

Daily Activity Budgets and Movements of Winter Roosting Double-crested Cormorants Determined by Biotelemetry in the Delta Region of Mississippi

D. TOMMY KING¹, JAMES F. GLAHN¹ AND KEITH J. ANDREWS^{1,2}

¹U.S. Department of Agriculture, Denver Wildlife Research Center
Mississippi Research Station, Mississippi State, Mississippi 39762-6099, USA

²Present address: U.S. Department of Agriculture, Animal Damage Control
Stoneville, Mississippi 38776, USA

Abstract.—During the winters of 1990-91 and 1991-92, 59 Double-crested Cormorants (*Phalacrocorax auritus*) were captured and fitted with radio telemetry transmitters in the Delta region of Mississippi. The cormorants were monitored to determine the distances between night roosting sites and foraging locations, and the amount of time spent foraging versus other activities, such as diving, loafing, and day roosting. Double-crested Cormorants flew an average of 15.7 km from their night roost to a foraging location during the winters of 1990-91 and 1991-92. During the winters of 1990-91 and 1991-92 foraging averaged 17.7% of cormorant daily activity.

Key words.—Activity budgets, biotelemetry, Double-crested Cormorant, Mississippi Delta, movements, *Phalacrocorax auritus*, winter roosting.

Colonial Waterbirds 18 (Special Publication 1):152-157, 1995

Little is known about the movements and daily activity budgets of wintering Double-crested Cormorants (*Phalacrocorax auritus*). Cormorant movement and activity involving freshwater aquaculture facilities are even less well known. Custer and Bunck (1992) and Ross (1974) studied Double-crested Cormorant foraging activities at breeding colonies and Bartholomew (1942) reported on Double-crested Cormorant foraging activities on San Francisco Bay (see also, Stenzel *et al.* 1995).

In the Delta region of Mississippi cormorants have readily adapted to foraging in commercial Channel Catfish (*Ictalurus punctatus*) ponds, thereby coming into conflict with aquaculture practices (Stickley and Andrews 1989). This study was conducted to determine the foraging behavior of Double-crested Cormorants and to provide data on daily activity budgets for a bio-energetics model (Glahn and Brugger 1995) to determine the impact of cormorants on the catfish industry in Mississippi.

STUDY AREA AND METHODS

The study area is comprised of 16,000 km² of the Mississippi River alluvial plain in the state of Mississippi (Fig. 1). Cypress swamps are dispersed throughout this

region and are used as winter roosting sites by the cormorants. The agricultural economy of the Delta region of Mississippi is primarily based on cotton, soybeans and catfish. The production of catfish in this area has increased dramatically in the last 20 years. In 1991 over 40,000 ha of catfish ponds were in operation, or being constructed, in Mississippi (Brunson 1991).

Double-crested Cormorants were captured at six major night roost sites and fitted with radio telemetry transmitters (164-167.999 MHz) supplied by the Denver Wildlife Research Center bioelectronics project. The transmitters weighed approximately 25 g, or about one percent of an adult's body weight (Glahn and Brugger 1995). The transmitters were tail-mounted using hot glue (Fitzner and Fitzner 1977) and two nylon laces. Transmitters were attached to one to 13 cormorants per capture session. The cormorants were captured after dark in their night roosts. Once the cormorants were flushed from the roost trees to the water they were netted from a boat equipped with flood lights. During 13 capture sessions, 59 cormorants were captured and fitted with radio transmitters over the winters of 1990-91 and 1991-92.

Data collected during the capture sessions included: date, location, estimated age based on plumage characteristics (Palmer 1962), weight, wingcord, exposed culmen, tarsus, U.S. Fish and Wildlife Service band number, and transmitter frequency and channel. Methods of tracking and locating the cormorants were those identified by Mech (1983) and Gilmer *et al.* (1981). For ground tracking, a vehicle roof-mounted dual three-element Yagi antenna system with R2000 and R4000 (ATS, Inc.) and LA-12 (AVM Instruments Co.) receivers was utilized (use of trade names does not imply government endorsement). Aerial tracking from a Cessna 172, using similar equipment, was conducted on several occasions in attempts to locate cormorants not previously followed.

