JOURNAL OF FIELD ORNITHOLOGY

Published by
Association of Field Ornithologists

Vol. 67, No. 2	Spring 1996	Pages 205–354

J. Field Ornithol., 67(2):205–211

MOVEMENTS OF DOUBLE-CRESTED CORMORANTS AMONG WINTER ROOSTS IN THE DELTA REGION OF MISSISSIPPI

D. Tommy King

United States Department of Agriculture
Denver Wildlife Research Center
Mississippi Research Station
P. O. Drawer 6099
Mississippi State, Mississippi 39762-6099 USA

Abstract.—From 12 Jan.–9 Apr. 1993, 25 Double-crested Cormorants (*Phalacrocorax auritus*) were captured, fitted with radio-telemetry transmitters, and monitored to determine night-roost fidelity and movements in the Delta Region of Mississippi. Transmitter-equipped cormorants were located at 15 different roost sites during the study. The mean number of roosts used by cormorants was 2.08 ± 0.172 SE. The mean number of transmitter-equipped cormorants located each week was 8.25 ± 0.87 SE. The distances moved by cormorants among night roosts ranged from 0–398 km. In the eastern part of the Delta Region two studies were conducted concurrently with this telemetry study to determine if repeated harassment of roosting cormorants using pyrotechnics would cause cormorants to abandon selected roosts and nearby aquaculture facilities. Dispersed roosts were repeatedly harassed with pyrotechnics in the eastern part of the Delta Region and non-dispersed roosts in the western part of the Delta Region were not harassed. There was no significant difference in cormorant movement to more than one roost after transmitter attachment between birds captured in dispersed roosts versus non-dispersed roosts. Three transmitter-equipped cormorants were located on the Gulf coast approximately 390 km from the study area. One subsequently moved back to the study area. These observations provide evidence that in Mississippi wintering populations of cormorants show no strong fidelity to a primary roost, but shift throughout the Delta Region and to the Gulf coast.

MOVIMIENTOS DE *PHALACROCORAX AURITUS* ENTRE DORMIDEROS INVERNALES EN LA REGIÓN DEL DELTA DEL MISSISSIPPI

Sinopsis.—Entre el 12 de enero y el 9 de abril 199 se capturaron 25 *Phalacrocorax auritus*, se ajustaron con transmisores para ia radio-telemetría y se siguieron para determinar la fidelidad a los dormideros y sus movimientos en la región del Delta del Mississippi. Durante el estudio se localizaron aves con radio-transmisores en 15 dormideros diferentes. El promedio de dormideros usados por individuo fué de 2.08 ± 0.172 ES. El promedio de aves con radio-transmisor localizada por semana fué de 8.25 ± 0.87 ES. La distancia recorrida por las aves entre dormideros fluctuó entre 0 y 398 km. Dos estudios de dispersión de dormideros se lievaron a cabo concurrentemente con el estudio telemétrico en la región oriental de la región del Delta para determinar si molestias repetitivas de los dormideros usando pirotecnia forzarían las aves a abandonar ciertos dormideros y las facilidades adyacentes de acuacultura. Dormideros dispersos fueron molestados repetidamente en la porción este de la región del Delta, mientras que dormideros no dispersos en la región oeste de la región del Delta no fueron molestados con pirotecnia ni se incluyeron en los estudios de dispersión. No se encontraron diferencias significativas en los movimientos de aves a más de un dormidero despues de colocarseles los radiotransmisores entre aves capturadas en dormideros dispersos contra dormideros no-dispersos. Tres aves con radio-transmisores se localizaron en la costa del Golfo aproximadamente a 390 km del área de estudio. Uno retornó subsecuentemente al área de estudio. Estas observaciones proveen evidencia de que las poblaciones de esta especie que invernan en Mississippi no muestran gran fidelidad a sus dormideros primarios, sino que se mueven a través de la región del Delta y de la Costa del Golfo.

Although Double-crested Cormorant (*Phalacrocorax auritus*) populations are increasing (Craven and Lev 1987, Vermeer and Rankin 1984), little research has been done on their winter roost fidelity and movements (King et al. 1995). Cormorants wintering in the Delta Region of Mississippi commonly forage in commercial Channel Catfish (*Ictalurus punctatus*) ponds and come into conflict with catfish producers (Stickley and Andrews 1989, Stickley et al. 1992). Most attempts to reduce cormorant predation involve the use of bird-scaring devices at the catfish ponds, but these efforts are usually short term in effectiveness because the birds rapidly habituate to the devices. Mott et al. (1992), however, found that cormorants could be easily dispersed from their night roosts by using pyrotechnics. King et al. (1995) and Custer and Bunck (1992) found that Double-crested Cormorants prefer to roost during winter and breed near their main food source. To develop adequate strategies to limit cormorant damage in the Delta Region of Mississippi, biologists need to know if individual cormorants show fidelity to the same night roost throughout the winter. Therefore, data from this study will be used to determine if cormorants stay in one roost during the entire winter or if they regularly change roosts and foraging areas.

