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BREEDING BIOLOGY AND PRODUCTIVITY OF FLORIDA'S CRESTED CARACARAS[1]

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Abstract. I studied the breeding biology of Crested Caracaras (*Caracara plancus*) in south-central Florida from 1994 through 1996. Reproductive activity was monitored year-round on 30, 48, and 55 territories, respectively. Pairs remained on breeding territories throughout the year and exhibited strong fidelity to the nest site between years; however, annual turnover rate among known breeding individuals was approximately 18%. Territorial occupancy and breeding rates on known occupied territories averaged 95% and 98%, respectively. Observed patterns of breeding activity and nesting success suggested a link between reproduction and precipitation. Active nests were found from September through June, but most nesting activity corresponded with the dry season, November through April. Egg laying in many pairs occurred following an abrupt decline in precipitation in the fall each year. The overall probability of a nest producing at least one independent young was 72%; however, nest success varied throughout the breeding season, being lowest and most variable for early- and late-season nests. Based on 98 nests with complete records, mean clutch size was 2.23 eggs, 61.2% of nestlings fledged successfully, and 48.4% of all eggs laid resulted in independent young. Clutches of three produced the most independent young per breeding attempt in all years. Annual population productivity was enhanced because pairs made more than one nesting attempt per breeding season, either by renesting following an early season failure or by producing second broods. Clutch size, probability of nest success, probability of renesting, and number of fledglings produced per attempt all declined as the breeding season progressed. Mortality factors included weather, predation, chicks falling out of nests, and vehicle collisions with fledglings. Environmental variability may influence spatial and temporal variation in timing of reproduction and nesting success of Crested Caracaras in Florida.

Key words: breeding biology, Caracara plancus, *Crested Caracara, productivity, raptor.*

INTRODUCTION

The Crested Caracara (*Caracara plancus*) is one of nine species in the subgroup Caracarinae (caracaras), family Falconidae. Although some species are widely distributed throughout parts of Central and South America (del Hoyo et al. 1994), caracaras as a group have been little studied. The Crested Caracara is the only species of caracara that occurs in North America, where it primarily inhabits open grassland, pasture, and brushland habitats. Breeding populations in Texas (Oberholser 1974), southern Arizona (Ellis et al. 1988), and Florida (Stevenson and Anderson 1994) are at the northern limit of the species' geographic range. The reproductive biology of this species is poorly known throughout its range, although populations in Texas (Dickinson and Arnold 1996) and Baja California Sur, Mexico (Rivera-Rodríguez and Rodríguez-Estrella, unpubl. data) have received recent attention.

Florida's Crested Caracara population has a limited distribution, is isolated from other populations, and is suspected to be in decline (Layne 1996). Conversion of grassland and pasture for urban and agricultural development throughout the species' range in Florida has presumably reduced the amount of suitable nesting and foraging habitat, and this loss is expected to continue. This population is currently listed as Threatened by the U.S. Fish and Wildlife Service (USFWS 1987) and the state of Florida (Florida Game and Freshwater Fish Commission 1997).

I studied Crested Caracaras in Florida year-round from August 1993 through July 1996. The intent of this research was to elucidate the re-

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productive biology of this species and to provide data useful for conservation and management of Florida's caracara population.

METHODS

STUDY AREA

The study area encompassed approximately 21,000 km² in south central Florida and was centered on the MacArthur Agro-Ecology Research Center (27°10'N, 81°12'W) in Highlands County. The landscape in this region is a mosaic of habitats, primarily grasslands and pastures interspersed with cropland, citrus groves, dairies, pine flatwoods, freshwater marshes and lakes, oak scrub, hardwood hammocks, and urban developments. Primary land uses are cattle ranching, citrus production, and other agricultural crops. Breeding pairs of Crested Caracaras occupy open grasslands and pastures. These habitats are characterized by large expanses of low-growing (<0.5 m in height) ground cover of grasses and forbs and are dotted with numerous shallow ponds, wetlands and marshes, and single or small clumps of live oaks (*Quercus virginiana*), cabbage palms (*Sabal palmetto*), and cypress (*Taxodium* sp.).

Southern Florida has a humid, subtropical climate with a distinct annual cycle of temperature and precipitation (Chen and Gerber 1990). During the rainy season, June through September or October, temperatures are warm and relatively uniform, averaging about 28°C. Convective rains and thunderstorms occur almost daily. During the dry season, usually from November through May, temperatures are cooler but rarely drop below freezing. Daily 24-hr temperatures average around 20°C but can vary as much as 15° between daily maxima and minima.

During the 3 years of this study, I monitored 33, 62, and 62 breeding attempts, respectively by pairs of Crested Caracaras in 30, 48, and 55 territories (65 different territories in total). I considered a breeding attempt to be egg laying, not just nest building. I captured and color-banded 49 breeding adult caracaras representing 41 territories (Morrison and McGehee 1996). I color-banded 189 nestling caracaras and radiotagged 116 to obtain data on fledgling survival to independence. Nestlings were banded and radiotagged between 7 and 8 weeks of age while they were still in the nest or just after fledging when they could be captured easily on the ground.