After an acclimation period of 48 hours post instrumentation, attempts were made to follow individual cor-

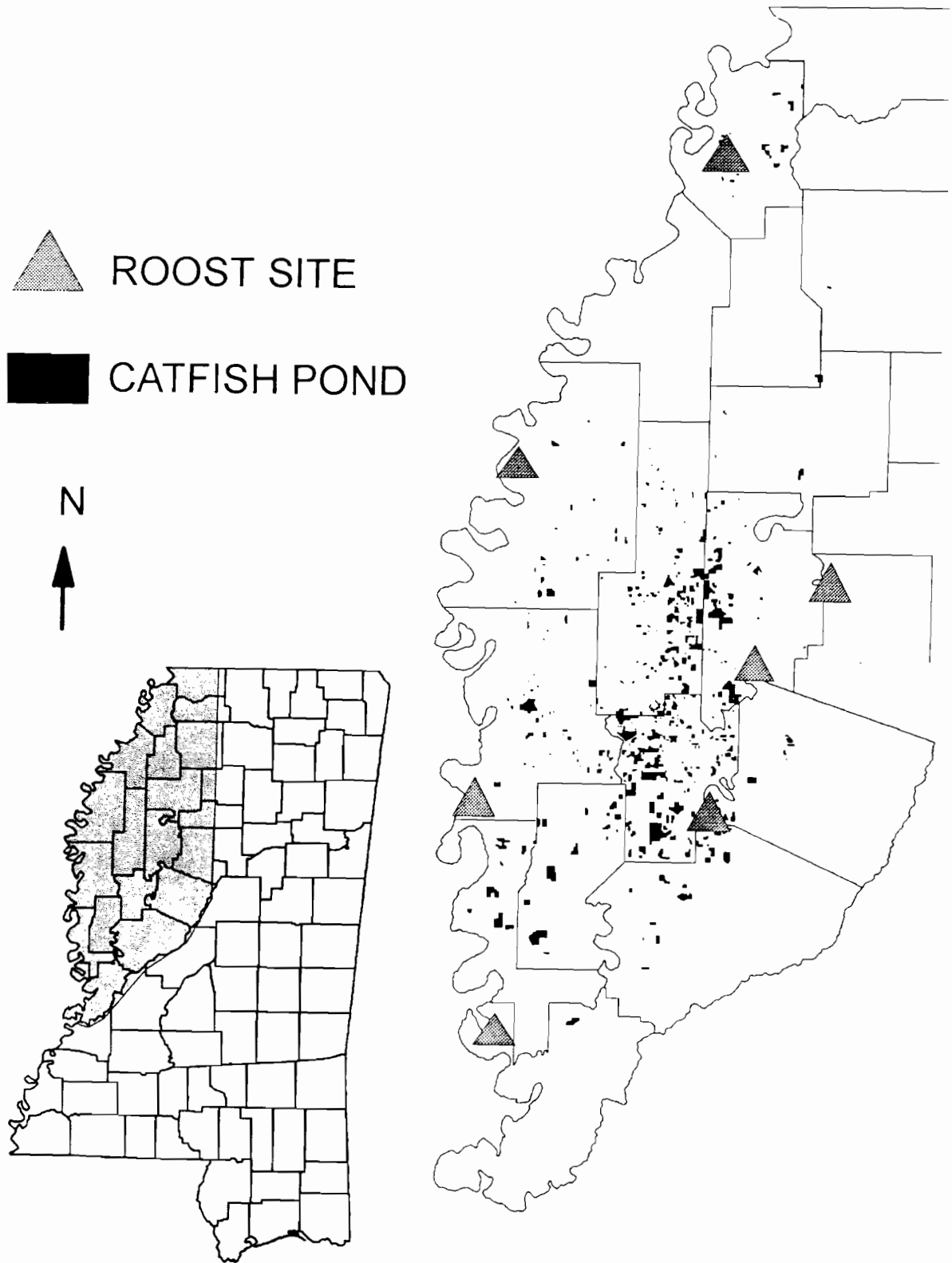


Figure 1. The distribution of Double-crested Cormorant winter roost sites and catfish ponds in the Delta region of Mississippi.

morants from daylight to dark for two or more successive days. Tracking of the cormorants began at the night roost site at first light. A single cormorant was then followed throughout the day until dark. Times and dis-

tances were recorded for the following movements: night roost to first forage site, forage site to day roost, forage site to forage site, and last forage site to night roost.

