# Winter diet of Blue-winged Teal *Anas discors*, Green-winged Teal *Anas carolinensis*, and Northern Shoveler *Anas clypeata* in east-central Texas

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**Abstract**

Whilst dabbling duck diet has been studied in some detail on the breeding grounds, it has not been studied as exhaustively at wintering sites in North America. We therefore aimed to describe the diet of Blue-winged Teal *Anas discors*, Green-winged Teal *Anas carolinensis*, and Northern Shoveler *Anas clypeata* using moist-soil managed wetlands in east-central Texas by determining from gut samples the food items ingested and the variation in dry mass of each item taken. A variety of 33 food items (mostly seeds and invertebrates, with only trace amounts of other plant material) were recorded in gut samples of 174 birds. Aggregate dry mass varied among and between species and age-sex cohorts. Several food items occurred frequently in each of the three species – most notably knotweed *Polygonum* sp., panic grass *Panicum* sp., Water-pepper *Persicaria hydropiper* and Curly Dock *Rumex crispus* – indicating the importance of these plant seeds, along with Gastropods, in the diet of dabbling ducks wintering on the wetlands of east-central Texas.

**Key words**: diet, Blue-winged Teal, food habits, Green-winged Teal, Northern Shoveler, Texas.

 

A basic knowledge of food requirements, food availability and food preferences is crucial for understanding the ecology of a species (Olney 1963; Dessborn *et al.* 2011). Food intake, which reflects both energetic demands and food resource availability, has a direct influence on body condition and on an individual's ability to survive and breed successfully (Smith & Sheeley 1993). Moreover, for migratory waterbirds, the food ingested and feeding patterns (*e.g.* timing and duration of feeding each day) are likely to vary considerably in relation to the birds' energy needs over the annual cycle and food resources available in different parts of the migratory range (Hartman 1985; Guillemain *et al.* 2007; Arzel *et al.* 2009). While the diet of wintering waterfowl has been relatively under-studied in comparison with studies undertaken during the breeding season, the quality and quantity of food taken plays a key role in influencing not only the birds' winter site selection but their body condition and potentially their survival and productivity (Heitmeyer & Fredrickson 1981; Miller 1986; Euliss & Harris 1987; Moon *et al.* 2007; Callicutt *et al.* 2011).

Dietary studies therefore are one of four key research objectives (along with habitat use, time budgets and body condition) required for a full assessment of the wintering requirements for waterfowl (Korschgen *et al.* 1988). Moreover, many ducks of the *Anatini* tribe share similar feeding behaviours and patterns, including utilising the same food resources during winter, which may lead to interspecific competition or resource partitioning at the wintering sites (DuBowy 1988; Guillemain *et al.* 2000). For example, Blue-winged Teal *Anas discors*, Green-winged Teal *Anas carolinensis* and Northern Shoveler *Anas clypeata* all use moderate amounts of semi-aquatic and aquatic vegetation in shallow to moderately deep water habitats (White & James 1978). Northern Shoveler often sieve for small crustaceans in the water column, however, whereas Blue-winged and Green-winged Teal, which seemingly are more generalised in their foraging behaviour and food selection, tend to focus upon plant material (*i.e.* seeds, tubers, or leafy parts of vegetation; Dirschl 1967; Baldassarre & Bolen 1984; Eulis & Harris 1987; Dubowy 1988; Botero & Rusch 1994; Anderson *et al.* 2000; Dessborn *et al.* 2011).