NEST LOCATION AND VISITATION

I located occupied territories by visiting known historic sites (J. N. Layne and B. A. Millsap, unpubl. data), by conducting observations at sites where I had seen adult caracaras, and by searching other suitable habitat. I conducted observations in all territories at least once per month throughout each year to look for nesting activity. Once found, nests were checked weekly to determine their fate, although I monitored nests every few days near the suspected time of fledging. Most nests in 1994 were found after hatching. Because other territories were identified before the reproductive season began in 1995 and 1996, I was able to follow all reproductive activity, including courtship and nest building, in most territories during these years. During visits to each territory, I attempted to determine the identity of adults to assess site fidelity.

For each active nest, I determined clutch size, hatching date, brood size, and chick age using a mirror attached to an extendible pole. I assigned each nest a week of initiation based either on the known time of egg laying or by back-dating from known hatching or fledging dates. I then calculated week of initiation from the first week of September, which I assigned as the first week of the breeding season each year, based on the earliest known egg laying during all 3 years. I defined breeding season length each year as the number of weeks during which I found nests containing eggs or nestlings. Following nest failures, I continued to check these territories at least monthly for signs of renesting. I also regularly searched all territories that had successfully fledged one brood in a breeding season, for second nests.

REPRODUCTIVE PERFORMANCE

I recorded the following reproductive parameters annually: breeding rate (percentage of territorial pairs laying eggs), clutch size, nest success, and productivity (number of young fledged per territorial pair). Because some pairs renested and second clutches may not be independent of first clutches, I considered clutch size separately for two categories of nests: (1) first (first of two nests either succeeded or failed, or single nest, only one clutch produced per season), and (2) second (second nest of a double-brooded pair, or replacement nest, second clutch after first nest failed). I estimated probability of success for all breeding attempts using the Mayfield method (Mayfield 1961, Johnson 1979). Because of the length of the caracara's breeding cycle, I estimated weekly rather than daily probabilities of nest success. I defined a successful nest as one that fledged at least one young.

Because conclusions based on reproductive output measured at fledgling independence can differ strongly from those measured at fledging, I also determined Mayfield nest success and productivity at independence for each territory each year. Here, I defined productivity as the number of independent young per territorial pair. Young were considered independent at the end of the post-fledging dependency period (PFDP), i.e., the first 8 weeks post-fledging. During the PFDP, fledglings remain close to the nest and are primarily dependent on their parents for food. Survival of fledglings during the PFDP and after independence was determined by radiotelemetry.

As an additional measure of reproductive performance, I examined the proportion of eggs from first and second clutches that produced independent young. I recorded hatching, nestling survival to fledging, and fledgling survival to independence, and attempted to determine the fate of eggs that were lost.

Territorial occupancy also may be used as an indicator of the stability and productivity of a population (Newton 1979, Steenhof and Kochert 1982). In 1994, I knew the occupancy status of 37 territories. I tracked occupancy in these territories through all 3 years of the study and assessed changes in occupancy rates between years using Cochran's Q-test (Sokal and Rohlf 1995). I defined an occupied territory as one in which adult caracaras were seen on three or more visits to the territory.

SEASONAL TRENDS AND COMPONENTS OF VARIATION

To evaluate seasonal trends in reproductive performance, I evaluated success among nests initiated at different times throughout the breeding season. For each year separately, I first ranked all nests in ascending order according to the week in which the clutch was laid. I assigned the earliest nest each year a rank of 1 (whether or not it occurred in the first week of the breeding season, see above), the second nest in which a clutch was laid was assigned a rank of 2, etc. I then divided the set of rankings for each year into quartiles to determine the percentage rank for each nest. I considered early-season nests to be those with a percentage rank of 0–25%, late-season nests those with a percentage rank of 75–100%, and middle-season nests those within the middle 50%. I used a Z-test (Hensler and Nichols 1981) with Bonferroni corrected α (Sokal and Rohlf 1995) to compare Mayfield nest success probabilities between time periods. I also assessed monthly trends in clutch size, number of fledglings per nesting attempt, and probability of nest success to fledging. I used weighted regression analysis for unequal sample sizes among categories (Sokal and Rohlf 1995). To examine variation among reproductive parameters, I calculated the coefficient of variation for clutch size, number of young fledged per territorial pair, number of independent young per territorial pair, and Mayfield nest success.

ENVIRONMENTAL DATA

Because patterns of egglaying in other birds have shown association with precipitation (Ogden et al 1980, Bildstein et al. 1990), I analyzed precipitation data for my study area to examine the potential influence of this environmental factor on patterns of egglaying in Florida's caracaras. Data collected from weather stations located throughout the study area by the National Weather Service and the South Florida Water Management District were used for analysis of the precipitation cycle. I averaged daily precipitation values for each month from 35 stations. Monthly values for all stations were then averaged to obtain monthly values for the overall study area, for all 3 years.

STATISTICAL ANALYSES

Because each year's sample of territories contained a subset of the previous year's territories, data were not pooled across years unless indicated. I conducted statistical analyses using SigmaStat v. 2.0 (Jandel Scientific 1995). Results are reported as means ± SE unless otherwise indicated.