The daily activity budgets of transmitter-equipped cormorants were calculated using the percent of time tracked per activity. Activities were divided into: roosting (time spent out of the water, in trees, or on land resting, preening, or sleeping), loafing (time spent in the water not actively foraging), flying, and foraging (time spent actively hunting and feeding). Transmitter signal strength decreased dramatically or disappeared when the transmitter package was under water, thereby allowing precise timing of cormorant dives. A foraging session is defined as the amount of time spent actively hunting and feeding in one bout (i.e., the time when a cormorant begins diving until diving has ceased for more than one minute). The data for daily activity budgets are presented as percent of time tracked during daylight hours. Data for distance traveled are presented as mean \pm standard error (SE). A Student t-test ($P < 0.05$ being significant) was used to determine if there were significant differences in the data between winters. Only the data collected during the winter of 1991-92 were used to calculate foraging/diving parameters.

RESULTS

From November through April in the winter of 1990-91, 11 cormorants were successfully tracked for 203 h. From December through March in the winter of 1991-92, seven cormorants were successfully tracked for 197 h. These 18 cormorants were tracked for a total of 400 h over 36 days during the study. The 41 remaining cormorants were either not tracked for most of a day, lost their transmitters, or apparently left the study area.

Movements

The mean distance traveled by cormorants from their night roost to their first for-

age site was $15.7 \text{ km} \pm 2.0 \text{ SE}$ while the mean distance traveled from a forage site to a day roost for both winters combined was only $2.6 \text{ km} \pm 0.5 \text{ SE}$. The mean distance traveled between forage sites was $10.5 \text{ km} \pm 2.8 \text{ SE}$ in 1990-91 versus $3.4 \text{ km} \pm 0.5 \text{ SE}$ in 1991-92. This was the only significant between-winters difference found in the distances traveled ($t=7.32$, 21df, $P < 0.05$). The mean distance traveled between foraging sites (both winters) was $5.6 \text{ km} \pm 0.9 \text{ SE}$. The last foraging site was an average of $11.8 \text{ km} \pm 1.3 \text{ SE}$ from the night roost for both winters (Table 1).

Daily Activity Budgets

During daylight hours cormorants spent 56.5% of their time roosting, and 17.7% foraging during both winters (Fig. 2). This foraging percentage of 17.7% may be divided into foraging in catfish ponds (15.6%) and foraging in roost sites (2.1%). There were some differences in time spent on activities in 1990-91 versus 1991-92 (Fig. 3): foraging percentages, 25.0% in 1990-91 and 10.2% in 1991-92 ($t=6.03$, 34df, $P < 0.05$) and loafing percentages, 21.9% in 1990-91 and 14.2% in 1991-92 ($t=3.4$, 34df, $P < 0.05$).

Cormorants averaged $6.2 \pm 0.7 \text{ SE}$ foraging sessions per day during the winter of 1991-92. The mean time spent foraging each day was 60.3 minutes $\pm 9.4 \text{ SE}$ during the win-

Table 1. Distances traveled during the daily movement of transmitter-equipped Double-crested Cormorants in the Delta region of Mississippi during the winters of 1990-91, 1991-92, and both winters combined.

