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COLONIAL WATERBIRD POPULATIONS IN THE SIAN KA'AN BIOSPHERE RESERVE (QUINTANA ROO, MEXICO)

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ABSTRACT.—This is the first colonial waterbird survey in the Sian Ka'an Biosphere Reserve, the largest wetland ecosystem (ca 350,000 ha) in the Yucatán peninsula. We counted birds at breeding sites and feeding concentrations during aerial and boat surveys in seasons between 1982 and 1988. An annual mean of 1259 pairs of three species of Pelecaniformes and 3118 pairs of nine species of colonial Ciconiiformes were found breeding at 15 locations in the study area. Seasonal variations of the Ciconiiform populations were found to follow the changes in the water levels. For some of the breeding species, populations in the study area were found to be of regional and national importance to the Atlantic and Pacific coasts of Mexico. *Received 27 June 1991, accepted 26 Jan. 1992.*

Wetlands in Mexico have received little attention from ornithologists, although they are known to harbor important populations of waterbirds (Sprunt and Knoder 1980, Saunders and Saunders 1981, Scott and Carbonell 1986). Some of the most extensive coastal wetlands in North and Central America and the Caribbean occur in southeastern Mexico, namely in the Usumacinta-Grijalva Delta on the gulf coast, and in the limestone wetlands that almost entirely surround the flat Yucatán peninsula. This wetland belt around the peninsula has a varying width, up to 25–35 km inland in the central coast of Quintana Roo where the Sian Ka'an reserve lies.

Coastal wetlands in Mexico were periodically censused for wintering ducks and geese, from 1937 to 1964, by the U.S. Fish and Wildlife Service (Saunders and Saunders 1981), but few references were made to Ciconiiformes. Although these birds share their habitat with the waterfowl, their populations do not concentrate at the same time of the year. Other information on colonial waterbirds in southeastern Mexico are from annual aerial censuses carried out from 1971 to 1980 (Sprunt and Knoder 1980, Ogden 1987) on the gulf coast and in the western and northern coasts of the Yucatán peninsula. None of these workers, however, surveyed the Caribbean coastal wetlands in detail due to their great size, limestone ecology with low productivity, and apparently unimportant populations of waterfowl (Saunders and Saunders 1981) and colonial waterbirds (Sprunt and Knoder 1980). Only the Greater Flamingo (*Phoenicopterus ruber*)

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breeding colony in the northern coast of the Yucatán State has been studied in some detail (Espino-Barros and Baldassarre 1989).

Together with the establishment of a large protected area in Quintana Roo, flights and field trips were carried out on these almost unknown wetland systems, and important populations of breeding Ciconiiformes and Pelecaniformes were found. The results of periodic visits to the main breeding colonies and feeding grounds in 1982 through 1988 are presented in this paper. The importance of these populations at regional and national levels is discussed.

STUDY AREA

The study area is the Sian Ka'an Biosphere Reserve in the eastern coast of the Yucatán peninsula (state of Quintana Roo) (Fig. 1). The reserve includes 178,000 ha of coastal marshes, mangroves, inland savannas, 20,000 ha of freshwater lagoons, 180,000 ha brackish coastal lagoons, and two broad shallow bays, Ascensión and Espíritu Santo.

The weather is classified as "Savanna" by García (1964); mean annual precipitation (between 1961 and 1980) was 1150 mm, most of it (72.4%) between June and October. Seasonal flooding affects most of the reserve's surface. Water varies from fresh to marine, depending on distance to the coast and the precipitation input at each different time of the year. The vegetation varies accordingly. Wetlands are covered with grasses such as *Phragmites australis, Typha angustifolia* and especially *Cladium jamaicense* (sawgrass) together with some emergent savanna trees. A description of the vegetation types in the reserve is found in Olmsted et al. (1983).

Eleven hurricanes have hit the coast of Sian Ka'an since 1900 (Jauregui et al. 1980), periodically flooding parts of these lowlands with salt water. In depressed areas, salinity can be high even far from the coast, and they are covered by dwarf red mangrove (*Rhizophora mangle*). These important areas for waterbirds (62,000 ha) are the only remaining surface water during most of the dry season when *Cladium* marshes are dry (Lopez-Ornat 1983a). red mangrove trees, 6 to 10 m high, form a forested fringe around the coastline; mangrove trees of *Rhizophora* and *Avicennia* also cover the numerous small islands emerging from the bays and the coastal lagoons and are the favorite breeding sites for the colonial waterbirds.

