Lesser Scaup diets during migration and winter in the Mississippi flyway

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Received January 29, 1990

AFTON, A. D., HIER, R. H., and PAULUS, S. L. 1991. Lesser Scaup diets during migration and winter in the Mississippi flyway. Can. J. Zool. **69**: 328–333.

We examined diets of Lesser Scaup (*Aythya affinis*) during midwinter ($N = 41$) in southwestern Louisiana (1986), and during spring ($N = 57$) and fall ($N = 48$) in northwestern Minnesota (1984–1988). Diets of males and females generally were similar during migration and winter. Diets of adults and immatures differed during fall migration but were similar during winter. In fall, immature scaup fed heavily on amphipods and did not consume certain foods, such as fish and fingernail clams, that were important in adult diets. Aggregate percent dry weight of animal foods was higher during fall (adults 91%, immatures 93%) and spring (92%) than during midwinter (61%). Important foods during all periods were crustaceans, insects, and mollusks.

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Nous avons étudié le régime alimentaire du Petit Morillon (*Aythya affinis*) au milieu de l'hiver ($N = 41$) dans le sud-ouest de la Louisiane (1986), au printemps ($N = 57$) et à l'automne ($N = 48$) dans le nord-ouest du Minnesota (1984–88). Les mâles et les femelles ont généralement le même régime alimentaire durant la migration et au cours de l'hiver. Le régime des adultes et celui des individus immatures diffèrent au cours de la migration d'automne, mais sont semblables au cours de l'hiver. À l'automne, les morillons immatures se nourrissent abondamment d'amphipodes et s'abstiennent de certains aliments, comme les poissons et les sphaeriidés qui constituent une part importante du régime des adultes. La masse sèche relative des organismes animaux dans les contenus stomacaux est plus élevée à l'automne (adultes 91%, immatures 93%) et au printemps (92%) que durant l'hiver (61%). Les principales proies consommées durant toute l'année sont des crustacés, des insectes et des mollusques.

[Traduit par la rédaction]

Introduction

Several studies have shown that young birds are less efficient foragers than adults (reviewed by Baillie and Milne 1982; Giroux and Bédard 1988). Lower foraging efficiency has been implicated as a factor in greater winter mortality of juveniles in some species (Goss-Custard and Durell 1987; Conroy *et al.* 1989). Poor reproductive performance of young female ducks has been attributed to (*i*) less experience in locating, competing for, and exploiting food resources, (*ii*) less ability to accumulate large endogenous reserves, and (*iii*) lower efficiency at foraging for specific nutrients needed for egg formation (reviewed by Afton 1984).

Sexual differences in diets are well documented for dabbling ducks during egg laying, when females consume large quantities of invertebrates to satisfy protein demands (see Swanson and Duebbert 1989). Diets seemingly should differ between sexes during other periods of the annual cycle because ducks exhibit sexual differences in molt chronology and nutrient reserve dynamics before and after reproduction (Hoppe *et al.* 1986; Alisauskas and Ankney 1991; Hohman *et al.* 1991). Our objectives were to investigate sex and age variations in diets of Lesser Scaup (hereafter called scaup) during migration and winter.

Study areas

Midwinter

We collected scaup in southwestern Louisiana on Rockefeller Wildlife Refuge (WR) in January 1986. Rockefeller WR is bounded on the south by the Gulf of Mexico and on the north by the Grand Chenier ridge complex (Wicker *et al.* 1983). It contains 30 797 ha, of which approximately 2025 are lakes and 16 000 are impounded marshes (Chabreck 1960; Wicker *et al.* 1983). Collections were confined to Unit 2 and Price Lake Management Unit, areas of highest use by scaup.

Spring migration

We collected scaup in northwestern Minnesota on Thief Lake Wildlife Management Area (WMA) and Roseau River WMA in April 1986–1988. Thief Lake WMA includes the 2891-ha Thief Lake and its adjacent marshes (Parker *et al.* 1980). Roseau River WMA includes three large impoundments totalling 4291 ha (Hansen *et al.* 1980). Collections at Roseau River WMA were confined to Pool 1, where scaup were most abundant.

Fall migration

We collected scaup in northwestern Minnesota on Thief Lake WMA and Agassiz National Wildlife Refuge (NWR) in October and November 1984–1987. Agassiz NWR has 18 impoundments and a total of 14 980 ha of wetlands (Parker *et al.* 1980). Collections at Agassiz NWR were confined to Tamarack and Thief Bay pools, areas of highest use by scaup during the study.