Movement		Distance (km)		
		1990-1991	1991-1992	Combined
Night Roost to	N	18	15	33
Forage Site	Mean \pm SE	17.6 ± 3.4	13.3 ± 1.7^1	15.7 ± 2.0
	Range	4.8 - 61.8	3.5 - 23	3.5 - 61.8
Forage Site to	N	15	14	29
Day Roost	Mean \pm SE	3.1 ± 0.6	2.2 ± 0.8^1	2.6 ± 0.5
	Range	1.6 - 9.7	0.1 - 9.2	0.1 - 9.7
Forage Site to	N	7	16	23
Forage Site	Mean \pm SE	10.5 ± 2.8	3.4 ± 0.5^2	5.6 ± 0.9
	Range	1.9 - 24.5	1.5 - 6	1.5 - 24.5
Forage Site to	N	7	17	24
Night-Roost	Mean \pm SE	9.5 ± 2.0	12.8 ± 1.6^1	11.8 ± 1.3
	Range	4.8 - 20.9	2.5 - 23	2.5 - 23

¹Not significantly different from 1990-91 data ($P > 0.05$).

²Significantly different from 1990-91 data ($P < 0.05$).

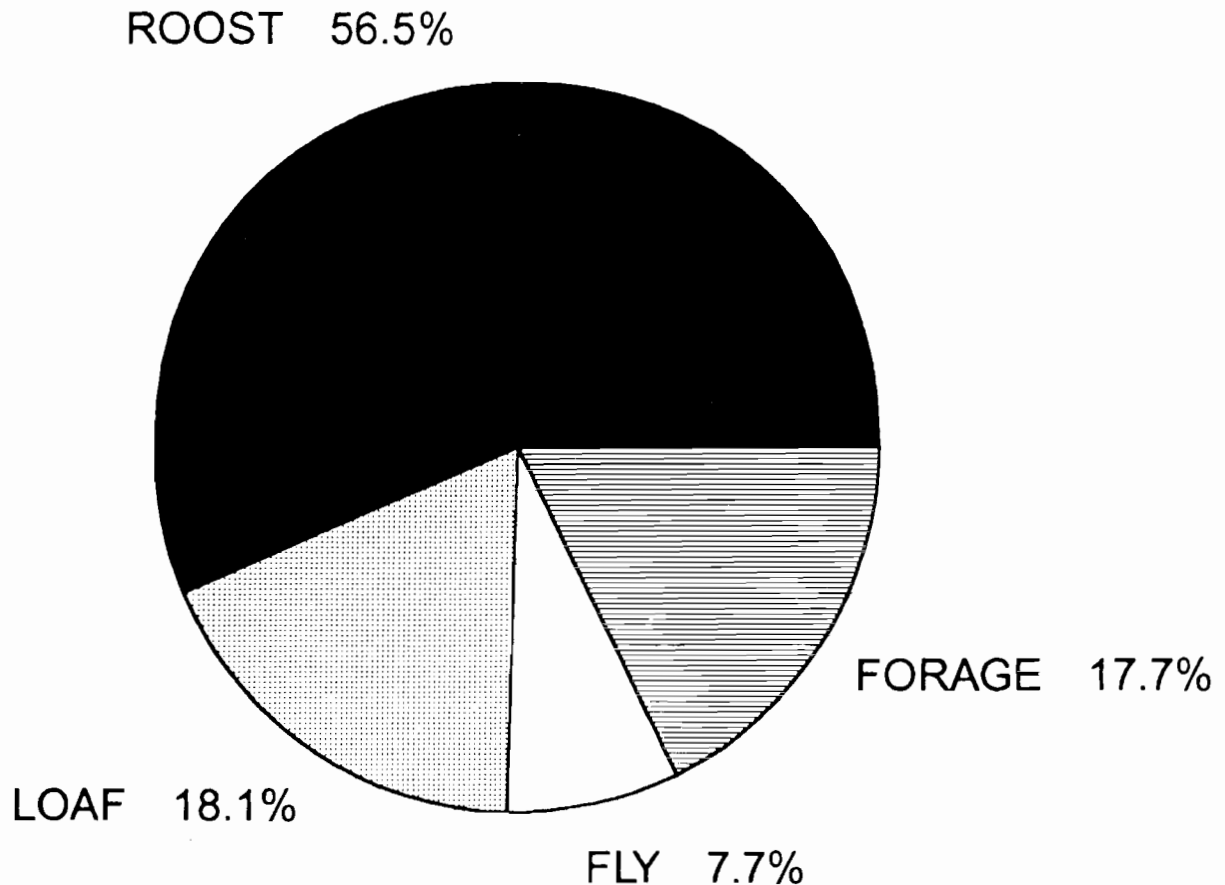


Figure 2. Daily activity budget for transmitter equipped Double-crested Cormorants in the Delta region of Mississippi during the winters of 1990-91 and 1991-92.

