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NUMBERS, MIGRATION CHRONOLOGY, AND ACTIVITY PATTERNS OF NONBREEDING CARIBBEAN FLAMINGOS IN YUCATAN, MEXICO[1]

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Abstract. The ecology of nonbreeding Caribbean Flamingos (*Phoenicopterus ruber ruber*) in Yucatan, Mexico, was studied from October 1986 through February 1987. Nonbreeding birds were present on their primary wintering area (the Celestun Estuary) in October and increased to peak numbers of 19,895 in January. Total flamingo-use days in the estuary from October through February was 1,334,104. Flamingos were observed for 325 hr during this period, with feeding, resting, and preening combined comprising the major activities of adults (69–88%) and immatures (83–89%). Time spent in courtship activity by adults increased from October (0.2%) to peak in February (21%); courtship activity of immatures was <1% during all months. Time spent in any other activity usually was <10% for both age classes. Habitat conditions in the estuary did not appear threatened, however, the potential for disturbance exists as increasing numbers of tourists are guided upriver to view flamingos.

Key words: Activity patterns; behavior; Caribbean Flamingo; Mexico; nonbreeding; Phoenicopterus ruber ruber; *Yucatan.*

INTRODUCTION

Flamingos (Phoenicopteridae) are among the oldest groups of living birds whose relict populations are found associated with large bodies of saline water in Africa, Asia, Europe, and the Americas (Scott 1975, Ogilvie and Ogilvie 1986). Most populations generally exist in remote areas, and thus were not studied in detail until recently (Morrison 1975). For example, the first extensive studies of flamingo life history were not completed until the 1950s (Gallet 1950, Allen 1956). The remoteness of many colonies has further restricted research efforts because investigators often cannot remain on site for extended periods.

Studies have now addressed all species of flamingos (see Ogilvie and Ogilvie 1986), but nearly all investigations have focused on the breeding portion of the annual cycle. Indeed, of 303 literature citations reported in the symposium entitled Flamingos (Kear and Duplaix-Hall 1975), none specifically addressed the nonbreeding period.

This is significant given the worldwide concerns for flamingo conservation, because events during the nonbreeding season can impact survival and subsequent reproductive performance in birds (Ankney and MacInnes 1978, Raveling 1979). Of particular concern should be the apportionment of time in space (activity patterns) as a baseline for understanding the ecology of flamingos during the nonbreeding portion of the annual cycle.

In Mexico, the population of Caribbean Flamingos (*Phoenicopterus ruber ruber*) on the Yucatan Peninsula constitutes the northernmost mainland flock in the Americas. This population breeds in the Rio Lagartos Estuary on the north coast of Yucatan, and winters primarily on the Celestun Estuary, about 280 km distance on the west coast of the peninsula (Allen 1956, Hernandez and Garcia 1976).

Some aspects of the breeding biology of this population were the focus of the landmark work of Allen (1956), but the population has never been studied during winter. The objectives of this study were to provide information on numbers and migration chronology of the Yucatan fla-

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mingo population on their major wintering area (the Celestun Estuary), to document associated nonbreeding activity patterns, and to relate these data to conservation of flamingos in the estuary.

STUDY AREA

The study was conducted on the Celestun Estuary (Fig. 1), which is situated <1 km inland from the Gulf of Mexico from which it is separated by a barrier of short deciduous thorn thicket (e.g., *Acacia*) and several smaller lagoons that parallel the gulf. The estuary is 24–25 km long, 0.5–2.5 km wide, and approximately 60,000 ha total area, of which about 10,000 ha are open water (Scott and Carbonell 1986). Lower elevations adjacent to the open water of the estuary are dominated by red mangrove (*Rhizophora mangle*), white mangrove (*Laguncularia racemosa*), black mangrove (*Avicennia germinans*), and buttonwood (*Conocarpus erectus*). Widgeongrass (*Ruppia maritima*) and muskgrass (*Chara* spp.) were the dominant aquatic plants in the open water and covered much of the bottom. Salinity of this portion of the estuary ranged from 8.0–24.0 ppt.

The Celestun Estuary was designated a national park refuge in 1979, primarily to protect flamingo habitat. A similar park protects breeding flamingo habitat in the Rio Lagartos Estuary. Study activities were confined to that portion of the estuary north of the bridge connecting the only main highway to the town of Celestun because this area traditionally received the most use by flamingos; about 1,490 ha of open water.

