Consumption of Agricultural and Natural Foods by Waterfowl Migrating Through Central Oklahoma

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Conversion of wetlands to agricultural fields along much of the North American flyway has resulted in migrating waterfowl using agricultural crops to fulfill their nutritional requirements. To determine the extent that waterfowl use agricultural plants in north central Oklahoma, we examined food habits of mallards (*Anas platyrhynchos*), gadwalls (*A. strepera*), and American wigeons (*A. americana*) during fall migration. Agricultural plants constituted 47-61% of the diet in all three species, followed by invertebrates (23-30%), natural vegetation (12-22%), and algae (1-4%). Subadult mallards and wigeons consumed more invertebrates than did adults, and subadult mallards consumed fewer agricultural plants than adults. Age did not affect diet composition in gadwalls. Sex did not affect diet in gadwalls and wigeons, but female mallards consumed more natural vegetation than did males. Agricultural crops have become an important source of forage for migrating waterfowl, and using both natural wetland plants and crops are necessary for proper waterfowl management.

INTRODUCTION

With the recent decreases in natural wetlands, agricultural plants have become an important source of food for migrating waterfowl. Migratory waterfowl face increased nutritional demands during winter and must consume more carbohydrates to meet these increased energy demands (*1*). Agricultural plants are often high in energy, and waterfowl spend more time feeding on crops in the evening to prepare for cold nights (2-5). However, feeding exclusively on agricultural crops may not satisfy their protein or mineral requirements (2,4). Waterfowl must also include foods that fulfill protein and lipid requirements. Natural plants found in wetlands and invertebrates constitute foods high in protein and amino acids, as well as many minerals (*6*).

The central flyway runs from central Canada to the Texas coast, encompassing Oklahoma (*7*). Oklahoma wetlands provide important habitat for waterfowl to rest, feed, or overwinter (*8*). However, much of Oklahoma has been converted to agricultural use and relatively few natural wetlands remain where waterfowl can fulfill certain nutritional requirements. To obtain insight into foraging patterns relative to agricultural and natural vegetation, we surveyed the food habits of waterfowl during their migration through Oklahoma.

METHODS

Study area. The study was conducted from November to December 1998 in Payne, Noble, and Pawnee Counties in north central Oklahoma. Waterfowl collection took place primarily on private lands that surround the Arkansas River system. Predominant agricultural foods in the region consist of soybean, milo, millet, and winter wheat. Dominant wetland vegetation used in the area consists of green algae, pondweed (*Potamogeton* spp), smartweed (*Polygonum* spp), duckweed (*Lemna* spp.), coontail (*Ceratophyllum demersum*), wild millet (*Echinochloa walterii*), buttonbrush (*Cephalantus occidentalis*), rushes (*Scirpus* spp.), curly dock (*Rumex crispus*), and sedges (*Cyperus* spp.).

Collection. We collected waterfowl by using a shotgun and steel shot to prevent lead contamination of the surrounding aquatic ecosystem (*9*). We observed migrating birds on fields or wetlands and collected them while they were actively feeding for (5 min. Collections were done in both early morning and evening. Collection of waterfowl and preservation of the digestive tract followed methods described by Swanson and Bartonek (*10*). Immediately after each duck was harvested, its digestive tract was removed, immersed in 80% ethanol to minimize post-mortem digestion and then frozen (*11,12*). Esophagus, crop, and proventriculus were later separated from the rest of the digestive tract and analyzed. Food items were separated into four categories: natural plant, agricultural plant, invertebrate, and algae. Plant fragments were identified by using manuals prepared by Mason (*13*), and invertebrates were identified to order according to Pennak (*14*). Gizzard content was not included in the analysis of food items because Swanson and Bartonek (*10*) indicated that using gizzard contents may be biased because of differences in the amount of resistance that hard and soft food items have to the muscular action of the gizzard. A more accurate method of sampling foods consumed by waterfowl is by esophageal content (*10*).

The three most often used volumetric calculations to determine food habits are (a) frequency of occurrence, (b) aggregate volume, and (c) aggregate percentage. Frequencies of occurrence and aggregate volume have two biases: (a) overestimation of foods occurring in a few individuals but in large volumes tend to exaggerate their importance in the overall diet, and (b) the calculations are based on grand totals for each food item instead of multiple individual observations. These biases serve to reduce the statistical power of the analysis (*3*). However, Baldassarre and Bolen (*3*) stated that both biases are removed by using the aggregate percentage method, as each individual is treated as a complete statistical unit. Thus, we selected the aggregate percent volume method for analyzing the food habits of the duck species in this study.

Waterfowl were aged by using characteristics of the tail feathers and primary, secondary, and tertial coverts (*15*). Specifically, subadult plumage was typically frayed with faded or missing coloration. Edging coloration was not present in subadult mallards (*Anas platyrhynchos*), the cinnamon coloration was not found in subadult gadwalls (*A. strepera*), and subadult American wigeon (*A. americana*) tertials were small, brown, and lacked points.

