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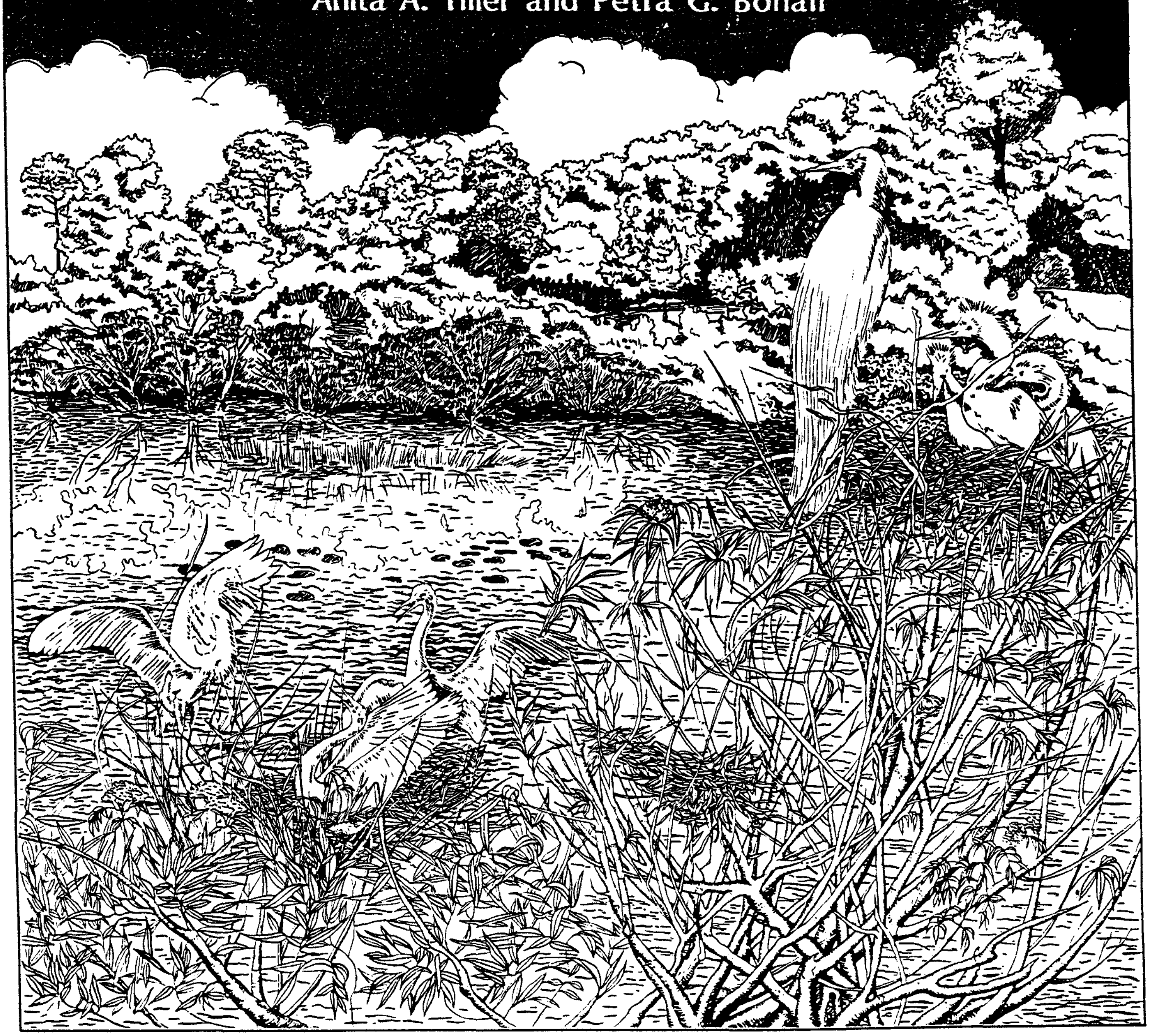

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TECHNICAL REPORT NO. 7

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ABSTRACT

During 1983 and 1984 the effect of low level military training flights on the establishment, size and reproductive success of wading bird colonies was studied in Florida. Based on the indirect evidence of colony distributions and turnover rates in relation to military areas (training routes designated to 500 feet or less above ground level and military operations areas), there was no demonstrated effect of military activity on wading bird colony establishment or size on a statewide basis. Colony distributions were random with respect to military areas and turnover rates were within 2% when military and non-military areas were compared. Colony distributions and turnover rates, however, were related to the amount and type (estuarine or freshwater) of wetland, respectively.

During two breeding seasons the behavioral responses and reproductive success of selected species were monitored in a non-habituated treatment colony (military overflights) and a control colony (no overflights). Breeding wading birds responded to F-16 overflights at 420 knots indicated airspeed, 82-84% maximum rpm, 500 feet above ground level and sound levels ranging from 55-100 dBA by exhibiting no response, looking up or changing position (usually to an alert posture): no productivity limiting responses were observed. High-nesting Great Egrets responded more than other species, nestling Great Egrets and Cattle Egrets responded significantly ($\underline{P}$ <.05) more intensely than adults of their respective species, and adults responded less during incubation and late chick-rearing than at other times. In addition, no differences in adult attendance, aggressive interactions or chick feeding rates were observed to result from F-16

overflights. No evidence of habituation to overflights was noted. Humans entering the colony or airboats approaching the colony vicinity elicited the most severe responses (flushing and panic flights) observed at both sites.

Since relatively little coastal military activity occurs at low levels (≤500 ft) and only one Brown Pelican colony (5-6% of the breeding population) was located in such an area, the reproductive success of five, more "exposed" study species (Great Egrets, Snowy Egrets, Tricolored Herons, Little Blue Herons, Cattle Egrets) nesting in interior freshwater colonies was studied. Reproductive activity including such factors as nest success, nestling survival, nestling mortality, and nesting chronology was independent of F-16 overflights but related to ecological factors including colony location, colony characteristics and climatology. The responses to and effects of F-16 overflights, as reported here, should not be considered representative of military aircraft at lower altitudes or greater noise levels.

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INTRODUCTION

The study of noise effects on domesticated and free-ranging animals had its advent in the early 1970's subsequent to an EPA report (EPA 1971) which identified noise as a relatively non-investigated, environmental influence (Fletcher 1978). Though most investigations have been conducted with humans and laboratory animals, results suggest that the sound environment may elicit behavioral and physiological responses which could affect the well-being of other species (Bond 1971). Generally speaking, studies of the effects of aircraft-generated, environmental sound levels on non-laboratory animals may be categorized by subject (domestic versus wild populations) and stimuli (sounds produced by aircraft flying at subsonic or supersonic speeds). Sounds derived from subsonic sources have relatively slow rise or onset times, are of a continuous or intermittent duration and are typically measured in decibels (loss in power in 1 mile of standard cable at 860 cycles) at the peak noise level. Sonic booms produced by supersonic aircraft or simulated sources have short rise times (1-10 milliseconds), are instantaneous (signal intervals or duration of 50-300 milliseconds) and are measured as overpressures (newtons/square meter or pounds/square foot) above atmospheric pressure. This increased pressure results from high energy sound waves produced at the wings, tail and fuselage of the aircraft. These waves cannot escape since the plane's speed exceeds their speed and a resulting cone-shaped shock wave, the sonic boom, trails the aircraft.

Investigations of sonic boom effects on non-laboratory species have been conducted under a variety of experimental conditions, however, some general trends are noteworthy. Sonic booms have been found to have little effect on the behavior (Casady and Lehmann 1967 in Cottereau 1978, Hubbard 1968) or reproductive output (Travis et al. 1968 in Bond 1971) of selected domestic and wild mammalian species, however, species differences in reaction (i.e. horses responded more than other species) have been reported (Cottereau 1978). Domesticated birds have exhibited mild startle responses followed by inurement to sonic booms (Cottereau 1978) with no significant changes in onset of laying, egg production, hatching success, growth rates, feed conversion or mortality (Heinemann 1969, Teer and Truett 1973 in Cottereau 1978, Cottereau 1978, Cogger and Zegarra 1980). Results from wild avian species are more variable and range from non-productivity limiting, alert reactions in turkeys, raptors and seabirds (Lynch and Speake 1978, Schreiber and Schreiber 1980, Ellis 1981) to a mass hatching failure in Sooty Terns (Sterna fuscata) (Robertson 1970).

The effects of environmental noise from subsonic aircraft flights and similar auditory stimuli also have been studied under a range of experimental conditions with varied results. Ames (1978) found initial heart and respiration rate increases and subsequent growth rate and thyroxine decreases in domestic sheep subjected to continual noise levels of 75-100 dB over 12 days. Laying hens subjected to 75 aircraft overflights at 85-140 dB exhibited "alert" reactions and flock shifting but there was no evidence of altered egg production, weight gains, feed efficiency or flock mortality (Heinemann 1969).

Aircraft sounds of 96 dB inside an incubator and 131 dB outside caused no damaging effects to eggs, however, sounds of 115 dB did interrupt hen setting tendencies (Stadelman 1957). Hamm (1967) reported that single short stresses of aircraft noise did not affect production in laying hens but that extended periods (>3 days) of maneuvers interrupted hen activities and reduced production. Selected raptor and wading bird species have been reported to respond minimally to jet (100-110 dBA) and prop plane (92 dBA) overflights, respectively, (Ellis 1981, Grubb 1978); however, Herring Gulls (*Larus argentatus*) significantly increased their aggressive interactions within the colony and their flights over the colony during SST (101-116 dBA) overflights (Burger 1981).

Reactions of colonially breeding birds to sonic booms and aircraft overflights, though variable, are among the most adverse of those reported. The potential for disturbances impacting substantial segments of regional or statewide populations is enhanced in these species, since breeding activity is concentrated at specific localities. This is especially true in the case of endangered species (e.g. Brown Pelican, *Pelecanus occidentalis*, and Wood Storks, *Mycteria americana*) with already reduced population levels.

Florida is an appropriate setting for testing the possible effects of low level military flight activity on colonially breeding wading bird species since the state has widespread military airspace and numerous wading bird colonies. Military airspace incorporates both Military Operation Areas (MOAs) and military training routes (VRs - visual routes, IRs- instrument routes and SRs - slow speed routes). In Florida, the Military Training Route (MTR) program began in 1977 as the sequent to the LAHSTR (low-altitude high-speed training route) system, a complex of training routes used for at least a decade prior to redesignation in 1977. Under the MTR system, the Federal Aviation Administration has issued a waiver to the Department of Defense to permit the operation of aircraft below 10,000 feet mean sea level in excess of 250 knots indicated airspeed along DOD/FAA mutually developed routes (Fig. 1). These routes accommodate subsonic sorties by aircrews in numerous phases of training for tactical air warfare including low-level high-speed navigation, terrain following, and air-to-ground weapons delivery. The objective of such training is proficiency in accessing target areas in high performance aircraft at low altitudes to avoid enemy detection systems.

Based on the most recent statewide surveys conducted from 1976-78 (Nesbitt et al. 1982), 74 wading bird colonies were located in military operations areas or on military training routes designated for use at 500 ft or less above ground level (hereafter referred to as military areas or active military areas). Twenty-three colonies were found in MOA's and 51 on training routes (Appendix 1): 14.8% (35 of 237) of coastal county colonies were located in active military areas whereas 38.2% (39 of 102) of interior county colonies were located in such areas (Fig. 2). These 74 colonies comprised 21.8% of the state's total 339 colonies and over 3 years supported an average of 65,046 nesting pairs of various species (Appendix 2). What impact military activity has on the establishment and size of such colonies and reproductive success within such colonies is the focus of this report.

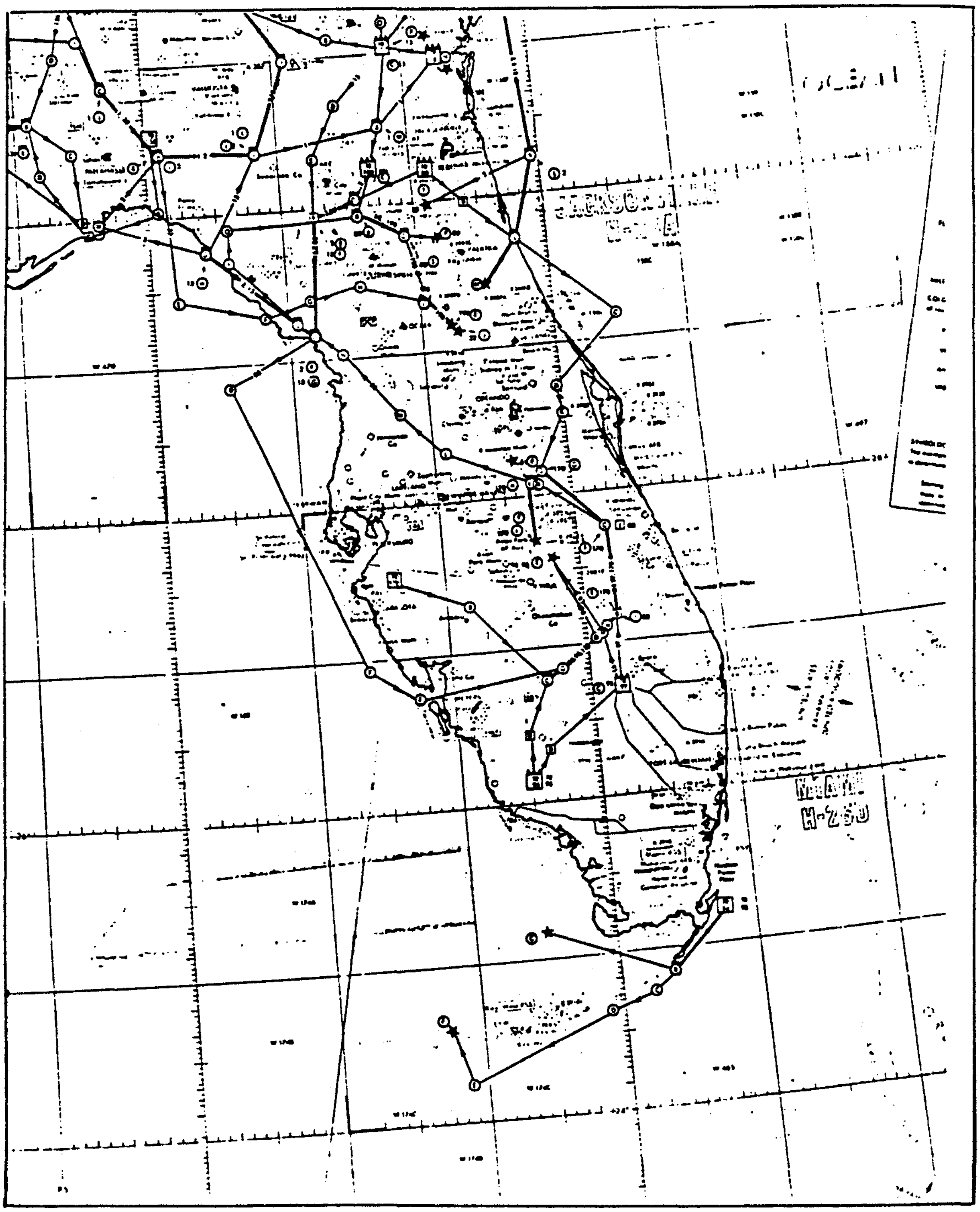


Figure 1. Military training route (MTR) system in Florida from 1976 to 1978.