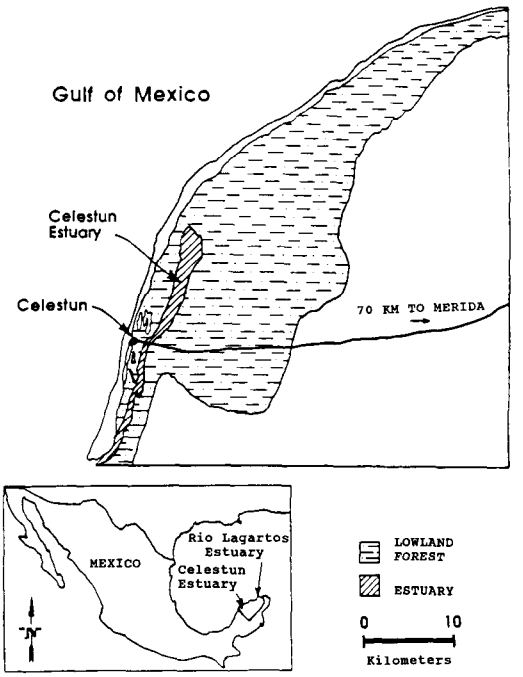

FIGURE 1. Study area map of the Celestun Estuary in Yucatan, Mexico. Location map shows outline of the state of Yucatan.

METHODS

Activity-budget data were collected during diurnal hours (sunrise to sunset) from October 1986 through February 1987. All observations were made using a 15–60× spotting scope within one of five blinds spaced to view the entire estuary. Behaviors were recorded using scan sampling techniques (Altmann 1974) because flock activities of flamingos often are synchronized (Kahl 1975). Thus, the activity of nearly all birds in a flock could be determined, which minimizes potential bias associated with selecting a focal individual for activity-budget sampling (Baldassarre et al. 1988).

Sampling was conducted on three randomly selected days per week with each day divided into four equal time blocks of: (1) early morning; (2) late morning; (3) early afternoon; and (4) late afternoon. Each time period was then divided into equal 30-min blocks from which four were selected randomly. Scan samples stopped at 30 min if the flock was large enough to avoid double counting. However, for flocks that could be scanned in less time (e.g., 5 min) the scan was repeated until approximately 30 min of data were obtained.

Three scans focused on adults and one scan focused on immatures. Activities were categorized as feeding (Rooth 1976), resting, locomotion (flying and walking), preening, comfort, courtship, aggression (Kahl 1975), and alert. Age (adult or immature) was determined based on plumage characteristics (Bent 1926, Allen 1956, Rooth 1965).

Activity patterns were compared among months and time blocks by analysis of variance following arcsine transformation of the nonnormal percentage data (Zar 1974). Duncan's multiple range test separated means where appropriate, and comparisons between adults and immatures were made using *t*-tests. All statistical tests followed procedures in Steel and Torrie (1980).

The flamingo population in the estuary was

TABLE 1. Numbers and use days for nonbreeding Caribbean Flamingos using the Celestun Estuary in Yucatan, Mexico, from October 1986 through February 1987.

Month	Mean number			Use days[a]		
	Adults	Immatures	Total	Adults	Immatures	Total
October			3,500			108,500
November	5,723	514	6,237	171,690	15,420	187,110
December	7,453	3,388	10,841	231,043	105,028	336,071
January	6,516	5,109	11,625	201,996	158,379	360,375
February	7,449	4,767	12,216	208,572	133,476	342,048

[a] Use days per month = mean number of flamingos per month × number days per month.

censused by boat at 14- to 16-day intervals from October 1986 through February 1987. The census was conducted from south to north, thus if the birds were disturbed only those flying south were counted.

RESULTS

NUMBERS AND MIGRATION CHRONOLOGY

Highest use of the Celestun Estuary by nonbreeding Caribbean Flamingos occurred from December through February (10,000–12,000 individuals) with peak use days (360,375) occurring in January (Table 1). The total number of use days from October through February was 1,334,104.

Some flamingos (3,500) were present during the first census on 12 October, but the population increased steadily to peak numbers (19,895) on 5 January 1987. Total numbers declined 83% during the next census on 17 January, but this was attributed to poor census conditions; the census tallied 14,977 by February. Large numbers of flamingos (3,000–7,000) remained in the estuary during March, but no detailed census was conducted.

