Possible Effects of Catfish Exploitation on Overwinter Body Condition of Double-Crested Cormorants

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Abstract: Concurrent with the rapid growth of the Mississippi catfish industry during the 1980's, there was evidence of similar growth of double-crested cormorant *(Phalacrocorax auritus)* populations wintering in the delta region of Mississippi. Observational and food habits studies indicate that this expansive industry, incorporating more than 100,000 acres of ponds, provides an enormous food base for overwintering populations estimated in recent years to exceed 50,000 birds. As much as 75 percent of the diet in certain roosting areas of the Mississippi delta consisted of catfish, and according to bioenergetic models cormorants can exploit as much as 940 metric tons of catfish per winter. Despite these data, there has been little attempt to demonstrate whether exploitation of this food base has increased body condition and possibly survival of wintering cormorants that return primarily to the Great Lakes region to breed. To examine this possible effect, we analyzed monthly changes in body masses of wintering cormorants collected in the delta region of Mississippi and compared premigratory body masses and fat deposition of Mississippi cormorants with those from areas without extensive aquaculture production. With the exception of adult females, all sex and age groups of cormorants collected in the delta during the winters of 1989–90 and 1990–91 increased *(P* < 0.05) their body mass from November to April. Over all months, body masses of adult males and adult females were greater than that of subadults. Standardized by wing chord length, the premigratory body masses of Mississippi males and females differed *(P* < 0.0004) from premigratory males and females collected from Alabama in areas remote from catfish production. Premigratory fat deposition appeared to be responsible for the body mass increases, and omental fat mass was highly correlated *(R* = 0.721, *P* < 0.0001) with body mass and also differed *(P* = 0.0003) between Mississippi and Alabama birds. We hypothesize that the improved body condition of cormorants resulting from exploiting catfish has increased their survival and contributed to the population explosion of cormorants observed over the past decade. We suggest additional studies to substantiate our findings and to clarify the importance of southern aquaculture on improving body condition and survival of cormorants.

Keywords: body condition, body mass, catfish exploitation, double-crested cormorant, omental fat deposits, *Phalacrocorax auritus*

Since the late 1970's, double-crested cormorant (DCCO) populations have steadily increased throughout most of their breeding range (Scharf and Shugart 1981, Milton and Austin–Smith 1983, Buckley and Buckley 1984, Hatch 1984, Ludwig 1984, Blokpoel and Harfenist 1986, Price and Weseloh 1986, Roney 1986, Craven and Lev 1987, Hobson et al. 1989, Weseloh et al. 1995). Within the Great Lakes region, this population growth has been estimated to average almost 30 percent annually (Weseloh et al. 1995). Concurrently, there has been a resurgence of wintering populations in the mid-South (Jackson and Jackson 1995) that has been most prominent in areas with catfish production in the delta region of Mississippi (Glahn and Stickley 1995, Jackson and Jackson 1995).

In part, growth of the wintering cormorant populations in this region appears to be directly related to growth of the catfish industry (Glahn and Stickley 1995, Glahn et al. 1996, Jackson and Jackson 1995), which may have caused a shift in the wintering range of this species (Weseloh and Ewins 1994). Growth of breeding populations has been attributed mainly to the resurgence of forage fish, particularly alewife *(Alosa pseudoharengus)* on the breeding grounds, as well as to a decrease of persistent pesticides such as dichlorodiphenyl trichloroethane (DDT) and reduced persecution (Ludwig et al. 1989, Weseloh and Ewins 1994, Weseloh et al. 1995). But some authors speculate that improved overwinter survival of cormorants from the exploitation of commercially raised catfish may also be responsible (Duffy 1995, Weseloh and Ewins 1994). Catfish production may be particularly important to subadult birds, which in stable populations are estimated to sustain a 70-percent annual mortality rate (compared with a 15-percent annual mortality for adults) (Price and Weseloh 1986). Most authors agree that if one assumes no immigration of birds, a substantial reduction in mortality would be necessary to account for the dramatic population increases seen in the Great Lakes DCCO population over the past 20 years (Price and Weseloh 1986, Weseloh and Ewins 1994).