Methods

We attempted to collect scaup that were actively feeding (Swanson and Bartonek 1970), but this was not always possible. Actively feeding birds constituted 55, 67, and 87% of samples during winter ($N = 41$), spring ($N = 57$), and fall ($N = 48$), respectively. Contents of the esophagus and proventriculus were removed immediately from ducks observed feeding, and preserved in 10% formalin.

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Printed in Canada / Imprimé au Canada

TABLE 1. Foods consumed by Lesser Scaup ($N = 41$) during midwinter on Rockefeller Wildlife Refuge, Louisiana, 1986

Food item	% occurrence	Aggregate %
Total animal	83	60.9
Chironomidae (midges)[a]	68	45.9
Gastropoda (snails)[a]	22	7.7
Palaemonidae[a]	12	7.3
Palaemonetes pugio (grass shrimp)	7	7.3
Unclassified shrimp	5	<0.05
Misc. animal (fish fragments, Nematoda)[a]	5	<0.05
Total plant	78	39.1
Seeds[a]	78	36.1
Cyperus spp. (sedge)	2	<0.05
Distichlis spp. (saltgrass)	10	<0.05
Eleocharis spp. (spikerush)	2	<0.05
Paspalum spp. (Gramineae)	2	<0.05
Potamogeton spp. (pondweeds)	2	<0.05
Scirpus spp. (bulrush)	76	36.0
Vegetative parts[a]	17	3.0
Green algae	2	2.3
Unknown foot fibers	12	0.6
Unknown vegetative parts	7	0.2

NOTE: Samples included 16 adult males, 12 adult females, 6 immature males, and 7 immature females.
[a]Category used as response variable in MANOVA.

TABLE 2. Foods consumed by Lesser Scaup ($N = 57$) during spring migration in northwestern Minnesota, 1986–1988

Food item	% occurrence	Aggregate %
Total animal	100	91.8
Amphipoda (scuds)[a]	51	33.2
Gammarus spp.	46	31.1
Hyallela spp.	14	2.1
Insecta[a]	63	16.0
Chironomidae (midges)	25	2.3
Coleoptera	11	1.9
Dytiscidae (predaceous diving beetles)	2	<0.05
Haliplidae (crawling water beetles)	9	1.8
Hydrophilidae (water scavenger beetles)	2	<0.05
Corixidae (water boatmen)	14	1.5
Ephemeroptera (mayflies)	2	<0.05
Odonata	7	1.5
Anisoptera (dragonflies)	4	0.3
Zygoptera (damselflies)	4	1.2
Trichoptera (caddis flies)	35	8.8
Gastropoda[a]	53	31.9
Hydrobiidae (spire snails)	7	4.0
Lymnaeidae (pond snails)	14	2.7
Physidae (pouch snails)	4	0.4
Planorbidae (orb snails)	26	11.1
Valvatidae (round-mouthed snails)	21	11.0
Viviparidae (snails)	4	1.0
Unidentified parts	5	1.8
Sphaeriidae (fingernail clams)[a]	19	6.0
Hirudinea (leeches)[a]	11	1.3
Fish[a]	12	3.5
Culaea inconstans (brook stickleback)	5	2.2
Unidentified parts	7	1.3
Total plant	60	8.2
Seeds[a]	42	6.0
Carex spp. (sedge)	4	<0.05
Ceratophyllum spp. (coontail)	2	1.6
Myriophyllum spp. (water milfoil)	4	<0.05
Nymphaea spp. (water lilly)	2	0.4
Polygonum spp. (smartweed)	7	0.9
Potamogeton spp. (pondweed)	21	1.7
Rumex spp. (dock)	9	<0.05
Scirpus spp. (bulrush)	35	1.3
Vegetative parts [a]	28	2.2
Chara spp. (muskgrass)	9	1.8
Lemna trisulca (duckweed)	14	<0.05
Myriophyllum spp. (water milfoil)	4	0.1
Zizania aquatica (wild rice)	2	0.1

NOTE: Samples included 27 males and 30 females.
[a]Category used as response variable in MANOVA.