Concurrent with this telemetry study, the Mississippi State University's U.S. Fish and Wildlife Service Cooperative Research Unit (K. Hess, pers. comm.) and the Denver Wildlife Research Center's Mississippi Research Station (D. Mott, pers. comm.) conducted studies to determine if repeated harassment using pyrotechnics would cause cormorants to abandon selected roosts and nearby aquaculture facilities. Two main cormorant roosts in the eastern part of the Delta Region were dispersed repeatedly using pyrotechnics from 28 Jan.–25 Mar. 1993. Other eastern roosts were also dispersed as cormorants attempted to relocate within the dispersal area (D. Mott, pers. comm.). Telemetry data on roost-site fidelity and movements of Double-crested Cormorants will also help determine if roost dispersal would be a useful tool in controlling cormorant damage to aquaculture.

STUDY AREA AND METHODS

The Delta Region of northwest Mississippi is comprised of 16,000 km^2 of the Mississippi River alluvial plain. The center of this region is approximately 33°15′N, 91°30′W. During the last 20 yr commercial Channel Catfish production has increased to over 40,000 ha of ponds in operation in

Mississippi (Brunson 1991). Cormorants use bald cypress (*Taxodium distichum*) swamps interspersed throughout this region as winter roosting sites and use nearby catfish ponds as foraging and loafing sites.

Cormorants were captured after dark by flushing them from their roost trees to the water. The birds were then pursued and netted from a boat equipped with flood lights (King et al. 1994). Transmitters weighing approximately 25 g, or about 1% of an adult's body mass (Glahn and Brugger 1995), were tail-mounted using hot glue (Fitzner and Fitzner 1977) and two nylon laces. Twenty-five cormorants were captured and fitted with radio-telemetry transmitters at four night roosts between 12 Jan.–16 Mar. 1993. Eleven cormorants were captured and fitted with transmitters in two of these roosts one night before disturbance with pyrotechnics began (hereafter referred to as dispersed roosts). Fourteen cormorants also were captured and fitted with transmitters in two roosts not dispersed with pyrotechnics in the western part of the Delta Region (hereafter referred to as non-dispersed roosts). All research activities were conducted with appropriate state and federal permits.

Methods of tracking and locating cormorants were those described by Mech (1983) and Gilmer et al. (1981). A vehicle roof-mounted dual three-element yagi antenna system was used for ground tracking. Ground tracking was conducted at roost sites following transmitter attachment and during roost dispersal. All known cormorant roosts in the Delta Region were checked by ground tracking on 20 Jan. 1993. A Cessna 172 equipped with similar yagi antennas attached to the wing struts was used for aerial tracking. A total of 13 flights, at least one a week, was made over the study area from 28 Jan.–9 Apr. 1993 in attempts to locate the night roosts of all transmitter-equipped cormorants. Flights on 19 February and 19 March were made outside the study area, concentrating on large bodies of water (lakes, large rivers, wetland areas and cypress swamps), and the Louisiana, Mississippi and Alabama Gulf Coasts in attempts to locate cormorants not found in the study area.

Locations of cormorants and their night roosts were plotted on USGS 30 × 60 min quad maps of the Delta Region. I quantified distance moved to first recorded night roost after instrumentation, total distance moved between night roosts, greatest linear distance moved from the capture roost, and greatest distance moved between night roosts. A Fisher's exact test ($\alpha < 0.05$) (Norusis 1992) was used to compare the movements of cormorants from non-dispersed and dispersed roosts that did or did not change roosts more than once after transmitter attachment. I used t-tests (Norusis 1992) to test for differences in the distances moved by cormorants known to be exposed to pyrotechnics and cormorants not exposed to pyrotechnics.

RESULTS

The post-capture night roosts of 25 transmitter-equipped cormorants were located at least once during the study; three of the 25 active transmitters were located underwater. The mean number of cormorants lo-

TABLE 1. Tracking history of radio-instrumented Double-crested Cormorants in the Delta Region of Mississippi from 12 January through 9 Apr. 1993.