Although feeding behaviour including food selection is typically the product of interactions among biological and nutritional demands, physical capabilities, and environmental conditions (Swanson *et al.* 1974), it tends to vary between species and across seasons, in line with changes in food availability resulting from local environmental conditions. For example, in the case of Blue-winged Teal in the Saskatchewan River Delta, Dirschl (1967) reported fluctuations in the food ingested during summer, when invertebrates dominated the diet, but the seeds of some plant species – sedges *Carex* sp. and *Eleocharis* sp., cattails *Sparganium* sp. and bulrush *Scirpus* sp. – were consistently (18–35% occurrence) consumed over time. Thompson *et al.* (1992) similarly reported that Blue-winged Teal wintering in Mexico consumed > 98% Gastropods during early winter, before switching to a plant-dominated diet (*i.e.* > 96% plant material,

 

primarily stonewort *Chara* sp.) during mid–late winter. Studies of Blue-winged Teal in Central and South America (Botero & Rusch 1994), in Mexico (Saunders & Saunders 1981) and in the southern United States (Swiderek *et al.* 1988) however found that the birds relied primarily on plant food in these areas.

In contrast, Green-winged Teal in the Southern High Plains of Texas were found to consume mostly plant matter and seeds (> 70%; Anderson *et al.* 2000) during autumn and early winter, with considerably less (8–37%) of their diet represented by animal matter (primarily Insecta; Euliss & Harris 1987; Anderson *et al.* 2000), although invertebrates were taken in greater proportion than their availability (Anderson *et al.* 2000). Typically, Green-winged Teal seed consumption reflects the availability of food items in the environment, but they also select larger seeds, such as those produced by *Eleocharis* sp., knotweed *Polygonum* sp., paspalum *Paspalum* sp., barnyard grass *Echinochloa* sp. and docks *Rumex* sp. (Anderson *et al.* 2000). Mouronval *et al.* (2007) also found *Polygonum* to be present in 54% of Eurasian Teal *Anas crecca* collected in northeast France.

Early studies of the Northern Shoveler's diet reported that they primarily consumed vegetation or seeds (Anderson 1959), but more recent work has questioned the extent to which this is prevalent. For example, Mouronval *et al.* (2007) found animal prey in 89% of the samples examined from Northern Shoveler collected in northeast France, whereas although 14 species of seeds were identified, none were frequent. Vest and Conover (2011) found that Northern Shoveler and Green-winged Teal in a saline system – the Great Salt Lake in Utah – consumed primarily aquatic invertebrates (*i.e.* brine shrimp *Artemia* sp. adults and cysts) during winter, but noted that in late-winter both species increased consumption of wetland plant seeds.

Studies to date therefore suggest that these three dabbling duck species consume similar food items, albeit in differing proportions and that this may also vary with physiological demands, food availability, season and geographic region. The objectives in the study presented here were to quantify and compare the food ingested by Blue-winged Teal, Green-winged Teal, and Northern Shoveler during winter using moist-soil managed wetlands in east-central Texas, to provide information for habitat managers and conservation planners on the food taken by these species when wintering in the region. Whether the sex and age (adult or juvenile) of the birds influenced their diet was also considered. Given that some earlier studies found a seasonal change in the food taken in by the birds, whether there was a change in the birds' diet between autumn and winter, and whether it was evident in one or more of these dabbling duck species wintering in the same area, was investigated in further detail.

## Methods

### Study area

The study was conducted on the Richland Creek Wildlife Management Area (RCWMA), located in Freestone and Navarro Counties, Texas, USA (31°13'N, 96°11'W). The RCWMA lies almost entirely within the Trinity River floodplain, covering

6,271 ha in the area between the Post Oak Savannah and Blackland Prairie ecological regions (TPWD 2005). All work occurred within the managed moist-soil wetlands of the northern part of the RCWMA.

### Sampling gut contents

Birds were collected opportunistically during morning flights or after observation of diurnal foraging (*i.e.* 07:00–18:00 h), from 15 September–28 February in winters 2004/05, 2005/06 and 2006/07 (following Anderson *et al.* 2000). We divided the collection dates into two seasons: 1) autumn (September 1–November 15), and 2) winter (November 16–February 28), to identify any changes in diet between the autumn and mid-winter period. Attempts were made to obtain equal numbers of individuals for each sex within each species, to permit assessment of any differences between the sexes in the food ingested. Upon collection, a 75% ethanol solution was immediately injected into the oesophagus to preserve material *post-mortem* (Anderson *et al.* 2000). Birds were then eviscerated, the digestive tract removed, and stored in 75% ethanol.