For specimens not observed feeding, 10% formalin was injected immediately into the upper digestive tract, and foods were removed later, usually within 1 h of collection. Esophageal and proventricular contents were combined for analysis to maximize sample size (Sugden 1973). Fall and winter specimens were sexed and aged as adult (>1 year) or immature (<1 year) (Hochbaum 1942; Kortright 1942; Carney 1964); only sex was determined for spring birds.

Food items were sorted, identified, dried at 50–70°C for 24 h, and weighed to the nearest 0.1 mg. Data were summarized by percent occurrence (Swanson *et al.* 1974) and aggregate percent dry weight (Prevett *et al.* 1979).

We used multivariate analysis of variance (MANOVA) to assess differences in overall diets (aggregate percent dry weights) between sex and age classes during winter and fall migration, and between sexes during spring migration (PROC GLM, SAS Institute Inc. 1987). Sample sizes during migration precluded rigorous statistical tests of annual variation in diets; thus, we pooled data over all years for analysis. Food categories used as response variables in MANOVAS are noted in footnotes on tables. F values reported from MANOVAS were determined using Wilks' criterion. Univariate analysis of variance (ANOVA) of each dependent variable was used to examine group differences following a significant overall MANOVA (Barker and Barker 1984). Angular transformations were applied to percent values to more closely meet assumptions of normality (Sokal and Rohlf 1969, p. 386).

Results

Midwinter

Diets of scaup on Rockefeller WR did not differ between sex ($F = 0.45$; 6,32 df; $P = 0.84$) or age classes ($F = 0.78$; 6,32 df; $P = 0.59$). The sex × age interaction also was not significant ($F = 0.86$; 6,32 df; $P = 0.53$). Animal foods constituted 61% of diets and were recorded in 83% of samples (Table 1). Although plant foods represented smaller proportions of the diets, they were recorded in 78% of samples. Important foods were chironomid larvae, snails, palaemonid shrimps, and *Scirpus* spp. seeds.

Spring migration

Diets during spring were similar for males and females ($F = 0.69$; 8,48 df; $P = 0.70$). Animal foods constituted 92% of diets and were recorded in every sample (Table 2). Plant foods were recorded in 60% of samples but constituted only 8% of diets. Important foods were amphipods, trichopteran larvae, fingernail clams, and a variety of snails.

Fall migration

Diets during fall differed between adults and immatures ($F = 2.47$; 9,36 df; $P = 0.0259$), and tended to differ between sexes ($F = 2.06$; 9,36 df; $P = 0.0605$). The sex × age interaction also

TABLE 3. Foods consumed by adult (A) ($N = 14$) and immature (I) ($N = 34$) Lesser Scaup during fall migration in northwestern Minnesota, 1984–1987

Food item	% occurrence		Aggregate %	
	A	I	A	I
Total animal	93	94	90.5	92.8
Astacidae (crayfish)[a]	0	3	0	2.9
Amphipoda (scuds)[a]	86	82	54.9	74.5
Gammarus spp.	71	79	48.9	67.1
Hyallela spp.	29	29	6.0	7.4
Insecta[a]	36	32	10.0	11.2
Diptera	0	15	0	8.9
Chaoborinae (phantom midges)	0	3	0	0.2
Chironomidae (midges)	0	12	0	8.6
Odonata	21	6	2.4	0.2
Anisoptera (dragonflies)	21	3	2.4	0.2
Zygoptera (damselflies)	0	3	0	<0.05
Corixidae (water boatmen)	0	12	0	0.1
Trichoptera (caddis flies)	36	9	7.6	1.9
Haliplidae (crawling water beetles)	7	0	<0.05	0
Gastropoda[a]	50	29	10.2	3.0
Lymnaeidae (pond snails)	36	0	5.7	0
Planorbidae (orb snails)	14	12	0.9	<0.05
Physidae (pouch snails)	14	6	3.6	2.5
Unidentified parts	0	15	0	0.5
Sphaeriidae (fingernail clams)[a]	21	0	5.1	0
Hirudinea (leeches)[a]	14	12	0.3	1.2
Fish[a]	29	0	10.0	0
Culaea inconstans (brook stickleback)	21	0	4.1	0
Etheostoma nigrum (Johnny darter)	7	0	1.0	0
Pimephales promelas (fathead minnow)	7	0	5.0	0
Total plant	71	68	9.5	7.2
Seeds[a]	50	26	9.4	6.2
Cyperus spp. (sedge)	7	3	1.0	<0.05
Myriophyllum spp. (water milfoil)	0	6	0	<0.05
Najas spp. (bushy pondweed)	7	6	7.1	5.8
Potamogeton spp. (pondweed)	14	6	0.6	0.1
Scirpus spp. (bulrush)	36	18	0.7	0.2
Vegetative parts[a]	29	47	0.1	1.0
Algae	7	9	<0.05	0.1
Chara spp. (muskgrass)	0	6	0	<0.05
Other green algae	7	3	<0.05	0.1
Lemna trisulca (duckweed)	14	38	<0.05	0.3
Myriophyllum spp. (water milfoil)	14	3	<0.05	<0.05
Potamogeton spp. (pondweed)	7	3	0.1	<0.05