	Week of study												
	1	2	3	4	5	6	7	8	9	10	11	12	13
No. of Cormorants Captured	6		7					8		4			
Total No. Cormorants in Study	6	6	13	13	13	12[a]	12	20	18[b]	22	22	22	22
No. Cormorants Located	—[c]	4	10	7	8	9	8	12	9	13	9	8	2
% Cormorants Located	—[c]	67	77	54	62	75	67	60	50	59	41	36	9

[a] One transmitter located underwater.
[b] Two transmitters located underwater.
[c] Tracking was not begun until the second week of the study.

cated each week was 8.25 ± 0.87 SE (range 2–13) (Table 1). Cormorants were located at 15 of 34 known roost sites during the study. The night following transmitter attachment, 7 (50%) of the 14 cormorants captured in non-dispersed roosts changed roosts. All 11 cormorants captured in dispersed roosts changed roosts the night following transmitter attachment when the roosts were dispersed with pyrotechnics. Movement of cormorants to more than one roost after transmitter attachment did not differ significantly between birds captured in dispersed roosts and non-dispersed roosts (Fisher's exact test $P = 0.20$). Three (21%) of the 14 cormorants captured in non-dispersed roosts changed roosts more than once, whereas 5 (45%) of the 11 cormorants captured in dispersed roosts changed roosts more than once.

Seven cormorants (all captured in non-dispersed roosts) remained in their capture roost until contact was lost during spring migration. Of the remaining 18 transmitter-equipped cormorants, 10 (55%) cormorants were located at two roosts, 7 (39%) cormorants were located at three roosts, and 1 (6%) cormorant was located at four different roosts during the study. The mean number of roosts used by cormorants during the study was 2.08 ± 0.17 SE.

The mean distance cormorants moved to their first recorded night roost after capture and radio attachment was 24.2 km ± 4.36 SE (range 0–61 km). The mean total distance cormorants moved between night roosts was 95.6 km ± 25.28 SE (range 0–398 km). The mean greatest distance moved from the capture roost was 75.9 km ± 22.88 SE (range 0–385 km). The mean greatest distance moved between night roosts was 71.2 km ± 21.45 SE (range 0–350 km).

Four of the 11 cormorants captured in dispersed roosts were in a roost immediately prior to dispersal efforts and are known to have been directly exposed to pyrotechnics. Two of these four cormorants attempted to enter the same roost during the second night of dispersal efforts and were subsequently followed to the nearest non-dispersed roost. I compared the distances moved by the four cormorants known to be exposed to pyrotechnics to distances moved by the 21 other cormorants. There were no significant differences in the distance moved to the first recorded night roost after instrumentation (t = 0.82, df = 23, P = 0.42), the greatest linear distance moved from the capture roost (t = 0.30, df = 23, P = 0.77), the greatest distance moved between night roosts (t = 0.27, df = 23, P = 0.79), and the total linear distance moved (t = 0.02, df = 23, P = 0.99) for these cormorants.

Three cormorants were located on the Mississippi and Alabama Gulf coasts approximately 350 km from their capture roosts. One cormorant from a non-dispersed roost was located on the coast 14 d after contact was lost in the study area. Four days later the signal from this cormorant's transmitter was located underwater in a roost in the study area. The second cormorant from a non-dispersed roost was located on the coast 23 d after contact was lost in the Delta Region. The third cormorant was dispersed from its second known night roost on 17 February and was located on the Mississippi Gulf Coast on 19 February.

DISCUSSION

The reason for locating a mean of only 8.25 of cormorants each week is unclear. I believe, however, that the movement of cormorants in and out of the study area and spring migration during the last few weeks of the study are possible explanations (Table 1). Prior to the initiation of the roost dispersal studies, cormorants were known to use 23 traditional roost sites in the Delta Region (USDA, unpubl. data). After the dispersal studies were completed, the number of known roost sites used by cormorants increased to 34. The dispersal of traditional roosts may have caused cormorants to move into roost sites not previously documented.

As expected, all of the cormorants captured in roosts scheduled for dispersal changed roosts the night following transmitter attachment when dispersal activities began. Similar to the findings of Mott et al. (1992), no instrumented cormorants were known to have attempted to re-enter a roost after the second night of dispersal efforts. The lack of a significant difference between cormorant movement to more than one roost after transmitter attachment suggests that no overall behavior differences occurred between birds from dispersed and non-dispersed roosts. Also, movements of four cormorants known to be exposed directly to dispersal activities did not differ significantly from the other birds. All roosts in the dispersal study area were not simultaneously dispersed, however. When cormorants were dispersed from traditional roosting sites, they would usually move to the nearest suitable roosting site not being dispersed. Often these new sites would be only a few km from a dispersed roost site. Once these new roosting sites were discovered, they were also dispersed, forcing the cormorants to again move into new sites or fly to roosts outside the dispersal study area. Although roost dispersal shows promise as a cormorant damage management strategy, further research needs to be done to determine the long-term effects of dispersal on cormorant movements and behavior.