ter of 1991-92. The cormorants had a mean dive time of $11.9 \text{ s} \pm 0.1 \text{ SE}$ in 1991-92 (Table 2).

DISCUSSION

Contrary to our finding that wintering Double-crested Cormorants flew an average of 15.7 km (range: 3.5-61.8 km) from their night roost to their first forage site, Custer and Bunck (1992) found that cormorants in Wisconsin flew less than 3 km (range: <1-40 km) from their breeding colony to their first forage site. The foraging ranges reported by Custer and Bunck (1992) were similar to the average distance we found between forage sites and day roosts ($2.6 \text{ km} \pm 0.5 \text{ SE}$). The breeding colonies studied by Custer and Bunck (1992), like day roosts in our study area, were surrounded by prime foraging ar-

reas. However, cormorants in our study area seemed to prefer larger cypress swamps as night roost sites that are farther removed from foraging areas. The reasons for the differences in the distance traveled from one forage site to another in 1990-91 versus 1991-92 are not clear and may be a function of sample size. However, some of the cormorants tracked in 1990-91 were roosting in an area with a low density of catfish ponds, so they would have had to travel greater distances to find alternate foraging sites than those roosting in areas where catfish ponds were more numerous.

In our study area it was common to see cormorants fly to a particular catfish pond, passing over many other ponds. Why they seemed to prefer some catfish ponds to others is unknown. Although research is needed to answer this question, perhaps these cor-