NOTE: Samples included 11 adult males, 3 adult females, 19 immature males, and 15 immature females.
[a]Category used as response variables in MANOVA.

was nearly significant ($F = 1.84$; 9,36 df; $P = 0.10$). Consumption of fingernail clams ($P = 0.0176$) and fish ($P = 0.0052$) differed between age classes. These two foods represented 5 and 10% of the diets of adults, respectively; neither food was consumed by immatures (Table 3). Males tended to consume more insects ($P = 0.0695$) and fewer leeches ($P = 0.0555$) than did females. Other taxa were consumed in similar (all P values >0.16) proportions between age and sex classes.

Animal foods constituted 91 and 93% of diets and were recorded in 93 and 94% of samples for adults and immatures, respectively (Table 3). Amphipods were the primary food of both age classes. Although plant foods were recorded in 71 and 68% of samples for adults and immatures, they constituted only 10 and 7% of diets, respectively.

Discussion

Diets were expected to differ between sexes during migration and winter (cf. Hoppe *et al.* 1986; Alisauskas and Ankney 1991; Hohman *et al.* 1991). In contrast, we found that diets of male and female scaup generally were similar, as reported for migrating and wintering Mallards (*Anas platyrhynchos*) (Jorde *et al.* 1983), Northern Pintails (*Anas acuta*) (Miller 1987), Gadwalls (*Anas strepera*) (Paulus 1982), Canvasbacks (*Aythya valisineria*) (Hohman *et al.* 1990), Ring-necked Ducks (*Aythya collaris*) (T. S. Taylor, unpublished data; but see Hoppe *et al.* 1986), and Barrow's Goldeneyes (*Bucephala islandica*) (Koehl *et al.* 1982). However, male scaup tended to consume more insects and fewer leeches than did females during fall migration.

Diets of adult and immature scaup differed during fall migration, but not during winter. Diets of Canvasbacks (Hohman *et al.* 1990) and Ring-necked Ducks (T. S. Taylor, unpublished data) also did not differ between age classes during winter. In fall, immature scaup fed heavily on amphipods and did not consume certain foods, such as fish and fingernail clams, that were important in adult diets. Age variation in fall diets may occur because (*i*) young scaup feed extensively on amphipods on breeding areas but rarely if ever consume fish and fingernail clams (Bartonek and Hickey 1969; Bartonek and Murdy 1970; Sugden 1973); (*ii*) adults have previously migrated and are more experienced in locating and exploiting food resources on stopover areas; and (*iii*) nutritional requirements may differ between ages because adults generally have larger nutrient reserves (A. D. Afton, unpublished data) and immatures may still be growing.

Animals foods constituted the majority of diets during winter. Several other studies, which analyzed esophageal and proventricular contents, also documented the importance of animal foods to wintering scaup (Cronan 1957; Harmon 1962; Rogers and Korschgen 1966; Bowman 1973; Hoppe *et al.* 1986). An exception was Chabreck and Takagi (1985), who reported that plant foods made up 99% of diets of 23 scaup shot from a single blind on an impoundment managed for crayfish (*Procambarus clarkii*). Other studies also stressed the importance of plant foods to wintering scaup (e.g., Quay and Critcher 1965; Kerwin and Webb 1972), but they relied entirely on analysis of gizzard contents, which produces biased results (Swanson and Bartonek 1970, and references therein).