Directly measuring survival of overwintering cormorant populations is fraught with difficulty because of the dynamics of these wintering populations (Glahn et al. 1996, King 1996). However, measures of body condition may support some inferences about their potential survival. Glahn and McCoy (1995) noted that body masses of male and female cormorants collected in the delta region of Mississippi from January through April were slightly heavier than those reported for the same subspecies in the literature, but other measurements were also slightly larger. Glahn and Brugger (1995) reported the monthly changes in body mass of cormorants from November to April but did not analyze differences between sexes. Body mass and omental fat mass are often used as indices of body condition of waterfowl (Owen 1981, Whyte and Bolen 1984, Woodall 1978). As defined by Owen and Cook (1977), body condition reflects the potential ability of a bird to cope with its present and future needs. On the basis of this premise, we analyzed body masses of cormorants collected throughout the winter months in the delta region of Mississippi and compared premigratory body mass and omental fat mass to that of cormorants collected in areas without commercial aquaculture production.

Methods

We reanalyzed data on the body mass of cormorants collected during food habits collections in the delta region of Mississippi during the winters of 1989–90 and 1990–91 (Glahn et al. 1995). We combined data from both years and separated the adjusted body mass by month. Body masses were adjusted by subtracting the mass of stomach contents from the mass of each whole bird before dissection. We conducted separate analyses of variance for adult males, subadult males, adult females, and subadult females to compare body masses among months. In this study, we defined subadults as birds having juvenal plumage which, in part, is retained to the age of 13 months (Palmer 1962). All other birds were considered adults. We used a Tukey's post-hoc analysis to separate differences among months and considered all tests significant at an alpha level of 0.05. We analyzed the sexes separately because of the known differences in body size (Glahn and McCoy 1995). Despite the lack of precision in age classification (Palmer 1962), we used a *t* test ($\alpha = 0.05$) to analyze for differences between age groups for each gender separately because of probable differences in winter survivability.

We collected additional cormorants in 1997 to examine possible differences in body mass and omental fat mass of premigratory cormorants from catfish-production areas versus birds from areas without catfish production. Both samples were collected by shotgun during the premigratory period from mid-March to mid-April. We collected 51 cormorants from a roost 8 km Southwest of Moorhead, MS, an area of intensive catfish production. In Alabama, 77 cormorants were collected from Lake Jackson and Lake Eufaula, 2 roost sites that were approximately 95 and 220 km, respectively, from the nearest catfish farm. Immediately after collection, birds were weighed to the nearest 0.05 kg with a Pesola scale, and the flattened wing chord was measured to the nearest millimeter. Wing chord length was measured as an index of structural size and has been shown to be the single best predictor of the structural size differences between male and female cormorants (Glahn and McCoy 1995). The age of each bird was determined by examining plumage characteristics (Palmer 1962), and sex was determined by internal examination of reproductive organs. The stomach, including omental fat, was dissected out from each bird, labeled, and transported on ice to the National Wildlife Research Center's (NWRC) Starkville, MS, field station. Stomachs were rinsed clean of any debris and towel dried. Omental fat was carefully scraped with a scalpel blade from the outside of each stomach lining, placed in a plastic weighing dish, and weighed to the nearest gram. The stomach contents were removed, weighed to the nearest gram, and analyzed as to composition and size of fish species (Glahn et al. 1995).

On the basis of differences in wing chord lengths between Alabama and Mississippi birds, we scaled the adjusted body masses by dividing the body mass by the flattened wing chord measurement for each bird (Whyte and Bolen 1984). Owing to the paucity of female cormorants collected in Mississippi during spring collections in 1997, we included data on the adjusted body mass of 21 females collected during the same period and in a similar area during 1990 and 1991. We analyzed for differences in adjusted body mass and wing chord length between years of collection in Mississippi and for differences in scaled body mass between Mississippi and Alabama samples using a *t* test ($\alpha = 0.05$) for each sex separately. We used an identical procedure for examining differences in omental fat content between States and sexes and conducted a within-sex Pearson correlation analysis between omental fat mass and body mass.

