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# DIET OF DOUBLE-CRESTED CORMORANTS WINTERING IN TEXAS

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Abstract.—The diets of 420 Double-crested Cormorants (*Phalacrocorax auritus*) were studied during November 1986–March 1987 on eight public reservoirs in Texas. Prey included 29 fish species and the mean live weight of fish per bird was 122 g. Fishes ≤415 mm long were ingested, but those ≤125 mm accounted for 90% of cormorant food contents by number. Shad (*Dorosoma* spp.) and sunfishes (*Lepomis* spp.) accounted for 90% of the total food items by number. Consumption of fishes (percent by weight) was different for male vs. female and adult vs. juvenile cormorants. Total consumption of fish by weight was consistent throughout the period; however, fewer but much larger fish were consumed after 15 February. Cormorants ate fishes that were most abundant in reservoirs. Sport fishes made up a substantial portion of cormorant food by weight, but not by number on some reservoirs. Cormorants ate very few large sport fish, however.

**DIETA DE INDIVIDUOS DE *PHALACROCORAX AURITUS* QUE PASAN EL INVIERNO EN TEXAS**

Sinopsis.—De noviembre de 1986 a 1987, se estudió la dieta de 420 cormoranes (*Phalacrocorax auritus*) en ocho reservorios públicos de Texas. La dieta incluyó 29 especies de peces y el promedio de peso de pez vivo por ave fue de 122 g. Peces con longitud <415 mm fueron ingeridos. Aquellos con tamaño <125 mm formaron el 90% del contenido alimentario por número. Peces de los géneros *Dorosoma* y *Lepomis* formaron el 90% de la dieta de las aves por número. El consumo de peces (porciento por peso) por parte de los cormoranes resultó diferente para machos vs. hembras y adultos vs. juveniles. El consumo de peces por peso, fue uniforme a través del período de estudio. Sin embargo, después del 15 de febrero, menos peces pero de mayor peso fueron consumidos. Las aves consumieron los peces que resultaron ser más abundantes en los reservorios. *Lepomis* spp. formó una porción sustancial por peso de la dieta de las aves, pero no así por número en algunos reservorios; los cormoranes ingirieron muy pocas presas de alto peso.

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The Double-crested Cormorant (*Phalacrocorax auritus*) is a locally abundant winter resident along the Gulf Coast and on inland lakes and reservoirs throughout Texas, but primarily east of the 100th meridian. Rappole and Blacklock (1985) reported wintering cormorants are more prevalent from November through March. A few cormorants, however, are summer residents in southeast Texas (Holm et al. 1978). Cormorant predation on fish has been and is a major topic of discussion among fisheries biologists, private lake owners, fishing guides, anglers, marina owners and aquaculturists. Increased numbers of cormorants, particularly in eastern and southern Texas, have caused routine public complaints about possible deleterious effects on sport fish populations. Diets of cormorants wintering in Texas have not been quantified, however. Extensive discussion and accusations from fishery interests prompted our review of literature concerning cormorant feeding and diets. Apparently, cormorants do have the potential to impact sport fish populations adversely. Popular magazines have presented rational and irrational views of cormorants (Butler 1987, Dukes 1987). Cormorants in many areas have been documented to feed in large numbers, but typically ingest small fish that are considered to have limited value to human recreational and/or economic interests (Craven and Lev 1987, Draulans 1988). We hypothesized that cormorants in Texas lakes would consume relatively large numbers of small fish, typically species of limited direct importance to human uses. Our attempts to negate predictions from that hypothesis yielded dietary data presented herein.

## METHODS

The study was conducted on eight public reservoirs used in winters by cormorants (Fig. 1). Most of the reservoirs were located in eastern Texas, but study areas were also in central and south Texas. Reservoirs were located on the Rio Grande River, San Antonio River, Brazos River, Lake Fork Creek, Purtis Creek, Neches River, Angelina River and West Fork of the San Jacinto River.