Once in the laboratory, digestive tracts (*i.e.* oesophagus, proventriculus and gizzard) were dissected and washed to remove all materials contained within. Birds without any food in their digestive tract were omitted from the analysis. Digestive tract contents were examined under a dissecting microscope (VRW® Stereo Basic Halogen Microscope), animal and plant matter were separated, and these were then identified to lowest taxon possible. Seeds and animal matter were thus identified to genus and species level; other plant material (*e.g.* leaves) was present in only small amounts and these were recorded as "miscellaneous vegetation" (as in Anderson *et al.* 2000). The food items were dried at 50°C for 24 h, weighed to the nearest 0.1 g, and the percent occurrence and aggregate percent dry mass of each food item was calculated for each bird (following Swanson *et al.* 1974). Aggregate percent dry mass for food taken by each species was determined by summing the dry mass of each food item per individual and converting it into an overall aggregate percent dry mass (Swanson *et al.* 1974; Vest & Conover 2011). All percentage data were arcsine transformed to improve normality (Zar 1999; Vest & Conover 2011).

### Data analysis

Multivariate analysis of variance (MANOVA, with Wilks' testing for differences between groups) was used to examine differences in the aggregate percent dry mass of plant and animal food items ingested, among and between species, age-sex cohorts, and between seasons (*i.e.* autumn and winter), following the methods described by Anderson *et al.* (2000) and by Vest and Conover (2011). If significant differences ($P \leq 0.05$) were found between groups in the MANOVA, univariate analysis of variance (ANOVA) was used to identify more specifically whether species, age, sex or season was associated with the food ingested by the birds.

## Results

A total of 33 different food items were identified, cumulatively occurring 600 times in all three focal species (Table 1). Plant food items occurred in 98–100% of

**Table 1.** Percent occurrence and aggregate percent dry mass of food items consumed by Blue-winged Teal ($n$ = 66), Green-winged Teal ($n$ = 54), and Northern Shoveler ($n$ = 54), during winters 2004/05–2006/07 in east-central, Texas. Plants identified to genus or species are all seeds; other vegetation material (*e.g.* leaves) is included as "miscellaneous vegetation".