Results

Adjusted body masses of all sex and age groups of cormorants collected during the winters of 1989–90 and 1990–91 increased or remained stable over the wintering period with significant ($P < 0.05$) changes occurring between November and April samples in all cases except adult females (fig. 1). When age groups were combined, adjusted male body mass increased ($F = 18.51$, df = 5, $P = 0.0001$) by 15.7 percent from November to April and averaged 2.54 kg (SE = 0.026 kg) in April. Adjusted female body mass also increased ($F = 2.93$, df = 5, $P = 0.0158$) by 10.4 percent over this period and averaged 2.16 kg (SE = 0.035) in April. Over all months, adjusted body masses of adult males and females were greater ($P = 0.0001$) than that of subadults.

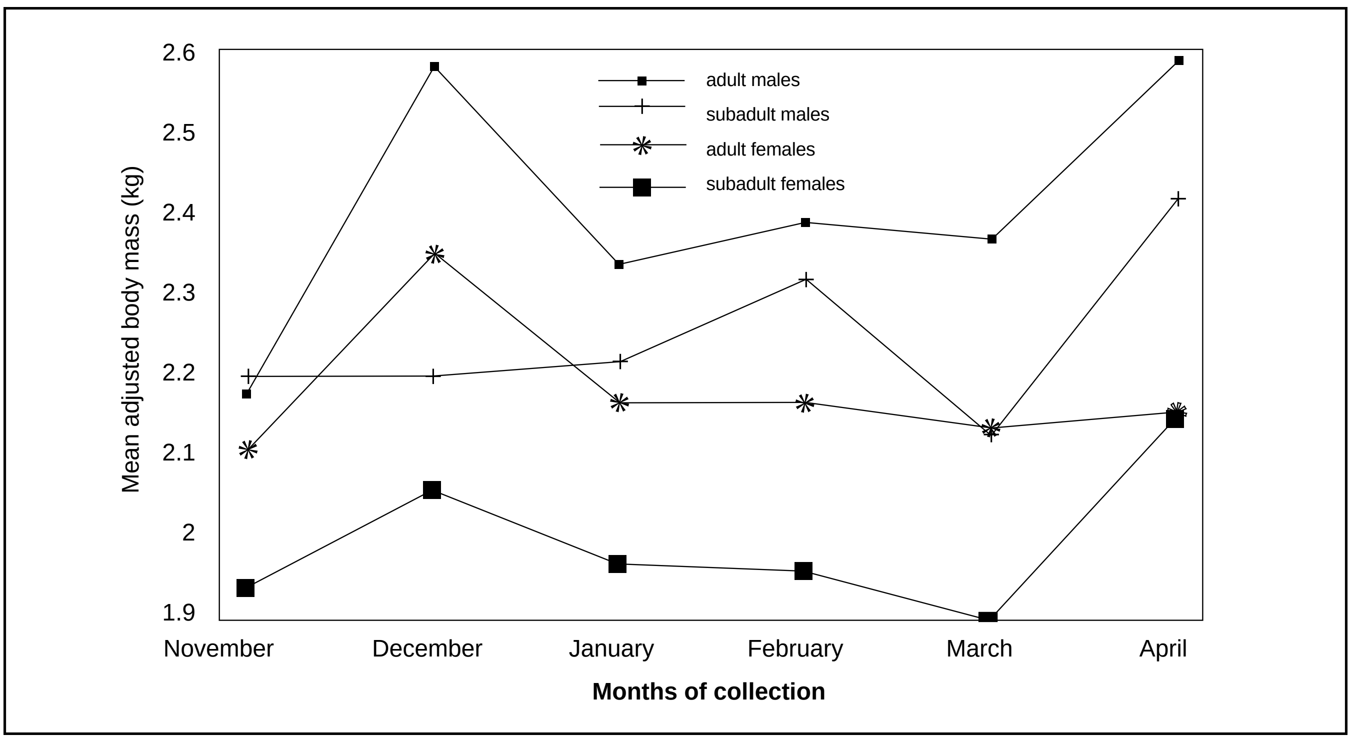

Figure 1—Mean adjusted body mass of double-crested cormorants collected at night roosts in the delta region of Mississippi during the winters of 1989–90 and 1990–91. Body masses were adjusted by subtracting the mass of stomach contents from the total mass for each bird.

Within gender groups, adjusted body mass and wing chord lengths were greater for cormorants collected in Mississippi than for birds collected in Alabama (table 1) but were not different *(P* > 0.1) between years for females collected in Mississippi. When we corrected for size differences observed, the scaled body masses of DCCO's of both sexes in Mississippi were larger *(P* = 0.0004 for each) than those in Alabama. All Mississippi cormorants with identifiable stomach contents had evidence of catfish remains. In contrast, none of the identifiable stomach contents from Alabama cormorants contained catfish; most contained primarily either threadfin *(Dorosoma petenense)* or gizzard shad *(D. cepedianum)*.

Table 1. Body mass and wing chord length of double-crested cormorants collected from Alabama and Mississippi during March and April 1997