We collected cormorants during November 1986–March 1987. The study was divided into three periods (early arrival, 1 November–15 December; overwinter, 16 December–15 February; and pre-migration, 16 February–31 March). With shotguns, we attempted to collect from a variety of feeding locations, 54 cormorants on each study area (18 per period). We collected cormorants after they had been observed feeding for at least 15 min. Immediately after collection, the esophagus and stomach of each bird were removed and stored in a plastic bag for later analysis. We recorded location, specimen number, weight, sex, age, date and time for each specimen.

We recorded genus and species (when possible), total length (mm), and estimated live weight for each food item. Weight of each food item was estimated from weight-length relationships calculated for each species of fish from previous independent samples (Texas Parks and Wildlife Department, unpubl. data).

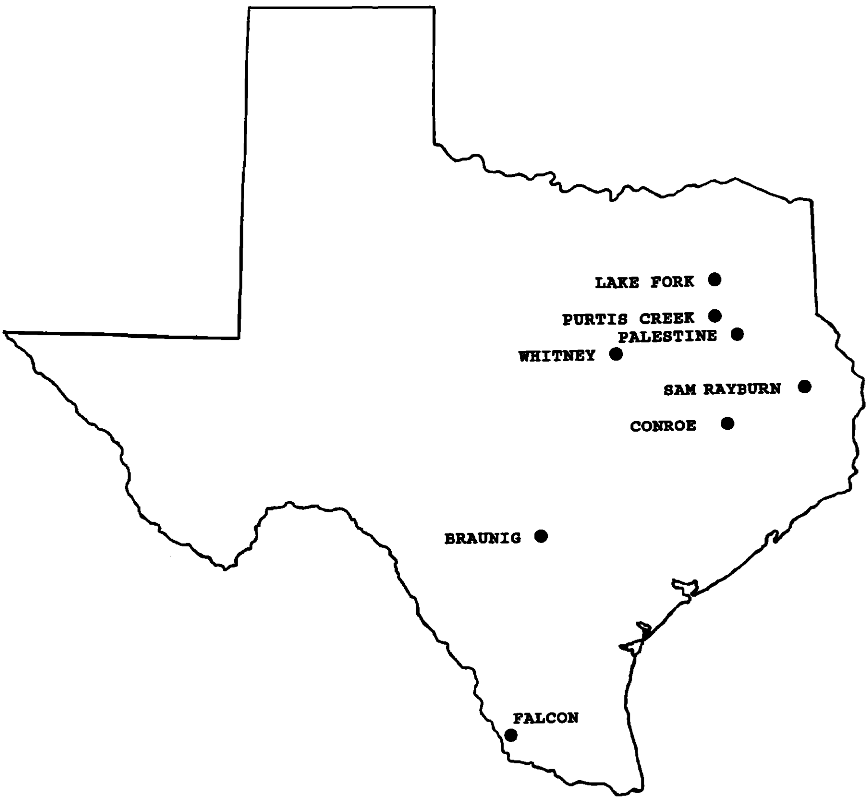


FIGURE 1. Reservoirs used in the study of diets of Double-crested Cormorants wintering in Texas during 1986–1987. Falcon (35,208 ha), Braunig (546 ha), Whitney (9535 ha), Fork (11,206 ha), Purtis Creek (121 ha), Palestine (10,117 ha), Sam Rayburn (46,338 ha) and Conroe (8492 ha).

Number and weight of food contents were analyzed by sex and age of cormorants and period. Our objective was not to present comparative data for each reservoir. We knew *a priori* that fish populations differed among reservoir in species composition and abundance. Widely dispersed reservoirs were used to estimate diets on a statewide basis. Detailed analysis included only those cormorants identified to sex, age and period. Otoliths and invertebrate remains were not considered for the analysis. Single classification and factorial ANOVA of the ranked data was computed (PROC GLM, SAS 1985) and, in the absence of significant interaction, LSD was used for mean separation. When we refer to percent by weight, we mean the ratio of the weight of a group (e.g., shad, *Dorosoma* spp.) to the total weight of all groups. Prey use is presented as percent by number and weight of food items. Averages and standard errors are presented as $\bar{x} \pm SE$.

