er, Poult. Sci. 51:1764–1765, 1972; Rothstein, Wilson Bull. 84:469–474, 1972; Capen, Wilson Bull. 89:99–106, 1977; Pulliainen and Marjakangas, Ornis. Scand., Fenn. 57:65–70, 1980; but see Ohlendorf et al., U.S.D.I., Fish and Wildl. Serv., Spec. Sci. Rept. Wildl. No. 216, 1979). However, incubation thinning is apparently not equal for all eggs of a species (Capen 1977).

Unfortunately, pre-1947 Great Blue Heron eggshells were probably not incubated long, so a comparison between pre-1947 and current eggshells dropped from the nest will not be rigorous until there are data available concerning thinning during incubation of eggshells of *A. herodias.* Nevertheless, using 8% as a standard of incubation thinning (Pulliainen and Marjakangas 1980), I estimate that much of the difference I found between pre-1947 and current-hatched eggshell thicknesses may result from this form of thinning. However, the yearly variation in thicknesses and the variation among colonies (Table 1) indicates that incubation thinning is not the only cause of current eggshells being thinner than those prior to 1947. In any case, I found that the degree of thinning of current-hatched eggshells compared with pre-1947 eggshells was generally less than the 15–20% thinning associated with declining bird populations (Anderson and Hickey 1972).

*Research design.*—To make collections of eggs yielding the most information one should collect both whole eggs and dropped eggshells. Whole eggs are necessary for the determination of pesticide or heavy metal levels. Collecting eggs at the same stage of incubation as represented by pre-1947 eggshells (generally shortly after being laid [see Anderson and Hickey, Wilson Bull. 82:14–28, 1970]) is required to compare present day and pre-1947 shells. However, collecting eggs that have fallen from the nest is often the only practical way to collect eggshells in inaccessible colonies, e.g., at Yaquina-S where nests are 20–30 m above the ground, or to determine the thickness of shells of hatched or unhatched eggs and the proportion of unhatched eggs. Furthermore, collection of eggshells from the ground minimizes disturbance to nesting birds while maximizing the proportion of the colony's eggshells sampled.

*Acknowledgments.*—I am grateful to V. Weber and E. Thayer of the Oregon State University Marine Science Center for the loan of a micrometer, to H. M. Ohlendorf for providing unpublished data and to E. McMahon for collecting some of the eggshells from the Coos and Coquille colonies. H. M. Ohlendorf, L. Kiff, E. E. Klaas, G. A. Fox and L. J. Blus critically read earlier drafts of this paper.—RANGE D. BAYER, *423 SW 9th, Newport, Oregon 97365.* *Accepted 13 May 1981.*

*Wilson Bull.*, 94(2), 1982, pp. 201-206

**Nesting phenology of the Double-crested Cormorant.**—The Double-crested Cormorant (*Phalacrocorax auritus*) is a locally common, colonially nesting bird of the lakes, rivers and estuaries of much of North America. The nesting cycle of the cormorant is decidedly seasonal over much of this range. Published accounts indicate spring–sumer nesting to be the rule (e.g., Bent, U.S. Natl. Mus. Bull. 121, 1922; Palmer, Handbook of North American Birds, Yale Univ. Press, New Haven, Connecticut, 1962; Weseloh et al., Proc. Colonial Waterbird Group 2:10–18, 1977). A few data suggest that cormorants may have a longer reproductive season in Florida, where nesting has been reported as early as December and as late as October (Palmer 1962). In this note, we describe the nesting cycle and other population characteristics of cormorants in southern Florida.

*Methods.*—Cormorant colonies were located and the number of nests were counted to