RESULTS

TERRITORIAL OCCUPANCY AND BREEDING RATES

Occupancy rates for the subset of 37 territories differed slightly among the 3 years ($Q_2 = 6.5$, $P < 0.05$) but remained high overall (97%, 100%, and 89%, respectively). Two territories

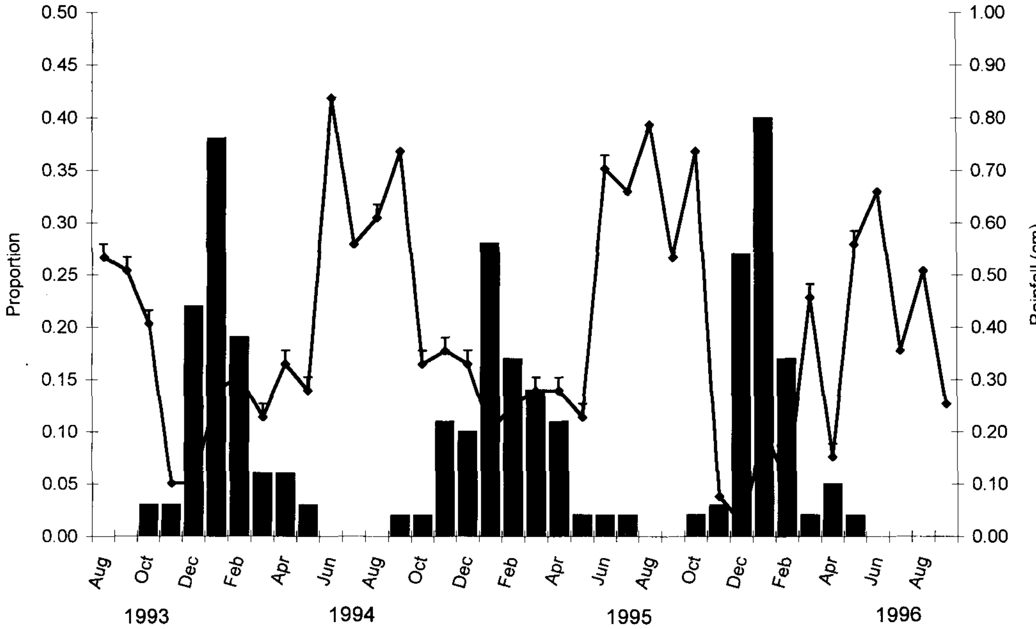

FIGURE 1. Mean (± SE) monthly rainfall and breeding chronology (proportion of sample nests each month in which egg laying occurred; solid bars) of Crested Caracaras in south-central Florida, 1994–1996. Monthly values for rainfall were averaged from 35 weather stations located throughout the study area. Number of nest attempts: 1994, $n = 33$; 1995, $n = 62$; 1996, $n = 62$.

were occupied only during 1995. Among known occupied territories, the percentage of pairs that laid eggs did not differ among years, at 100%, 97%, and 97%, respectively ($Q_2 = 2.0$, $P > 0.25$).

BREEDING BEHAVIOR AND SITE FIDELITY

Breeding pairs of caracaras remained on the territory throughout the year, although they were not easily observed outside the breeding season. The beginning of the breeding season was signaled by several changes in the adults' behavior. Pairs were often observed around the traditional nesting site perching together, preening, allopreening, and sharing food. Thirty-nine of 49 banded adults, including both banded members of 5 pairs, were present in the same territory and reproduced there for at least 2 years. This represents a potential annual turnover rate of at least 18%, although I do not know the fate of the birds that disappeared.

NEST BUILDING AND INCUBATION

Both males and females build the nest. All pairs that built nests eventually produced a clutch. Building time ranged from 2 to 4 weeks ($n = 34$ pairs), and sometimes up to 2 months elapsed between nest completion and egg laying. Both parents developed a brood patch and incubated the clutch. Neither mate was observed delivering food to the other during incubation, but one would remain on the nest while the other left the nest area to forage.

LENGTH OF THE BREEDING SEASON AND TIMING OF BROODS

Caracaras in Florida exhibit a prolonged breeding season. Early-, middle-, and late-season nesting pairs laid eggs in mid-September through December, January through March, and April through mid-July, respectively. Chicks from early-season nests fledged as early as mid-December, and the latest eggs were laid in July 1995, although these nests failed ($n = 2$, both were second attempts). Most young fledged during March and April. Chicks from late-season and second nests fledged as late as July.

The caracaras' nesting activity generally corresponded with the dry season (Fig. 1). Egg laying in many pairs occurred following an abrupt