RESULTS

We collected 494 cormorants of which 420 contained measurable food items. Sample size for each reservoir was Braunig = 49, Conroe = 47, Falcon = 54, Fork = 51, Palestine = 47, Purtis Creek = 44, Sam Rayburn = 66 and Whitney = 62. Average cormorant weight was 2.30 ± 0.02 kg. More males (283) than females (184) were collected; 27 cormorants were not identified to sex. All age and sex categories were represented among all study periods for all reservoirs except for an unexplained lack of juveniles for the Lake Conroe sample.

We identified 29 fish species in food samples; only fishes occurred as food items (Table 1). Shad and sunfishes (*Lepomis* spp.) accounted for most of the food contents by number (Fig. 2). The aggregate of sport fishes including largemouth (*Micropterus salmoides*) and white bass (*Morone chrysops*), catfishes (*Ictalurus* spp.), and crappies (*Pomoxis* spp.) accounted for 3% by number and 32% by weight of food contents. Common carp (*Cyprinus carpio*) and blue tilapia (*Tilapia aurea*) accounted for most of the remainder of food contents.

Percent by number of the various fish groups appeared to be correlated between sexes for food samples from 230 male and 163 female cormorants. There was a significant difference in percent by number of groups between the sexes ($F = 9.30$; 1,428 df; $P = 0.002$). Female cormorants consumed more small food items (shad, minnows and sunfishes) by weight (52%) than males (38%) ($F = 6.76$; 1,381 df; $P = 0.009$). Male cormorants appeared to consume more catfish and bass by weight (32%) than females (14%), but this difference was not significant ($F = 2.91$; 1,381 df; $P = 0.139$).

Percent by number of small food items was similar between age categories for 279 adult and 161 juvenile cormorants ($F = 0.79$; 1,428 df; $P = 0.374$). There was a significant difference, however, in percent by number of large food items between ages ($F = 5.34$; 1,428 df; $P = 0.021$). There were 254 adult and 139 juvenile cormorants which contained food items that had weight estimates. Small food items (shad, minnows and sunfishes) accounted for 38% vs. 54% by weight of food contents for adult and juvenile cormorants, respectively, but these differences were not significant ($F = 3.06$; 1,381 df; $P = 0.081$). Large food items (catfishes and basses), however, accounted for 30% vs. 19% by weight of cormorant food contents for adults and juveniles, respectively, and these differences were significant ($F = 3.98$; 1,381 df; $P = 0.047$).

Shad species accounted for the greatest percent by number of food items in each period; however, shad decreased almost 40% by number and 50% by weight after 15 February. Both percent by number and percent by weight showed significant differences in shad items over time ($F = 6.71$; 2,437 df; $P = 0.001$ and $F = 6.52$; 2,390 df; $P = 0.001$, respectively). Consumption of sunfishes nearly tripled by number and doubled by weight during 16 December–15 February. Between 16 February and 31 March, percent by number of sunfishes doubled but the percent by weight de-

TABLE 1. Diet of 420 Double-crested Cormorants collected on eight inland public reservoirs in Texas, November 1986–March 1987.