METHODS

Wading birds were counted during all months, from 1982 to 1986, both at their breeding sites and dry season feeding concentrations. Pelecaniformes were counted only at breeding aggregations. Counts were made from fixed-wing aircraft and by boat. Breeding colonies, when possible, were photographed from aircraft from a height of 100 m. Ground surveys were then made by boat to identify species and to count the breeding pairs of those species nesting under the canopy. Transect flights were also made during the wet season (non-breeding) and during the dry season to locate feeding concentrations and seasonal changes in habitat use. Each linear transect on the Sian Ka'an wetlands is around 100 km long. We also made flights on the following dates: in 1982, 20 March, 12 July, and 2 December; in 1983, 16 February, 4 May, 30 June, 6 September, and 7 October; in 1984, 9 February and 14 April; in 1985, 4 March and 20 May. All flights were from 07:30 to 09:00, flying at 160 km/h and 100–150 m altitude on fixed transects over the coastal marshes and keys. Additionally, two flights on 11 and 26 April 1986 covered almost the entire wetland surface of the reserve, in search of other previously unknown colonies.

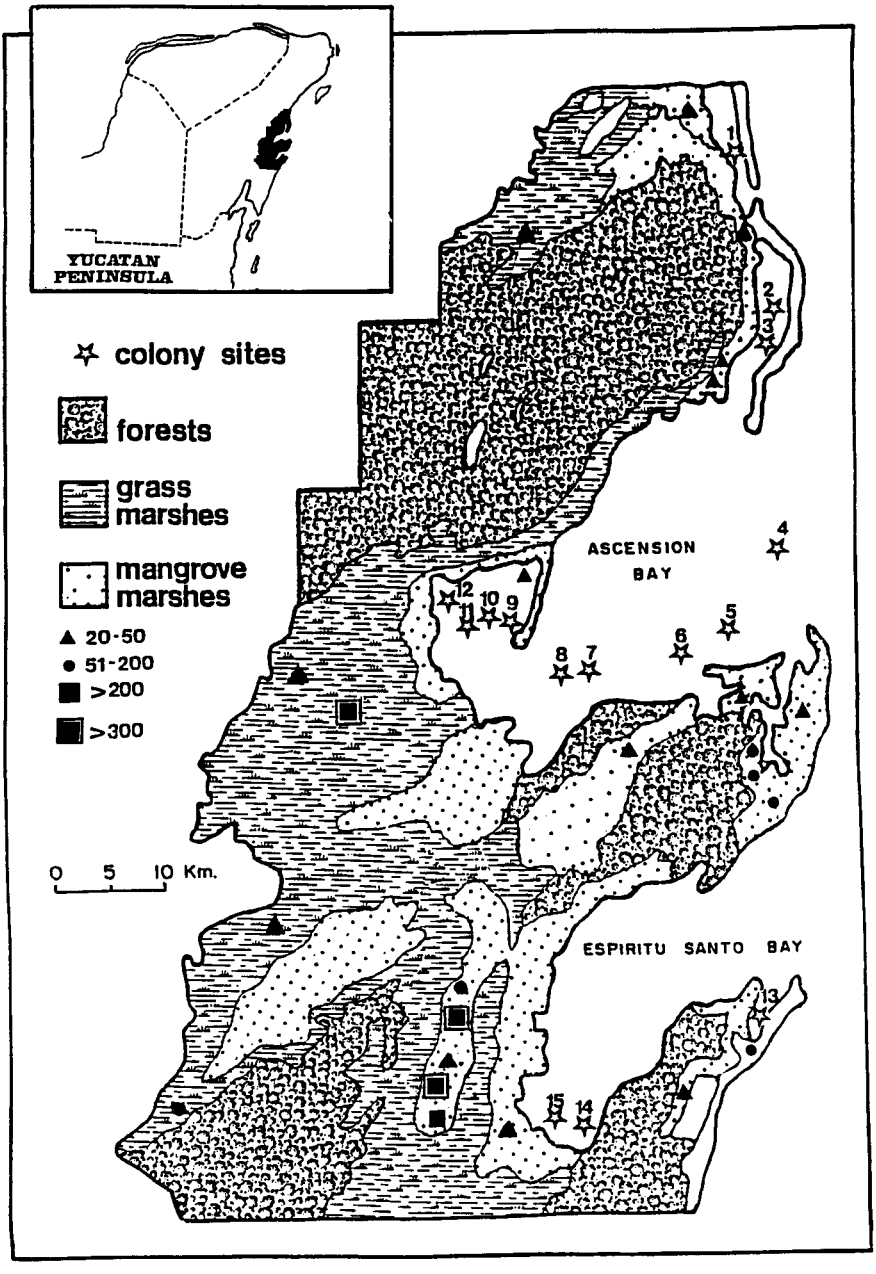

FIG. 1. Map of the Sian Ka'an Biosphere Reserve with vegetation types and locations of colonies and feeding concentrations. Data on concentrations of fewer than 200 individuals are from April 1986. Concentrations higher than 300 individuals are from May 1983.

A small boat, pushed by a pole to prevent noise, was used to check breeding colonies. We entered a colony only when accurate estimates or identification were otherwise impossible. In small colonies, all the active nests were counted. In those with more than ca 100 pairs, the number of adults was estimated by counting all active nests in two 100 m^2 plots (10 × 10 m) and extrapolating densities to the estimated surface of the key occupied by each species. Canopy nests were checked with a mirror attached to the end of a 6-m extensible aluminum pole. Boat trips around Ascensión Bay (localities 1 to 12 in Fig. 1) took place on the following dates: 1982, 22 May, 26 August, and 28 November; 1983, 30 January and 5 June; 1984, 10 April, 15 May, and 24 June; 24 April 1985, 7 June 1987, and 22 April 1988 plus once every 15 days throughout the breeding season (January to July) of 1986. Due to logistic difficulties, localities 13, 14, and 15 were visited only on 4 June 1983, 11 May 1984, and 22 March and 22 May 1986.