| | Blue-Winged Teal | | Green-Winged Teal | | Northern Shoveler | |
|---|---|---|---|---|---|---|
| | % Occurrence | % Dry mass | % Occurrence | % Dry mass | % Occurrence | % Dry mass |
| **PLANT** | 98.4 | 72.5 | 100.0 | 97.5 | 100.0 | 93.7 |
| *Amaranthus tuberculata* | 7.6 | 0.2 | 11.1 | 0.4 | 1.9 | 0.9 |
| *Ammania coccinea* | 6.1 | 0.1 | 1.9 | 0.0 | 0.0 | 0.0 |
| *Carex* sp. | 0.0 | 0.0 | 3.7 | 1.9 | 5.6 | 0.4 |
| *Chenopodium album* | 12.1 | 0.9 | 16.7 | 1.5 | 1.9 | 0.7 |
| *Cyperus erthrorshizos* | 3.0 | 0.0 | 5.6 | 1.8 | 1.9 | 0.0 |
| *Cyperus* sp. | 3.0 | 0.2 | 3.7 | 0.9 | 3.7 | 0.5 |
| *Echinochloa crusgalli* | 12.1 | 1.9 | 16.7 | 3.2 | 18.5 | 5.8 |
| *Echinochloa walteri* | 7.6 | 1.9 | 3.7 | 0.6 | 1.9 | 0.1 |
| *Echinodorus rostru* | 27.3 | 4.1 | 18.5 | 3.2 | 18.5 | 4.2 |
| *Eclipta prostrate* | 9.1 | 1.9 | 0.0 | 0.0 | 1.9 | 0.3 |
| *Eleocharis quadrangulata* | 13.6 | 2.4 | 7.4 | 1.7 | 14.8 | 3.2 |
| *Eleocharis* sp. | 12.1 | 0.6 | 14.8 | 3.4 | 11.1 | 3.5 |
| *Juncus effusus* | 0.0 | 0.0 | 5.6 | 0.6 | 3.7 | 0.2 |
| *Leptochloa fascicularis* | 3.0 | 0.1 | 11.1 | 2.6 | 5.6 | 1.5 |
| *Ludwigia peploides* | 0.0 | 0.0 | 0.0 | 0.0 | 1.9 | 0.9 |
| *Panicum* sp. | 47.0 | 8.1 | 46.3 | 12.7 | 33.3 | 6.3 |
| *Paspalum* sp. | 6.1 | 1.2 | 11.1 | 4.4 | 5.6 | 0.6 |
| *Persicaria hydropiper* | 30.3 | 10.6 | 40.7 | 17.4 | 25.9 | 7.4 |
| *Polygonum lapathifolia* | 66.7 | 26.5 | 46.3 | 21.8 | 48.1 | 24.3 |
| *Polygonum pennsylvanicum* | 27.3 | 9.9 | 18.5 | 8.8 | 31.5 | 20.9 |
| *Rumex crispus* | 37.9 | 11.2 | 18.5 | 7.8 | 11.1 | 0.7 |
| *Shoenoplectus californicus* | 10.6 | 0.8 | 3.7 | 1.1 | 7.4 | 0.4 |
| Misc. vegetation | 9.1 | 1.3 | 0.0 | 0.0 | 16.7 | 7.9 |
| **ANIMAL** | 39.4 | 27.5 | 7.4 | 2.5 | 24.1 | 6.3 |
| *Bivalvia* | 1.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Corixa* sp. | 1.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Gastropod* pieces | 33.3 | 12.0 | 1.9 | 1.1 | 22.2 | 9.0 |
| *Hermetiaillucens* | 1.5 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Hydrophilidae* | 3.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Odonata* | 1.5 | 0.1 | 1.9 | 0.3 | 1.9 | 1.5 |
| *Physidae* | 3.0 | 1.2 | 1.9 | 0.8 | 1.9 | 0.4 |
| *Planorbidae* | 7.6 | 1.8 | 0.0 | 0.0 | 1.9 | 0.3 |
| Unidentified invertebrate | 1.5 | 0.0 | 1.9 | 0.0 | 0.0 | 0.0 |

individuals, while animal food items were found in 7.4–39.4% of the Blue-winged Teal, Green-winged Teal and Northern Shoveler included in the study (Table 1). On considering seasonal variation in the food taken by each species, plant and animal food items were recorded in 100% and 0–40% respectively for birds collected in autumn, compared with 97–100% plants and 27–41% animal items for the three species during winter (Table 2). The most frequent seed items identified in Blue-winged Teal were Curlytop Knotweed *Polygonum lapathifolium* (67%), panic grass *Panicum* sp. (47%) and Curly Dock *Rumex crispus* (38%), with Gastropod pieces (33%) their most frequently identified invertebrate food. During autumn the most frequent food items in the Blue-winged Teal's diet were Curlytop Knotweed (30%), Gastropod pieces (17%) and Barnyard Grass *Echinochloa crusgalli* (13%), whereas in winter Erect Burhead *Echinodorus rostrus* (22%), California Bulrush *Shoenoplectus californicus* (14%) and Waterhemp *Amaranthus tuberculate* (11%) were more commonly ingested (Table 2). For Green-winged Teal, Curlytop Knotweed (46%), *Panicum* sp. (46%) and Water-pepper *Persicaria hydropiper* (41%) were the most frequently identified seeds overall, and no one invertebrate food item was more frequent than another (Table 1). Seeds ingested by Green-winged Teal were mostly of Curlytop Knotweed (56%), Water Hemp (22%), *Eleocharis* sp. (11%) and Water-pepper (11%) during autumn, and Barnyard Grass (16%), *Eleocharis* sp. (11%) and Erect Burhead (11%) during winter (Table 2). Finally, Curlytop Knotweed (48%), *Panicum* sp. (33%) and Pink Smartweed *Polygonum pennsylvanicum* (32%) were the most frequent seed items identified in Northern Shoveler throughout the study while Gastropod pieces (22%) were the most frequent invertebrate food item identified (Table 1). In autumn the Northern Shovelers were found to have fed primarily on the seeds of Curlytop Knotweed (33%), Barnyard Grass (16%), Water Pepper (17%) and California Bulrush (17%), and during winter the most frequent food items were Barnyard Grass (19%), Gastropod pieces (15%) and Pink Smartweed (15%) (Table 2).