We tested for dietary interactions between location and time of harvest (e.g., morning and evening) by using an analysis of variance. Differences in the diet among age and sex categories in each species were compared by using a t-test. All statistical analyses were conducted using SAS (*17*), and all statistical tests were considered significant at $P \leq 0.05$.

RESULTS

Of the 91 ducks harvested, 45 were from shallow, untilled wetlands and 46 were from agricultural fields. Mallards represented the majority of the ducks harvested (n = 55), followed by gadwalls (n = 23), and wigeons (n = 12). Males dominated the harvest, with 40 mallards (73%), 15 gadwalls (65%), and 7 wigeons (58%) being male. Similarly, adults represented the largest portion of the age categories, with 36 (65%) of the mallards being adult, 13 (56%) gadwalls, and 10 (83%) wigeons. Mallards, gadwalls, and wigeons showed similar levels of consumption among the 4 food categories (Fig. 1). Subadult mallards consumed more (P = 0.002) invertebrates and fewer (P = 0.003) agricultural foods than did adults (Fig. 2a). There was no difference between adult and subadult diets in gadwalls (Fig. 2b). However, subadult wigeons ate more (P = 0.025) invertebrates than did adults (Fig. 2c). However, no differences were detected among the other forage categories.

Female mallards ate more natural plants than did males (P = 0.040), but we did not detect differences between the sexes of gadwalls or wigeons (Fig. 3).

Consumption of invertebrates, natural plants, and agricultural crops by waterfowl varied with harvest location (e.g., over wa-

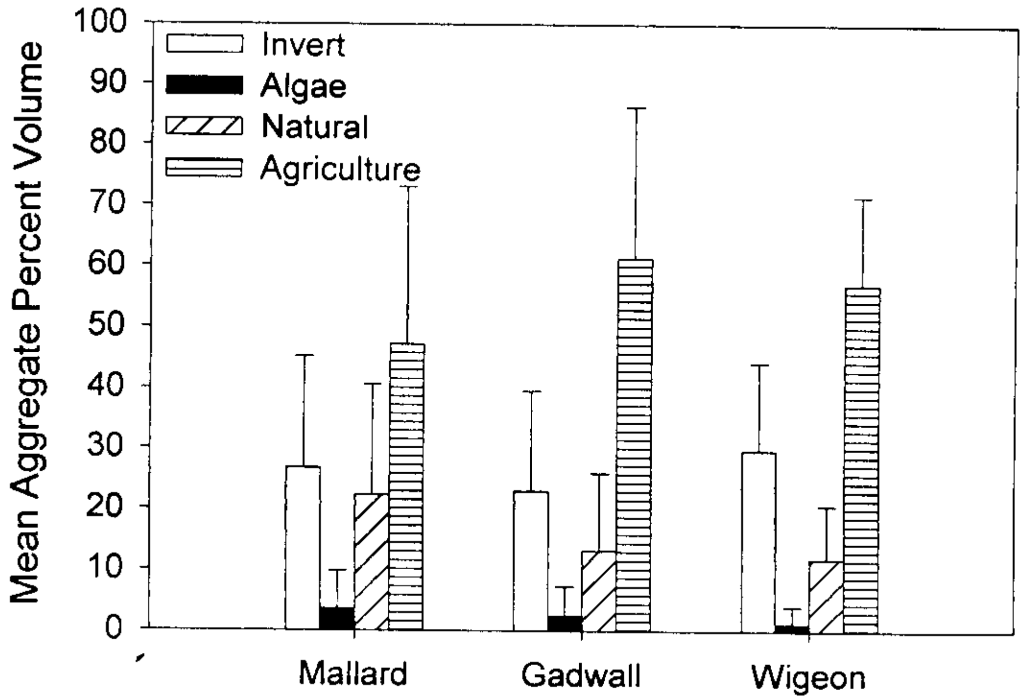

Figure 1. Mean aggregate percent volume of forages consumed by mallards, gadwalls, and American wigeons collected in north central Oklahoma during winter 1998. Error bars represent one standard deviation.

ter or land, Fig. 4). Invertebrate consumption was larger for animals that were harvested over water ($P < 0.001$), whereas ducks harvested over agricultural fields had more agricultural crops in their diet ($P = 0.004$). There was no difference by time of harvest in the proportion of food categories consumed.