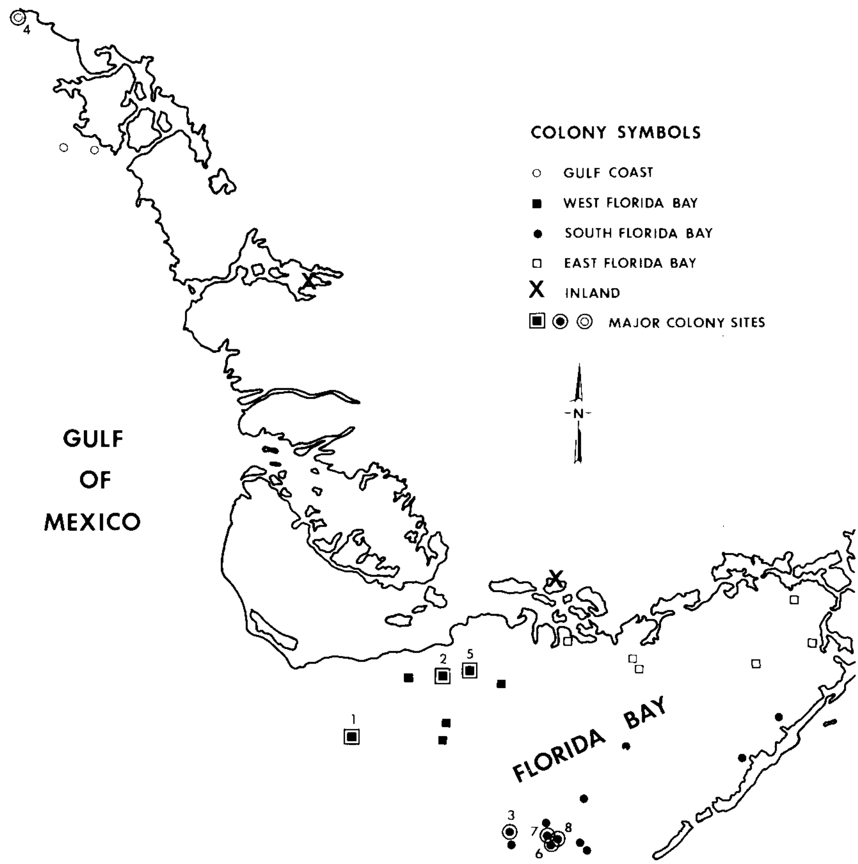


FIG. 1. Map of South Florida showing locations of Double-crested Cormorant colonies, 1977–78. Major colonies (>100 nests) are indicated by double symbols and numbers corresponding to Table 1. Single symbols show location of minor colonies. Colonies are divided geographically into eastern Florida Bay (open squares), southern Florida Bay (closed circles), western Florida Bay (closed squares), Gulf coast (open circles) and inland (x).

about ±10% during monthly aerial reconnaissance by fixed-wing aircraft or helicopters. The area of southern Florida covered included the southern Florida Gulf coast and Florida Bay (Fig. 1). Data reported were collected from May 1977–May 1978. Less accurate information collected in the succeeding year indicated that the 1977–78 season was not atypical.

*Results.*—During 1977–78, cormorants nested in 30 locations on the study area (Fig. 1). Three colonies were along the Gulf coast, seven in western Florida Bay, 12 in southern Florida Bay, six in eastern Florida Bay and two inland. The noncoastal colonies were on mangrove islands in an estuarine bay and in a brackish-water lake (Fig. 1). During the study year, 4700 nests were found in the study area. They were dispersed among a few large and many smaller colonies, with over 70% of the colonies containing fewer than 100 nests.