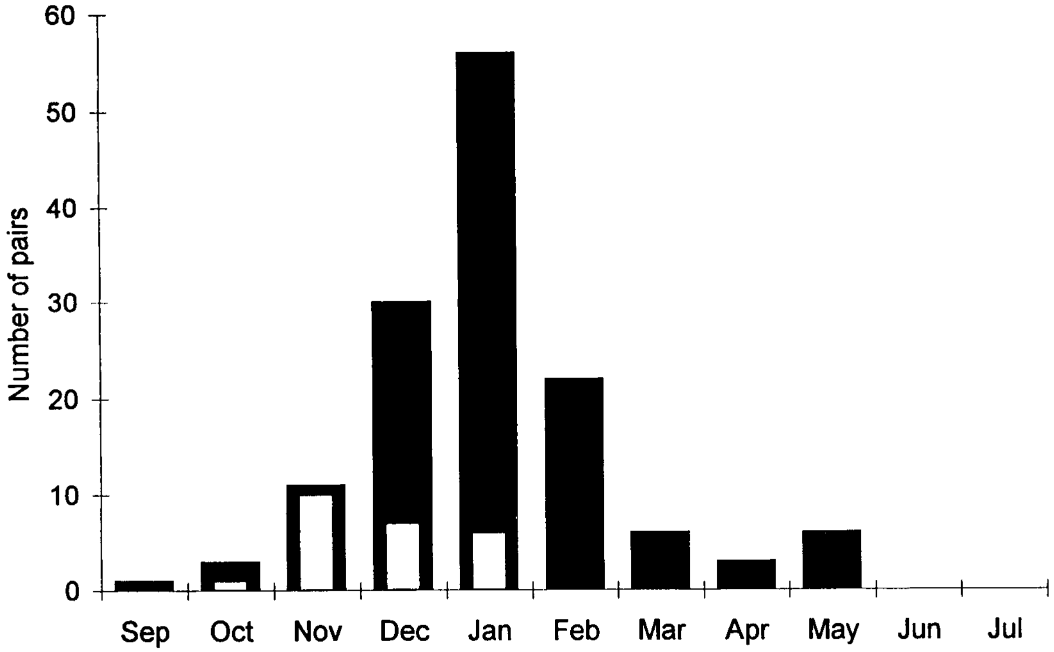

FIGURE 2. Numbers of pairs of Crested Caracaras that initiated their first nest each month (black bars) and occurrence of renesting by these pairs following either an early failure or a successful first brood (white bars), south-central Florida, 1994–1996.

decline in precipitation in the fall each year. In the 1994–1995 breeding season, mean monthly rainfall declined dramatically between September and October rather than between October and November as in other years. During that breeding season, I found nests with eggs during a longer period (40 weeks compared to 28 weeks in other years), and although egg laying began earlier overall, a smaller proportion of pairs had initiated egg laying by the end of January (Fig. 1).

Although yearly variation existed in onset and duration of the breeding season, the median week of egg laying for all single and first attempts was in late January each year and did not differ among years ($H = 0.51$, $P > 0.7$). Secondary peaks of egg laying in March and April each year (Fig. 1) represent territories where pairs made a second nesting attempt following a successful first brood. Considerable within-year variation existed in timing of nest initiation among pairs throughout the population, but between-year nesting intervals for individual pairs were remarkably consistent. The mean year-to-year interval between egg-laying for single-brood pairs was 50 ± 0.99 weeks ($n = 38$ pairs), thus individual pairs tended to initiate nests at about the same time each year.

NUMBER OF BROODS PER YEAR

Multiple nesting within a breeding season occurred during all 3 years. Early nesting pairs regularly renested, after a first attempt failed during the incubation or early nestling stages, or by attempting a second brood (Fig. 2). For all 3 years, an average of 15.7% of early nests failed (Table 1). Seventy-one percent of these pairs renested and 80% of these were successful. Time between failure of the first nest and egg laying in the second nest ranged from 3 to 14 weeks.

Successful double brooding was recorded during all 3 years. Although second nests failed more often and had smaller clutch sizes, pairs that attempted two broods during a breeding season had higher annual productivity than pairs that raised only one brood (Morrison 1998). During the 1994–1995 breeding season, more early nesting pairs failed, yet more of the pairs that renested were successful. More pairs also attempted a second brood during that breeding

TABLE 1. Reproductive parameters for Crested Caracaras. Results are presented as mean ± SE except where indicated otherwise.

Parameter	1994	1995	1996	Overall
No. territories followed	30	48	55	65[a]
All nest attempts	33	62	62	157
Early nests[b] (%)	11 (33.3)	20 (32.2)	20 (32.2)	51 (32.5)
Early nests that failed (%)	1 (9.1)	4 (20.0)	3 (15.0)	8 (15.7)
Late nests[b] (%)	6 (18.2)	15 (24.2)	11 (17.7)	32 (20.4)
First clutches	16	30	37	83
Mean clutch size	2.56 ± 0.16	2.30 ± 0.10	2.19 ± 0.09	2.30 ± 0.06
Eggs laid	41	69	81	191
hatched	34	62	76	172
fledged	27	44	52	123
survived to independence	22	30	46	98
No. clutches totally lost (%)	3 (18.8)	4 (13.3)	3 (8.1)	10 (12.0)
Second clutches	—	11	4	15
Mean clutch size	—	1.81 ± 0.12	2.00 ± 0.00	1.86 ± 0.09
Eggs laid	—	20	8	28
hatched	—	13	5	18
fledged	—	8	4	12
survived to independence	—	5	4	9
No. clutches totally lost (%)	—	5 (45.5)	2 (50.0)	7 (46.6)
Mayfield nest success probabilities ± SD				
Incubation period	0.75 ± 0.06	0.87 ± 0.02	0.94 ± 0.02	0.89 ± 0.02
Nestling period	0.95 ± 0.02	0.82 ± 0.02	0.92 ± 0.01	0.88 ± 0.01
Fledgling period (PFDP)	0.93 ± 0.02	0.83 ± 0.02	0.98 ± 0.01	0.92 ± 0.01
Overall, to fledging	0.71 ± 0.03	0.71 ± 0.02	0.86 ± 0.02	0.78 ± 0.01
Overall, to independence	0.66 ± 0.09	0.59 ± 0.04	0.85 ± 0.03	0.72 ± 0.03
Number fledged per territorial pair	1.86 ± 0.18	1.71 ± 0.12	1.61 ± 0.11	1.71 ± 0.08
Number independent young per territorial pair	1.47 ± 0.20	1.33 ± 0.13	1.50 ± 0.11	1.43 ± 0.08
Nest failures (% of all nest attempts)	7 (21.2)	24 (38.7)	11 (17.7)	42 (26.8)
During incubation/hatching	2	9	5	16
During nestling period	2	7	3	12
After fledging	3	8	3	14
Territories that did not produce any young despite a nesting attempt (%)	6 (20.0)	11 (22.9)	5 (9.1)	7.3 (16.6)[c]