| Food item | | % by number[a] | % by weight |
|---|---|---|---|
| | **Shad** | | |
| *Dorosoma cepedianum* | Gizzard shad | 9.9 | 14.3 |
| *D. petenense* | Threadfin shad | 69.3 | 11.8 |
| | **Large roughfish** | | |
| *Cyprinus carpio* | Common carp | 0.2 | 2.2 |
| *Erimyzon sucetta* | Lake chubsucker | 0.1 | 0.3 |
| | **Small forage species** | | |
| *Notropis venustus* | Blacktail shiner | 0.1 | tr |
| *Pimephales vigilax* | Bullhead minnow | 0.7 | tr |
| *Aphredoderus sayanus* | Pirate perch | tr | tr |
| *Notemigonus crysoleucas* | Golden shiner | tr | tr |
| *Fundulus notatus* | Blackstripe topminnow | 0.1 | tr |
| *Menidia beryllina* | Inland silverside | 0.9 | 0.2 |
| *Percina macrolepida* | Bigscale logperch | 0.6 | 1.0 |
| *Notropis proserpinus* | Proserpine shiner | tr | tr |
| — | Others | 0.3 | tr |
| | **Catfishes** | | |
| *Ictalurus melas* | Black bullhead | 0.2 | 3.2 |
| *I. natalis* | Yellow bullhead | tr | 0.3 |
| *I. punctatus* | Channel catfish | 0.9 | 6.1 |
| | **Black and White Bass** | | |
| *Micropterus salmoides* | Largemouth bass | 0.6 | 8.6 |
| *Morone chrysops* | White bass | 0.6 | 7.9 |
| | **Sunfishes** | | |
| *Lepomis cyanellus* | Green sunfish | tr | tr |
| *L. gulosus* | Warmouth | 0.2 | 0.9 |
| *L. macrochirus* | Bluegill | 4.9 | 10.6 |
| *L. megalotis* | Longear | 0.4 | 1.2 |
| *L. microlophus* | Redear | 1.9 | 1.9 |
| *L. punctatus* | Spotted | tr | tr |
| — | Others | 0.4 | 0.4 |
| | **Crappies** | | |
| *Pomoxis annularis* | White crappie | 0.4 | 2.8 |
| *P. nigromaculatus* | Black crappie | 0.3 | 2.8 |
| | **Other fishes** | | |
| *Esox americanus vermiculatus* | Grass pickerel | 0.1 | 0.1 |
| *Aplodinotus grunniens* | Freshwater drum | 0.6 | 4.1 |
| *Cichlisoma cyanogutatum* | Rio Grande cichlid | 0.2 | 0.5 |
| *Tilapia aurea* | Blue tilapia | 5.2 | 18.2 |
| — | Fish remains | 0.7 | 0.4 |

[a] tr = trace (<0.1%).

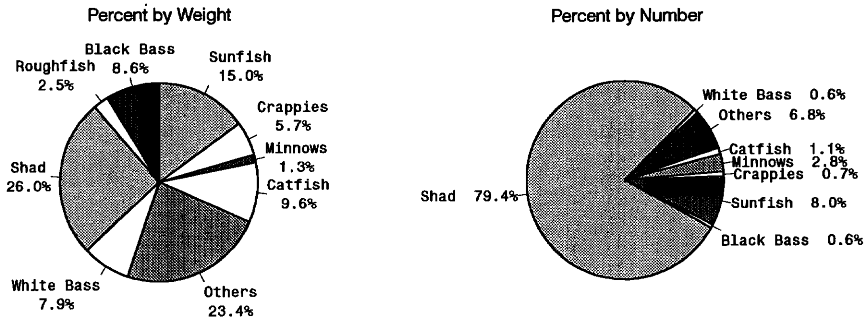


FIGURE 2. Percent by weight and number of fishes consumed by 420 Double-crested Cormorants collected on eight public reservoirs in Texas, November 1986–March 1987.

creased by nearly 50%. No significant differences were detected by number or by weight ($F$ = 1.20; 2,437 df; $P$ = 0.302 and $F$ = 1.48; 2,390 df; $P$ = 0.228), respectively. Both ratios for sunfish were erratic with no discernable pattern with respect to time periods. Percent by number of catfishes in the food contents increased from less than 1% during 1 November–15 February to more than 8% after 15 February ($F$ = 6.30; 2,437 df; $P$ = 0.002). Percent by weight of catfishes increased 10-fold from the first to the third period ($F$ = 7.05; 2,390 df; $P$ = 0.001). Consumption of basses appeared highest during 1 November–15 December, but there was no significant difference over time periods by either number or weight ($F$ = 1.09; 2,437 df; $P$ = 0.006 and $F$ = 1.21; 2,390 df; $P$ = 0.298). Percent by weight of crappies in food contents doubled from the first to the third period ($F$ = 3.56; 2,390 df; $P$ = 0.029). Consumption of other fish species was very similar throughout the study period. *A posteriori* LSD tests grouped data for 1 November–15 February separate from 16 February–31 March.

Length-frequency distribution of fishes in cormorant food contents indicated that 90% of food items were ≤125 mm long. A catfish 415 mm long was the longest prey found. Shad species and sunfishes accounted for 90% of fish ≤125 mm long. Length of most species did not vary greatly; however, gizzard shad ranged in size from 35 to 355 mm, channel catfish from 45 to 415 mm and largemouth bass from 125 to 345 mm. Distribution of estimated weights revealed that 91% of fish consumed weighed 200 g or less (Fig. 3).