The aggregate percent dry mass of plant and animal food items varied among species (Wilks' $\lambda = 0.980$, d.f. = 2, $P = 0.02$), but did not vary with season (Wilks' $\lambda = 0.995$, d.f. = 1, $P = 0.25$, n.s.), age (Wilks' $\lambda = 0.997$, d.f. = 1, $P = 0.43$, n.s.) nor sex (Wilks' $\lambda = 0.997$, d.f. = 1, $P = 0.54$, n.s.). There was also no significant interaction between age and sex in the percentage dry mass of plant compared with animal food ingested (Wilks' $\lambda = 0.995$, d.f. = 1, $P = 0.24$, n.s.). Subsequent analysis of variance similarly found that aggregate percent dry mass varied among species ($F = 5.57$, d.f. = 2, $P = 0.003$), but was similar for all other comparisons within each species. For example, within Blue-winged Teal, aggregate percent dry mass did not vary between autumn and winter (Wilks' $\lambda = 0.991$, d.f. = 1, $P = 0.32$, n.s.), nor was there any variation between sexes (Wilks' $\lambda = 0.995$, d.f. = 1, $P = 0.56$, n.s.), nor ages (Wilks' $\lambda = 0.994$, d.f. = 1, $P = 0.46$, n.s.), and there was no age x sex interaction (Wilks' $\lambda = 0.989$, d.f. = 1, $P = 0.26$). Similarly, aggregate percent dry mass within Green-winged Teal did not vary between

 

**Table 2.** Percent occurrence of food items consumed by Blue-winged Teal, Green-winged Teal, and Northern Shoveler in autumn and winter during 2004/05–2006/07 in east-central Texas. Plants identified to genus or species are all seeds; other vegetation material (*e.g.* leaves) is included as "miscellaneous vegetation".