ACTIVITY BUDGETS

A total of 292 hr and 33 hr was spent observing adult and immature flamingos, respectively. Feeding, resting, and preening combined comprised the major (69–88%) activity of nonbreeding adult flamingos during each month except February (Table 2). Feeding was highest (56–65%; $P < 0.05$) during November and December and lowest ($P < 0.05$) in February whereas there was no difference ($P > 0.05$) among months in time spent preening (16–22%). Resting averaged 5–22% of activity and was highest ($P < 0.05$) in October and February.

Courtship behavior of adults increased ($P < 0.05$) from October through December vs. January and peaked (21%; $P < 0.05$) in February. Corresponding to the peak in courtship were highest levels of alert and aggressive behavior. Flying was constant (5–9%) among months while walking was lowest ($P < 0.05$) in October and November and highest (8–11%; $P < 0.05$) from December through February.

Immature flamingos also spent most time (83–89%) during all months feeding, resting, and preening, however, patterns of behavior were unlike adults (Table 3). For example, although feeding time was lowest for both age classes in February, immatures spent less time feeding than adults during all other months ($P < 0.05$ for November and December).

Resting increased ($P < 0.05$) in January and February and was higher than adults (13–25%; $P < 0.05$) during all months. Overall, time spent

TABLE 2. Percent time spent in each activity by nonbreeding adult Caribbean Flamingos in Yucatan, Mexico, from October 1986 through February 1987.[a]

Month	Number of observation days	Observation time (hr)	Activity								
			Feeding	Resting	Flying	Walking	Preening	Courtship	Comfort	Aggression	Alert
October	15	35.9	43.8^{B}	22.4^{A}	8.7^{A}	0.1^{C}	21.9^{A}	0.2^{C}	1.8^{A}	1.2^{B}	0.1^{C}
November	14	68.7	64.6^{A}	4.5^{C}	5.4^{B}	3.9^{B}	16.4^{A}	0.1^{C}	1.1^{B}	1.3^{B}	2.7^{B}
December	12	53.7	55.6^{A}	$7.4^{B,C}$	4.9^{B}	8.0^{A}	17.8^{A}	0.9^{C}	0.5^{B}	1.4^{B}	3.5^{A}
January	16	77.4	42.2^{B}	10.3^{B}	6.5^{B}	7.0^{A}	16.0^{A}	12.0^{B}	1.0^{B}	1.6^{B}	3.4^{A}
February	11	56.3	19.1^{C}	17.7^{A}	6.4^{B}	10.9^{A}	17.5^{A}	20.8^{A}	1.7^{A}	2.3^{A}	3.6^{A}

[a] Means within a column denoted by the same letter are not different ($P > 0.05$).

TABLE 3. Percent time spent in each activity by nonbreeding immature Caribbean Flamingos in Yucatan, Mexico, from November 1986 through February 1987.[a]

Month	Number of observation days	Observation time (hr)	Activity								
			Feeding	Resting	Flying	Walking	Preening	Courtship	Comfort	Aggression	Alert
November	6	2.7	45.8^{A}	18.4^{B}	1.4^{A}	6.7^{A,B}	23.7^{A}	0.1^{B}	0.5^{B,C}	0.4^{B}	3.2^{A}
December	10	4.8	40.3^{A,B}	22.5^{B}	5.7^{A}	6.9^{A,B}	23.3^{A}	0.1^{B}	0.2^{C}	0.7^{B}	0.6^{A}
January	14	13.4	30.3^{B,C}	34.5^{A}	3.8^{A}	4.8^{B}	24.4^{A}	0.2^{B}	0.8^{B}	0.9^{B}	0.4^{A}
February	10	12.1	22.4^{C}	38.5^{A}	2.8^{A}	9.9^{A}	21.9^{A}	0.6^{A}	1.8^{A}	1.7^{A}	0.4^{A}

[a] Means within a column denoted by the same letter are not different ($P > 0.05$).

feeding by immatures decreased each month while time spent resting increased. As with adults, preening was not different ($P > 0.05$) among months, however, time spent preening by immatures was greater ($P < 0.05$) than adults during January and February.

Courtship activity was low and not different ($P > 0.05$) between immatures and adults in November and December, but time spent in courtship differed greatly ($P < 0.05$) between the age classes during January (0.2 vs. 12%) and February (0.6 vs. 21%). Aggressive behavior always was lower ($P < 0.05$) for immatures as was alert behavior ($P < 0.05$) except during November.