State	Sex	N	Body mass (kg) $^{1}\bar{\chi}$	Body mass (kg) SE	Wing chord (mm) $^{1}\bar{\chi}$	Wing chord (mm) SE
Alabama	Female	40	1.84^{A}	0.033	300.5^{A}	1.50
Mississippi	Female	[2]26	2.11^{B}	0.038	318.2^{B}	1.16
Alabama	Male	37	2.16^{B}	0.031	315.9^{B}	1.57
Mississippi	Male	46	2.43^{C}	0.031	332.7^{C}	1.16

[1] All means with different letter superscripts differed *(P* < 0.0001).

[2] Sample includes 21 females collected during the same period and in the same general location during the winters of 1989–90 and 1990–91.

Omental fat mass also was greater *(P* = 0.0003) for males collected in Mississippi than for Alabama males. Omental fat mass was highly correlated *(r* = 0.721, *P* = 0.0001) with adjusted body mass of males. The small sample of females collected in Mississippi precluded comparisons of omental fat between Mississippi and Alabama. In contrast to Mississippi, females made up more than 50 percent of the cormorants collected in Alabama. The omental fat mass of these females was significantly *(P* = 0.011) less than that of Alabama males. Within sexes and States, the only difference *(P* = 0.001) in omental fat between age groups was with males in Mississippi: adults had larger fat deposits.

Discussion

Cormorants in the delta region of Mississippi increased or maintained their body masses from November to April during the winters of 1989–90 and 1990–91 despite increasing energy requirements due to falling temperatures (Glahn and Brugger 1995). Males are more likely than females to occupy roosts in catfish production areas and eat catfish (Glahn et al. 1995). This might account for their overall higher percentage weight gain during the winter. Subadult birds appeared to have lower body masses during those winters and presumably lower fat reserves, but this issue is clouded by lack of an accurate aging technique for cormorants. However, if subadults had lower fat reserves, the large food base supplied by catfish production might have been particularly important to their overwinter survival.

