adults (collected simultaneously). Refuge staff provided data on flooding regime of impoundments.

RESULTS

Diet of adult Redheads.—Food items from 26 female and 9 male adult Redheads were analyzed. Adult birds consumed 34 animal taxa of 27 families and 30 plant taxa of 13 families.

Prelaying females consumed plant material nearly exclusively (Table 1). Seeds, largely from moist-soil plant species, predominated the diet of prelaying birds. The seed component was larger in diets of prelaying females than in diets of laying ($P = 0.03$) or incubating ($P = 0.02$) females. *Potamogeton* spp. tubers were also present in the diet. Estimated mean crude protein content of the diet of prelaying females was 11%.

Plant matter was also important in the diet of laying Redheads. Seeds, primarily *Scirpus* spp., green algae (*Rhizoclonium* sp.) vegetation, and *Potamogeton* sp. tubers were primary components of the diet. Animal matter was present in all laying females and consisted primarily of Chironomidae larvae and pupae, and gastropods. Estimated crude protein content of the diet of laying females was 17%.

The diet of incubating females also consisted primarily of plant material, principally *Rhizoclonium* sp. vegetation and *Polygonum* spp. seeds. Animal matter in incubating females consisted primarily of Cladocera and Chironomidae larvae. Laying and incubating females consumed greater proportions of animal matter than prelaying females ($P = 0.001$ and $P = 0.02$, respectively). Estimated crude protein content of the diet of incubating hens averaged 19%. The mean crude protein content of food items was higher in laying ($P = 0.04$) and incubating hens ($P = 0.02$) than in prelaying hens.

TABLE 1. Content of upper digestive tracts of adult female Redheads (*Aythya americana*) from the Horicon NWR, 1983–1985.

Food item[b]	(*n*)	Aggregate percent dry weight			Percent occurrence		
		Prelay[a] (6)	Laying (11)	Incub (9)	Prelay (6)	Laying (11)	Incub (9)
Animal		tr[c]	17	16	83	100	100
Crustacea							
Cladocera		tr	tr	9	50	36	89
Ostracods			3	tr		36	56
Other Crustacea			tr	tr		18	33
Insecta							
Coleoptera (L, A)[d]		tr	tr	1	17	27	67
Diptera							
Chironomidae (L)		tr	5	3	17	73	67
Diptera pupae			5	tr		55	56
Other Diptera (L, A)		tr	tr	tr	33	27	67
Mollusca							
Gastropoda							
Physidae			1	tr		18	22
Other Gastropoda		tr	2	tr	33	64	56
Miscellaneous		tr	1	tr	33	64	78
Plant		100	83	84	100	100	100
Vegetation		tr	14	35	50	73	56
Rhizoclonium			11	33		18	33
Cladophora				1			11
Lemna		tr	1	tr	33	36	44
Potamogeton		tr	tr	tr	17	18	33
Miscellaneous		tr	1	tr	33	64	44
Seeds		83	61	49	100	100	100
Polygonum		36	14	20	84	55	67
Scirpus		tr	21	5	50	82	33
Potamogeton		tr	3	2	50	55	22
Leersia		43	5	15	83	18	67
Bidens		tr	tr	2	67	36	67
Unidentified		2	12	2	100	73	67
Miscellaneous		1	7	3	100	100	89
Tubers		16	8	tr	17	18	11
Potamogeton		16	8	tr	17	18	11

[a] Reproductive categories: prelay = prelaying; laying = egg laying; incub = incubating.
[b] Foods with <1% aggregate percent dry weight in all reproductive categories were omitted from table.
[c] tr = trace.
[d] L = larvae; A = adult.

The diet of adult males differed with breeding status in seed component ($P = 0.05$) and dietary crude protein level ($P = 0.05$). Seeds composed a larger proportion of the diet of males paired with incubating hens than of males paired with laying females ($P = 0.02$). Estimated mean crude protein content of the diet of males paired with laying females (25%) differed from males paired with incubating females (11%) ($P = 0.02$).