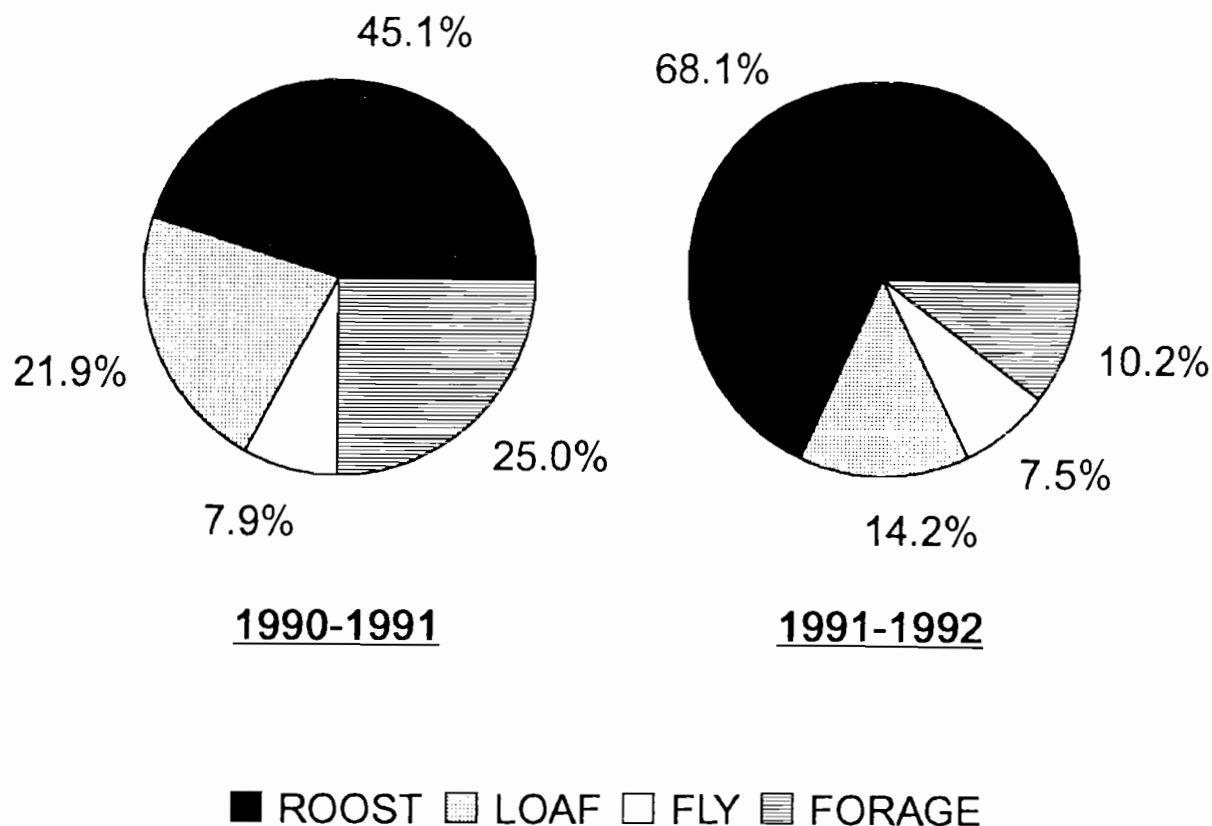


Figure 3. Daily activity budgets for transmitter-equipped Double-crested Cormorants in the Delta region of Mississippi for each of two winters: 1990-91 and 1991-92.

morants were keying on ponds with high densities of non-commercial fish, such as Gizzard Shad (*Dorosoma cepedianum*), or catfish fingerlings (<23 cm in length) (Glahn *et al.* 1995). Water color and turbidity may also play a roll in cormorant forage site preference.

In our study Double-crested Cormorants had a mean dive time less than half that recorded in Nova Scotia by Ross (1974): 11.9 and 25.1 seconds, respectively. Wanless and Harris (1991) found that Rock Shags (*Phala-*

crocorax magellanicus) foraging in Port Stanley Harbour, Falkland Islands, had a diving rate similar to that of Double-crested Cormorants in Mississippi: 1.8 and 1.6 dives per minute, respectively. The comparatively low dive rate of Double-crested Cormorants in Mississippi may be due to the presence of high densities of prey confined to shallow ponds (average water depth of 1.4 m, Wellborn 1987) versus free-ranging prey in deeper estuaries, bays and oceans. Catfish ponds would seem to be a near perfect foraging en-

Table 2. Foraging/diving ratio parameters of transmitter-equipped Double-crested Cormorants during the winter of 1991-92 in the Delta region of Mississippi.

Foraging/diving rates	N	Mean	SE	Range
Foraging sessions ¹ /day	20	6.2	0.7	1 - 12
Dives/day	20	100.3	19.1	8 - 307
Dives/foraging session	122	17.0	2.0	1 - 101
Dives/minute	20	1.6	0.1	0.6 - 2.3
Seconds/dive	2020	11.9	0.1	2 - 45
Foraging minutes/day	20	60.3	9.4	7 - 153
Underwater minutes/day	20	20.3	4.0	1.7 - 57

¹Foraging session = the amount of time spent actively hunting and feeding in one bout (see Methods).

vironment for cormorants since they seem to prefer shallow water (Custer and Bunck 1992, Palmer 1962).

Overall, in this study, cormorants spent most of their day roosting and loafing instead of actively foraging. One possible explanation for the differences in the activity budgets between winters is that the winter of 1991-1992 was very mild compared to the winter of 1990-91 (Bryan Owings, pers. comm.). As with other birds, in colder weather cormorants would need to spend more time foraging and less time loafing and roosting (Gill 1990).

Although radio-telemetry has not been used in many cormorant studies, possibly due to the cost of equipment and the difficulty of capturing adult cormorants, we feel that without the use of radio-telemetry most of the data presented in this study could not have been collected. Constraints of habitat, catfish pond construction, and cormorant behavior in the Delta region of Mississippi usually made it impossible to visually observe an individual cormorant for more than a few minutes. We therefore recommend the use of radio-telemetry in future studies of cormorants.