Average number of food items per sample was 10.5 ± 1.2 and live weight of food contents was 121.9 ± 5.7 g (Table 2). Two-way ANOVA of the ranked data by sex and age indicated significant interaction in total estimated live weight of food contents ($F$ = 6.79; 1,389 df; $P$ = 0.009). Mean total weight consumed per cormorant was 142.4 ± 8.2 g for males and 92.9 ± 7.1 g for females. Differences in consumption of fish by weight between adult and juvenile female cormorants were not significant ($F$ = 1.78; 1,161 df; $P$ = 0.1841). Adult males consumed more fish by weight

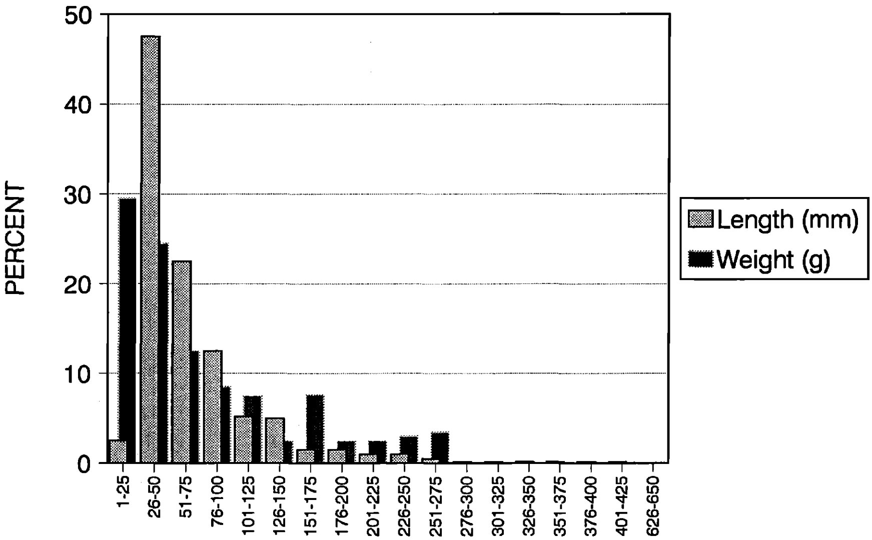


FIGURE 3. Distribution of 4337 fish identified in food contents of 420 Double-crested Cormorants collected on eight public reservoirs in Texas, November 1986–March 1987.

($F$ = 5.65; 1,228 df; $P$ = 0.018) than did juvenile males, however. No differences ($F$ = 1.23; 1,381 df; $P$ = 0.2680) were observed in the number of fish in the stomach samples of either adult or juvenile cormorants. Also, no differences ($F$ = 2.38; 1,389 df; $P$ = 0.124) by number of food items were detected between sexes.

No differences ($F$ = 1.51; 1,381 df; $P$ = 0.222) were observed in total weight consumed among study periods (Table 2). There was a difference ($F$ = 26.32; 2,390 df; $P$ = 0.0001), however, in the number of food items among the three periods. An *a posteriori* $t$-test (LSD = 25.46; 381 df; $P$ < 0.001) indicated that consumption per cormorant during the first two periods combined ($\bar{x}$ = 14.0) differed from the last ($\bar{x}$ = 2.8).

## DISCUSSION

Cormorants wintering in Texas largely originate from populations breeding in the northern prairie states, prairie provinces of Canada and the upper Midwest. Over the entire Great Lakes system, total growth of cormorant breeding colonies since 1972 was 40% per year (Ludwig 1984). A nearly four-fold increase in the nesting cormorant population was documented at Lake Winnipegosis, Canada between 1979 and 1987 (Hobson et al. 1989, Vermeer and Rankin 1984). An important factor in the exponential growth of cormorant populations in Wisconsin has been the installation of artificial nesting platforms (Matteson 1985). Thus, some resource agencies have consciously managed for cormorants that may be perceived as problems elsewhere.