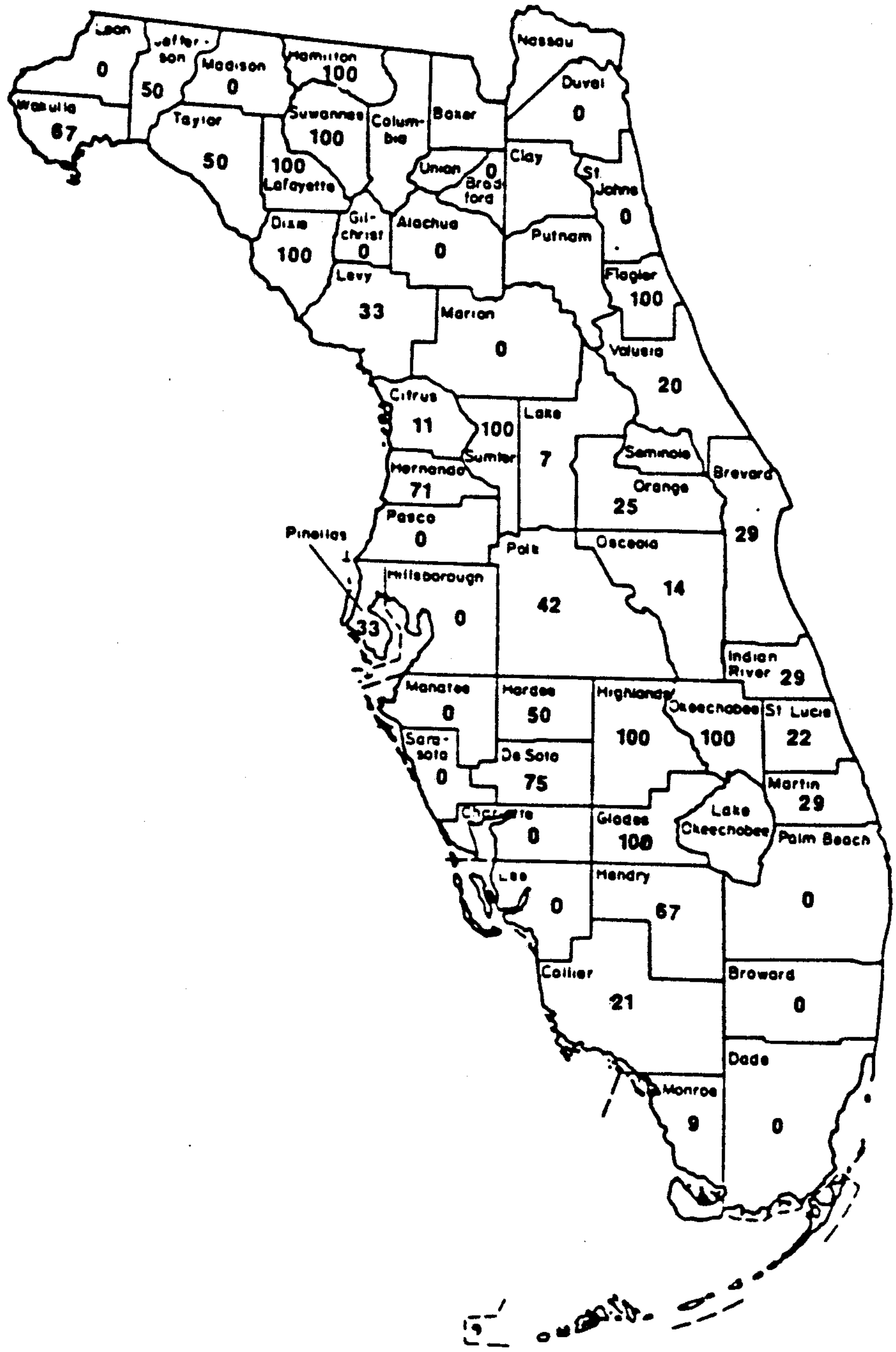


Figure 2. Percentage of wading bird colonies in U.S. Air Force military operations areas or low flight training routes (≤500 AGL) in coastal and interior counties in Florida. Counties with missing values had no colonies (Nesbitt et al. 1982).

OBJECTIVES

1. To determine if wading birds establish colonies independent of the presence or absence of jet overflight areas.
2. To determine if colony size is influenced by the presence or absence of low altitude training flights.
3. To determine if the reproductive success of species such as Brown Pelicans and wading birds is significantly reduced as a result of low altitude training flights.

MATERIALS AND METHODS

Data for the first and second objectives were drawn from existing records of military activity and of colony location and size. Available published information was inadequate to thoroughly address the third objective, thus, field research was carried out during the spring of 1983 and 1984 to collect relevant data. The specifics of methodology are presented in this report as the individual objectives are discussed.

IMPACT OF LOW ALTITUDE MILITARY TRAINING FLIGHTS ON THE ESTABLISHMENT AND SIZE OF WADING BIRD COLONIES

Introduction

Factors affecting the establishment and size of wading bird colonies are multi-dimensional, species variable, neither readily apparent nor well understood. However, the composite findings of individual investigators are facilitating the identification of influential factors. Colonies may become active at novel sites (Jenni 1969, Milstein and Jacka 1970, Kushlan 1976), remain active annually for many years at well established sites (Baynard 1912, Jenni 1969, Waterman et al. 1971) or be intermittently active and empty over several years (ffrench and Haverschmidt 1970, Nesbitt et al. 1982). Colonies have been established at sites used formerly as roosting sites (Kushlan 1976) or nesting sites (Nesbitt et al. 1982) and at sites that are temporarily suitable because of unusual conditions (Milstein and Jacka 1970). For differing species the onset of breeding has been associated with rain and wet conditions (Lowe-McConnell 1967, ffrench and Haverschmidt 1970, Siegfried 1971, Ogden et al. 1980) or with drying conditions (Kushlan 1976, 1978, 1979a, Kushlan et al. 1975) and may be influenced by temperature (Ogden et al. 1980). Ogden et al. (1980) reported that each of five species in Florida showed different nesting responses to yearly differences in rainfall patterns.

Colony movements and shifts may occur for unexplained reasons (ffrench and Haverschmidt 1970), with the alteration or destruction of nesting habitat (Kerns and Howe 1967, Vermeer 1969, Grant 1971, Wiese 1978a) from physical and chemical site changes caused by previous nesters (Kerns and Howe 1967, Weseloh and Brown 1971, Wiese 1978a) and with changes in water levels (Moseley 1936, Cypert 1958, Ryder 1967, Waterman et al. 1971, Kushlan 1976) that affect both nesting site availability and feeding conditions (Kushlan 1978, Ogden et al. 1980). Colony abandonment has been reported under drought conditions (Dusi and Dusi 1968, Ogden et al. 1980) and may result also from excessive disturbance at critical nesting phases.

Colony size is under multiple influences since within a colony species may respond differently to physical, temporal, spatial (McCrimmon 1978) and social (Burger 1978) variables. As suggested by McCrimmon (1978) "nest site availability and food availability may ultimately act together to determine the size of a population available for breeding and which members of the population actually do breed." Kushlan (1979a) suggested that given stable nesting habitat the condition and location of food resources is the most important factor in colony site dynamics.

Given the complexity and the limitations of the current understanding of factors governing colony establishment and size, we have elected to evaluate the effect of military activity on these parameters indirectly by analyzing colony distributions (evidence of previous establishments) and colony turnover rates (evidence of establishment, stability and abandonment) comparing military and non-military areas in Florida.

Material and Methods

Colony data for both the first and second objectives are from the "1976-78 Florida Atlas of Breeding Sites for Herons and Their Allies" (Nesbitt et al. 1982). Only military areas active during that period are considered in analyses, however, current (DOD 1982, USDC 1981a, USDC 1981b) rather than former designations are used in discussion for easier reference presently and in the future. In the analyses, colony distributions were compared to random distributions based on the proportion of land area being considered. Land area under military activity was estimated for each county by calculating the area (width by segment length (DOD 1977, McCauley and Westcott 1977)) of non-overlapping routes with minimum altitudes of 500 feet or less above ground level and by computer planimetry for military operations areas. County land areas (Terhune 1982) were grouped as coastal (one boundary on the Gulf or Atlantic) or interior and into NE, NW, SE, AND SW regions (Fig. 3). To coincide with the area of the wading bird survey, only counties east of the Ochlockonee River are considered in this study. For discussion purposes, the term "statewide" refers to the study area whereas "peninsular" refers to the study area minus Florida Bay and the Florida Keys. In reviewing the National Wetlands Reconnaisance Survey for Florida (USFWS 1982), it was apparent that a fairly uniform intergrade of wetlands and non-wetlands exists in the state except for a predominance of wetlands in the SW region and three large areas of extensive (>200 sq. mi.) uplands in the NE, NW, and SE. The areas of these uplands were deleted from analyses of colony distribution in relation to military area since they could not be considered to potentially contain suitable wading bird nesting habitat and would skew calculations of the expected values. These upland areas were included in analyses of colony distribution in relation to wetlands.

Colonies were classified by type of wetland, species, and size. The type of wetland (marine, estuarine, freshwater) is that designated for the site by the National Wetlands Reconnaisance Survey for Florida (USFWS 1982). The "most numerous species" is that species which is most numerous when counts are averaged over all survey years. Colony size refers to the average number of breeding pairs of all species

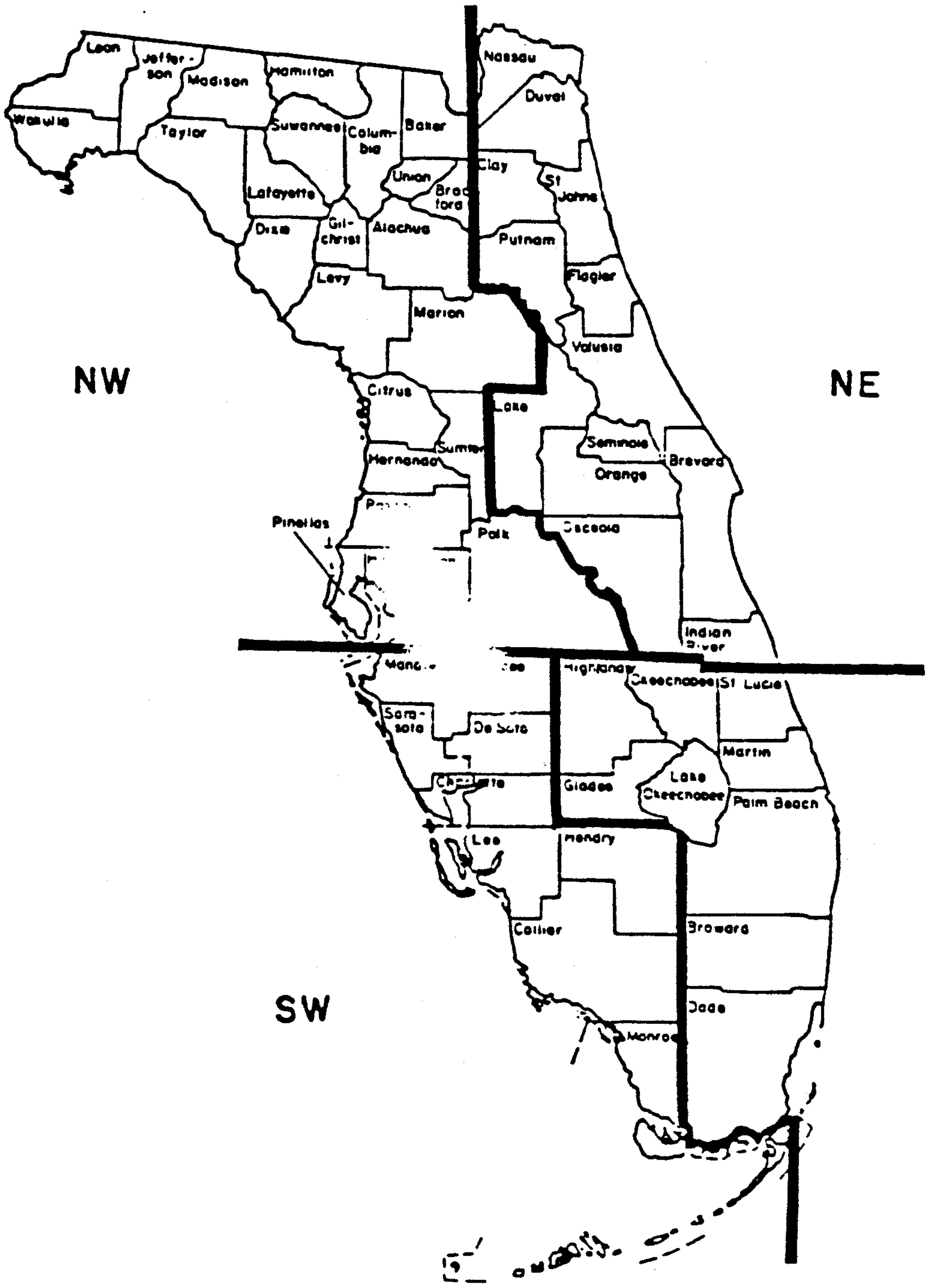


Figure 3. Counties and regions of the state included in the study.

over all survey years: size I >500 breeding pairs, size II = 101-500 breeding pairs and size III $\leq$100 breeding pairs. For example, a colony with 200, 600 and 300 breeding pairs in three survey years would be categorized as a size II (avg. 367 breeding pairs) colony.

The distributions of colonies, military areas, and wetlands (USFWS 1984) were described; and, where appropriate, comparisons were made using a Chi-square goodness of fit or contingency test (Steel and Torrie 1960). The significance level was set at $P < 0.01$ because of the number of comparisons being made on the same relationships.