Chabreck and Takagi (1985) suggested that scaup "preferred" plant foods in their study, and concluded that crayfish impoundments represented high-quality habitat for wintering scaup. However, macroinvertebrate populations (other than crayfish) may not have been well established in the impoundment (see also Takagi 1983, p. 13), given the water management regime employed (cf. Kadlec 1962; Euliss and Grodhaus 1987), i.e., dry from June through September and reflooded from October through May. Furthermore, we believe that it is premature to conclude that such areas are high-quality habitat for wintering scaup because (*i*) animal foods predominated in diets in all other studies that analyzed esophageal and proventricular contents, (*ii*) use of crayfish impoundments by scaup is relatively low (e.g., Nassar *et al.* 1988), and (*iii*) comparative information on body condition and survival of scaup in various habitats is not available.

Results from our study and an earlier one near Rockefeller WR (Rogers and Korschgen 1966) were remarkably similar in that animal foods constituted 61 and 64% of diets, respectively. However, consumption of various animal taxa varied markedly between studies. Rogers and Korschgen (1966) reported that fish were the most important animal foods and that a variety of crustaceans were of secondary importance. In contrast, we found that chironomid larvae predominated in diets and that fish were unimportant. The high incidence of chironomid larvae in diets that we observed probably reflected high densities of this taxon in the Rockefeller WR during the winter of 1985–1986 (Gaston and Paulus 1987).

Scaup consumed predominantly animal foods during migration in northwestern Minnesota. As previously suspected (R. L. Jessen, cited in Bartonek and Murdy 1970), amphipods were the principal food during spring and fall. Other important foods were insects, mollusks, fish, and seeds. Amphipods also were principal foods of scaup during fall on the Saskatchewan River Delta (Dirschl 1969), Devils Lake in North Dakota (A. D. Afton, unpublished data), and small lakes near Erickson, Manitoba (Austin 1983; A. D. Afton, unpublished data) and Dundurn, Saskatchewan (R. T. Alisauskas, unpublished data). Contrary to data recently summarized by Korschgen (1989: Table 3), we conclude that amphipods are an important food for migrating scaup in the upper midwest.

Many shallow lakes and marshes in the upper midwest are important stopover areas for migrating scaup (Jessen 1981; Korschgen 1989; Swanson and Duebbert 1989). While en route to breeding areas, migrant scaup may acquire nutrient reserves that are used later during reproduction (Afton 1984). Stopover areas probably also provide necessary foods for scaup during fall, allowing them to replenish lipid stores for subsequent migration. The importance of maintaining a high-quality food base for migrating ducks was clearly demonstrated on the Illinois River, where pollutants destroyed much of the macroinvertebrate fauna (Mills *et al.* 1966). Scaup responded to that loss in food resources by shifting migration routes (Mills *et al.* 1966; Bellrose *et al.* 1979).

Competition between fish and waterfowl (laying hens, ducklings) for macroinvertebrates is widely recognized as a major deterrent to waterfowl production (Kear and Burton 1971; Eriksson 1979; Andersson 1981; Eadie and Keast 1982; Pehrsson 1984; DesGranges and Rodrigue 1986; Hill *et al.* 1987; and others). Euliss and Grodhaus (1987) recommended that fish be discouraged from permanent marsh impoundments that are managed for production of invertebrate foods for wintering waterfowl. Sport and bait fish are stocked and reared in many shallow lakes, ponds, and other wetlands used by migrant scaup (e.g., Peterka 1989), and lake aeration systems are being used in increasing numbers to prevent winterkill of fish in these wetlands (e.g., Pederson 1982). Consequently, research is needed on the effects of these practices upon amphipods and other invertebrate foods of migrant scaup.

Acknowledgements

We are indebted to numerous personnel of the Minnesota Department of Natural Resources, Louisiana Department of Wildlife and Fisheries, and U.S. Fish and Wildlife Service for support and assistance. We are especially thankful to T. Eberhardt of the Wetlands Wildlife Populations and Research Group, J. Maertens and P. Telander of Thief Lake WMA, K. Kramer and R. Markl of Roseau River WMA, J. Kotok and J. Mattsson of Agassiz NWR, and to T. Joanen, L. McNease, G. Perry, and D. Richard of Rockefeller WR. We appreciate the assistance of D. Rave and M. Sperry in collecting birds, and G. Gaston in identifying invertebrates. F. Bryan, R. Chabreck, M. Conroy, T. Eberhardt, W. Hohman, D. Johnson, C. Korschgen, R. Lake, J. Lawrence, R. Pace, III, M. Peters, and L. Smith made suggestions for improving the manuscript.

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