To determine the regional importance of the breeding populations in the reserve, we surveyed information available for colonial waterbirds in Mexico, which is detailed only for some areas. For the Pacific coast, we found only local surveys (Vargas 1976, Voelzer et al. 1980, Alvarez del Toro 1980). More information was found for the gulf coast (Sprunt and Knoder 1980, Blankinship 1986, Correa 1987, Ogden 1987) and for the Yucatán peninsula (Brazda et al. 1980, Rogel Baena 1980, Sprunt and Knoder 1980, Blankinship 1986, Espino-Barros and Baldassarre 1989). The Neotropical wetland survey of Scott and Carbonell (1986) provided some complementary information.

RESULTS

Nesting populations.—We regularly encountered six species of Pelecaniformes and 20 species of Ciconiiformes in the study area and 12 total species in breeding colonies. Fifteen breeding colonies were located in the reserve (Fig. 1), nine of which held more than 100 pairs. All colonies were on small islands at distances of 0.5–12 km from the coast.

An estimated mean of 1259 pairs of three species of Pelecaniformes and 3118 pairs of nine species of colonial Ciconiiformes bred in the study area (Table 1). The Magnificent Frigatebird (*Fregata magnificens*) accounted for 70% of pelecaniform nests; the White Ibis (*Eudocimus albus*) and the Woodstork (*Mycteria americana*) accounted for 41% and 23% of all ciconiiforme nests, respectively. Inter-year variations in the number of nests censused for each species in five years were small (Table 1), the standard deviation being of 17% of the mean in Ciconiiformes and 27% in Pelecaniformes. Table 2 shows the number of active nests for each colony and colonial species in the intensive counts during 1986. In 1987 and 1988, the number of breeding Pelecaniformes remained at about 80% of the 1982–1986 mean, while the breeding Ciconiiformes (1988) dropped to 25% of the previous five-year mean (see Discussion).