Colony turnover rates for wading birds in general were calculated for colonies censused in all survey years using the following derivation of the species turnover rate formula (MacArthur and Wilson 1967, Diamond and May 1977) as adapted by Erwin (1978) and Erwin et al. (1981) and used recently by McCrimmon and Parnell (1983):

$$T = \frac{1}{2}\left(\frac{S_1}{N_1} + \frac{S_2}{N_2}\right)$$

where T = turnover rate per year
S_1 = number of sites used only at first census
N_1 = total sites, first census
S_2 = number of sites used only at second census
N_2 = total sites, second census

The annual turnover rate, T, varies between 0 and 1 and can be interpreted as the percentage of colonies changing use each year. Since surveys were conducted in three years, two annual turnover rates, T for 1976-77 and T for 1977-78, were calculated and a mean taken for an average turnover rate per year.

Results

Impact of Military Activity on the Establishment of Colonies

The distribution of wading bird colonies differs significantly (X^2 = 44.21, 3df, P <0.00001) from a random distribution in the four regions of the state (Fig. 4). There are fewer colonies than expected in the NE (n = 60), NW (n = 99) and SE (n = 65) and more colonies than expected in the SW (n = 115). Colony distribution also varies significantly (X^2 = 30.98, df = 1, P <0.00001) in relation to the coast. There are more colonies (n = 237) than expected in coastal counties and fewer colonies (n = 102) than expected in interior counties when compared to a random distribution based on total land area (Fig. 5).

If military area was distributed proportionately between regions then each region would be 32.8% military area or approximately the percentages found in the SE and SW (Fig. 6). The NE region has relatively less military area and the NW region relatively more military area than the other regions. Overall, 33.9% of the state's military area is in coastal counties and 66.1% is in interior counties.

Activity on military training routes is not consistent throughout the state since the types of aircraft, route usage, and minimum altitudes vary. Since its inception, regular use of the MTR system in peninsular Florida has been by four tactical training squadrons (61^{st}, 62^{nd}, 63^{rd}, 72^{nd}) at MacDill Air Force Base, one reserve squadron

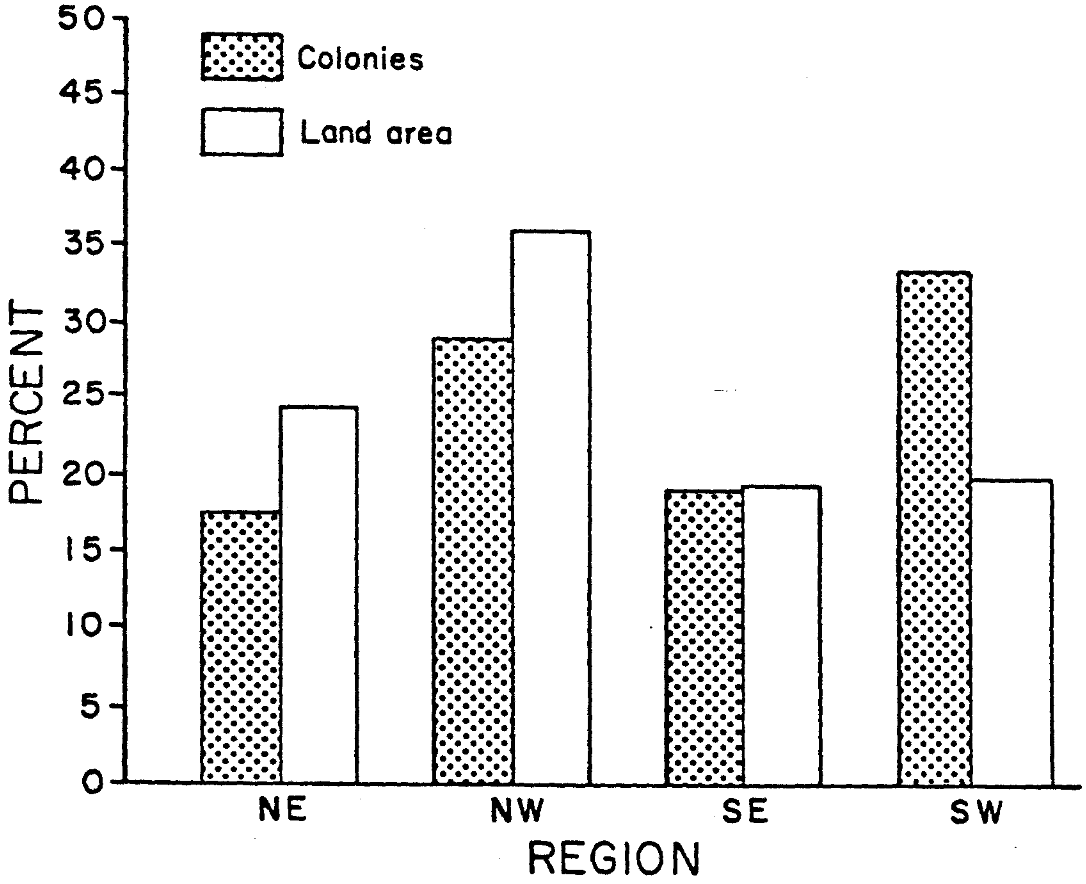


Figure 4. Colony distribution in relation to total land area in the four regions of the state.

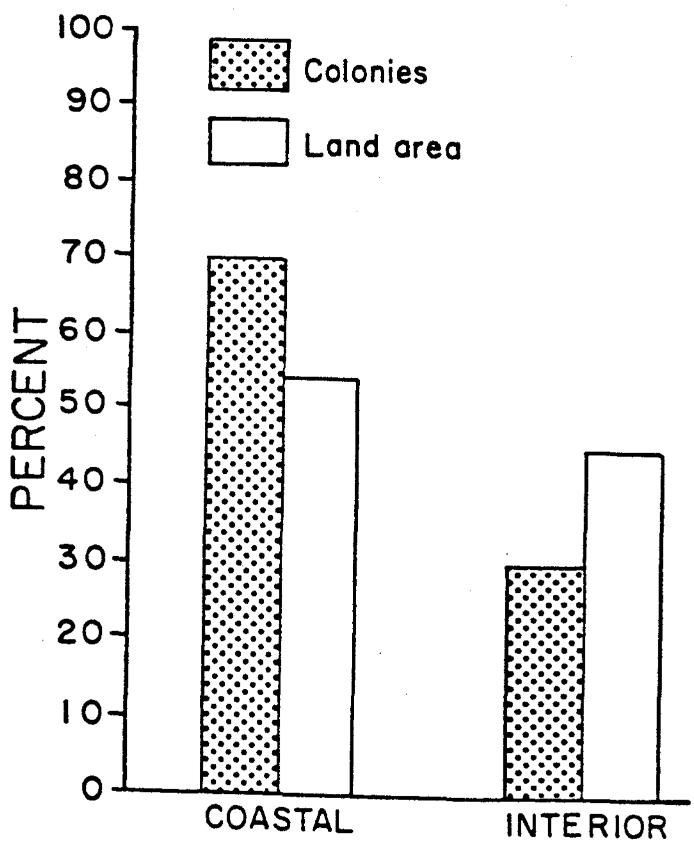


Figure 5. Colony distribution in relation to total land area in coastal and interior counties in Florida.

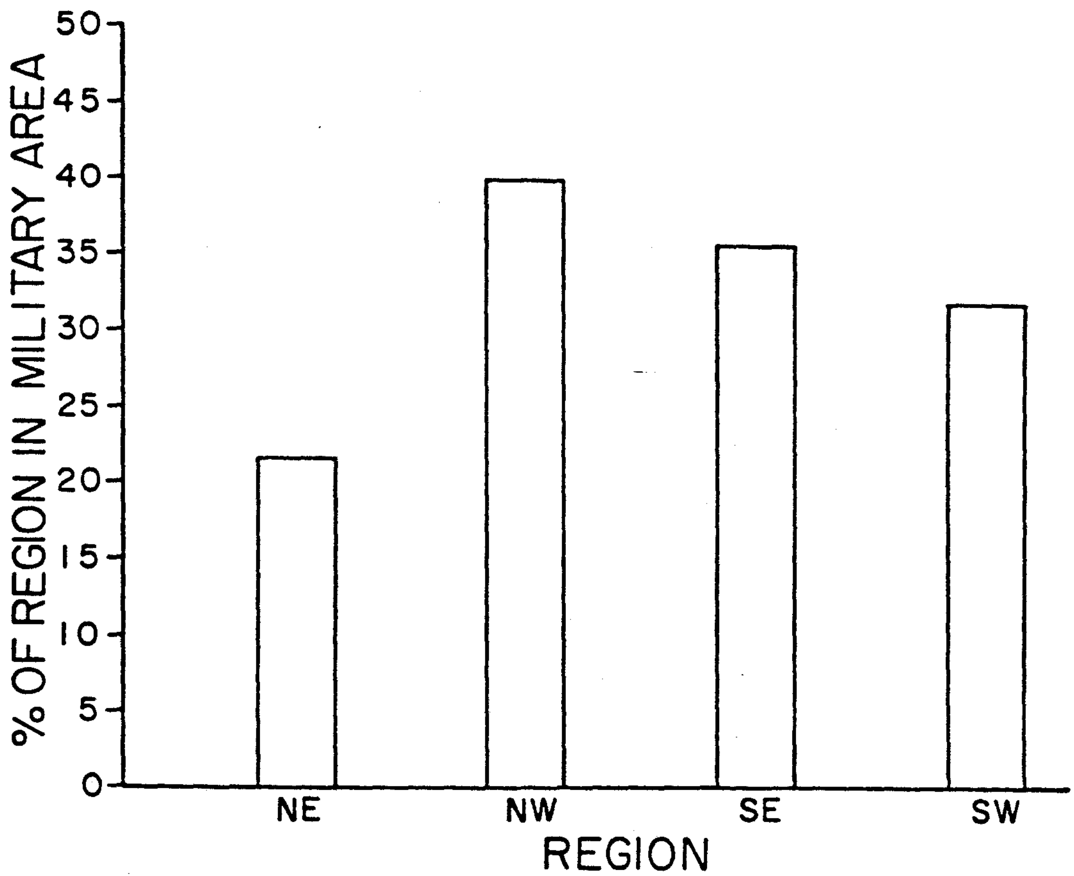


Figure 6. Percentage of each region of the state that is comprised of military area.

(93rd) and four training squadrons (306th, 307th, 308th, 309th) at Homestead Air Force Base, and squadrons based at the Key West and Jacksonville Naval Air Stations. Naval flights from Jacksonville are primarily to the Pinecastle bombing range in Restricted Area R-2910 southwest of Lake George. Air Force flights are primarily to the Avon Park Air Force Range, 65 nm east of MacDill AFB, in Restricted Area R-2901 for which MacDill is the originating/scheduling authority. MacDill based aircraft generally use the northern scorable range and simulated airfield, Bravo and Foxtrot ranges, respectively; whereas Homestead based aircraft usually use the southern, Charlie and Echo ranges.

The types of aircraft using training routes have varied. Originally both MacDill Air Force Base and Homestead Air Force Base flights were almost exclusively F-4's; however, in October 1979 MacDill Air Force Base began its conversion to F-16's, a slightly quieter craft, and presently 99% of aircraft flying routes under MacDill's scheduling authority are F-16's (R. Whitcomb pers. comm.). Homestead squadrons continue to fly almost exclusively F-4 aircraft.

Route usage varies, however, more variation is evident between routes (Table 1) than between years within routes. For example, 1981 flight figures are within ±5% of 1982 figures for MacDill routes (R. Whitcomb per. comm.). Route usage data before initiation of the MTR program is not exact (G. Syarto pers. comm.); however, flight activity from 1977-80 should be similar to that in 1981-83 since the number of training squadrons and number of students was similar (W. Bateman pers. comm.). The majority of MacDill's flights are on IR-046 and IR-048, and the majority of Homestead's flights are on IR-034.

Table 1. Average flights per month on low routes scheduled by MacDill Air Force Base and Homestead Air Force Base from 1981-1984.

Scheduling Authority	Route	Average flights per month			
		1981	1982a	1983	1984b
56 TFW MaCDill	IR-046	356	356	394	310
	IR-049 (VR1098)	61	61	35	33
	IR-050	40	40	44	50
	IR-051	3	3	4	18
31 TFW Homestead	IR-034	212	264	291	292
	IR-053	40	12	13	17
	IR-056	24	37	64	71
	VR-1088	8	2	8	8

[a]MacDill data for 1982 are within ± 5% of actual flights.

[b]MacDill data are based on the first 6 months of 1984. Homestead data are projected flights estimated by Homestead Airspace Management.

Military training routes are defined by several features. The width and vertical airspace above routes are designated in the regularly published DOD Flight Information Publication AP/1B. Within each route are segments defined by designated turning points and within segments are one or more "leg segment centerlines" which portray a standardized flight pattern.

Route segment altitudes have remained relatively constant since the beginning of the MTR program and compared to pre-MTR levels show slight trends toward higher altitudes (Defense Mapping Agency archival data). Seventy-five to 80% of training flights will be at minimum altitude for that segment (D. Bowen pers. comm.) unless minimum altitudes are below 500 feet above ground level. In that case, since no training squadrons (8 of 9 Air Force squadrons) can fly below 500 feet (AF Regulations 60-16 DOD 1980, TAC Regulations 55-16 and 55-4), their flight altitudes should be above the designated floor. In the case of reservists, who can perform "low level step down training" to 100 feet above ground level, extremely low altitude flying can occur for up to five minutes of a flight (R. Hancock pers. comm.). Of approximately 450 flights made over land annually by the 93rd squadron, about 60-75% (270-338) include some five-minute segment from 100 to 300 feet above ground level. This squadron uses primarily routes IR-034, IR-055, IR-056, and previously VR-1006, with most of the extremely low level flights on IR-034 from Copeland to Ritta Island at the southern edge of Lake Okeechobee.

The amount of military area varies among counties in the state ranging from 97% of the area in Highlands county to 0% in Nassau, Seminole, Hillsborough, Pasco, Pinellas, Broward, Dade, Charlotte, Lee, and Sarasota counties (Table 2). Each region has at least one county with more than 50% of its area under military activity and at least two counties with no military activity. MacDill Air Force Base and Homestead Air Force Base are located in Hillsborough and Dade counties, respectively, but routes typically originate some distance from the bases and flights climb to 1,600 feet above ground level within 2-3 minutes of take-off before further altitude assignment (R. Whitcomb pers. comm.).

The distribution of wetlands is disproportionate among regions. The SE and SW have relatively more wetland area (39.8% and 43.1%, respectively) and the NE and NW have relatively less wetland area (30.4% and 28.3%, respectively) when compared to a proportionate distribution (33.9%) among regions. The distribution of wetlands is also disproportionate between coastal and interior counties. Sixty-five percent of the state's wetlands are in coastal counties compared to 35% in interior counties. Coastal counties contain all of the 10.6% of the state's wetlands that are designated estuarine and a slightly disproportionate amount of the state's freshwater wetlands (34.3% as compared to 30.2% if freshwater wetlands were distributed proportionately between coastal and interior counties).