DISCUSSION

Baldassarre and Bolen (*3*) stated that the feeding ecology of waterfowl is a complex interaction of nutritional needs, resource availability, habitat quality, and waterfowl behavior. Feeding ecology is further complicated during winter when waterfowl are migrating, preparing for reproduction, and facing increased energetic demands because of lower temperatures (*1,18*). Hence, feeding in agricultural fields may be observed when it tends to minimize overall feeding time and other costs (e.g., exposure to predators) and tends to maximize other parameters (e.g., extra energy for the flight compared to foraging in natural wetlands). Prior to widespread agriculture, wintering waterfowl were limited to natural wetland habitats where nutritionally complete diets presumably were available. Today, with the conversion of wetlands to cropland, foraging strategies have become more complex and have included agricultural fields as a major source of food (*18*). Agricultural crops have become especially important to waterfowl as a quick energy source to increase their lipid stores during migration (*5*). Agricultural plants composed at least 45% of the diet for all three species of waterfowl in this study. Natural vegetation and invertebrates were also consumed in large quantities. The observed consumption of crops follows the patterns previously suggested that wintering waterfowl use agricultural crops as an easily obtainable energy source and use natural vegetation and invertebrates to supplement their protein requirements (*19-23*).

Gadwalls and wigeons relied more on agricultural plants than did mallards, which

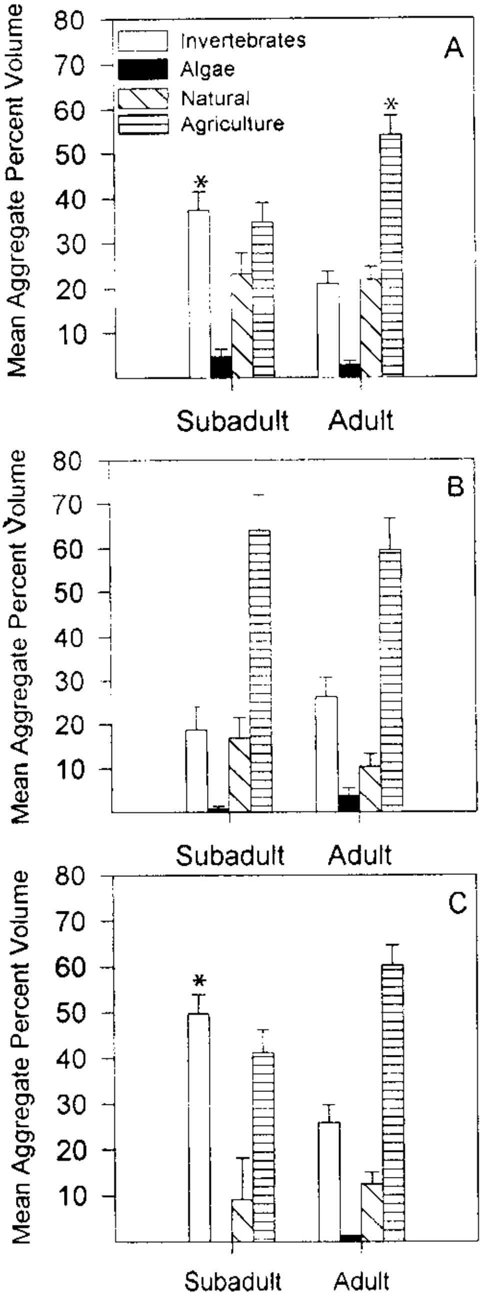

Figure 2. Mean aggregate percent volume of forages consumed by adult and subadult mallards (a), gadwalls (b), and American wigeons (c) collected in north central Oklahoma during winter 1998. Categories that are different ($P \leq 0.05$) between age classes are indicated with an *. Error bars represent standard error.

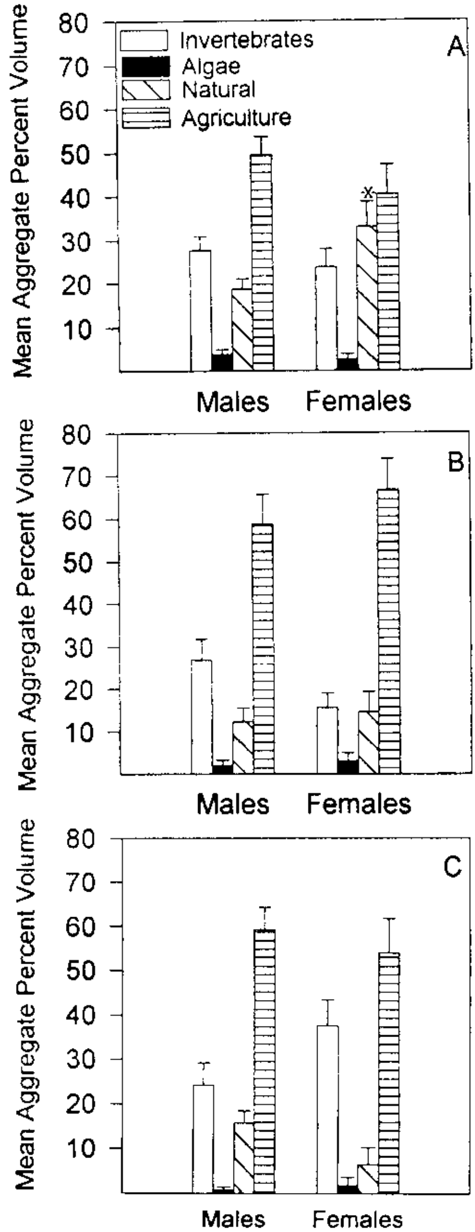

Figure 3. Mean aggregate percent volume of forages consumed by male and female mallards (a), gadwalls (b), and American wigeons (c) collected in north central Oklahoma during winter 1998. Categories that are different ($P \leq 0.05$) between sex classes are indicated with an *. Error bars represent standard error.