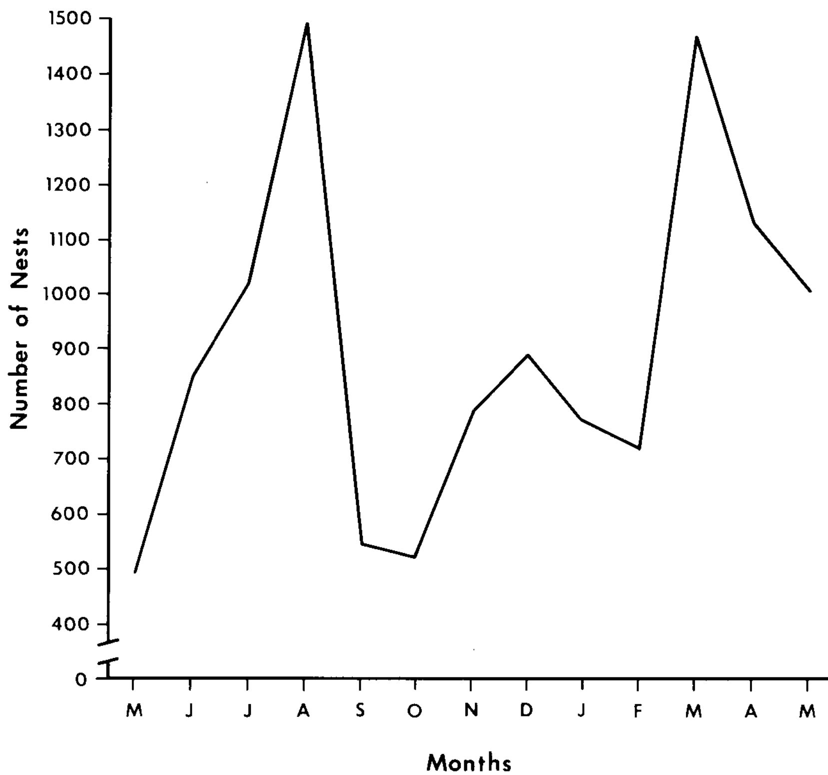


FIG. 2. Number of Double-crested Cormorant nests found in south Florida each month from May 1977–May 1978.

Seventy-three percent of the nests were concentrated in eight colonies, each having more than 100 nests (Table 1). These colonies were located mostly in western and southern Florida Bay (Fig. 1).

Cormorants nested year-round in southern Florida during the study period (Fig. 2). Although some colony sites were active for only part of the year, cormorants nested in every month at colonies at Frank Key and at Sandy Key in western Florida Bay. Numbers of active nests at a specific time varied from 490 in May 1977 to 1500 in August 1977 (Fig. 2). Three peaks of nesting activity occurred within the year (Fig. 3). The winter peak (Nov.–Jan.) was considerably smaller than the summer (June–Aug.) or spring (Mar.–May) peaks.

Cormorants nesting in western Florida Bay accounted for most of the birds found in winter and spring (Fig. 3). Birds nested on the Gulf coast in summer. Most nests in fall were in southern Florida Bay. Regional variation can be seen in the timing of nesting among major colonies (Table 1). The number of summer nesting birds peaked first in colonies on the west coast in June, followed by colonies in southern Florida Bay in July and August. In spring, nesting peaked first in western Florida Bay in March and then in southern Florida Bay in May.

*Discussion.*—The Double-crested Cormorant has undergone long-term decreases in many

TABLE 1

PEAK NUMBERS OF DOUBLE-CRESTED CORMORANTS NESTING AT MAJOR COLONY SITES IN SOUTH FLORIDA, MAY 1977–MAY 1978

| Colony name | Area | Peak number (month) Summer | Winter | Spring |
|---|---|---|---|---|
| 1.[a] Sandy Key | western Florida Bay | — | 300 (Dec.) | 1500 (Mar.) |
| 2. Frank Key | western Florida Bay | 200 (July) | 300 (Dec.) | 400 (Mar.) |
| 3. Upper Arsnicker Key | southern Florida Bay | 350 (Aug.) | — | — |
| 4. Chokoloskee | western Gulf Coast | 230 (June) | — | — |
| 5. Palm Key | western Florida Bay | — | — | 200 (Mar.) |
| 6. West Buchanan Key | southern Florida Bay | 175 (Aug.) | — | 150 (May) |
| 7. Green Mangrove Key | southern Florida Bay | 170 (Aug.) | — | — |
| 8. East Buchanan Key | southern Florida Bay | 130 (Aug.) | 150 (Jan.) | — |

[a] Numbers indicate locations of colonies on Fig. 1.

areas of North America, especially inland populations, (Anderson and Hamerstrom, Passenger Pigeon 29:3–15, 1967; Mitchell, Am. Birds 29:927–930, 1975; Thompson, Proc. Colonial Waterbird Group 2:26–37, 1977). Recently, cormorant populations of the eastern part and interior of North America have begun to recover (Robertson, pers. comm.; Weseloh et al. 1977). During the study year, we found at least 4700 cormorant nests in south Florida. This is the best available estimate of the size of the breeding population, although some birds might have nested more than once during the year and been counted each time, or some might have reused nest-sites which were counted only once. The present survey did not include the southern Florida Keys, which held at least 4500 cormorant nests when we surveyed them in 1976. In that same year, another 650 nests occurred along the southeastern Florida coast in Biscayne Bay. If these data from 1976 were also representative of the situation in 1977–78, we can estimate the total population in south Florida to be about 20,000 birds.