| | **Blue-winged Teal** | | **Green-winged Teal** | | **Northern Shoveler** | |
|---|---|---|---|---|---|---|
| | **Autumn (*n* = 30)** | **Winter (*n* = 36)** | **Autumn (*n* = 9)** | **Winter (*n* = 45)** | **Autumn (*n* = 6)** | **Winter (*n* = 48)** |
| **PLANT** | 100.0 | 97.2 | 100.0 | 100.0 | 100.0 | 100.0 |
| *Amaranthus tuberculata* | 3.3 | 11.1 | 22.2 | 8.9 | 0.0 | 2.1 |
| *Echinochloa crusgalli* | 13.3 | 8.3 | 0.0 | 15.6 | 16.7 | 18.8 |
| *Shoenoplectus californicus* | 6.7 | 13.9 | 0.0 | 4.4 | 16.7 | 2.1 |
| *Carex* sp. | 0.0 | 0.0 | 0.0 | 2.2 | 0.0 | 2.1 |
| *Chenopodium album* | 3.3 | 2.8 | 0.0 | 6.7 | 0.0 | 2.1 |
| *Cyperus* sp. | 3.3 | 2.8 | 0.0 | 2.2 | 0.0 | 4.2 |
| *Eclipta prostrate* | 3.3 | 8.3 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Eleocharis* sp. | 0.0 | 5.6 | 11.1 | 11.1 | 0.0 | 8.3 |
| *Echinodorus rostru* | 10.0 | 22.2 | 0.0 | 11.1 | 0.0 | 8.3 |
| *Juncus effusus* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Polygonum lapathifolia* | 30.0 | 2.8 | 55.6 | 4.4 | 33.3 | 12.5 |
| *Panicum* sp. | 3.3 | 2.8 | 0.0 | 8.9 | 0.0 | 8.3 |
| *Paspalum* sp. | 0.0 | 0.0 | 0.0 | 2.2 | 0.0 | 0.0 |
| *Polygonum pennsylvanicum* | 0.0 | 5.6 | 0.0 | 6.7 | 0.0 | 14.6 |
| *Cyperus erthrorshizos* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Rumex crispus* | 0.0 | 0.0 | 0.0 | 8.9 | 0.0 | 0.0 |
| *Leptochloa fascicularis* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Eleocharis quadrangulata* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Ammania coccinea* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Persicaria hydropiper* | 3.3 | 2.8 | 11.1 | 4.4 | 16.7 | 2.1 |
| *Ludwigia peploides* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Echinochloa walteri* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Misc. vegetation | 0.0 | 0.0 | 0.0 | 0.0 | 16.7 | 0.0 |
| **ANIMAL** | 40.0 | 41.6 | 11.1 | 33.3 | 0.0 | 27.0 |
| *Bivalvia* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Corixa* sp. | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Gastropod* pieces | 16.7 | 11.1 | 0.0 | 0.0 | 0.0 | 14.6 |
| *Hydrophilidae* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Odonata* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Physidae* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Planorbidae* | 3.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Hermetiaillucens* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Unidentified invertebrates | 0.0 | 0.0 | 0.0 | 2.2 | 0.0 | 0.0 |

autumn and winter (Wilks' λ = 0.987, d.f. = 1, $P$ = 0.36, n.s.), nor sex (Wilks' λ = 0.986, d.f. = 1, $P$ = 0.33, n.s.), nor age (Wilks' λ = 0.995, d.f. = 1, $P$ = 0.67, n.s.), and there was no age x sex interaction (Wilks' λ = 0.997, d.f. = 1, $P$ = 0.82, n.s.). Aggregate percent dry mass within Northern Shoveler was also remarkably consistent, and did not vary between autumn and winters (Wilks' λ = 0.995, d.f. = 1, $P$ = 0.73, n.s.), nor sex (Wilks' λ = 0.998, d.f. = 1, $P$ = 0.90, n.s.), nor age (Wilks' λ = 0.996, d.f. = 1, $P$ = 0.73, n.s.), and there was no age x sex interaction (Wilks' λ = 0.985, d.f. = 1, $P$ = 0.32, n.s.).

## Discussion

### Food item occurrence

The results of our study indicated that Blue-winged Teal, Green-winged Teal and Northern Shoveler wintering on the moist-soil managed wetlands in east-central Texas have a varied omnivorous diet. Digestive tract contents consisted mainly of plant seeds, but 39.4%, 7.4% and 24.1% of the food items identified (measured as % occurrence) in the samples collected for each species were invertebrates, predominantly Gastropods. Previous studies of the food taken by two of these species (Green-winged Teal and Northern Shoveler) at different sites but a similar time of year (*i.e.* during migration and in winter) also found that the dabbling ducks ingest a range of food items, albeit that invertebrates comprised a higher proportion of the birds' diet (Vest & Conover 2011; Tietje & Teer 1996). For instance, in a saline system, both Northern Shoveler and Green-winged Teal foraged primarily on brine shrimp adults and cysts, which accounted for > 70% of the food taken (Vest & Conover 2011). Elsewhere, in southern Texas, Northern Shoveler likewise ingested more animal matter, although this varied with habitat with a higher proportion of animal food found in birds from saline wetlands (where it comprised 80% of the diet) compared with those at freshwater sites (50% of the diet; Tietje & Teer 1996).