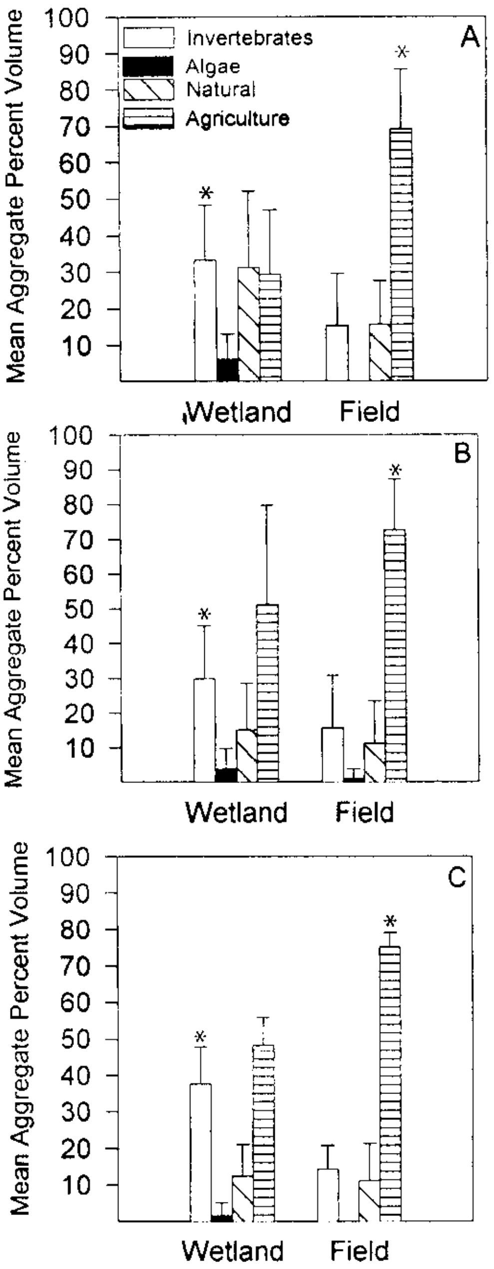

Figure 4. Mean aggregate percent volume of forages consumed by mallards (a), gadwalls (b), and American wigeons (c) feeding over water or on agricultural fields. Categories that are different ($P \leq 0.05$) between locations are indicated with an *. Error bars represent standard error.

had more natural food items in their diet. Sugden (*24*) reported that gadwalls consume vegetation almost exclusively, nearly eliminating invertebrates from their diet by 3 wk of age. Such increased reliance on vegetation (either natural or agricultural) by gadwalls may reflect an increased ability of the digestive system of this species to extract more nutrients from vegetation.

Subadult mallards and wigeons consumed more invertebrates and fewer agricultural foods than did adults. Cox, et al. (*25*) observed similar results finding that duckling survival and growth was positively associated with increased invertebrate numbers in lakes. Cox, et al. (*25*) also suggested that this is a function of increased food availability and not related to the nutritional quality of the invertebrates. Gadwalls did not show an age-stratified difference in using seed crop, a reflection of their intense use of vegetation at an early age (*24*).

The only difference between the diets of males and females was in mallards. Females used more natural vegetation in their diet compared to males, which may reflect increased nutrient demands for reproduction (*26*). Female mallards that do not obtain enough nutrients had delayed nesting and decreased hatchability (*27*).

In this study ducks that were harvested over fields or wetlands showed significant differences in their diet composition. These differences are an important consideration in designing food habits studies because the location of a collection may yield a bias in the actual diet of the species being studied. Collection over various types of habitat should reduce the stratification of food types and provide a more accurate picture of food habits.

Migrating waterfowl face a patchy natural wetland system and must include human-made habitats, such as agricultural crops, to satisfy energy and nutritional requirements of migration and reproduction. Feeding in agricultural fields may be a response to the decreasing availability of natural foods along the Central Flyway, and has occurred at least in part because of the overall degradation of wetland habitat in North America (*3*). With the fragmented availability of wetland habitats, agricultural fields provide waterfowl with readily available sources of carbohydrates, but may be limiting in other nutrients such as protein.

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