Only the Magnificent Frigatebird concentrated its nests every year at the same key. Other species used 2–10 different breeding sites each year (Table 3). Some species of colonial wading birds seemed to have a single "preferred" breeding colony, which accounts for about 50% of all nests in any given year. The exceptions to this trend were the Roseate Spoonbill

TABLE 1
NUMBER OF ACTIVE NESTS OF COLONIAL WATERBIRDS IN SIAN KA'AN

Species	1982[a]	1983	1984	1985	1986	1982–1986[b]	1987[a]	1988[a]
Pelecanus occidentalis	25	85	58	32	35	47 ± 24	30	37
Fregata magnificens	700	1000	1130	1000	550	876 ± 241	600	700
Phalacrocorax olivaceus	202	456	416	325	284	336 ± 101	300	267
All Pelecaniformes	927	1541	1604	1357	869	1259 ± 343	930	1004
Ardea herodias	ND[c]	ND	ND	ND	36	—	ND	ND
Casmerodius albus	ND	360	430	ND	437	409 ± 42	ND	45
Egretta thula	ND	162	140	ND	168	157 ± 15	ND	25
E. rufescens	ND	41	48	ND	51	47 ± 5	ND	35
E. tricolor	ND	285	253	ND	226	254 ± 29	ND	36
Cochlearius cochlearius	ND	32	27	36	27	30 ± 4	ND	16
Eudocimus albus	900	1120	1660	895	1465	1208 ± 343	ND	550
Ajaia ajaja	162	150	138	144	182	155 ± 17	ND	110
Mycteria americana	765	740	630	700	548	676 ± 88	ND	33
All Ciconiiformes	—	2890	3326	—	3140	3118 ± 218	—	850
Total pairs	—	4431	4930	—	4009	4456 ± 461	—	1854

[a] Keys 13, 14, and 15 not censused.
[b] Mean ± SD.
[c] ND = birds not censused.

(*Ajaia ajaja*), Great Egret (*Casmerodius albus*), and Snowy Egret (*Egretta thula*), which distributed their nests fairly regularly among 7–10 colonies every year. White Ibis (*Eudocimus albus*) moved from its favorite site after the irregular precipitation of 1986.

Seasonal variations.—Flight counts showed a clear seasonal pattern for the Ciconiiformes. Most of these species were absent from the study area in summer (mid-June to late-September; Fig. 2), while numbers peaked between February and May. Feeding concentrations occurred where water bodies had receded. The first groups (5–20 individuals) were found in inland marshes of sawgrass and *Typha* as water receded in January. The size of these aggregations grew (5–200) in February and March as the dry season progressed. In March and April, feeding groups (20–150 individuals) were frequently found in the mangrove scrub, as this formation dries later than the sawgrass marsh. In May, when chick feeding should be at its highest demand, the peak of the dry season had dried out most of the "dense" mangrove scrub; the last flooded grounds remained in the "scattered" mangrove scrub, where the highest concentrations of wading birds (250–600 individuals) were found at this time of the year (Fig. 1). When the rains began in late May or in June, the wetlands were gradually reflooded. By mid June, all the birds had completed their breeding, and

TABLE 2

NUMBER OF ACTIVE NESTS FOR EACH COLONY AND COLONIAL SPECIES IN THE INTENSIVE COUNTS OF 1986 AT SIAN KA'AN

Species	Colonies														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Pelecanus occidentalis	26	—	—	9	—	—	—	—	—	—	—	—	—	—	—
Phalacrocorax olivaceus	83	—	—	68	100	—	6	7	—	—	—	—	20	—	—
Anhinga anhinga	—	—	—	—	—	—	—	—	—	?	—	—	—	—	—
Fregata magnificens	—	—	—	550	—	—	—	—	—	—	—	—	—	—	—
Ardea herodias	2	2	—	—	30	—	—	1	—	—	—	—	1	—	—
Casmerodius albus	48	—	—	—	1	5	—	50	—	55	11	—	46	80	141
Egreta thula	50	13	—	—	20	1	—	15	—	50	?	—	19	—	—
E. rufescens	2	6	—	—	—	34	—	7	—	?	?	—	2	—	?
E. tricolor	6	16	20	—	100	20	—	26	—	?	—	—	38	—	—
Cochlearius cochlearius	12	3	—	—	4	2	—	—	—	?	—	—	6	—	?
Mycteria americana	—	—	—	—	—	—	—	—	—	376	100	53	—	—	19
Eudocimus albus	—	—	150	—	1255	—	—	—	—	60	—	—	—	—	—
Ajaia ajaja	13	8	—	—	34	20	—	58	14	10	6	—	7	—	12