Our findings for Green-winged Teal are very similar to those reported by Anderson *et al.* (2000), who found no differences in the aggregate percent dry mass of total seeds or invertebrates consumed by these birds in the Southern High Plains of Texas, 600 km northeast of our own study site. They found that seeds comprised 69–92% and invertebrates 8–31% of the Green-winged Teal's diet, which is generally consistent with the overall occurrence of native seeds (100%) and aquatic invertebrates (7.4%) in the digestive tracts of the individuals collected in the RCWMA. Like Anderson *et al.* (2000), we also found no difference in the occurrence or in the aggregate percent dry mass of invertebrates compared with seeds consumed among the age-sex cohorts for Green-winged Teal. The results concur with those from studies in Europe. Mouronval *et al.* (2007) reported that teal are almost exclusively granivorous in northeastern France, where all samples ($n$ = 48) collected that had food items present contained seeds. Likewise, Arzel *et al.* (2007) found that invertebrate food items were relatively scarce in winter, consistent with studies which show that teal are mainly granivorous during winter not only in

 

France but also Sweden. Reports on the diet of Northern Shoveler in the United States and Europe during winter generally vary with geographic location. As stated previously, Vest and Conover (2011) found aquatic invertebrates to occur in > 90% of samples, whilst Mouronval *et al.* (2007) found shovelers to be essentially benthivorous, but that they would also frequently consume seeds. Of interest, one plant species – Curlytop Knotweed – was an important and frequent seed identified in shovelers in northeastern France (Mouronval *et al.* 2007), and this was also identified as an important frequent seed species found in Northern Shoveler in the RCWMA.

### Variation in food items ingested with habitat and season

That Gastropod pieces were more frequently identified in Blue-winged Teal than in Northern Shoveler at the RCWMA is of interest. Studies of Northern Shoveler elsewhere typically have found a high occurrence of aquatic invertebrates, such as brine fly larvae, brine shrimps, bivalves, Gastropods and Cladocerans in the diet (DuBowy 1988; Thompson *et al.* 1992; Tietje & Teer 1996; Mouronval *et al.* 2007; Vest & Conover 2011), although this seems to vary with geographic location with Gastropods less commonly found in some studies. For example, Northern Shoveler diets consisted primarily of water boatmen *Corixidae* sp. (51.6%), Rotifers (20.4%) and Copepods (15.2%) in California (Euliss *et al.* 1991), whereas in contrast Gastropods were important for the species in southern Texas, where they accounted for 27% and 38% of the food taken by shovelers in freshwater and saline wetlands respectively during early winter (Tietje & Teer). Thompson *et al.* (1992) found that Gastropods comprised > 98% of the diet of both Blue-winged Teal and Northern Shoveler in Yucatan, Mexico. Gastropod occurrence was not quite as high as this in our own study (~ 26%), but our findings undoubtedly indicate that Gastropods are an important food item for Northern Shoveler in east-central Texas in winter, and for Blue-winged Teal during both autumn and winter (see Tables 1 & 2).

That Gastropods were a major part of the diet for Blue-winged Teal throughout autumn and winter in our study differs from observations made elsewhere, which described seasonal changes in the extent to which Gastropods were taken by the teal, and suggested that the importance of Gastropods also varies with geographic location. In Mexico, for instance, Thompson *et al.* (1992) found that Blue-winged Teal switch from a primarily Gastropod diet during the first half of winter to a seed-based diet during the second half. Moreover, Rollo & Bolen (1969) and Swiderek *et al.* (1988) found that Blue-winged Teal rely primarily on plant foods. In contrast, both seeds and Gastropods were consistently identified as items taken by Blue-winged Teal during both autumn and winter in our study area, which may indicate the availability of these foods for these teal and indeed other dabbling duck species throughout autumn and winter at RCWMA.