[a] Total number of different territories.
[b] Early nests are those with a percentage rank of 0–25% when timing of egglaying was considered, as compared to the entire sample each year. Late nests are those with a percentage rank of 75–100% (see text).
[c] Mean for all years.

season, although a higher percentage of second broods failed than during other years.

CLUTCH SIZE AND EGG SUCCESS

For known-size clutches (n = 98), the overall mean was 2.23 eggs. Modal clutch size was 2 for all years, although I found a higher proportion of 3-egg first clutches in 1994 (Fig. 3). I found no 3-egg second clutches; 13 of 15 second clutches contained 2 eggs. Mean clutch size did not differ among years for first clutches (H = 5.74, $P > 0.05$) or second clutches (T = 36.0, $P > 0.6$, Table 1), although overall, mean clutch size was higher for first than for second clutches (T = 501.0, $P < 0.01$, Table 1). For the same females (n = 11), clutch size decreased between first nests (2.36 ± 0.45) and replacement or double brood nests (1.91 ± 0.09, two-tailed paired t-test, t_{10} = 2.22, $P < 0.05$). A higher percentage of eggs from first clutches than from second clutches produced independent young (Table 1).

BROODS

Hatching was asynchronous. Eggs hatched one to two days apart. Both parents fed and cared for the young. Nestlings were in the nest for 7 to 8 weeks, although the earliest recorded fledging occurred at age 42 days. After fledging, the young remained in the general area around the nest and were dependent on the adults for food

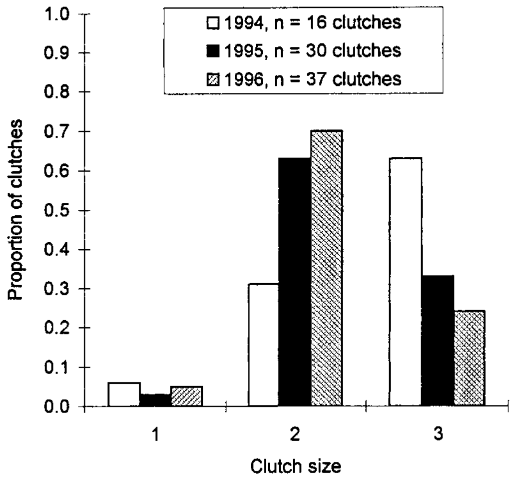

FIGURE 3. Distribution of clutch sizes for first clutches by year, for Crested Caracara nests in south-central Florida, 1994–1996.

for at least 2 months. Even after independence, approximately 25% of young fledged each breeding season remained in their natal territory until the adults began breeding the following year.

NEST SUCCESS AND PRODUCTIVITY

Overall mean (± SD) probability of nest success to independence for all attempts for all 3 years was 0.72 ± 0.03 (Table 1). Low nesting success during the 1994–1995 breeding season was apparently caused by higher failure rates of early nesting pairs and second brood attempts (Table 1) and by higher mortality of juveniles during the PFDP in that year.

Neither the number of young fledged (H = 2.74, P = 0.25) nor the number of independent young (H = 0.71, P = 0.70) per territorial pair varied significantly among years (Table 1). In all years, productivity per territorial pair was enhanced because pairs successfully renested following early-season failure or raised second broods. Clutch sizes of 3 produced the most fledglings and independent young during all years (Fig. 4). Five of six 1-egg clutches failed.