TABLE 3

EXTREME DATES FOR EGG OBSERVATIONS, TOTAL NUMBER OF BREEDING COLONIES, LOCATION OF THE MAIN COLONIES (SEE FIG. 1), AND ESTIMATED RELATIVE IMPORTANCE OF THE SIAN KA'AN BREEDING POPULATIONS IN ALL OF THE MEXICAN ATLANTIC COAST AND IN ALL OF MEXICO

	Number of breeding colonies	Main colonies at keys num.	Extreme dates for egg observations	Percent population of	
				Atlantic Coast	All México
Phalacrocorax auritus	6	4, 5	18 Jan.–24 Aug.	ND	ND
Fregata magnificens	1	4	11 Nov.–4 May	10–12	ND
Pelecanus occidentalis	5	4	17 Jan.–21 May	20	15
Ardea h. occidentalis	3	1, 5	3 Dec.–5 May	100?	100?
Casmerodius albus	8	14, 15	3 March–14 Apr.	2	ND
Egretta thula	8	1, 10	3 Apr.–18 May	2	ND
E. rufescens	8	6	3 Dec.–6 June	25	15
E. tricolor	8	5	2 March–23 June	5	ND
Cochlearius cochlearius	6	1	5 Jan.–15 Apr.	ND	ND
Jabiru mycteria	—	—	13 Jan.–18 Feb.	20	20
Mycteria americana	4	9, 10	25 Feb.–19 Apr.	5	5
Eudocimus albus	4	8	3 Apr.–7 June	20	20
Ajaia ajaja	10	8, 15	18 Jan.–18 Apr.	20	10

both adults and immatures soon left the reserve. From July to October, only scattered Ciconiiformes were found, accounting for 0–10% of the populations censused during the breeding season (Fig. 2). Immature Wood Storks, White Ibises, and Roseate Spoonbills were found in small roosts in open fields far from the coast in summer.

Breeding species accounts: status, seasonality and regional importance of populations.—The timing, location, and size of breeding of Sian Ka'an colonial breeders is shown in Table 3 and the following species accounts:

Olivaceus Cormorant (*Phalacrocorax olivaceus*).—Nests were located at least on six keys, sometimes scattered along the mangrove fringes. There are no surveys on this species for the Atlantic coasts of Mexico.

Magnificent Frigatebird.—Extreme dates for males observed with extended red pouch are 14 October and 4 May. Feathered young were still in the nests by late October. Frigatebirds were seen scavenging over other colonies where Ciconiiformes bred (see Gibbs and Gibbs 1987, Mora 1989). In Mexico, 500–1000 pairs are reported for the mid and south Pacific coast (Scott and Carbonell 1986) and ca 3000 pairs for the Atlantic coast, all of them at small islands around the Yucatán peninsula (Rogel Baena 1980, Sprunt and Knoder 1980). The Sian Ka'an population would then harbor at least 20% of all the Atlantic coast population.