### Management implications

In this study, native seeds (such as Curlytop Knotweed, Pink Smartweed, Water Pepper, Curly Dock, and *Panicum* sp.) were the most

 

frequent seeds recorded, perhaps due to their hardness and persistence in crops and digestive tracts, or because they were the food most readily available, as suggested by botanical surveys undertaken in the study area (Collins 2012). Botero & Rusch (1994) postulated that *post mortem* digestion of invertebrates may occur and make seeds easier to detect, but the preservation of the gut contents on collecting the birds aimed to keep any such bias to a minimum. Recognising major seasonal foods of importance that influence waterfowl use of areas and how these are obtained through active management practices is key. At moist-soil wetlands such as the RCWMA, water inundation and drawdown regimes are timed precisely in order to promote the germination, growth and seed production of desirable hydrophytic plants (during drawdown), and also to provide food and structural substrates for invertebrate colonisation (during inundation), with both the seeds and invertebrates being key food resources for migrating and wintering waterfowl (Collins *et al.* 2015). Providing suitable habitat for waterfowl should be the main goal of any wetland/waterfowl land manager providing wintering habitat through active management techniques (*e.g.* moist-soil management), as these resources play a key role in improving the probability of successful life history events during other portions of the annual cycle, such as breeding, egg laying, and nesting (Baldassarre *et al.* 1986; Miller 1986; Rave 1987; Thompson & Baldassarre 1990; Rave & Baldassarre 1991; Devries *et al.* 2008; Collins *et al.* 2015). In addition, estimating and collecting long-term data on vegetation and duck-use days will provide information on potential food production as well as the carrying capacity of the managed wetlands, which can be useful for adjusting management techniques, if necessary, to maximise the birds' use of these sites (Collins 2012). The findings presented here, along with studies conducted concurrently (*i.e.* on aquatic invertebrates and vegetation composition; Collins 2012), will allow area managers to identify potential variables influencing food habits. The data and analyses should provide an understanding of how the dabbling duck species use moist-soil managed wetlands during winter in east-central Texas, and thus inform management schemes (*e.g.* inundation regimes) and influence directly the occurrence of plant species occurrence in these managed moist-soil wetlands.

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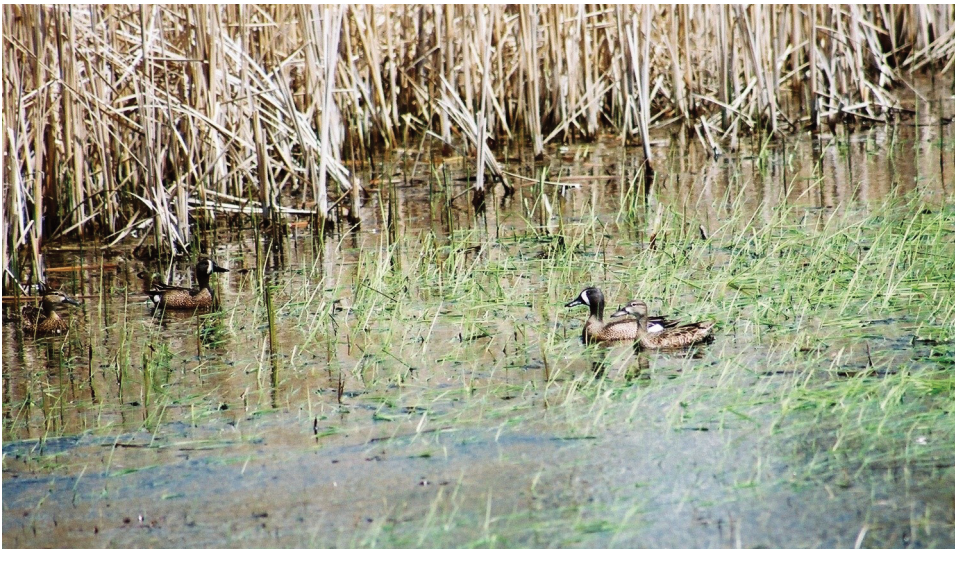

**Photograph:** Blue-winged Teal at the Richland Creek Wildlife Management Area by Dan Collins.