The distribution of wading bird colonies was independent of military activity in the NE (X^2 = 3.04, 3df, $\underline{P}$ = 0.38) (Fig. 7), NW (X^2 = 4.22, 3df, $\underline{P}$ = 0.24) (Fig. 8), and SE (X^2 = 6.09, 3df, $\underline{P}$ = 0.11) (Fig. 9), but not in the SW (X^2 = 36.35, 3df, $\underline{P}$ = 0.00001) (Fig. 10) when distributions were compared using a Chi-square 2 X 2 contingency test with coastal and interior counties and military and non-military activity as variates within region. In the SW the greatest deviation

Table 2. Amount and percentage of each county's land area that is under military training routes or military operations area or both. Data are ordered by percent military area and summed by region.

Region	County	Area (sq. mi.)	MTR		MOA		Total Military	
			Area	%	Area	%	Area	%
NE	Flagler	487	274	56			274	56
	Putnam	765	105	13	284	37	389	50
	Osceola	1,313	273	21	208	16	481	37
	Volusia	1,062	146	14	135	13	281	27
	Brevard	1,011	244	24	244	24		
	Lake	938	127	14	98	10	225	24
	Indian River	506	73	14			73	14
	Clay	593	60	10			60	10
	Orange	910	69	8			69	8
	St. Johns	605	35	6			35	6
	Duval	766	14	2			14	2
	Nassau	650					0	0
	Seminole	305					0	0
	TOTAL	9,911					2,145	21.6
NW	Suwannee	256	32	1	224	88	229	89
	Wakulla	601	438	73	25	4	463	77
	Dixie	633	452	71			452	71
	Sumter	555	356	64			356	64
	Polk	1,858	161	9	990	53	1,151	62
	Lafayette	466	23	5	262	56	285	61
	Jefferson	605	334	55			334	55
	Columbia	669	82	12	238	36	320	48
	Levy	730	333	46			333	46
	Baker	585	262	45			262	45
	Hernando	484	207	43			207	43
	Madison	553	150	27	76	14	226	41
	Taylor	1,051	417	40	9	1	426	41
	Leon	670	219	33			219	33
	Union	241	69	29			69	29
	Marion	664	92	14	92	14	184	28
	Alachua	639	151	24			151	24
	Hamilton	463	74	16	33	7	107	23
	Gilchrist	160			28	18	28	18
	Citrus	539	40	7			40	7
	Bradford	294	18	6			18	6
	Hillsborough	1,038					0	0
	Pasco	742					0	0
	Pinellas	265					0	0
	TOTAL	14,761					5,860	39.7

Continued.....

Table 2. Continued.....

Region	County	Area (sq. mi.)	MTR		MOA		Total Military	
			Area	%	Area	%	Area	%
SE	Highlands	997	79	8	886	89	965	97
	Glades	753	683	91	38	5	721	96
	Okeechobee	777	407	52	326	42	733	94
	Martin	556	119	21			119	21
	Palm Beach	1,291	222	17			222	17
	St. Lucie	584	74	13			74	13
	Broward	1,219					0	0
	Dade	1,807					0	0
	TOTAL	7,984					2,834	35.5
SW	Desoto	648	456	71	1	0	457	71
	Hendry	1,089	727	67			727	67
	Collier	2,006	764	38			764	38
	Manatee	739	241	33			241	33
	Monroe	1,034	300	29			300	29
	Hardee	629	38	6	91	15	129	21
	Charlotte	703					0	0
	Lee	785					0	0
	Sarasota	587					0	0
	TOTAL	8,220					2,618	31.8

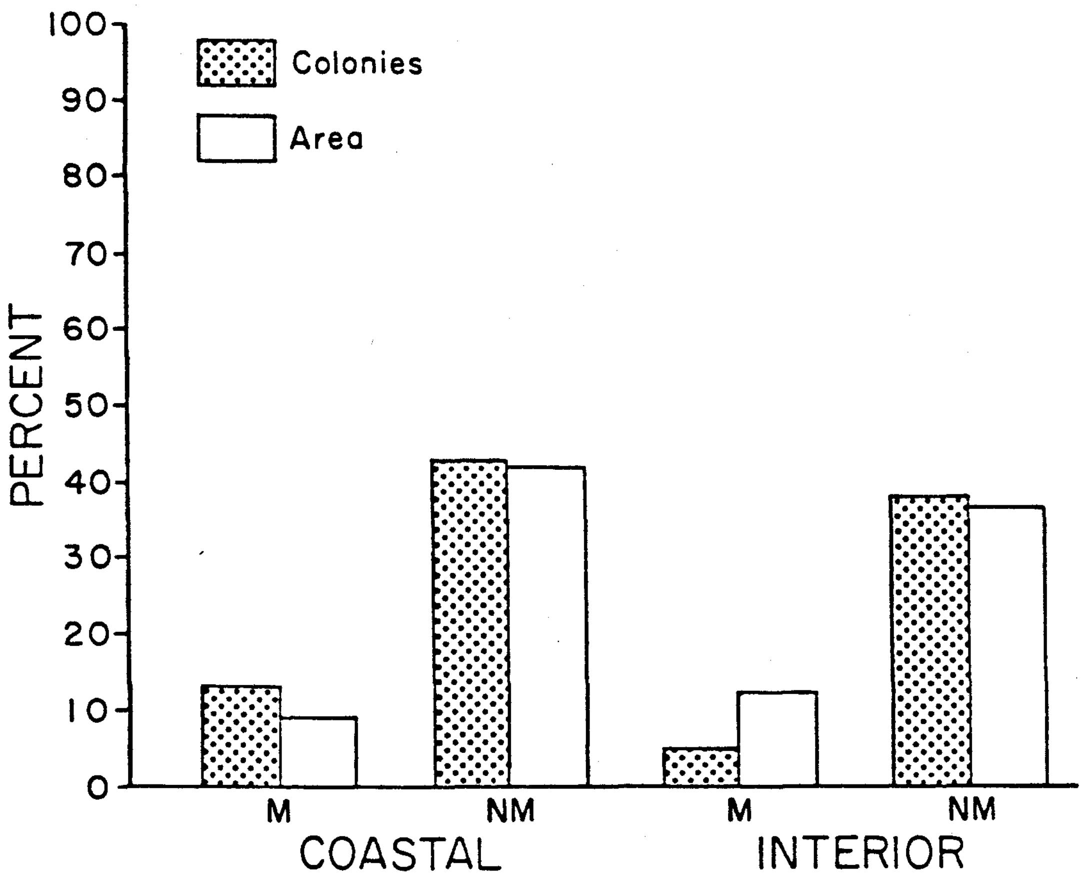


Figure 7. Colony distribution (N=60) in relation to military (M) and non-military (NM) area in coastal and interior counties in the NE region of the state.

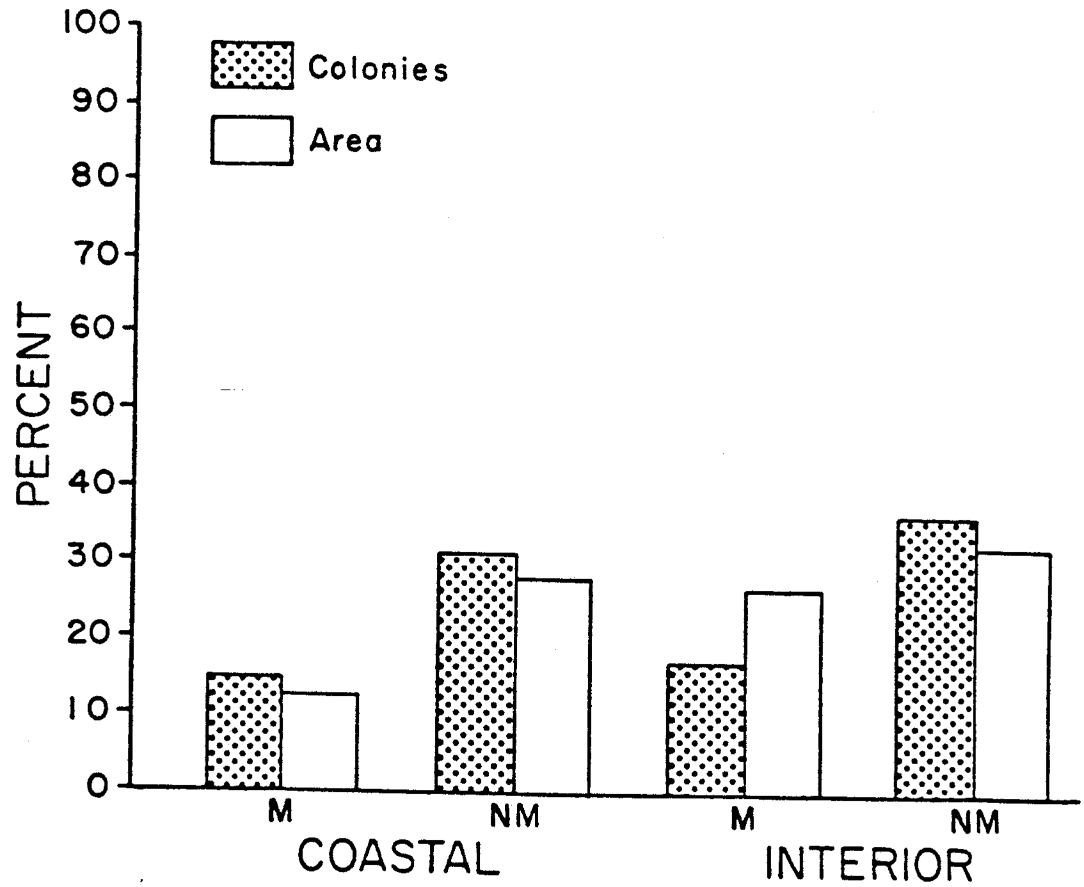


Figure 8. Colony distribution (N=99) in relation to military (M) and non-military (NM) area in coastal and interior counties in the NW region of the state.

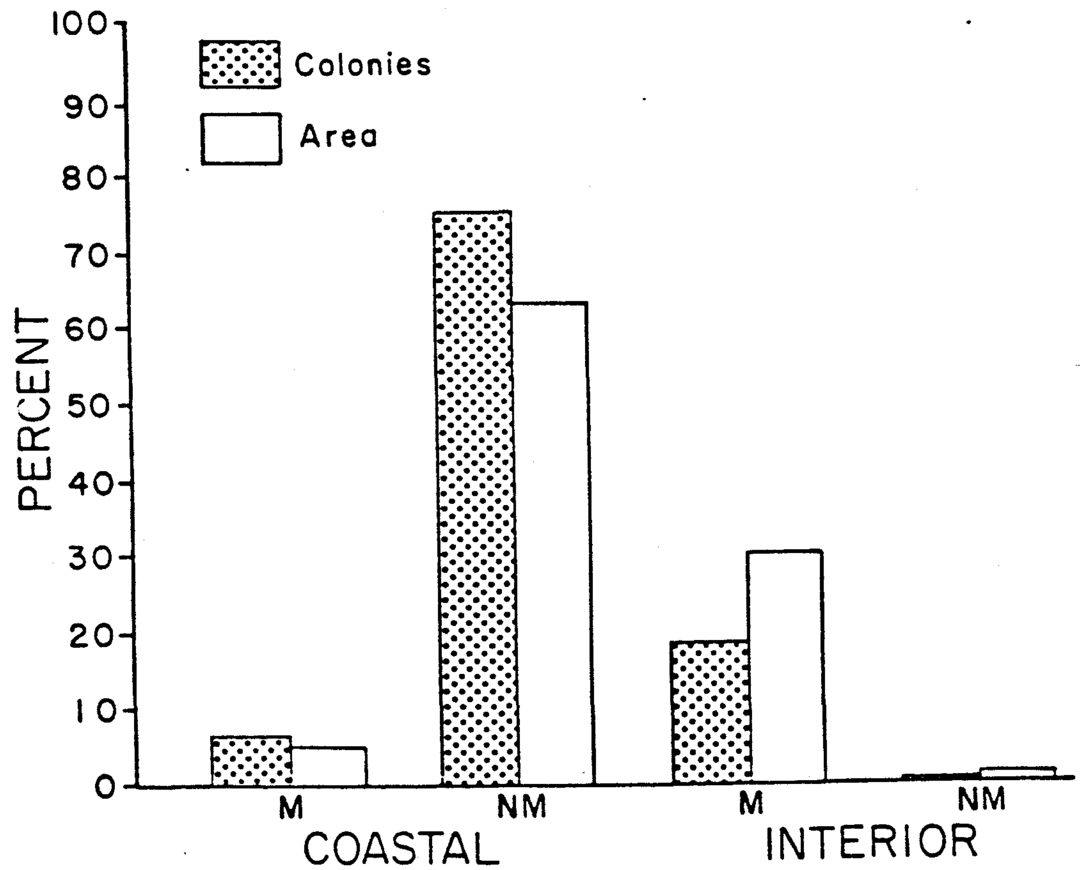


Figure 9. Colony distribution (N=65) in relation to military (M) and non-military (NM) area in coastal and interior counties in the SE region of the state.