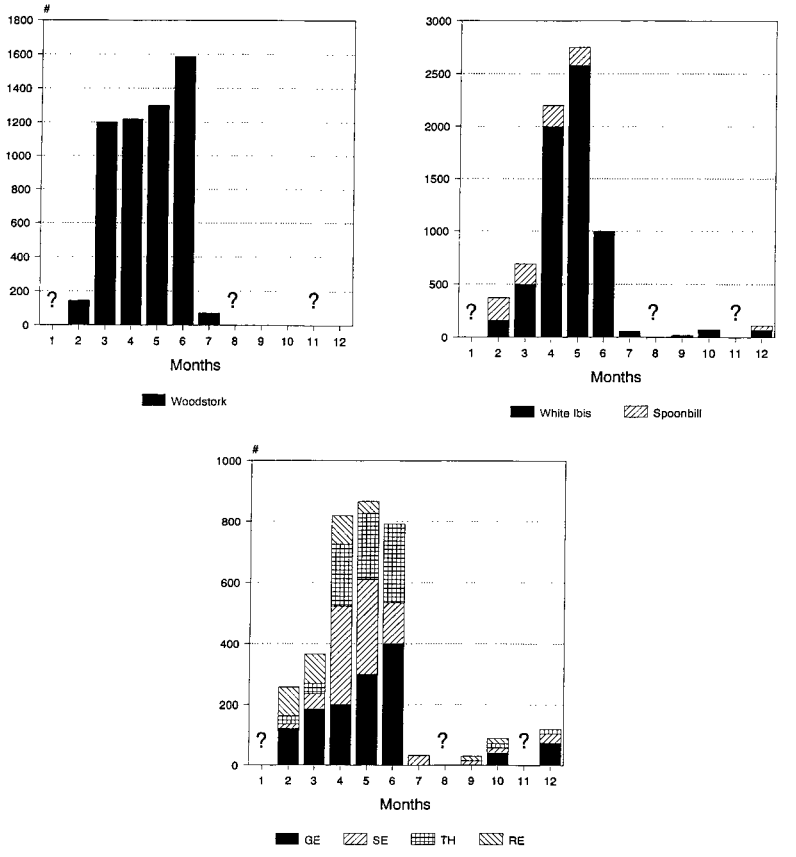

FIG. 2. Indicators of seasonal variations in the number of individuals of seven Ciconiiform species in Sian Ka'an. Combined data of 1983 thru 1986 aerial censuses. (RE = Reddish Egret; TH = Tricolored Heron; SE = Snowy Egret; GE = Great Egret.) Months of January, August, and November were not censused by aircraft in any year. Months from February through June were censused more than once.

Brown Pelican (*Pelecanus occidentalis*).—Brown Pelicans have recovered in their Texas breeding grounds from 10 nesting pairs in the early 1970s to 300 nesting pairs in 1986. In Mexico, however, a contrary trend brought down the population of breeding pairs in the Atlantic coasts from 910 in 1980 to 428 in 1986, the possible causes being human disturbance, ticks and disease, and chemical pollution (Blankinship 1986). The Sian Ka'an breeding population would then be 10–12% of that in all the Mexican Atlantic coasts.

Great Blue Heron (*Ardea herodias*).—The feeding population dropped

to about one third in summer. In Sian Ka'an, this species presents three different color phases which are considered to belong to the same species (Meyerriecks 1957). The white phase (*A. h. occidentalis*) in Florida favors marine environments as compared to the dark one (Mayr 1956, Meyerriecks 1957), and so does the intermediate morph (*A. h. würdemanni*). In Sian Ka'an, coastal-marsh boat surveys reveal that 65% of the Great Blue Herons are dark, 25% intermediate and 10% white, while in marine environments (outer keys), white birds constitute 50% and dark birds 30% of all the individuals counted. Monitoring over 13 nests of the species in 1986, containing one to three young each, revealed that eight nests had dark young, 4 had only white young and one nest in key 5 had one dark and one white young. The highest density of *A. h. occidentalis* is found in Florida Bay (Robertson and Kushlan 1974) (2500 individuals), where populations seemed stable (Ogden 1978), although reproductive success has recently declined (Powell et al. 1989). The species is also present in small numbers in some Caribbean islands (Meyer de Schauensee and Phelps 1978). The five nests reported here are the first known in Mexico for this subspecies.

Great Egret.—Roosts of up to 200 birds were found in July, away from the breeding grounds. Scattered individuals (ca 10–25% of total breeding population) could still be found in inland marshes during the rainy season (July to October). By late October, Great Egrets started coming back into the area, and by December they formed the first important feeding concentrations in the inland marshes.

Snowy Egret.—Postbreeding dispersal in July, and other patterns in the repopulation of the area during the fall, were similar to those of the Great Egret. Based on current literature, the Sian Ka'an populations of these two species would represent only 2% of the population of Mexico. Both Snowy and Great egrets have their main populations in the Usumacinta Delta.

Reddish Egret (*Egretta rufescens*).—Both known color phases were present. Seventeen nests monitored in 1986 (1 to 3 chicks each) had 24 dark and 11 white chicks. Two of these nests had one dark chick and one or two white ones at a time. The species was almost absent during the summer. In the United States, this species was close to extinction due to feather collectors in the early part of this century and to high pesticide concentration in the mid century (Paul 1977), but populations were stable around 2000 pairs thereafter (Portnoy 1978, Ogden 1978). The whole Mexican population is estimated at 300–400 pairs. Sian Ka'an harbors 15–20% of these, second in importance only to the Holbox coast (about 130 pairs) in northern Q. Roo and the Mar Muerto in Chiapas (about 70 pairs) according to Alvarez del Toro (1980).