SEASONAL TRENDS IN PERFORMANCE AND COMPONENTS OF VARIATION

For all years combined, mean clutch size (all clutches) was negatively correlated with laying date ($r = -0.85$, $P < 0.01$, Fig. 5a). The number

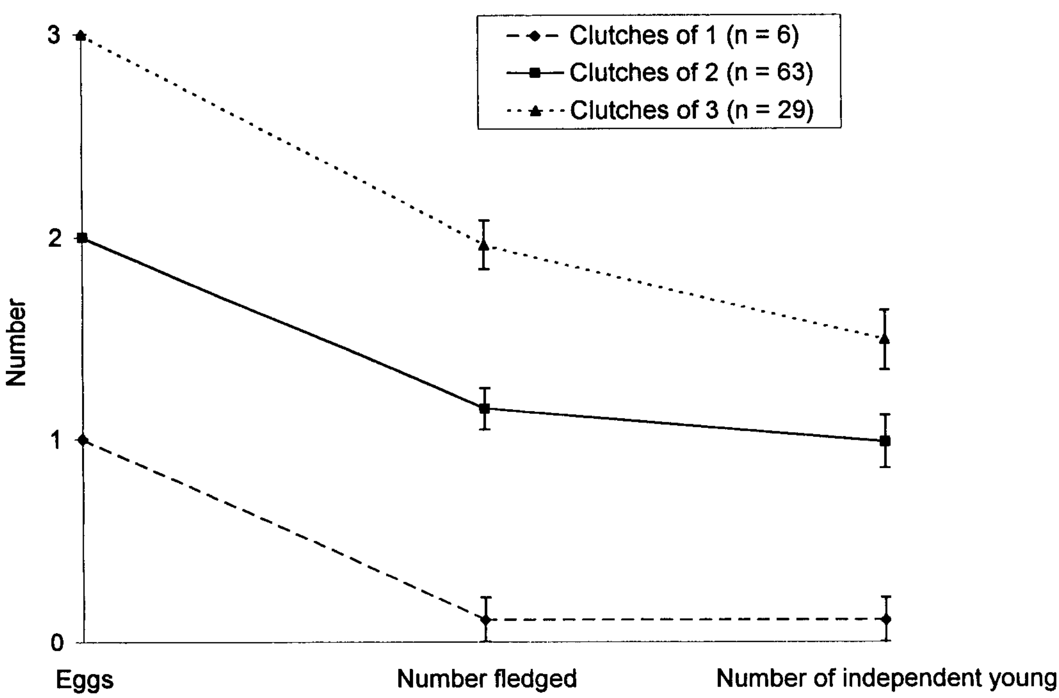

FIGURE 4. Mean (± SE) numbers of fledglings and independent young produced per nest for each clutch size for Crested Caracaras in south-central Florida, 1994–1996. n indicates number of clutches.

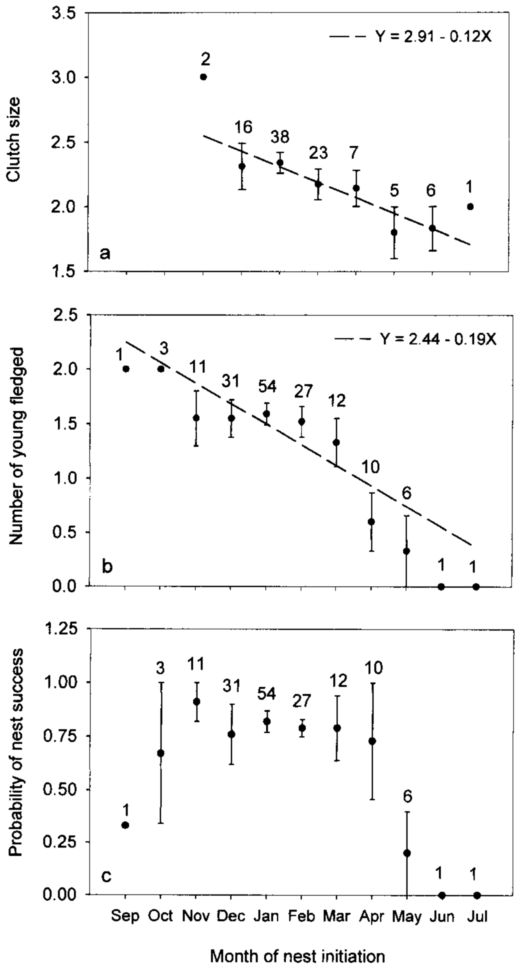

FIGURE 5. Relationships between month of nest initiation and (a) mean clutch size (± SE) for 98 known-size clutches, (b) mean number of young fledged per nesting attempt (± SE) for 157 attempts, and (c) mean Mayfield probability of nest success (± SD) for 157 nesting attempts, for Crested Caracaras in south-central Florida, 1994–1996. Number of clutches or nesting attempts is shown above each month. The slope of the regression line in both (a) and (b) is significantly different from 0 ($P < 0.01$).

of fledglings per nesting attempt also declined with progressive laying date ($r = -0.36$, $P < 0.01$, Fig. 5b). Approximately 76% of the variation in clutch size and 68% of the variation in number of fledglings per nesting attempt could be explained by month of nest initiation.

The probability of nest success varied throughout the breeding season (Fig. 5c). Early-season pairs had slightly lower nesting success (mean ± SD = 0.73 ± 0.05, n = 51) than pairs

TABLE 2. Coefficients of variation for reproductive parameters for Crested Caracaras. Productivity per territorial pair includes young from renesting attempts.