Activity patterns differed little ($P < 0.05$) among time periods of the day for both adults and immatures (Table 4). Immatures did feed less in late morning, however, and rested less in the afternoon, but results were not significant ($P > 0.05$).

DISCUSSION

NUMBERS AND MIGRATION CHRONOLOGY

The census and use day estimates from Celestun demonstrate that the estuary is the major concentration site for Mexico's population of Caribbean Flamingos during the nonbreeding period although Sprunt (1975) reported that nonbreeding flamingos occurred on both the Caribbean and Gulf coasts of the Yucatan Peninsula. The use data from Celestun therefore strongly support designation of the estuary as a national park for the protection of flamingo habitat. This protection on both wintering and breeding areas may be responsible for the increase in the Yucatan flamingo population from 12,100 in 1971 (Sprunt 1975) to 18,420 in 1979 (Hernandez and Garcia 1979) to 26,000 in the mid-1980s (Ogilvie and Ogilvie 1986). Thus, using the mid-1980s estimates, the peak population in the Celestun Estuary in January represented at least 76.5% of the total Yucatan population.

The estuary was not censused in March when large numbers of flamingos were still present, thus the 1,334,104 total use days is a conservative number. Indeed, local fishermen reported that small numbers of flamingos (500–2,000) occur in the estuary from April through September, but the census data demonstrate that major use occurs from December through March. The estuary must be extremely productive to support

TABLE 4. Daily activity patterns (percent time) of nonbreeding adult and immature Caribbean Flamingos in Yucatan, Mexico, from October 1986 through February 1987.[a]

Activity	Time periods							
	Early morning		Late morning		Early afternoon		Late afternoon	
	Adults	Immatures	Adults	Immatures	Adults	Immatures	Adults	Immatures
Feeding	44.1^{A}	34.5^{A}	44.6^{A}	24.2^{A}	46.1^{A}	30.0^{A}	42.4^{A}	32.5^{A}
Resting	11.0^{B}	31.8^{A}	15.1^{A}	40.6^{A}	13.6^{A,B}	29.7^{A}	12.9^{A,B}	23.8^{A}
Flying	6.0^{B}	2.3^{A}	6.0^{B}	3.5^{A}	5.4^{B}	3.7^{A}	8.2^{A}	4.1^{A}
Walking	6.1^{A}	5.4^{A}	5.9^{A}	6.7^{A}	5.8^{A}	7.7^{A}	6.1^{A}	9.4^{A}
Preening	20.9^{A}	24.4^{A}	16.3^{C}	22.4^{A}	17.8^{B,C}	25.2^{A}	19.3^{A,B}	25.4^{A}
Courtship	7.2^{A}	0.2^{A}	6.9^{A}	0.3^{A}	5.5^{A}	0.4^{A}	4.9^{A}	0.2^{A}
Comfort	0.9^{B}	0.4^{B}	0.8^{B}	0.6^{B}	2.0^{A}	2.0^{A}	2.1^{A}	1.8^{A}
Aggression	1.3^{A}	0.9^{A}	1.6^{A}	1.0^{A}	1.5^{A}	1.0^{A}	1.6^{A}	0.9^{A}
Alert	2.6^{A}	0.3^{A}	2.9^{A}	0.8^{A}	2.7^{A}	0.4^{A}	2.5^{A}	1.9^{A}

[a] Within each row, values denoted by the same letter are not different ($P > 0.05$) for adults and immatures, respectively.

a population of this size because flamingos have been estimated to consume about 270 g of food/day or 10% of their body weight (Rooth 1976). Thus, the population in Celestun minimally may consume 360,208 kg of food from October through February (1,334,104 use days × 270 g/day).

ACTIVITY BUDGETS

Feeding usually was the major monthly activity of adults and immatures, which undoubtedly reflects the high effort required to obtain large amounts of small-sized food items. For example, Ogilvie and Ogilvie (1986) calculated that Caribbean Flamingos would need to consume 32,000 brine fly chrysalids (*Ephydra* spp.) per day to meet the estimated 270-g daily food requirement calculated by Rooth (1976). However, immatures spent less time feeding than adults during all months except February ($P < 0.05$ in November and December). The metabolic requirements for growth and development by immatures seemingly would contradict reduced feeding time, but immatures may have compensated for the lower food intake than adults by increasing resting time, which was greater ($P < 0.05$) than adults during all months.