Tricolored Heron (*Egretta tricolor*).—Around 20% of the individuals remained in the area during the summer, especially in salt water.

Wood Stork.—The first adults were seen in early November, and numbers grew until breeding activities started around mid-February. It bred only on the most secluded keys. The number of pairs showed small annual variations, with extremes of 550 and 765 active nests per year. All birds left the area in mid-June, although in dry years, small groups were found feeding until mid-July. All chicks died in 1986, due to a premature and heavy rainfall in May, which flooded all habitats, dispersing the prey (Ramo and Busto, unpubl. data). Only 33 nests were counted in 1988. This is an endangered species in the United States (U.S. Fish and Wildlife Service 1984), very sensitive to habitat destruction and water drainage (Kushlan 1981, Frederick and Collopy 1989). 12,000 pairs of this species breed in Mexico, 65% of them in the Usumacinta Delta region (Ogden 1987), which by far constitutes the greatest concentration in Central and North America. Sian Ka'an is the next area in importance for this species in the Atlantic coasts of Mexico.

White Ibis.—The White Ibis was the most abundant colonial waterbird in the reserve. In different years, 900 to 1600 nests were active from April to June. Key 5 contained 80% of the nests. An estimated 10% of these birds stayed in the area during the summer; other than this, their seasonal pattern was similar to that of the Wood Stork. After the 1986 chick mortality, the main colony in key 5 was deserted during the 1987 and 1988 breeding seasons. In 1987, only 150 nests were found (key 6) and in 1988, 500 pairs were again breeding, mostly in the keys previously occupied by Wood Storks (10 and 11). Around 9000 pairs of the White Ibis have been censused in Mexico, roughly half of them in the Usumacinta Delta region. Our study area is the second area in importance for this species in the country.

Roseate Spoonbill.—Between January and May, active nests were found in small numbers at almost every colony. Almost no birds were found from June to September, and in October groups of 5–10 roost or feed with other Ciconiiformes in the mangrove scrubs and shallow coasts. Greater aggregations (15–30 and up to 60) were found from November on. After the breeding depression in 1986, no apparent negative impact was noticed in the species' breeding numbers. Along the coasts of Mexico, 4000 individuals of this distinctive species have been surveyed, one third at the Usumacinta Delta region, and another third in the Pacific coasts of Nayarit. About 10% have been found breeding at Sian Ka'an.

Other species.—Groups of up to 150 Greater Flamingos (*Phoenicopterus ruber*) were found every winter (extreme dates 7 October and 22 May) in areas located close to keys 1, 9 and 14. They breed in April–August at

Rio Lagartos in the northern Yucatán coast, ca 400 km away from the Sian Ka'an wintering grounds.

Only a few pairs of Anhingas (*Anhinga anhinga*) have been found in inland water bodies. The Brown Booby (*Sula leucogaster*) was also scarce; only four to 12 immatures were found every year in key 4 between April and August; Double-crested Cormorant (*Phalacrocorax auritus*) was seen in small numbers (3 to 7) in February and March.

Yellow-crowned Night-Herons (*Nycticorax violaceus*) and Black-crowned Night-Herons (*N. nycticorax*) probably also breed in small numbers in mixed heronries in Sian Ka'an, as immatures and adults were seen in several mangrove stands.

Cattle Egrets (*Bubulcus ibis*) were found inland at cattle ranches and dumps. We have not found any nests in Sian Ka'an. Noteworthy migratory movements were registered northwards in April–May and southwards in October; the birds flew close to the coast in groups of 30–200, adding up to more than 1000 birds most of the days. Extreme dates for northward movements in Puerto Morelos were 12 April and 9 June, and for southward movements 27 September and 30 October. Both in April and November, we found roosts of 30–200 birds at different keys and coastal localities in Sian Ka'an.