Parameter	1994	1995	1996	Total
Clutch size (all clutches)	24.6	24.9	23.0	24.4
Fledged per territorial pair	54.3	48.0	51.6	50.9
Independent young per territorial pair	72.8	63.9	53.3	61.5
Nesting success to fledging (%)	8.9	4.2	2.3	2.6
Nesting success to independence (%)	13.6	6.7	3.5	4.2

that initiated nesting in the middle of the season (0.83 ± 0.03, n = 71, $Z = -1.80$, $P = 0.07$). Nest success of late-season pairs (0.38 ± 0.07, n = 32) was significantly lower than pairs that nested both early ($Z = 4.14$, $P < 0.001$) and in the middle ($Z = 5.84$, $P < 0.001$) of the nesting season.

Measures of productivity showed the highest variability among reproductive parameters measured (Table 2). Clutch size varied little and nesting success showed the least variability among parameters, indicating that during all years, most nests fledged at least 1 young.

NEST FAILURE, EGG AND CHICK MORTALITY

In all years, more second clutches than first clutches were totally lost (Table 1), mostly due to abandonment. Total nest failure occurred most often during late incubation and just after hatching (Table 1). Only 38% of nests with 3-egg clutches fledged all three chicks. The fate of most eggs that did not result in independent young was unknown (Table 3). Overall, an average of 26.8% of nests failed each year, but due to renesting, only an average of 16.6% of pairs each year failed to produce any young despite a nesting attempt (Table 1).

DISCUSSION

The reproductive rate of birds presumably represents the maximum number of young that individuals in a population can raise given the prevailing environmental conditions during a breeding period (Amadon 1964, Lack 1968). Raptors typically have lower reproductive rates than most birds (Newton 1979). Territorial occupancy rates vary widely, and a percentage of pairs annually may not attempt to breed or may abandon

TABLE 3. Fates of eggs from known-size clutches (first and second clutches combined) for Crested Caracara nests in south-central Florida.

Fate	1994	1995	1996	Overall
Total eggs	41	89	89	219
No. chicks survived to independence (%)	22 (53.7)	34 (38.2)	50 (56.2)	106 (48.4)
No. Failures (%)				
Incubation stage				
Unknown egg/chick[a]	5 (12.2)	20 (22.5)	23 (25.8)	48 (21.9)
Eggs did not hatch	3 (7.3)	2 (1.1)	0	5 (2.3)
Eggs abandoned	0	8 (9.01)	0	8 (3.7)
Known predation	3 (7.3)	2 (2.2)	0	5 (2.2)
Nestling stage				
Chick died in nest[b]	0	0	2 (2.2)	2 (0.01)
Chick defect/disease[c]	0	2 (2.2)	0	2 (0.01)
Chick disappeared, fate unknown	2 (4.9)	4 (4.4)	7 (7.9)	13 (5.9)
Chick fell out of nest	1 (2.4)	1 (1.1)	1 (1.1)	3 (1.3)
Fledgling stage				
Killed by vehicle	1 (2.4)	7 (7.9)	6 (6.7)	14 (6.4)
Fledgling found dead, cause unknown	2 (7.3)	8 (9.0)	0	10 (4.6)
Fledgling disappeared, fate unknown	2 (2.4)	1 (1.1)	0	3 (1.3)

[a] Not known whether eggs were lost during incubation or whether they hatched and chicks were lost during early nestling stage.
[b] Chicks found dead in nest during first two weeks, from unknown causes; two different nests.
[c] Chick died of injury or defect before it fledged; two different nests.

an attempt, often due to weather, food availability, or density-dependent effects (Newton and Marquiss 1976, Kostrzewa 1996).

Results from this study provide little indication that Florida's Crested Caracara population suffers from low territorial occupancy or breeding rates or poor reproductive success. In this resident population, breeding pairs were generally socially monogamous within each breeding season. Pairs remained on their territory year-round, thus, the individual's familiarity with both territory and respective mate may facilitate successful annual breeding. Estimates of annual nest success and productivity for Florida's caracaras are commensurate with those of other large non-migratory raptors, including some Florida species and other populations of Crested Caracaras (Table 4). Clutch sizes for Florida's caracaras were similar to those reported for Crested Caracaras in Texas (2.14 ± 0.14, n = 7 clutches, Dickinson and Arnold 1996).

Cues that function to initiate the Crested Caracara's breeding season in Florida are unknown; however, my results suggest a link between timing of the breeding season and the rainfall cycle. Egg laying in many pairs occurred following an abrupt decline in precipitation in the fall each year. In the 1994–1995 breeding season, when the decline in precipitation began earlier, egg laying began earlier and occurred during a longer period than in other years.

Weather has been implicated as a factor influencing the timing and success of raptor reproduction by affecting their food supply or directly affecting survival of adults and young (Kostrzewa and Kostrzewa 1991, Steenhof et al. 1997). In tropical and subtropical regions, the abundance of food resources is closely tied to rainfall cycles (Skutch 1950). The influence of water levels on food resources is an important factor in the timing of nesting and reproductive success for wading birds in Florida and elsewhere (Ogden et al 1980, Bildstein et al. 1990). Florida's climatic cycle may provide predictable cues to resource availability for Crested Caracaras. Reproduction mainly occurred during the winter dry season following a period of dramatically reduced precipitation each fall. During this dry-down period, fish and other prey become concentrated in ephemeral wetlands, ponds, and ditches (Kushlan 1990, Babbitt 1996), and their availability increases to foraging wading birds (Bancroft et al. 1992). Caracaras regularly forage in these habitats, feeding on fish and frogs, and also kleptoparasitize wading birds that feed there (Rivera-Rodríguez and Rodríguez-Estrella 1992, pers. observ.). Seasonal and predictable availability of food during this dry-down period

TABLE 4. Estimates of breeding rate (proportion of territorial pairs that laid eggs), nest success to fledging, and productivity (number fledged per territorial pair) among populations of medium to large non-migratory raptors, including some Florida species. Method for estimating nest success: T = traditional, number of successful nests/number of total nests; M = Mayfield's method. ND = no data.