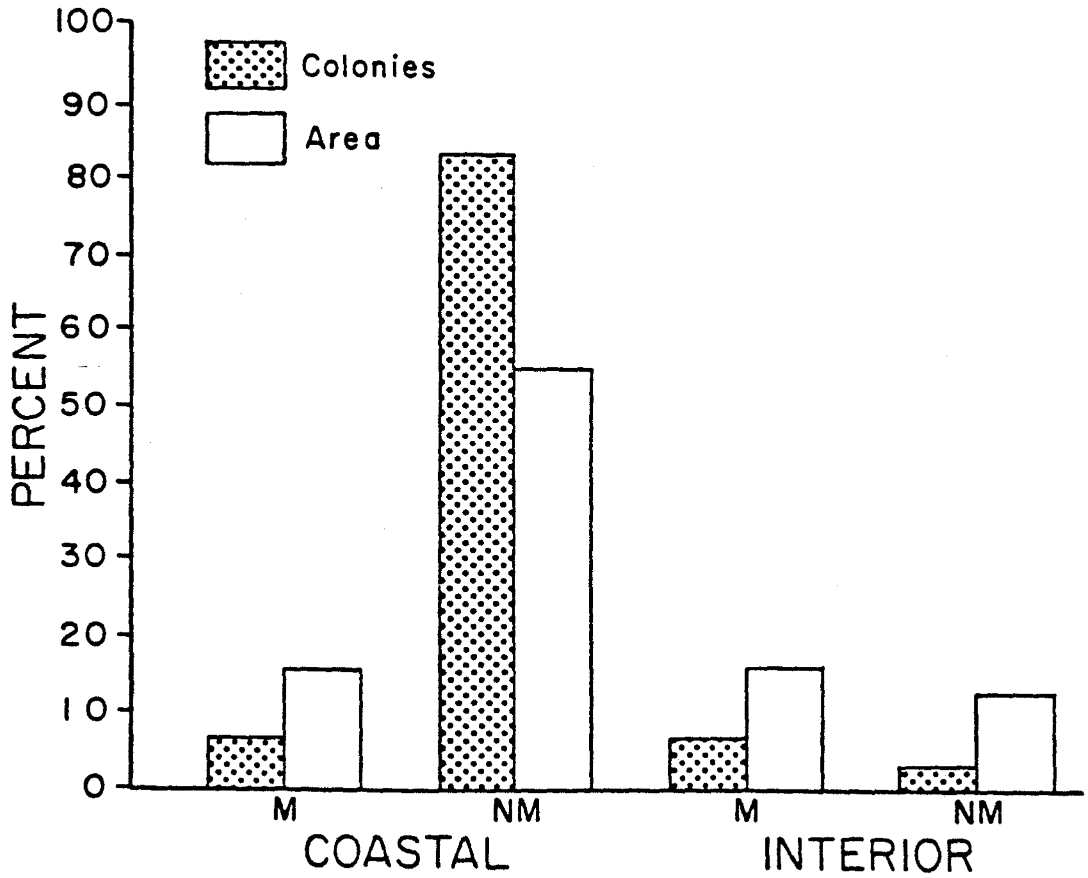


Figure 10. Colony distribution (N=115) in relation to military (M) and non-military (NM) area in coastal and interior counties in the SW region of the state.

from the expected distribution was the large number of colonies in coastal-county, non-military areas.

The distribution of wading bird colonies corresponds to the distribution of wetlands in peninsular Florida but is skewed statewide by the many small colonies in Florida Bay and the Florida Keys (Fig. 11). When the Florida Bay/Florida Keys area is omitted, colonies in the four regions are distributed randomly with respect to wetlands (X^2 = .78, df = 3, P = 0.85) but not with respect to total land area (X^2 = 12.38, df = 3, P = .006). In peninsular Florida there is a close association between the number of wading bird colonies and wetland area (Fig. 12). Coastal counties contain 65.1% of the state's wetlands and 69.6% of the state's wading bird colonies.

Colony turnover rates are almost equal in military and non-military areas: average turnover rates and the percentage of colonies active in all three survey years are each within 2% (Table 3). Colony turnover rates did vary, however, in relation to other factors. Turnover rates were more than two times greater in interior counties than in coastal counties, more than three times greater in freshwater colonies than in marine/estuarine colonies, and slightly higher in interior county freshwater colonies than in coastal county freshwater colonies. In addition, turnover rates were twice as high in the NE as in the SW and,overall, were higher in eastern (.122) than in western (.078) counties in the state.

Impact of Military Activity on the Size of Colonies

Size I colonies (n = 115) were distributed randomly with regard to region (X^2 = 2.98, 3df, P = 0.61) whereas size II (n = 105) and

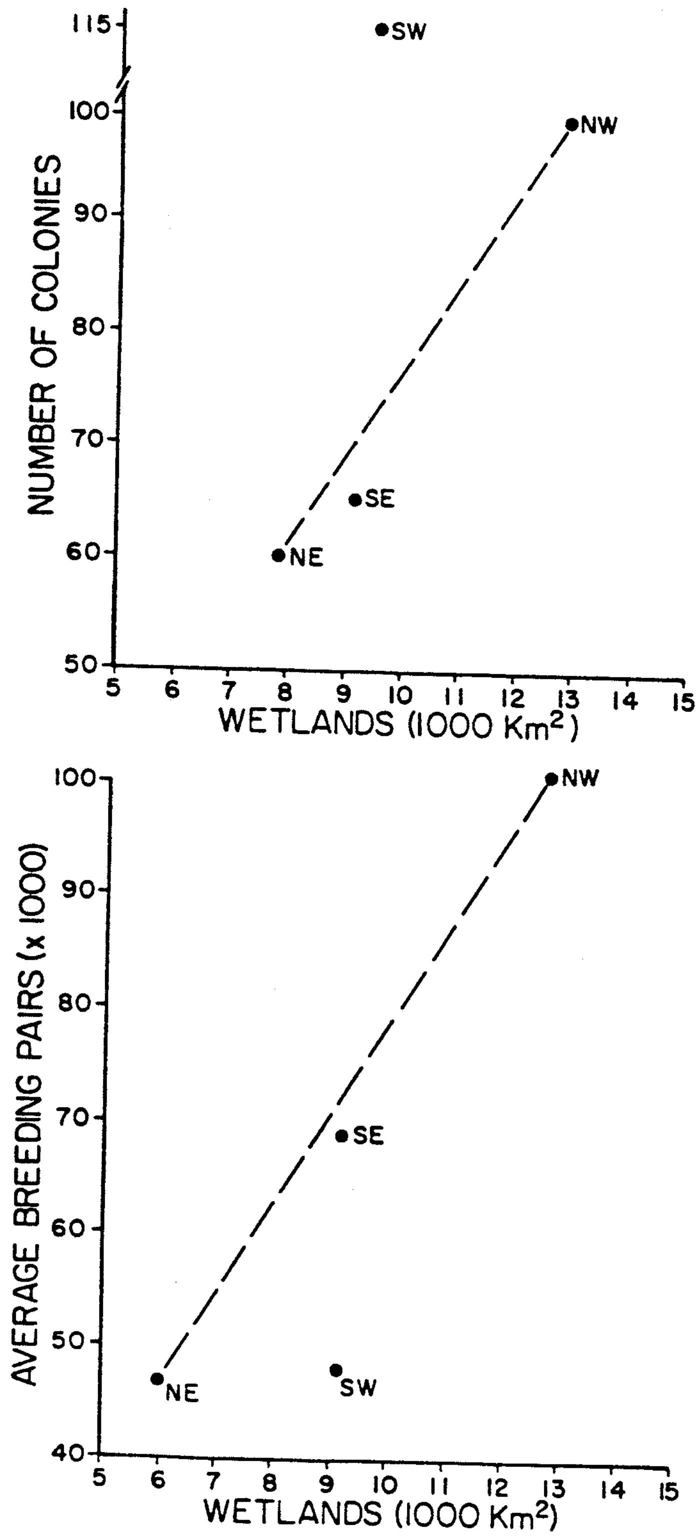


Figure 11. Number of colonies and average number of breeding pairs per wetland area in the four regions of the state. Dashed lines represent general trends.

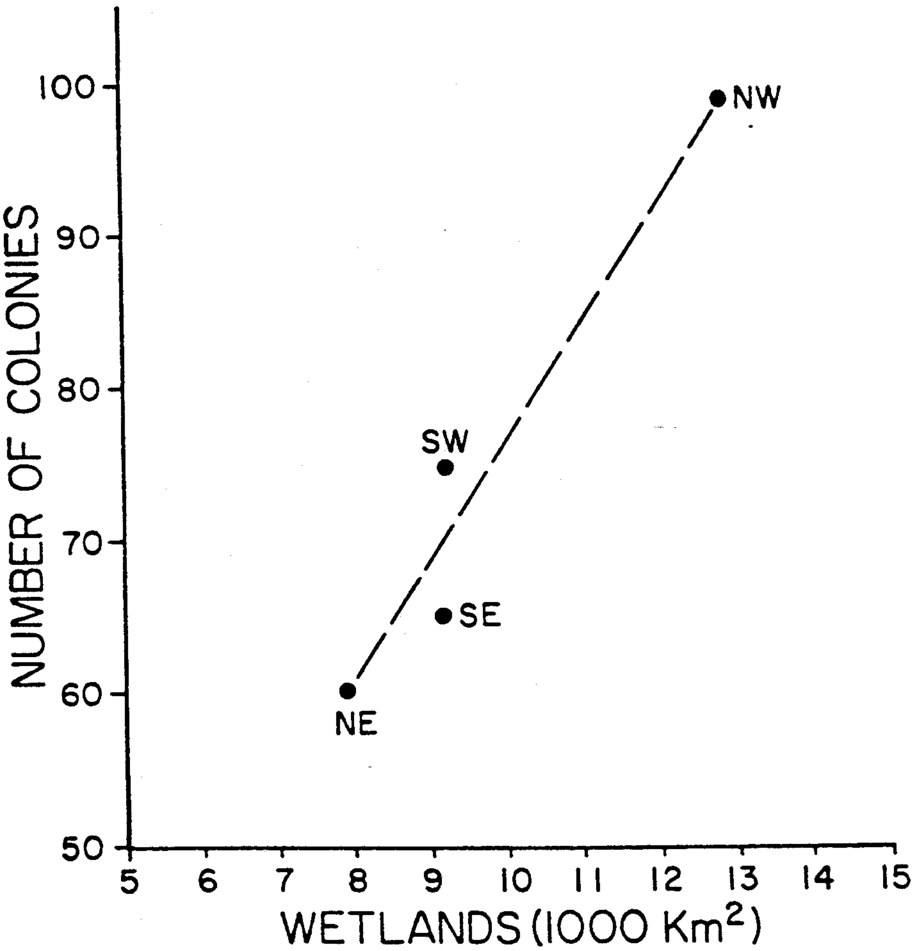


Figure 12. Number of colonies per wetland area in the four regions of the state excluding the Florida Bay/Florida Keys. The dashed line represents a general trend.

Table 3. Percentage of colonies active in all three survey years and turnover rates of colonies in selected categories.

Category	Level	# of[a] Colonies	% Active in All 3 Survey Years	Average[b] Turnover Rate (yr^{-1})
Military Activity	Military	37	72.9	.082
	Non-military	140	71.4	.096
Location	Coastal Counties	119	78.2	.064
	Interior Counties	58	58.6	.154
Environment	Freshwater	106	61.3	.137
	Marine/Estuarine	71	87.3	.045
Freshwater	Coastal Counties	48	64.6	.111
	Interior Counties	58	58.6	.154
Region	NE	39	61.5	.144
	NW	53	73.6	.094
	SE	33	63.6	.099
	SW	52	82.7	.061

[a]Colonies surveyed in all three years of the census (Nesbitt et al. 1982).

[b]Two-year average 1976-77, 1977-78.

size III (n = 119) colonies were not ((X^2 = 15.96, 3df, P = 0.001) and (X^2 = 60.80, 3df, P <0.00001), respectively): both had more colonies than expected in the SW. There were fewer size II colonies than expected in the NE and fewer size III colonies than expected in the NE and NW.

Size I colonies also were distributed randomly with regard to military area (X^2 = 2.98, 3df, P = 0.61) when compared statewide in coastal and interior counties. Comparisons for size II and size III colonies were made by region where appropriate (Table 4). Observed and expected distributions were similar by region for all colony sizes except for size II and size III colonies in the SW where there were more colonies than expected in coastal-county, non-military areas (Table 4).

Colony turnover rates were within 2% when military and non-military areas were compared by colony size (Table 5). Overall, turnover rate was inversely related to colony size (Table 6): the largest colonies had the lowest turnover rates, intermediate colonies had intermediate turnover rates and the smallest colonies had the highest turnover rates. This relationship may or may not exist within species; however, since colonies categorized by the most numerous species had varying turnover rates (Table 6). In the data analyzed, colonies in which Great Blue Herons were most numerous had the highest turnover rates, those in which White Ibis and Double-crested Cormorants were most numerous had the lowest turnover rates, and those in which Cattle Egrets and Great Egrets were most numerous had intermediate turnover rates. Cattle Egrets and White Ibis were the most numerous species in 86% of size I colonies; Cattle Egrets, Great

Table 4. Observed and expected distributions of size I, II, and III colonies in military and non-military areas of coastal and interior counties in the four regions of the state. Significance values are given where chi-square tests are appropriate.[a]

Colony Size	Region	Observed or Expected Value	Coastal Counties		Interior Counties		P
			Military	Non-Military	Military	Non-Military	
I	NE	E	3	12	4	10	
(>500 bp)		0	6	16	2	5	
	NW	E	4	17	8	9	
		0	5	12	8	13	
	SE	E	3	11	5	6	
		0	2	14	9	0	
	SW	E	3	10	5	5	
		0	3	14	2	4	
II	NE	E	1	5	2	5	
(101-500 bp)		0	0	5	1	7	
	NW	E	5	11	11	13	0.08
		0	6	12	4	18	
	SE	E	1	11	5	0	
		0	0	16	1	0	
	SW	E	5	19	6	5	0.00062
		0	1	31	3	0	
III	NE	E	2	7	2	7	
(≤100 bp)		0	2	5	0	11	
	NW	E	3	6	6	6	
		0	4	6	5	5	
	SE	E	1	15	7	0	
		0	2	19	2	0	
	SW	E	9	32	9	7	0.00001
		0	4	51	2	0	

[a]Chi-square test is not appropriate when cells contain expected values less than 5 (Steel and Torrie 1960).

Table 5. Turnover rates of colonies in three size classes in military and non-military areas in Florida.

Size Class	Military[a] Activity	# of Colonies	# Active All 3 Years	% Active All 3 Years	Average[b] Turnover Rate (yr^{-1})
I (>500 bp)	M	20	17	85.0	.039
	N	49	41	83.7	.047
II (101-500 bp)	M	10	7	70.0	.107
	N	42	32	76.0	.091
III ($\leq$ 100 bp)	M	7	3	42.9	.163
	N	49	27	55.0	.159

[a]M = military area, N = non-military area (see methods for description).

[b]Two-year average 1976-77, 1977-78.

Table 6. Percentage of colonies active in all three survey years and turnover rates of colonies by size and most numerous species.

Category	Level	# of[a] Colonies	% Active in All 3 Survey Years	Average Turnover Rate (yr^{-1})
Size	Size I (> 500 bp)	69	84.1	.046
	Size II (101-500 bp)	52	75.0	.095
	Size III (≤ 100 bp)	56	53.6	.115
Most numerous species	Cattle Egret	86	72.1	.090
	Double-crested Cormorant	14	92.8	.036
	Great Blue Heron	17	52.9	.166
	Great Egret	22	72.7	.073
	White Ibis	10	80.0	.053

[a]Colonies surveyed in all three years of the census (Nesbitt et al. 1982).

Egrets, and Double-crested Cormorants were the most numerous species in 83% of size II colonies, and Great Blue Herons, Great Egrets, and Cattle Egrets were the most numerous species in 68% of size III colonies (Table 7). Generally, colonies in which White Ibis and Cattle Egrets were the most numerous species were the largest (number of breeding pairs of all species) colonies. Those colonies in which Double-crested Cormorants and Great Egrets were the most numerous species were intermediate to small colonies while those in which Great Blue Herons were the most numerous species were small colonies (Fig. 13).