TABLE 2. Content of upper digestive tracts of juvenile Redheads (*Aythya americana*) from the Horicon NWR, 1983–1985.

Food item[b]	(*n*)	Aggregate percent dry weight			Percent occurrence		
		0–3[a] (9)	4–6 (23)	7–11 (18)	0–3 (9)	4–6 (23)	7–11 (18)
Animal		47	9	1	100	74	78
Insecta							
Lepidoptera							
Pyralidae (L)[c]		1	tr[d]	tr	11	4	6
Hemiptera (N, A)							
Corixidae		5	3	tr	44	26	33
Gerridae		25			56		
Other Hemiptera		1	1	tr	44	26	39
Diptera							
Ceratopogonidae (L)		11	tr	tr	11	4	11
Chironomidae (L)		tr	2	tr	33	44	56
Diptera adults		3	tr		56	17	
Other Diptera (L, P)		tr	1	tr	22	17	17
Miscellaneous		tr	1	tr	78	48	78
Plant		52	91	99	89	100	100
Vegetation		12	57	63	78	91	94
Potamogeton		5	42	28	22	57	50
Lemna		tr	7	21	56	48	50
Zannichellia		4			11		
Anacharis				6			6
Ceratophyllum			5	5	11	22	44
Wolffia		tr	1	1	44	22	67
Miscellaneous		2	4	2	44	35	56
Seeds		40	34	27	78	91	89
Polygonum		5	1	tr	33	26	28
Scirpus		16	6	11	44	39	44
Potamogeton			18	11		52	67
Leersia		tr	3	tr	11	9	11
Zannichellia		6	tr	tr	11	4	6
Sparganium			3			4	
Unid.		12	2	4	56	39	50
Miscellaneous		tr	1	1	33	48	67
Tubers				10			11
Potamogeton				10			11

[a] Age class categories: 0–3 = 0–3 wk; 4–6 = 4–6 wk ; 7–11 = 7–11 wk.

[b] Food items with <1% aggregate percent dry weight in all age categories omitted from table.

[c] N = nymph; L = larvae; P = pupae; A = adult.

[d] tr = trace.

Of nine Redhead pairs (female and male collected simultaneously), females contained a larger proportion of animal matter than their mates ($P = 0.02$). Vegetation and seed components of the diets and estimated dietary protein levels did not differ by sex.

Diet of juvenile Redheads.—Juvenile Redheads ($n = 50$) consumed 29 animal taxa of 27 families and 32 plant taxa of 18 families. Animal matter

was a large component of the diets of ≤3-wk-old ducklings and consisted largely of Hemipterans and larval and adult Dipterans (Table 2). Diet contained more animal matter in ≤3-wk-old ducklings than in 4–6-wk-old ($P = 0.001$) or ≥7-wk-old ducklings ($P < 0.001$). Seeds, primarily *Scirpus* spp., and vegetation (*Potamogeton* spp. and *Zannichellia palustris*) were also important foods. The estimated crude protein content of the composite diet of ≤3-wk-old ducklings was 37%.

Plant material, primarily vegetative parts and seeds of *Potamogeton* spp. made up a large portion of the diet. Animal matter was present in smaller quantities and consisted primarily of Hemipterans and Dipterans. The mean crude protein content of the diet of 4–6-wk-old ducklings was 18%.

Diets of ≥7-wk-old ducklings were almost entirely plant material, primarily *Potamogeton* spp. and duckweed (Lemnaceae) vegetation, and seeds of *Scirpus* spp. and *Potamogeton* spp. Mean crude protein content of the diet of this age group was 16%.

Vegetation was a smaller component of the diet of ≤3-wk-old ducklings than of 4–6-wk-old ($P = 0.007$) or ≤7-wk-old ducklings ($P = 0.005$). Animal, seed, and vegetation components and mean crude dietary protein of diets of ducklings in the 4–6-wk-old and 7–11-wk-old age groups did not differ.