Species	Location	Breeding rate	Nest success	Method	Productivity	Source
Crested Caracara (*Caracara plancus*)	FL	0.97–1.00	0.67–0.86	M	1.61–1.86	this study
Crested Caracara	TX	ND	0.46–0.73	M	1.14	Dickinson and Arnold (1996)
Crested Caracara	MX	ND	0.38–0.75	M	1.91	R. Rodríguez-Estrella, unpubl. data
Bald Eagle (*Haliaeetus leucocephalus*)	FL	0.81	0.89	T	1.00	Broley (1947)
Snail Kite (*Rostrhamus sociabilis*)	FL	0.00–1.00	0.23–0.36	M	1.44–1.65	Sykes et al. (1995)
Red-shouldered Hawk (*Buteo jamacaensis*)	FL	0.59–1.00	0.36–0.94	T	0.48–1.75	M. McMillian, unpubl. data
Red-tailed Hawk (*Buteo lineatus*)	various	0.74–0.90	0.58–0.93	T	0.91–1.80	Preston and Beane (1993)
Harris' Hawk (*Parabuteo unicinctus*)	NM	ND	0.29–0.85	T	1.74–2.45	Bednarz (1988)
Prairie Falcon (*Falco mexicanus*)	ID	0.97–0.99	0.18–0.93	M	0.66–3.79	Steenhof (1998)

may enhance individual female caracaras' ability to attain body condition necessary for breeding.

The role of weather as an influence on reproduction in Florida's caracara population is further suggested by the observed pattern of nest success throughout the breeding season. The probability of nest success was lowest and most variable both early and late in the breeding season, and highest and least variable during November through March when most pairs were breeding. Although the winter climate in south-central Florida is generally mild, severe storms and cold fronts often pass through the region and may influence nesting success either directly or by affecting the food supply. The potential high risk of nest failure incurred by the earliest nesting pairs in particular, may be offset by the strategy of multiple nesting. Pairs that successfully renest after failure or successfully double-brood ultimately may produce more young that are eventually recruited into the breeding population. Despite the risk of failure due to environmental stochasticity, nesting as early as possible is advantageous because early nesting pairs generally fledge more young per attempt and have the opportunity to make a second nesting attempt. Lower nesting success observed late in the breeding season each year may have been related to rising air temperatures, which may affect breeding directly by imposing additional physiological stress on late breeders or indirectly by affecting the food supply.

Although annual breeding rates were high, Florida's Crested Caracaras exhibit much spatial and temporal variation in the timing of reproduction and reproductive performance. Considerable within-year variation existed in timing of nest initiation among pairs throughout the population. In addition, as has been well-documented for other birds (Newton and Marquiss 1984, Verhulst and Tinbergen 1991), reproductive performance of Florida's caracaras as measured by clutch size, number of young fledged per nesting attempt, probability of nest success to fledging, and probability of renesting declined as the breeding season progressed. The probability of an egg from a first or single clutch resulting in a fledgling was higher than that for an egg from a second or replacement clutch, and the probability of success for nests initiated early in the breeding season was higher than that for nests initiated later in the season.

Large variability in productivity among pairs and years may be attributable to variable environmental conditions and a myriad of potential causes for loss of eggs and chicks. Most eggs lost during incubation disappeared right around hatching, possibly due to predation of either eggs or newly-hatched young by crows (*Corvus sp.*) or raccoons (*Procyon lotor*) (Layne 1996, pers. observ.). Most fledging mortality was caused by vehicles colliding with fledglings feeding on carrion along roads. High variation in numbers of independent young per territorial pair also reflects the longer time period during which these additional mortality factors were acting. Clutch size varied little among years, and the low coefficients of variation for nest success suggest that most pairs have a good chance at producing at least one independent young during any year.

The observed variability in patterns of reproduction in Florida's Crested Caracaras presumably has evolved in response to the variable environmental conditions characteristic of this region. Although southern Florida's relatively mild climate may allow year-round breeding, the fact that most egg-laying occurred in December through March during all 3 years suggests an optimal time for reproduction. As with many wading birds in south Florida, the caracara's reproductive cycle may be influenced by the precipitation cycle, suggesting the importance of seasonal dry-down to this opportunistic scavenger/predator. The fact that some nests, albeit fewer, are initiated outside the peak period suggests variation in quality among territories or individuals. Finally, given the unpredictable occurrence of storms and changing environmental conditions throughout the caracara's range in Florida, large spatial and temporal variation in timing of nesting by individual pairs across the population's range will result in successful nesting by at least some pairs during any particular year.

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