Double-crested Cormorants are primarily coastal in southern Florida (Fig. 1; Owre, Ornithol. Monogr. 6, 1967). Nesting inland is rare, such as the few nests in the marshes of northern Everglades in the early 1970's (J. Schortemeyer, pers. comm.). Most birds occurring inland are juveniles, frequenting the limited deep-water habitats such as canals and borrow pits.

Cormorants are known to change colony sites in response to disturbance, changing environmental conditions and other factors (Palmer 1962). This may not be the rule in southern Florida, where the earliest recorded colony sites at Cuthbert Lake (Bent 1922; Howell, Florida Birdlife, Coward-McCann, New York, New York, 1932) and at Chokoloskee and Man-of-War Key (Howell 1932) were still active in 1977–78. Cuthbert Island, greatly reduced in area by a hurricane, can no longer be considered a large colony as described by Howell (1932). The six colony sites found in a census in 1974–75 (Kushlan and White, Florida Sci. 110:65–72, 1977) were all active 3 years later. Colony-site permanence, or at least slow turnover, suggests that the population is stable, perhaps because of its coastal location and probable low levels of ambient pesticide loading.

In southern Florida, Double-crested Cormorants nested year-round during the study year even at single colony sites, resembling in this other south Florida colonial water birds, such as Great Egrets (*Egretta albus*) (Kushlan and White 1977) and Great White Herons (*Ardea herodias*) (Robertson and Kushlan, pp. 414–452 *in* Environments of South Florida: Present

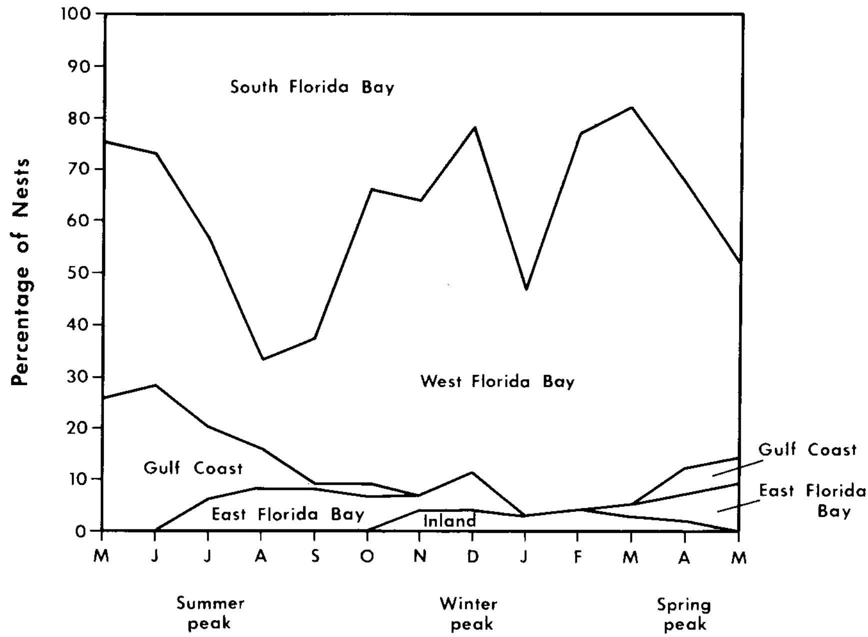


FIG. 3. Proportion of total cormorant nesting in different regions of south Florida.

and Past, Miami Geol. Soc., Miami, Florida, 1974). Possibly the subtropical environment allows exploitation of a more consistently available or consistently accessible food supply, at least during the present study period. Information from more tropical colonies in Cuba and the southern Bahamas would be of considerable comparative value in this respect. It is notable that the most seasonal of the southern Florida colonies were the most northern ones along the Gulf coast. There, nesting may be determined by sea surface temperatures, which are influenced by cool longshore currents. The single summer peak of nesting occurring in these colonies appears to be typical of cormorant colonies further north.