DISCUSSION

Adult foraging strategy.—Adult Redheads at the Horicon NWR predominantly consumed seeds of moist-soil plant species, notably *Leersia oryzoides* and *Polygonum* spp., during the prelaying period. These foods are apparently low in protein but high in energy value to the birds (Fredrickson and Taylor 1982). *L. oryzoides* rates high in metabolizable energy for ducks among other seed foods (3.070 kcal/g; Hoffman 1983). Sampling indicated selected areas managed under a seasonally flooded regime at the Horicon NWR produced large quantities of *L. oryzoides* (K. P. Kenow, unpubl. data) and provided a ready supply of high-energy food to breeding birds. Woodin and Swanson (1989) concluded seeds from shallow wetlands were important to female Redheads for energy requirements early in the breeding season when animal matter was scarce. Female Redheads probably accumulate lipid reserves on this high energy diet and draw on them during egg formation and incubation.

Consumption of animal matter at the Horicon NWR was higher during egg laying (17%) than during prelaying (1%) and indicated an increased protein demand and/or increase in availability of animal matter to laying females. However, Redheads in this study consumed less animal matter than conspecifics elsewhere; animal matter composed a substantial portion of the diets of laying (76.8%) and incubating (48.6%) Redheads at the Ruby Lake NWR, Nevada (Noyes and Jarvis 1985). Animal matter also was a large proportion of the diets of prelaying (66%), laying (70%), and postlaying (63%) female Redheads in North Dakota (Woodin and Swanson 1989). In a summary of several studies, Swanson and Meyer (1973)

reported breeding Aythinae consumed an average of 92% animal matter by volume.

The low intake of animal matter by breeding Redheads may point to an inadequate supply of animal food on the Horicon NWR. Consumed animal matter was primarily Chironomidae larvae and pupae. Trichoptera larvae and Odonata nymphs seem to be important food items in Redheads elsewhere (Bartonek and Hickey 1969, Noyes and Jarvis 1985) but were noticeably absent from the diets of Redheads at the Horicon NWR. Most species of Trichoptera larvae require good water quality with high levels of dissolved oxygen (Gaufin 1973). Low levels of several agricultural pesticides and extremely high levels of suspended solids (range = 6–248 mg/L, mean = 80.2 mg/L) were measured in runoff entering Horicon Marsh (K. P. Kenow, WI Coop. Wildl. Res. Unit, unpubl. data). The resulting poor water quality may affect the distribution and abundance of sensitive insect orders (Gaufin 1973) and overall biomass of invertebrates.

On the other hand, the low protein intake of breeding females at the Horicon NWR may be adequate considering the abundant and diverse seed supply. Holm and Scott (1954) concluded breeding female Mallards (*Anas platyrhynchos*) and Redheads required no greater than 18.6% protein in the diet. Krapu and Swanson (1975) noted that reduced food availability in the wild may necessitate greater protein content in the diet. The mean dietary protein levels of laying (17%) and incubating (19%) females is comparable to that considered adequate for breeding birds (Holm and Scott 1954). Consequently, managing areas for moist-soil plant seeds high in metabolizable energy, such as *Leersia oryzoides*, may be crucial to supplementing nutrient reserves of breeding females in the spring because of the apparent low invertebrate biomass available to females at that time.

In addition to providing an important seed source to prelaying and breeding Redheads, moist-soil management units seemed to be important to incubating Redheads. When water levels in these units receded, extensive beds of *Rhizoclonium* sp. developed and *Rhizoclonium* sp. then seemed to be an important food in the diet of incubating hens. Although *Rhizoclonium* sp. probably has a low energy value (based on metabolizable energy values for *Cladophora* sp.), *Rhizoclonium* is relatively high in crude protein (21%; Boyo 1968).