Colonies categorized by the most numerous species also were found in varying proportions in military areas (Fig. 14). Cattle Egrets and Great Egrets were the most numerous species in 81% of the colonies in active military areas; however, colony turnover rates for these two species were greater in non-military areas (.252 and .186, respectively) than in military areas (.171 and .137, respectively).

Discussion

The distribution of wading bird colonies was random with respect to military area in three of four regions and large colonies (>500 pairs) were distributed randomly with regard to military area in all four regions of the state. The distribution of colonies in general, and small (≤ 100 pairs) and intermediate (101-500 pairs) colonies in particular, outside of military areas and within coastal-county non-military areas in the SW region is probably not related to military activity but rather to historic distributions of resources

Table 7. The number and percentage of colonies in each size class categorized by the most numerous species and censused in all three years of the 1976-77 survey.

Size Class	Most Numerous[a] Species	# of Colonies	% of Colonies
I (> 500 bp)	CE	51	73.9
	WI	8	11.6
	BP	3	4.3
	DC	2	2.9
	SE	2	2.9
	WS	2	2.9
	LB	1	1.5
	TOTAL	69	100.0
II (101-500 bp)	CE	28	53.8
	GE	8	15.4
	DC	7	13.5
	WS	3	5.8
	BP	2	3.9
	GB	1	1.9
	RS	1	1.9
	SE	1	1.9
	WI	1	1.9
	TOTAL	52	100.0
III (≤100 bp)	GB	16	28.6
	GE	15	26.8
	CE	7	12.5
	DC	5	8.9
	GW	3	5.4
	BP	2	3.6
	LB	2	3.6
	MX	2	3.6
	RS	2	3.6
	WI	1	1.7
	WS	1	1.7
	TOTAL	56	100.0

[a]Most numerous species in a colony averaged over all survey years: BP = Brown Pelican, CE = Cattle Egret, DC = Double-crested Cormorant, GB = Great Blue Heron, GE = Great Egret, GW = Great White Heron, LB = Little Blue Heron, MX = mixed species (low numbers, even mix), RS = Roseate Spoonbill, SE = Snowy Egret, WI = White Ibis, WS = Wood Stork.

and species characteristic of that area. The SW region has proportionately more wetland area than any other region and much of that wetland area is continuous in the form of the Everglades. Robertson and Kushlan (1974) have suggested that "the nearly unique ability of the South Florida ecosystem to support such large numbers of 14 species of superficially similar secondary and tertiary consumers on a resource base that is reduced in species diversity by biogeographical factors is generally unappreciated." Those numbers were crudely estimated at 2.5 million in 1870 and 1.2 million in the post-plume hunting recovery of the 1930's. These same authors reported a reduction in wading bird numbers to about 10% of 1930 levels by 1970 due to progressive wetland loss and deterioration and stated "whereas birds nesting in estuarine areas have increased in the past 30 years and are probably near carrying capacity, those nesting in interior wetlands of Everglades National Park have declined as their habitat became smaller and more unstable." While movements to estuarine sites probably have occurred to some degree in other regions, they may have been amplified to some extent in the SW by the contiguous nature of the Everglades and the potential for widespread effects of hydrographic alterations.

The number of colonies in coastal areas in the SW also is influenced by the presence of two species, Roseate Spoonbills and Reddish Egrets, and one subspecies, Great White Heron, which nest in colonies only in coastal locations and within Florida almost exclusively in the SW region. Although these species nest alone in only five colonies, their presence plus that of other species in 40 colonies in the Florida Bay/Florida Keys area significantly skews colony distributions on a statewide basis.

The location of military area in the SW also influences the unexpectedly low number of colonies in such areas. To comply with a National Park Service request and FAA regulation, all MTR flights over the Everglades are restricted to altitudes above 1,000 feet. Additionally, only three of the 40 colonies in the Florida Bay/Florida Keys area are on the training route, IR-053, paralleling the Keys offshore to the southeast. These facts combined result in reduced low level military activity in an area of uniquely high colony numbers.

Both the high colony turnover rate and the distribution of colonies out of interior counties could be associated with the high concentration (65%) of military area in interior counties; however, these rates and distributions are thought to be associated with other factors, primarily type and distribution of wetlands, for a number of reasons. The high percentage of both military area and colonies in the NW and the low percentage of both military area and colonies in the NE are not consistent with colony movements away from concentrations of or to regions lacking military area on a statewide scale. In addition, Ogden et al. (1980) in dividing the state into three regions (north, central, south) and omitting a number of colonies in the Florida Bay/Florida Keys, found the greatest concentration of colonies in the central region of the state, an area corresponding to the greatest concentration of military area. Also, the similarity of colony turnover rates for all colonies and colonies in all size classes between military and non-military areas is inconsistent with increased colony movement in areas of military activity. Thus, there are no consistent findings in this study to indicate colony movement away from military areas; however, the health of estuarine colonies as compared to declining inland colonies as reported in Virginia, North Carolina, Florida, and Texas implies that coastal wetlands are not as stressed or reduced in area as interior wetlands in the southeastern states (Ogden 1978) and may explain better the distribution of colonies reported here.

Colonies were not distributed randomly with regard to total land area but were distributed randomly with regard to wetlands, and the number of colonies was closely related to wetland area by region in peninsular Florida. The number of colonies also was closely related to the amount of wetlands in coastal versus interior counties. These facts suggest that wading birds are using wetland habitat for colony sites as it is available. Similar patterns of wetlands availability and number of nesting wading birds have been reported (Custer and Osborn 1977, Kushlan 1978) and data presented here concur with those findings except for the apparently low number of nesting wading birds in the SW region. As mentioned, apparent shifts to estuarine colonies from the Everglades have occurred; however, in Florida in contrast to other southeastern states, movements to coastal colonies have been associated with an overall decline in wader populations (Ogden 1978). Even including the strictly estuarine breeders, Reddish Egret, Roseate Spoonbill and Great White Heron, the SW region has fewer nesting wading birds than one might expect based on the wetlands present and the relationships seen in the other regions of Florida and in other states.

Differences in colony turnover rates were greatest between estuarine and freshwater colonies with estuarine colonies being more stable. Differences in coastal and interior counties primarily reflect the estuarine-freshwater differences; however, coastal counties had slightly lower turnover rates when only freshwater colonies were considered. The stability of estuarine colonies as compared to freshwater sites is not unexpected in light of the relative constancy of tidal variations in coastal sites compared to the seasonality of freshwater marshes and their changing suitability as colony and feeding sites based on vississitudes of annual rainfall (Ogden et al. 1980). Generally, one might expect high turnover rates in dynamic or unstable habitats and low turnover rates in consistent, stable or limited habitats. Turnover rates were highest in the NE and slightly higher in the NW and SE when compared to a 6% turnover rate for wading birds in general in coastal North Carolina (McCrimmon and Parnell 1983). These three regions had higher percentages (70-84%) of freshwater colonies compared to the SW (46%) which had the lowest colony turnover rate. The low turnover rate in the SW is interesting in light of Robertson's and Kushlan's (1974) suggestion that estuarine colonies in the Everglades are near carrying capacity. Further analysis of freshwater versus estuarine colony turnover rates compared among regions may elucidate possible "stressed" regions showing unusually high or low turnover rates while controlling for the consistent differences in turnover rates found in the two settings.

In interpreting turnover rates, one should be cautious and recall that data presented here represent conditions in only three survey years. Hopefully turnover rates reported reflect true relationships but other patterns may come to light with additional surveys in other years.

In summary, based on the indirect evidence of colony distribution and colony turnover rates in relation to military training routes (≤ 500 feet above ground level) and military operations areas, there was no demonstrated effect of military activity on wading bird colony establishment or size on a statewide basis. Colony distributions and turnover rates were independent of military activity but were related to the amount and type (estuarine or freshwater) of wetland, respectively.

IMPACT OF LOW ALTITUDE MILITARY TRAINING FLIGHTS ON REPRODUCTIVE SUCCESS IN WADING BIRD COLONIES

Introduction

Factors affecting the reproductive success of colonially breeding, long-legged wading birds vary by site, breeding season and species. These factors include food supply as indirectly indicated by nestling starvation (Teal 1965, Jenni 1969, Pratt 1970, Weber 1975, Maxwell and Kale 1977, Girard and Taylor 1979, Rodgers 1980a, Rodgers 1980b, Hammatt 1981), egg and nestling predation by avian, reptilian and/or mammalian species (Meanley 1955, Teal 1965, Dusi and Dusi 1968, Jenni 1969, Siegfried 1972a, Maxwell and Kale 1977, Girard and Taylor 1979, Rodgers 1980a, Hammatt 1981), weather variants such as high winds and rain (Grant 1967, Jenni 1969, Pratt 1970) or severe drought (Dusi and Dusi 1968), diseases that affect nestlings (Pratt 1970, Wiese et al. 1977), accidents (Meanley 1955, Teal 1965, Jenni 1969, Siegfried 1972a, Maxwell and Kale 1977) or nest collapse (Jenni 1969, Girard and Taylor 1979, Rodgers 1980a), variation in parental care from attentiveness (Jenni 1969) to abandonment (Teal 1965, Pratt 1970, Custer et al. 1983) and human disturbance (Trembleay and Ellison 1979). Clutch sizes and in some cases nestling survival have been reported to vary with nesting chronology (early, middle or late breeding season) (Jenni 1969, Siegfried 1972a, Gaston and Johnson 1977) or ecological setting (estuarine vs freshwater setting (Table 8)) (Jenni 1969, Maxwell and Kale 1977, Girard and Taylor 1979, Rodgers 1980a, S. Nesbitt pers. comm.); however, causal relationships are difficult to define. In addition, other factors such as the age composition of the breeding population and nest placement within the colony are known to be influential in the reproductive biology of other colonially breeding species, namely seabirds, but are less studied and understood in ardeids.

Since multiple factors may act in concert to affect the overall reproductive success of wading birds, we selected to investigate one treatment (military overflights) and one control (no military overflights) colony intensively over two breeding seasons. This approach would allow investigators to control for and/or identify factors independent of the treatment effect that were potentially influencing the reproductive success of the study subjects.

Table 8. Comparative clutch sizes and mortality of selected wading birds in the southeastern United States.

Species	Clutch size	N	Percent mortality	Habitat	Latitude	State	Source
Cattle Egret							
	3.5±.07	85	17.9[a]	Freshwater	29°N	FL	Jenni 1969
	3.0±.13	31	30.9[b]	Estuarine	27°35'N	FL	Maxwell & Kale 1977
	2.86	36	--	Freshwater	28°56'N	FL	Weber 1975
	2.8	291	--	Estuarine	39°35'N	DL	Wiese 1978
	2.42	50	85.2[c]	Freshwater		AL	Dusi and Dusi 1970
	2.3	47	--	Estuarine	30°41'N	AL	Gaston & Johnson 1977
	1.77	952	--	Freshwater	31°-32°N	GA	Hopkins & Murton 1969
Tricolored Heron							
	4.1±.11	36	35.8[a]	Freshwater	29°N	FL	Jenni 1969
	3.13	15	68.0[c]	Estuarine	32°N	GA	Teal 1965
	3.1	7	--	Estuarine	39°35'N	DL	Wiese 1978
	3.1±.05	79	20.5[b]	Estuarine	27°35'N	FL	Maxwell & Kale 1977
	2.79±.10	109	35.3[a]	Estuarine	27°55'N	FL	Rodgers 1980a
	2.7	90	--	Estuarine	30°14'N	AL	Gaston & Johnson 1977

Table 8 (continued).

Species	Clutch size	N	Percent mortality	Habitat	Latitude	State	Source
Little Blue Heron							
	4.4±.71		--	Freshwater	33°10'N	MS	Summerour 1971
	4.04	50	26.0[a]	Freshwater	34°N	AR	Meanley 1955
	4.0±.79		--	Freshwater	33°10'N	GA	Werschkul 1977
	3.7±.10	58	37.7[a]	Freshwater	29°N	FL	Jenni 1969
	3.7	29	--	Estuarine	39°35'N	DL	Wiese 1978
	3.3±.16	21	15.9[b]	Estuarine	27°35'N	FL	Maxwell & Kale 1977
	2.91±.09	219	47.0[a]	Estuarine	27°55'N	FL	Rodgers 1980b
	2.3	160	--	Freshwater	31°-32°N	GA	Hopkins & Murton 1969
Snowy Egret							
	3.9±.07	102	42.5[a]	Freshwater	29°N	FL	Jenni 1969
	3.6	185	--	Estuarine	39°35'N	DL	Wiese 1978
	3.24	29	73.0[c]	Estuarine	32°N	GA	Teal 1965
	3.15±.15	41	37.5[a]	Estuarine	27°55'N	FL	Rodgers 1980a
	2.9±0.6	77	28.8[b]	Estuarine	27°35'N	FL	Maxwell & Kale 1977

Table 8 (continued).

Species	Clutch size	N	Percent mortality	Habitat	Latitude	State	Source
Great Egret							
	3.13	30	56.0[c]	Estuarine	32°N	GA	Teal 1965
	2.8±.17	13	33.3[b]	Estuarine	27°35'N	FL	Maxwell & Kale 1977
	2.0	5	--	Freshwater	31°-32°N	GA	Hopkins & Murton 1969

[a]Egg laying to 2 wks

[b]Egg laying to 10 days

[c]Egg laying to "fledging"

Materials and Methods

Study Colony Selection

Preliminary analyses revealed that only a small proportion (5-6%) of the Brown Pelican breeding population nested in military areas (Appendix 3); however, a high percentage (38.2%) of interior county colonies were located in active military areas. Research emphasis, thus, was focused on interior counties and study colonies were chosen to insure that the treatment colony was located on the leg-segment centerline of a training route ($\leq$500 ft above ground level), whereas the control colony was located at least 9 km from any training route.

To enhance study colony comparability the selection process was begun by sorting the 339 colonies listed in the Florida Atlas (Nesbitt et al. 1982) by environment (freshwater versus estuarine), average number of species, average number of birds, years censused, years active and type of military activity (none, visual training route, instrument training route, military operations area). Nineteen potential treatment colonies resulted from choosing those freshwater colonies with an average of at least 2.5 species per survey year, an average of at least 1500 breeding pairs per survey year, breeding activity in all survey years and a location in a military area. These 19 colonies were reviewed further to identify those colonies that occur in unusual settings (i.e. phosphate mine impoundments) or that were composed largely of Cattle Egrets as compared to those colonies found to be "good" based on the numbers and diversity of species in the colony. Overflight records for the low-level, frequently-flown routes IR-046, IR-050 and IR-034 were tabulated to evaluate scheduled military activity in the vicinity of these colonies.