Variability in timing and numbers of cormorants nesting within different areas of south Florida indicates that specific areas were differentially valuable in maintaining the cormorant population. Western Florida Bay was the most productive area, as evidenced by large population size and year-round nesting. Southern Florida Bay was also productive, although somewhat more seasonal. In general, the most productive colony sites were on the outer reaches of Florida Bay where productivity was probably influenced by both bay and Gulf waters. Sampling data in this area suggest that higher populations of some forage fishes occur there than further east in Florida Bay (T. Schmidt, pers. comm.), suggesting a possible relationship of cormorant nesting population size and food supply. A sizeable population, long-term occupation of colony sites and flexibility in population nesting cycle, including year-round nesting in some locations, characterize the Double-crested Cormorant population in southern Florida.

*Acknowledgments.*—We thank R. Miele and A. Lussier, our pilots on the aerial surveys; we also thank J. C. Barlow, O. L. Bass, Jr., P. C. Frohring, O. T. Owre, and W. B. Robertson, Jr. for reviewing the paper.—JAMES A. KUSHLAN AND LINDA C. MCEWAN, *Na-*

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*Wilson Bull.*, 94(2), 1982, pp. 206–208

**Replacement nesting and polyandry in the Wattled Jacana.**—Although polyandry has been documented for the Bronze-winged Jacana (*Hydrophasianus chirurgus*) (Hoffman, Ornithol. Bericht 2:119–126, 1950) and Northern Jacana (*Jacana spinosa*) (Jenni and Collier, Auk 89:743–789, 1972) its occurrence in the Wattled Jacana (*J. jacana*) has been speculative (Osborne and Bourne, Condor 79:98–105, 1977). Polyandry in *J. jacana* is predicted because females are freed from parental care of the precocial young (Osborne and Bourne 1977) thus potentially enabling them to lay additional clutches (Pitelka, Holmes and MacLean, Am. Zool. 14:185–204, 1974) and to monopolize several mates (Emlen and Oring, Science 197:215–223, 1977). In this paper, I report my observations on productivity, replacement nesting and pair bonding for jacanas breeding in coastal Guyana, and describe polyandry in this species for the first time.

*Study area.*—Field studies were conducted on a 28 ha study plot at Burma of MARDS, Guyana, South America, from June–November 1977. MARDS is under intensive rice cultivation and experiences two wet and two dry seasons annually (Giglioli, Crop Histories and Field Investigations 1951–1957, British Guiana Rice Develop. Co. Ltd., Georgetown, Guyana, 1959). During the 1977 study period the wet season extended from May–July, the dry season from August–November. The study plot, partitioned by dikes and canals, consisted of 90% ricefields, 4% drainage ditches, 3% cattle paddocks and 3% ponds, and was surrounded by about 1600 ha of ricefields.

*Productivity.*—Nests were checked daily over the 6 months and their success determined. Nest and egg loss was high. Of 52 nests, only eight (15.4%) were successful in producing at least one young. Fates of the precocial young after leaving the nest were not followed. Known causes of nest and egg loss included lizards (1.9%), Long-winged Harriers (*Circus buffoni*) (5.8%), children (5.8%), grazing cattle and horses (19.2%), and harrowing and drainage of the ricefields (9.6%). Thus, natural predators accounted for 7.7% of the known nest and egg loss and human related activities for 34.6%. Thirty-five percent of the nests were lost to unknown causes, perhaps to changing water depths, and 7% were presumed deserted.

*Pair bonds and replacement nesting.*—Jacanas were captured by mist-net, sexed by weight (Osborne and Bourne 1977) and marked with colored plastic leg bands (identified in this paper by acronyms or capital letters, e.g., WO/O and D, respectively). Censuses of the marked population were made twice weekly from June–November to determine pair bond relationships and the frequency of replacement nesting. The existence of a pair bond between a male and female was inferred from their foraging together on the territory, territorial defense and precopulatory behavior (Osborne and Bourne 1977). Many, but not all pairs were observed during repeated copulations.

Thirty-four males and 19 females were marked. Nineteen birds (38% of the males and 31% of the females) left the study area. Twenty-one of the 34 males (61.8%) and 13 of the 19 females (68%) nested in the study area. Eight of 21 males (38%) and 2 of 13 females (15.4%) paired with unmarked mates. Nine of 11 females (81.8%) were monogamous, two (18.2%) were polyandrous.

Females responded to acts of predation or nest destruction by laying replacement clutches