Feeding did not appear affected by variation from wind and tides because feeding effort of both age classes did not differ ($P > 0.05$) throughout the day (Table 4). Caribbean Flamingos probably are not affected by these factors because they feed close to the bottom in the substrate and also were observed "tipping-up" in deep water to feed like puddle ducks. Thus, they are able to exploit a wide variety of feeding niches, some of which are available during any permutation of tide and winds. In contrast other species such as the Lesser Flamingo (*Phoeniconaias minor*) feed on or just below the surface where food availability could be strongly affected by wind and tide (Ogilvie and Ogilvie 1986).

The increase in adult courtship during January and February (12 and 21%, respectively) concurrent with a sharp ($P < 0.05$) decrease in feeding time (particularly during February) implies that adults may acquire some nutrient reserves prior to initiation of reproduction or courtship activities. For example, acquisition of energy reserves prior to breeding is important to several species of geese (Ankney and MacInnes 1978, Raveling 1979), and thus might be expected if flamingos are indeed related to Anseriformes (but see Olson and Feduccia 1980). Conversely, it would be expected that competition for mates in a large flock might be intense given the synchrony of breeding behavior (Kahl 1975), thus reserves may be acquired before initiation of intensive courtship display. The importance of nutrient reserves to reproductive performance of Caribbean Flamingos will require collection of individual birds.

Immatures also decreased feeding time in January and February but showed only a slight increase in courtship behavior (0.2–0.6%). Rather, they increased resting time and often gathered in flocks isolated from adult birds. This could imply that flamingos are depleting food resources in the estuary by the end of winter as suggested by de Boer (1979) for flamingos on Bonaire, but an increased feeding effort would have been expected assuming energy requirements have not changed.

No data on flamingo food habits were collected during the study, but benthic samples contained very few macroscopic food items known to be taken by flamingos (e.g., chironomid larvae). The likely foods may have been the thousands of small (2–4 mm) gastropods that occurred in the muskgrass and widgeongrass beds in the estuary; both food items were eaten by Caribbean Flamingos in Venezuela (de Boer 1979). However, use of these resources would create competition with the large numbers of ducks and American Coots (*Fulica americana*) that used the estuary because gastropods were used heavily by three species of puddle ducks collected during the 1986–1987 and 1987–1988 winters (J. D. Thompson, unpubl. data).

Aggressive behavior increased in both age classes during all months, probably in response to increased courtship activity. Time spent alert also increased for adults after October, which may reflect disturbance by tourists guided upriver to see the flamingos. On many occasions flamingos were disturbed to the point of flight by local guides anxious to impress tourists. Indeed, flamingo tourism was increasing in the estuary whereby it was not uncommon to observe five to six groups per day during December, January, and February. This activity has the potential to interrupt feeding time, and thus may warrant some educational efforts directed at the local fisherman who act as tour guides.

Preening was the second or third most important activity of both age classes during all

months. Detailed molting patterns of wild flamingos are unknown, whereby it is debated whether individuals undergo a flightless period (Ogilvie and Ogilvie 1986). Indeed, de Boer (1979) suggests both a synchronous and asynchronous molt that may vary by age classes. A high preening effort would be expected for immatures, which probably were molting. However, the consistent preening efforts of adults are noteworthy and adult plumage did get brighter as the courtship period (January–February) approached. Regardless, large numbers of feathers indicative of a simultaneous molt from a population of this size never were observed in the Celestun Estuary or during observation from April through August on the breeding grounds in the Rio Lagartos Estuary; flamingos also never were observed flightless.

Overall, data from this study demonstrate that the majority of the Yucatan population of Caribbean Flamingos winters in the Celestun Estuary during which time their dominant activities are feeding, resting, and preening. Presence of the flamingos also provides a source of revenue to local fishermen acting as guides for tourists. However, increased boating activity could adversely affect flamingos by altering their time budgets. Tourist disturbances were greatest from Thursday through Sunday and often exceeded five boats per day; fishermen themselves also were a source of disturbance. Increased understanding of flamingo ecology in the estuary, however, would best be realized by future studies of feeding ecology, body weight, and nutrient reserve dynamics. Otherwise, the estuary appears to require little direct habitat management at this time.

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