Little Blue Herons (*Egretta caerulea*) were found in small numbers feeding with other Ardeidae at any time of the year, except in May and June when they were absent. The winter population estimate is of 100–200 birds. The average for twelve boat transects in winter months was of 75% adults and 25% immatures (86:29). Small migratory groups (3–15 individuals) followed the same routes and dates as Cattle Egrets, although in much smaller numbers and with an irregular schedule.

Two non-colonial breeding species have been observed: two Bare-throated Tiger-Heron (*Tigrisoma mexicanum*) nests with eggs in late March and one Jabiru (*Jabiru mycteria*) nest with two eggs (Lopez-Ornat et al. 1989). The latter species is noteworthy as one of the only four nests known for Mexico (Correa 1987) is found in the Sian Ka'an reserve, where up to five different individuals have been regularly seen between extreme dates of 22 November and 10 April. The Mexican lowlands constitute the Northern geographic limit for this always uncommon bird. 202 individuals were found at Los Llanos in Venezuela (Ramo and Busto 1984), only 127 individuals and 17 nests in Central America (Luthin 1984). Since 1987, this is the only wading bird species protected by law in Mexico.

Other Ciconiiformes present were Least Bittern (*Ixobrychus exilis*) and Pinnated Bittern (*Botarus pinnatus*), both apparently uncommon, and Green-backed Heron (*Butorides striatus*) a common solitary species, all three found throughout the year. Glossy Ibises (*Plegadis falcinellus*) were

found four times at two locations in groups of one to three individuals between 6 March and 24 May. No censusing of these species has been done in Mexico.

DISCUSSION

Seasonal variations.—Seasonality in the populations of Ciconiiformes follows the changes in prey availability with the receding water levels in the marshes, as was found in Florida (Kahl 1964, Kushlan et al. 1985, Frederick and Collopy 1989).

In May 1986, a very heavy early rain flooded all the lowlands of Sian Ka'an. Adult Wood Storks were forced out of the region, leaving more than 1000 feathered chicks to starve. Although these colonies could not be reached in 1987, only 33 Wood Stork pairs were counted in 1988. The negative impact of 1986's premature rains on the Ciconiiformes was severe on all species with late breeding (Wood Stork, Great Egret, Snowy Egret, and probably White Ibis); these same species were also negatively affected by early rains in Florida (Kushlan 1978a, Frederick and Collopy 1989). Early breeders like Roseate Spoonbill and Reddish Egret did not show a breeding population decrease in 1988. The latter species do not depend as strongly on inland water conditions, feeding mainly in the marine and brackish shallows. Ogden (1978) suggested that this fact has helped both species to maintain their populations in the southern Florida environments which are threatened by dessication of inland water bodies by human development.

Because the Pelecaniformes are not dependent on the flooding regimes in the marshes, they were found breeding at all times of the year; these species were apparently not affected by the 1986 anomalies. Lower breeding activity during the summer and early fall may be a consequence of the periodical occurrence of tropical storms and hurricanes at this time of the year.

Importance of the populations.—As compared to the Usumacinta Delta region, the density of Ciconiiformes breeding in Sian Ka'an is much lower. Primary productivity in limestone wetlands should be lower than in nutrient-rich deltaic ecosystems. Nevertheless, the extent and variety of wetland ecosystems in the study area allow for significant populations to breed.

The study area has both a regional and national importance for the conservation of colonial waterbirds. For a majority of the Ciconiiformes treated here, the wetlands protected in the Sian Ka'an reserve contain the most important breeding populations in the Yucatán peninsula. Within all of the Atlantic coastal wetlands of Mexico (gulf and Caribbean), the study area still harbors one-eighth to one-fourth of all the known breeding

pairs of species such as the Magnificent Frigatebird, Brown Pelican, Reddish Egret, Jabiru, White Ibis, Roseate Spoonbill, and possibly the Wood Stork, and contains all the known nests of the Great White Heron in Mexico.

Colonial waterbirds in Sian Ka'an are likely to maintain their present population levels in the long term, provided disturbances are kept as low as to date. The area is dotted by dozens of isolated keys that could be potentially used for breeding purposes; it also includes a broad array of diverse wetland systems which should provide feeding grounds in most seasonal circumstances, except perhaps when rains are premature and heavy. Natural events such as the latter take place periodically, but populations are likely to recover (Frederick and Collopy 1989) as long as the general ecological conditions do not change.

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