TABLE 2. Summary statistics for number and weight of food contents of 393 Double-crested Cormorants collected on eight inland public reservoirs in Texas, November 1986–March 1987.

| Age | Sex | Study period[a] | *n* | Live weight (g) $\bar{x}$ | Live weight (g) SE | # food items $\bar{x}$ | # food items SE |
|---|---|---|---|---|---|---|---|
| Adult | M | | 168 | 153.4 | 9.9 | 12.4 | 2.3 |
| | F | | 86 | 91.6 | 11.4 | 8.4 | 1.6 |
| | Total | | 254 | 132.5 | 7.8 | 11.1 | 1.6 |
| Juvenile | M | | 62 | 112.8 | 13.2 | 6.6 | 1.4 |
| | F | | 77 | 94.3 | 7.9 | 11.6 | 2.4 |
| | Total | | 139 | 102.6 | 7.4 | 9.4 | 1.5 |
| Adult and Juvenile | M | | 230 | 142.4 | 8.2 | 10.8 | 1.7 |
| | F | | 163 | 92.9 | 7.1 | 9.9 | 1.4 |
| | Total | 1 | 129 | 119.5 | 9.7 | 14.0 | 2.6 |
| | | 2 | 140 | 113.9 | 8.8 | 14.0 | 2.1 |
| | | 3 | 124 | 133.3 | 11.4 | 2.8 | 0.3 |

[a] = 1 November–15 December, 2 = 16 December–15 February, 3 = 16 February–31 March.

Our study indicated shad species, common carp, blue tilapia, freshwater drum, minnows and other non-sport fish species were the most common prey of cormorants. Diet analysis of cormorants in South Dakota (Trautman 1951), Wisconsin (Craven and Lev 1985), and in Canada (Hobson et al. 1989) found non-sport fishes were most frequently consumed, and that cormorants fed upon the most available and abundant fish source. Sport fishes were a substantial portion of cormorant food contents by weight, but not by number, on some of the public reservoirs during our study. The sport fish eaten by cormorants were much smaller than those taken by sportfishermen, however. On Lake Conroe, only three bass were taken by cormorants and the percent by weight of catfish in food contents was attributable to one large (415 mm) catfish. These data revealed that cormorants can and do consume sizable sport fishes. Our data indicate, however, that very few large fishes are taken by cormorants.

Male Double-crested Cormorants consumed larger fish than females, and the difference was attributed to more catfishes and basses in the food of males. Similar results were found for the food contents of adult and juvenile cormorants. The importance of these observations is that impact to the fisheries might be lessened by partitioning size and species composition of fishes eaten between sex and age groups of cormorants. Size and species composition of foods changed during the study (e.g., consumption of shad decreased ($P < 0.05$) after 15 February). One possible explanation is that shad moved into deeper water in response to cold weather thus reducing their availability to cormorants. Catfishes were a prevalent food item only after 15 February. Most largemouth bass were taken in the first period. This was possibly related to warmer water temperature and bass use of shallow water areas. Total consumption in terms of weight did not change throughout the winter, but fewer and much larger fish were consumed in the last study interval.

Length-frequency analysis of fishes consumed revealed that fish ≤125 mm long accounted for nearly all of the food items. Craven and Lev (1985) found that cormorants generally ate fish 120–150 mm in length.

Cormorants appeared to eat the fish species that were most abundant. For example, Falcon and Braunig reservoirs, in which cormorants consumed primarily blue tilapia, were classified according to the abundance of blue tilapia (Dolman 1990). Reservoirs in eastern Texas were classified according to the abundance of sport fish associations, especially sunfish which were predominant in cormorant diets.

Under some circumstances cormorants might have a beneficial effect by exerting some control on the numbers of forage and rough fish species (Ali and Bayne 1985, Kirk and Davies 1985). As expected from studies of cormorant diets elsewhere, our data indicated that consumption of desired sport fish in reservoirs was an insignificant portion of cormorant diets in Texas. Our hypothesis that cormorants preyed upon primarily small forage fish species was not rejected thus lending added credence to predictions from other available literature.

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