The cormorant movements I observed among roosts in the Delta Region of Mississippi and those to and from the Gulf coast indicate that these wintering birds may wander extensively and rapidly travel great distances. For example, one bird that traveled from the Delta Region to the Mississippi Gulf Coast flew at least 350 km in 2 d. As with other communal roosting birds (Bray et al. 1979; Eiserer 1984; Engel et al. 1992; Morrison and Caccamise 1985, 1990), cormorants that winter in Mississippi seem to show no strong fidelity to a primary roost.

ACKNOWLEDGMENTS

I thank J. O. King, R. D. Flynt, D. F. Mott, K. Hess, P. Mastrangelo, K. Bruce and J. Paulson for their assistance in cormorant capture and processing. I am especially grateful to B. Nygren of Nygren Air Service for providing many enjoyable hours of aerial tracking. The Denver Wildlife Research Center (DWRC) bioelectronics project supplied the transmitters (164–167.999 MHz) for this study. I thank E. Hill, D. Mott, A. Stickley, J. Glahn and two anonymous reviewers for their helpful comments on earlier drafts of this manuscript. Also, I thank J. Glahn for statistical assistance and L. Hodnett for help with manuscript preparation.

LITERATURE CITED

BRAY, O. E., W. C. ROYALL, JR., J. L. GUARINO, AND R. E. JOHNSON. 1979. Activities of radio-equipped Common Grackles during fall migration. Wilson Bull. 91:78–87.

BRUNSON, M. W. 1991. Status of fish farming in Mississippi. For Fish Farmers. Mississippi Cooperative Extension Service, Mississippi State University, Mississippi. 6 pp.

CRAVEN, S. R., AND E. LEV. 1987. Double-crested Cormorants in the Apostle Islands, Wisconsin, USA: population trends, food habits, and fishery depredations. Colonial Waterbirds 10:64–71.

CUSTER, T. W. AND C. BUNCK. 1992. Feeding flights of breeding Double-crested Cormorants at two Wisconsin colonies. J. Field Ornithol. 63:203–211.

EISERER, L. A. 1984. Communal roosting in birds. Bird Behaviour 5:61–80.

ENGEL, K. A., L. S. YOUNG, K. STEENHOF, J. A. ROPPE, AND M. N. KOCHERT. 1992. Communal roosting of Common Ravens in southeastern Idaho. Wilson Bull. 104:105–121.

FITZNER, R. E., AND J. N. FITZNER. 1977. A hot melt glue technique for attaching radio transmitter tail packages to raptorial birds. N. Am. Bird Bander 2:56–57.

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. Res. Pub. 140. U.S. Dept. Interior, Fish and Wildlife Service.

GLAHN, J. F., AND K. E. BRUGGER. 1995. The impact of Double-crested Cormorants on the Mississippi delta catfish industry: a bioenergetics model. Pp. 168–175, *in* D. N. Nettleship, and D. C. Duffy, eds. The Double-crested Cormorant: biology, conservation and management. Colonial Waterbirds 18 (Special Publication).

KING, D. T., K. J. ANDREWS, J. O. KING, R. D. FLYNT, J. F. GLAHN, AND J. L. CUMMINGS. 1994. A night-lighting technique for capturing cormorants. J. Field Ornithol. 65:254–257.

———, J. F. GLAHN, AND K. J. ANDREWS. 1995. Daily activity budgets and movements of winter roosting Double-crested Cormorants in the Delta Region of Mississippi determined by biotelemetry. Pp. 152–157, in D. N. Nettleship, and D. C. Duffy, eds. The Double-crested Cormorant: biology, conservation and management. Colonial Waterbirds 18 (special Publication).

MECH, L. D. 1983. Handbook of animal radio-tracking. University of Minnesota Press. Minneapolis, Minnesota. 107 pp.

MORRISON, D. W., AND D. F. CACCAMISE. 1985. Ephemeral roosts and stable patches? A radiotelemetry study of communally roosting starlings. Auk 102:793–804.

———, AND ———. 1990. Comparison of roost use by three species of communal roostmates. Condor 92:405–412.

MOTT, D. F., K. J. ANDREWS, AND G. A. LITTAUER. 1992. An evaluation of roost dispersal for reducing cormorant activity on catfish ponds. Proc. East. Wildl. Damage Control Conf. 5:205–211.

NORUSIS, M. 1992. SPSS for windows: base system user's guide. Release 5.0. SPSS, Incorporated. Chicago, Illinois. 201 pp.

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. Proc. East. Wildl. Damage Control Conf. 4:105–108.

———, G. L. WARRICK, AND J. F. GLAHN. 1992. Impact of double-crested cormorant depredations on channel catfish farms. J. World Aquacul. Soc. 23:192–198.

VERMEER, K., AND L. RANKIN. 1984. Population trends in nesting Double-crested and Pelagic Cormorants in Canada. Murrelet 65:1–9.

Received 28 Oct. 1994; accepted 12 Dec. 1994.