Based on this information four colonies (#612029 Mascotte, #612045 Lake Hamilton, #616032 Rabbit Island, #611009 Tsala Apopka South) were site visited and discussed with Airspace Management at MacDill AFB. The Mascotte colony (Fig. 15) was considered the best potential treatment colony because of its location towards the edge of the highest-use, low level route IR-046. Since centerlines are rarely plotted at route edges, it was unlikely that Mascotte had been overflown consistently in the past and, movement of the centerline to the route edge created a treatment site with breeding birds not habituated to low level overflights. Lake Hamilton, although technically in a military area, was selected as the control colony for three reasons: the lowest level for any overflight activity is 7000 ft, survey data since 1976 for both Mascotte and Lake Hamilton are available from National Audubon Society and human disturbance is expected to be much less than in the second potential control site (#612026 Lake Griffin South) which is located adjacent to a state park camping and recreation area. Based on this composite information we selected Mascotte (#612029) located in southwest Lake County (28° 34' N, 81° 54' W) as the treatment colony and Lake Hamilton (#612045) located in central Polk County (28° 03' N 81° 39' N) as the control colony (Fig. 16).

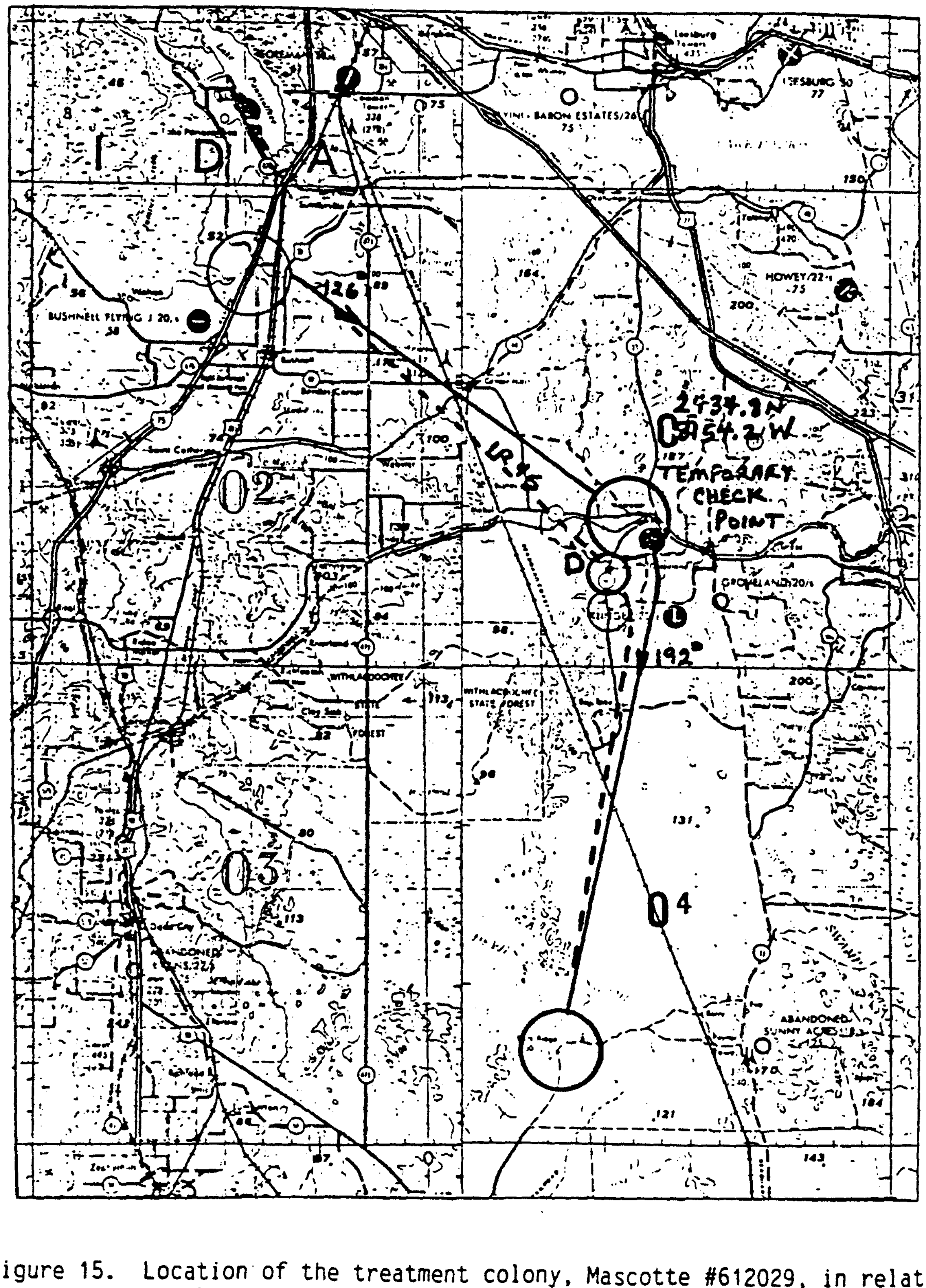


Figure 15. Location of the treatment colony, Mascotte #612029, in relation to the temporary segment centerline (solid line) of IR-046.

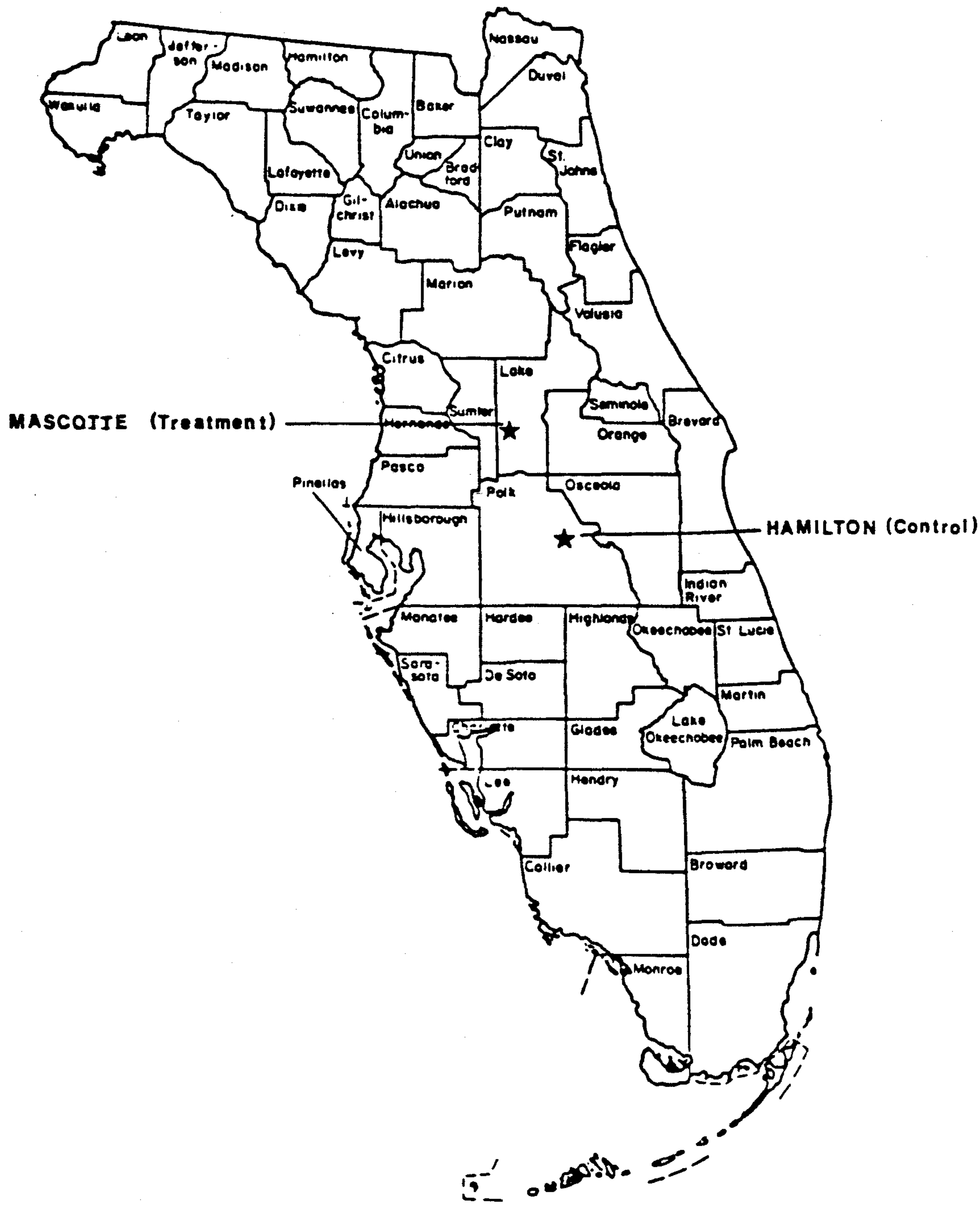


Figure 16. Locations of the treatment and control colonies in Lake and Polk counties, respectively.

Study Areas

Locations and Descriptions

The treatment colony, Mascotte, is located 0.8 km south of the town of Mascotte within a palustrine system (Cowardin et al. 1979) composed of floating and rooted vascular aquatic beds, persistent emergent wetland and broad-leaved deciduous wetland (Fig. 17). The predominantly non-inundated scrub-shrub zone consists primarily of wax myrtle (Myrica cerifera L.) (Fig. 17, M). Other shrubs and trees occurring in this area include elderberry (Sambucus simpsonii Rehd.), primrose-willow (Ludwigia leptocarpa (Nutt.) Hara.), buttonbush (Cephalanthus occidentalis L.) and red maple (Acer rubrum L.) (Appendix 4). Forbs, namely, water pennywort (Hydrocotyle umbellata L.), pokeweed (Phytolacca americana L.), boneset (Eupatorium serotinum Michx.), plume thistle (Cirsium sp.) and others comprise the ground layer (Appendix 4).

Adjacent to the wax myrtle zone are mixed stands of emergent aquatic plants and scrub-shrub including pickerelweed (Pontederia cordata var. lancifolia (Muhl.) Torrey), cattail (Typha sp.), water pennywort, saw-grass (Cladium jamaicense Crantz), wax myrtle, elderberry, buttonbush, willow and other species (Fig. 17, C-T; Appendix 4). These areas typically are inundated with water levels varying from 0-1m.

Emergent zones dominated by pickerelweed, flatsedge (Cyperus odoratus L.), water pennywort and aquatic beds dominated by fragrant white water-lily (Nymphaea odorata Ait.), bladderwort (Ultricularia inflata Walt.) and duckweed (Lemna sp.) occur throughout the wetland

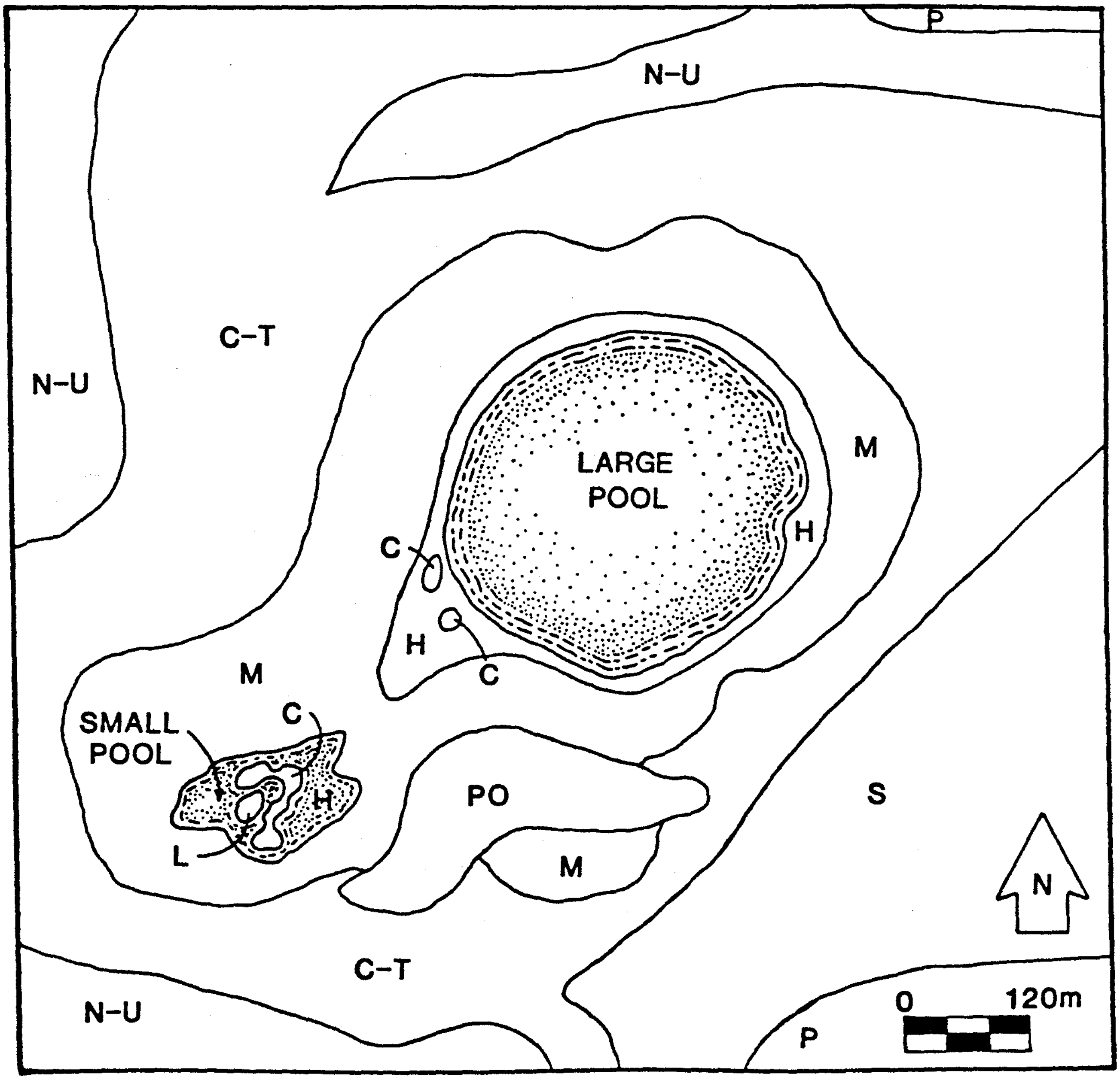


Figure 17. Vegetation map of the treatment colony and adjacent areas at Mascotte, Florida, May 18, 1983.