Juvenile foraging strategy.—Juvenile Redheads at the Horicon NWR exhibited a diet similar to that described for Redhead ducklings elsewhere (Jarvis and Noyes 1986). Diets of young ducklings (≤3 wk age) from the Horicon NWR contained 47% animal matter and the dietary protein levels in this age group were comparable to those reported of ducklings of similar age at the Ruby Lake NWR by Jarvis and Noyes (1986) (35% Ruby Lake, 34% Horicon NWR) and higher in 4–6-wk-old ducklings (9% for comparable age group at the Ruby Lake NWR, 18% Horicon NWR). Growth rate and survival of Wood Duck (*Aix sponsa*) ducklings were lower in groups fed lower protein diets than in groups fed diets high in protein (Johnson 1971). Johnson suggested a deficiency in availability of high-

protein natural foods could influence mortality by weakening the ducklings and extending the flightless period, rendering them more susceptible to decimating factors. Redhead ducklings at the Horicon NWR seemed to obtain sufficient animal matter and dietary protein critical for growth and survival.

Examination of the abundance and distribution of invertebrates potentially available to Redhead ducklings (Kenow and Rusch 1989, unpubl. data) suggested the greatest abundance of several groups of invertebrates consumed by young Redheads was in a plant community association of *Typha* sp., *Utricularia vulgaris, Ceratophyllum demersum* and *Lemna* spp. (mid-successional stage). Invertebrate abundance was less in areas associated with later successional stages (see also Voigts 1976). Invertebrate numbers increased during the first three years of flooding but decreased the fourth year (Kenow and Rusch 1989; Horicon National Wildlife Refuge, unpubl. data) in four impoundments continually inundated during a 4-yr period to average depths of 31–77 cm. This phenomenon was documented elsewhere by McKnight and Low (1969) and Whitman (1974) and linked to vegetation succession and variation in levels of detritus and primary productivity with impoundment age. A mid-successional vegetation stage and an impoundment age most productive of invertebrates should be fostered to ensure adequate foods are available to ducklings.

Potamogeton seems to be the single most important food-plant genus to Redhead ducklings because all parts (leaves, stems, tubers, and seeds) were consumed in significant proportions. At night, ducklings were common in or near areas with heavy growth of *Potamogeton pectinatus* and *P. pusillus,* even though only 5–6% of the marsh habitat in the study area produced *Potamogeton. Potamogeton* growth in the study area at the Horicon NWR was restricted to areas under a long-term flooding regime (i.e., ditches, peat burnouts, and subimpoundments subject to ≥8 yr of flooding).

MANAGEMENT IMPLICATIONS

Redheads at the Horicon NWR used a variety plant and animal food resources during the breeding and brood-rearing periods. Apparently moist-soil plants, produced in seasonally flooded areas, provide a dependable, high-energy food source to breeding Redheads. Invertebrate production, critical for optimum duckling growth, was high in recently flooded (i.e., 2–3 yr) impoundments but seemed to decrease with 4 yr of continuous flooding (Kenow and Rusch 1989; Horicon National Wildlife Refuge, unpubl. data). Invertebrate numbers may be enhanced through periodic drawdown of water levels (McKnight and Low 1969, Whitman 1974). Drawdowns should be scheduled to encourage growth of mudflat annuals, regenerate stands of emergent vegetation, stimulate primary productivity, and in turn improve the detrital base. *Potamogeton* spp., important to older ducklings and breeding adults, may require several years of flooding to become established and are usually associated with permanent to semipermanent flooding regimes of palustrine wetland systems (Co-

wardin et al. 1979, Stewart and Kantrud 1971). Millar (1973) found *P. pectinatus* only appeared in shallow marsh wetlands in Saskatchewan after >3 yr of inundation.

We suggest that managers should attempt to provide adequate amounts of habitats that produce important foods for Redhead production by employing a diversity of flooding regimes. Because independent water-level manipulation is possible on impoundments at the Horicon NWR and other intensively managed marshes, at any given time the array of impoundments should be under a variety of flooding regimes, ranging from seasonal to semipermanent. When possible, an asynchronous drawdown schedule should be used when 2 or more impoundments are placed under a semipermanent flooding regime. The resulting habitat types that produce foods for ducklings should be positioned such that they are readily accessible from nesting areas. An attempt should be made to monitor invertebrate abundance and food-plant production and use the information as a basis for drawdown schedules.

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