ACKNOWLEDGMENTS

We thank J. O. King, R. D. Flynt, R. B. McCoy, A. May, and M. Bodenchuk for their assistance in cormorant capture and processing. We are grateful to D. F. Mott and A. R. Stickley, Jr. for their helpful comments on earlier drafts of this manuscript, S. C. Hodnett for her help in manuscript preparation, and J. O. King for preparation of the figures.

LITERATURE CITED

- Bartholomew, G. A., Jr. 1942. The fishing activities of Double-crested Cormorants on San Francisco Bay. *Condor* 44:13-21.
- Brunson, M. W. 1991. Status of fish farming in Mississippi. For Fish Farmers. Mississippi Cooperative Extension Service, Mississippi State University, Mississippi State, Mississippi.
- Custer, T. W. and C. Bunck. 1992. Feeding flights of breeding Double-crested Cormorants at two Wisconsin colonies. *Journal of Field Ornithology* 63:203-211.
- Fitzner, R. E. and J. N. Fitzner. 1977. A hot melt glue technique for attaching radio transmitter tail packages to raptorial birds. *North American Bird Bander* 2:56-57.
- Gill, F. B. 1990. *Ornithology*. W.H. Freeman, New York.
- Glahn, J. F. and K. E. Brugger. 1995. The impact of Double-crested Cormorants on the Mississippi Delta catfish industry: a bioenergetics model. Pages 168-175 in *The Double-crested Cormorant: biology, conservation, and management* (D. N. Nettleship and D. C. Duffy, Eds.). *Colonial Waterbirds* 18 (Special Publication 1).
- Glahn, J. F., P. J. Dixon, G. A. Littauer and R. B. McCoy. 1995. Food habits of Double-crested Cormorants wintering in the Delta region of Mississippi. Pages 158-167 in *The Double-crested Cormorant: biology, conservation, and management* (D. N. Nettleship and D. C. Duffy, Eds.). *Colonial Waterbirds* 18 (Special Publication 1).
- Gilmer, D. S., L. M. Cowardin, R. L. Duval, L. M. Mechlin, C. W. Shaiffer and V. B. Kuechle. 1981. Procedures for the use of aircraft in wildlife biotelemetry studies. U.S. Fish and Wildlife Service Resource Publication No. 140. Washington, D.C.
- Mech, L. D. 1983. *Handbook of animal radio-tracking*. University of Minnesota Press, Minneapolis, Minnesota.
- Palmer, R. S. 1962. Double-crested Cormorant. Pages 325-340 in *Handbook of North American birds*, Vol. 1 (R. S. Palmer, Ed.). Yale University Press, New Haven, Connecticut.
- Ross, R. K. 1974. A comparison of the feeding and nesting requirements of the Great Cormorant (*Phalacrocorax carbo*) and Double-crested Cormorant (*P. auritus*) in Nova Scotia. *Proceedings of the Nova Scotia Institute of Science* 27:114-132.
- Stenzel, L. E., H. R. Carter, R. P. Henderson, S. D. Emslie, M. J. Rauzon, G. W. Page and P. Y. O'Brien. 1995. Breeding success of Double-crested Cormorants in the San Francisco Bay Area, California. Pages 216-224 in *The Double-crested Cormorant: biology, conservation, and management* (D. N. Nettleship and D. C. Duffy, Eds.). *Colonial Waterbirds* 18 (Special Publication 1).
- Stickley, A. R., Jr. and K. J. Andrews. 1989. Survey of Mississippi catfish farmers on means, effort and costs to repel fish-eating birds from ponds. Pages 105-108 in *Proceedings of the Fourth Eastern Wildlife Damage Control Conference*, September 1989 (S. R. Craven, Ed.). University of Wisconsin Cooperative Extension Service, Madison, Wisconsin.
- Wanless, S. and M. P. Harris. 1991. Diving patterns of full-grown and juvenile Rock Shags. *Condor* 93:44-48.
- Wellborn, T. L., Jr. 1987. *Catfish farmer's handbook*. Mississippi Cooperative Extension Service, Mississippi State University, Mississippi State, Mississippi.