Commercial catfish farms may be especially important to cormorants during February and March, when these birds need to accumulate fat reserves for their northern migration in April. Premigratory fat deposition from hyperphagia occurs in many species of birds (Farner and King 1975). Although cormorants are highly efficient piscivorous predators, hyperphagia would likely be best achieved from catfish ponds stocked with extremely high densities of fish (Glahn and Stickley 1995). Before migration, cormorants shift their diet primarily to catfish–particularly in March when 86.5 percent of the diet is catfish (Glahn et al. 1995). This shift in diet corresponds to a period when a large amount of catfish fingerlings are stocked into catfish ponds (Glahn et al. 1995) and satisfies the physiological need to build fat reserves. In the two areas we sampled in the spring of 1997, omental fat deposition and corresponding scaled body mass of male birds in catfish production areas were greater than those collected from birds outside of these production areas. Both variables have been shown to be good indices of body condition (Owen and Cook 1977, Whyte and Bolen 1984, Woodall 1978), suggesting that catfish exploitation increases the body condition of cormorants. Omental fat was positively correlated with unscaled body mass of males, suggesting that differences observed in the body mass data from 1989–90 and 1990–91 were related to fat reserves. Omental fat has been shown to be a good index of total fat reserves in waterfowl (Woodall 1978) and is related to increased reproductive success in female geese (Ankney and MacInnes 1978). Increased fat reserves in cormorants might also increase their survival, allow for earlier breeding of first- and second-year birds, and generally improve their reproductive success.

Although suggestive, our results can only be considered preliminary. To confirm them, more basic ecological information is needed about wintering populations in the Mississippi delta and elsewhere. One might assume that cormorants collected in the delta region of Mississippi had remained there the entire winter, but this is not clear. Some birds are known to move back and forth from the gulf coast (King 1996). Many cormorants do not appear to arrive in the delta until late in the winter (Glahn et al. 1996), and little is known about the exact wintering location of birds collected during the spring migratory period in March and April. Long-term satellite telemetry studies are clearly needed to monitor cormorant movements over a broad area and to define the dynamics of wintering cormorant populations more precisely.

Other factors besides the availability of catfish could explain the differences in body mass and fat content of birds collected in Mississippi and Alabama. Regional differences in the size of cormorants (Palmer 1962) added to the complexity of our analysis. However, wing chord length has commonly been used to adjust body mass for structural size (Owen and Cook 1977, Whyte and Bolen 1984, Woodall 1978) and should adequately have corrected for the differences we observed. Another possible factor that may have influenced our results is the migratory status of these populations. Mississippi populations are primarily migratory, but some cormorants at Lake Eufaula may be year-round residents (D. T. King, pers. commun.). Migratory status may have influenced premigratory body-fat deposition of some birds collected there because, in some species, nonmigratory individuals do not deposit premigratory body fat (Farner and King 1975).

We hypothesize that Mississippi and Alabama birds may have come from different breeding populations. Body masses of cormorants from Mississippi were similar to those of cormorants from the western Great Lakes region (Marshall and Erickson 1945) but not the Northeastern United States and eastern Canada (Kury 1968, Bédard et al. 1995), and banding records indicate that most cormorants that winter in Mississippi come from the western Great Lakes region (Dolbeer 1991). The body masses of birds collected in Alabama were similar to those reported for breeding birds in the Northeastern United States and Eastern Canada (Kury 1968, Bédard et al. 1995), indicating that Alabama birds might have originated from this region. Further banding studies or satellite telemetry studies are needed to clarify the origin of cormorants wintering in the southeastern United States. Further banding analysis might also be helpful in more directly examining the survival of cormorants before and after development of the catfish industry.

Although additional body mass and fat analysis studies in areas with and without aquaculture production would help determine the importance of aquaculture on improving the body condition of cormorants, more movement studies involving satellite telemetry are needed to determine where and when to sample birds. In addition, satellite telemetry would probably provide the most efficient means of monitoring the migratory movements and breeding success of individual cormorants wintering in the Mississippi delta and elsewhere and thus gauge the contribution of commercial catfish farms to the growth of cormorant populations.

Acknowledgments

We thank P. Smith and D. Reinhold of the USDA–APHIS Wildlife Services program in Alabama and Mississippi, respectively, for their assistance in field data collection. M. Avery and B. Blackwell reviewed an earlier draft of this manuscript.

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