C Cyperus
C-T Mix: Cephalanthus, Cladium, Hydrocotyle, Myrica, Pontederia, Salix, Sambucus, Typha
H Hydrocotyle
L Lemna
M Myrica
N-U Nymphaea, Utricularia
P Pinus
PO Pontederia
S Salix

area surrounding the treatment colony (Fig. 17, PO, C, L, N-U). A scrub-shrub zone of willow occurs to the southeast of the treatment colony (Fig. 17, S).

This colony is situated in a natural freshwater marsh system that extends approximately 2.8 km to its west, 0.8 km to the east, 1.2 km to the north and 0.4 km to the south. These wetlands grade upland into scattered pine (Pinus sp.) islands, hardwood hammocks and extensive cultivated orange groves.

The control colony, Hamilton, is located on a typically inundated island in the southeast quarter of Lake Hamilton. This palustrine system is composed of floating vascular aquatic beds, persistent emergent wetland, broad-leaved deciduous scrub-shrub wetland and a small portion of broad-leaved evergreen forested wetland (Fig. 18).

The scrub-shrub area occupying the central portion of the island is predominantly composed of Florida elderberry and, to a lesser extent, of primrose-willow, willow, buttonbush and others (Fig. 18, SM; Appendix 5). Forbs and grasses which occur in the central portion include alligator weed (Alternanthera philoxeroides (Mart.)), knotweed (Polygonum punctatum Ell.), water pennywort (H. umbellata L. and H. ranunculoides L.f.), dog-fennel (Eupatorium capillifolium (Lam.) Small), para grass (Brachiaria purpurascens (Raddi) Henr.), maidencane (Panicum hemitomum Schult.), duckweed, watermeal (Wolffia sp.), mud-midget (Wolfiella sp.) and others (Appendix 5).

Surrounding the central portion of the island is an area dominated by emergent aquatic plants including dog-fennel, alligator weed, water pennywort, para grass, maidencane, knotweed and others (Fig. 18, A-P). Shrubs, namely, primrose-willow and elderberry occur scattered through this area.

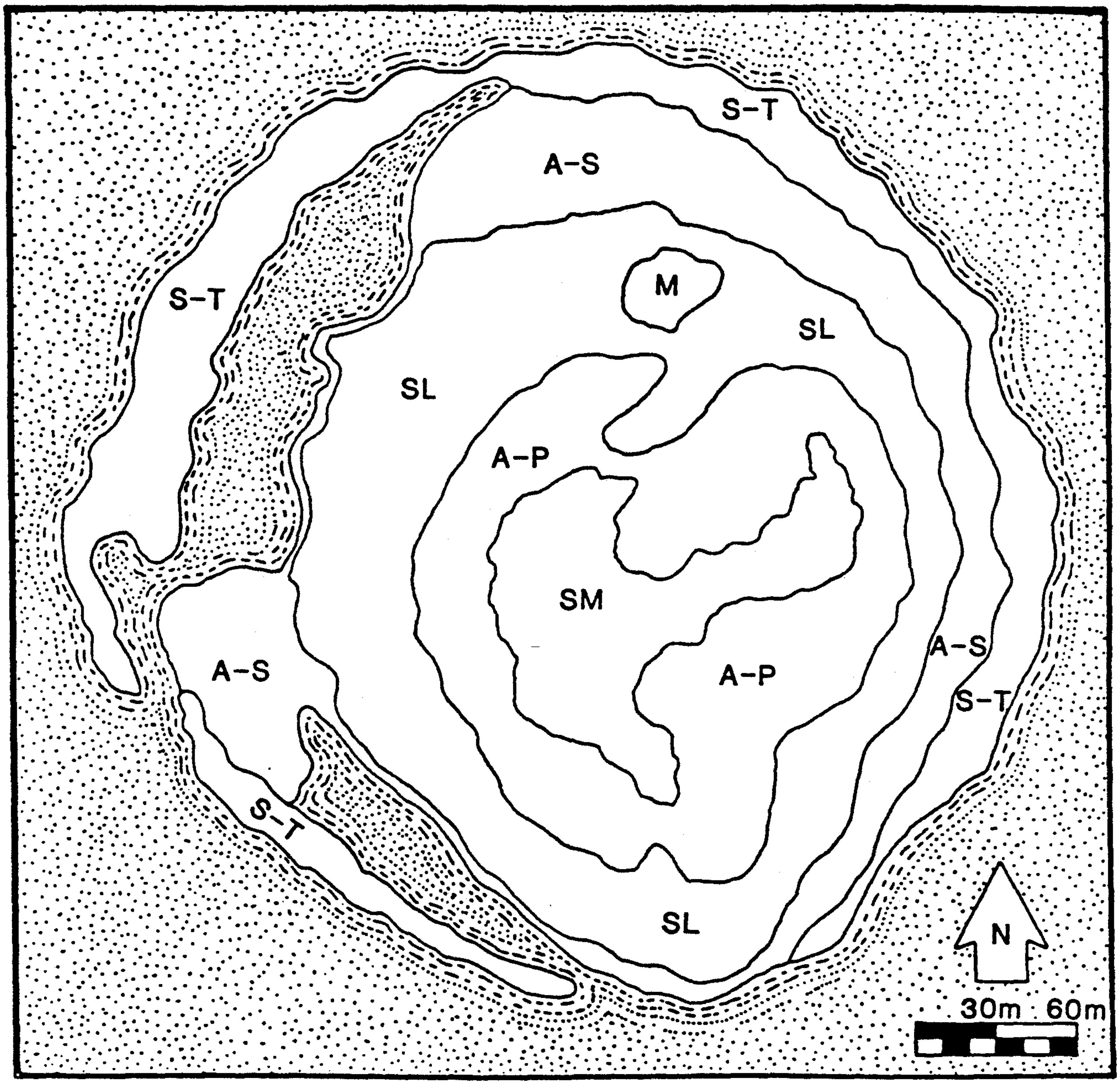


Figure 18. Vegetation map of the control colony at Lake Hamilton, Florida, May 18, 1983.

A-P Mix: Alternanthera, Brachiaria, Eupatorium, Hydrocotyle, Ludwigia, Panicum, Polygonum, Sambucus
A-S Mix: Alternanthera, Brachiaria, Eicchornia, Hydrocotyle, Ludwigia, Panicum, Pistia, Polygonum, Sagittaria
M Melaleuca
SL Salix
SM Sambucus
S-T Mix: Scirpus, Typha

Bordering the zone of emergent wetland is a scrub-shrub area dominated by willow (Fig. 18, S-L). Primrose-willow, elderberry and buttonbush also occur within this zone, but to a lesser extent than willow. Within the northern region of the willow zone lies a small portion of forested wetland composed of bottle-brush trees (Melaleuca quinquenervia (Cav.) Blake) (Fig. 18, M). Forbs, grasses and sedges which occur within the willow and bottle-brush tree areas include cattail, saw-grass, arrowhead (Sagittaria lancifolia L.), water pennywort, alligator weed and others (Appendix 5).

A band of emergent wetland and floating vascular aquatic beds surround the willow and bottle-brush tree zones (Fig. 18, A-S). Emergent aquatic plants comprising this zone include alligator weed, water pennywort, para grass, maidencane, arrowhead and others (Appendix 5). Floating aquatic plants found in this zone include water hyacinth (Eichhornia crassipes (Mart.) Solms) and water lettuce (Pistia stratiotes L.). Shrubs, namely, primrose-willow and buttonbush occasionally occur within this zone.

A band of bulrush (Scirpus sp.) and cattail forms the outer edge of the island and comprises the third zone of emergent aquatic plants found on the island (Fig. 18, S-T).

Lake Hamilton is a natural lake located in the headwaters of the Peace River in the Peace Valley Basin 1.9 km southwest of the town of Lake Hamilton. The lake is located downstream from Big, Middle and Little Lake Hamiltons and upstream from the Peace Creek drainage canal. The Hamilton lakes probably resulted from coalesced sinkhole depressions that formed when dissolved subsurface limestone allowed the land to sink below the local water table (Anderson and Simonds

1983). The lake's surface area is 8.78 km^2 and its drainage area is estimated at 53.1 km^2 (SWFWMD unpubl. data). Since July 1962 a control structure in the P-8 canal at the lake's south end has been used to maintain the lake's altitude between a maximum desirable level (121.25 ft msl) and a minimum desirable level (119.0 ft msl) established by the governing board of the South West Florida Water Management District. At an altitude of 120 ft msl the lake depth averages 2.3 m and the lake bottom grades gently to a natural shoreline which is approximately 50% developed with low density housing. The surrounding region supports a golf course, citrus groves, business and agricultural areas.

Colony Histories

Since 1976, the breeding populations and colony locations have varied at the study sites. At both sites the breeding populations were reduced in 1981 (treatment - 300 pairs of Cattle Egrets; control - 75 pairs of Cattle Egrets) and increased in 1977 and 1978 (treatment - 1765, 2000, respectively; control - 4550, 3150, respectively) (Appendix 6). The most numerous species breeding at both sites have been Great Egrets, Cattle Egrets and White Ibis; however, the number of breeding pairs of these species have fluctuated differently from year to year (Appendix 6).

Colony and subcolony (proximate though discrete breeding assemblage) locations have been more variable at the treatment site than at the control site. Since 1976, colonies or subcolonies at the treatment site have been located at at least 7 sites within the described marsh system (see Locations and Descriptions) with a range from 1 to 4 sites in any one year. The control colony, however, has been located on the island in Lake Hamilton (see Locations and Descriptions) every year since 1976 except 1980 and 1981 when it was located on the southern lake edge just east of and adjacent to the Lake Region Country Club.

In 1983, the treatment colony was located at one site (Fig. 19) as was the control colony (Fig. 20). In 1984, however, subcolonies formed at both sites (Figs. 19 and 20). At the treatment site, birds roosted throughout the winter preceding the 1983 breeding season at the 1983 colony site (B. Durden, pers. comm.) through it is unknown if this pattern continued through the winter of 1983-84. The 1983 colony site was, however, the primary evening roost being used from 5 March 1984 until 19 March 1984 when the primary evening roosting area became Area A east of Sunset Road. This move occurred coincidentally with two events: 1) Little Blue Herons and Great Egrets remaining throughout the day in Area A to initiate breeding and 2) an airboat entering the evening roost at roosting time. By 15 April 1984 nesting had begun in three subcolonies (Area A, Area B, Area C) and there was no further roosting at the 1983 colony site. At the control site in 1983 no pre-season roosting activity was observed since Great Egrets and Great Blue Herons were already nesting when researchers arrived on 17 February. In 1984, the control island was used as an evening roost by Great Egrets, Cattle Egrets, White Ibis, Glossy Ibis, Anhingas and a limited number of small herons from 6 March to 19 April during which time Great Egrets began breeding on the island and small herons began breeding in the subcolony. A nesting attempt by approximately 8 Great Egret pairs on Bonair Island at the north end of Lake Hamilton from 13-27 March failed by 2 April.

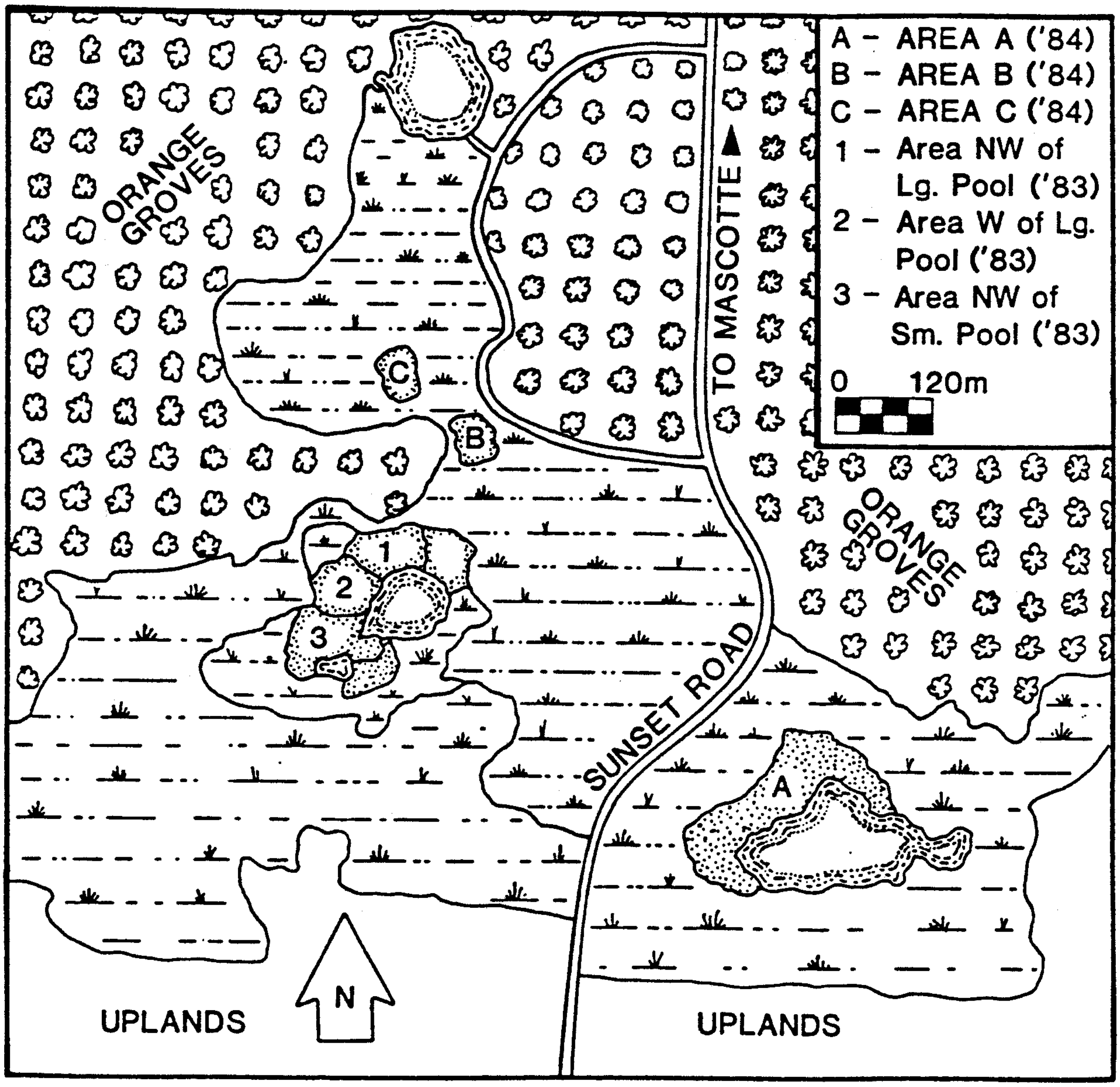


Figure 19. Treatment colony and subcolony locations and nesting areas (stipled regions) used as breeding sites in 1983 and 1984. Areas A, B and C in 1984 represent three subcolonies.

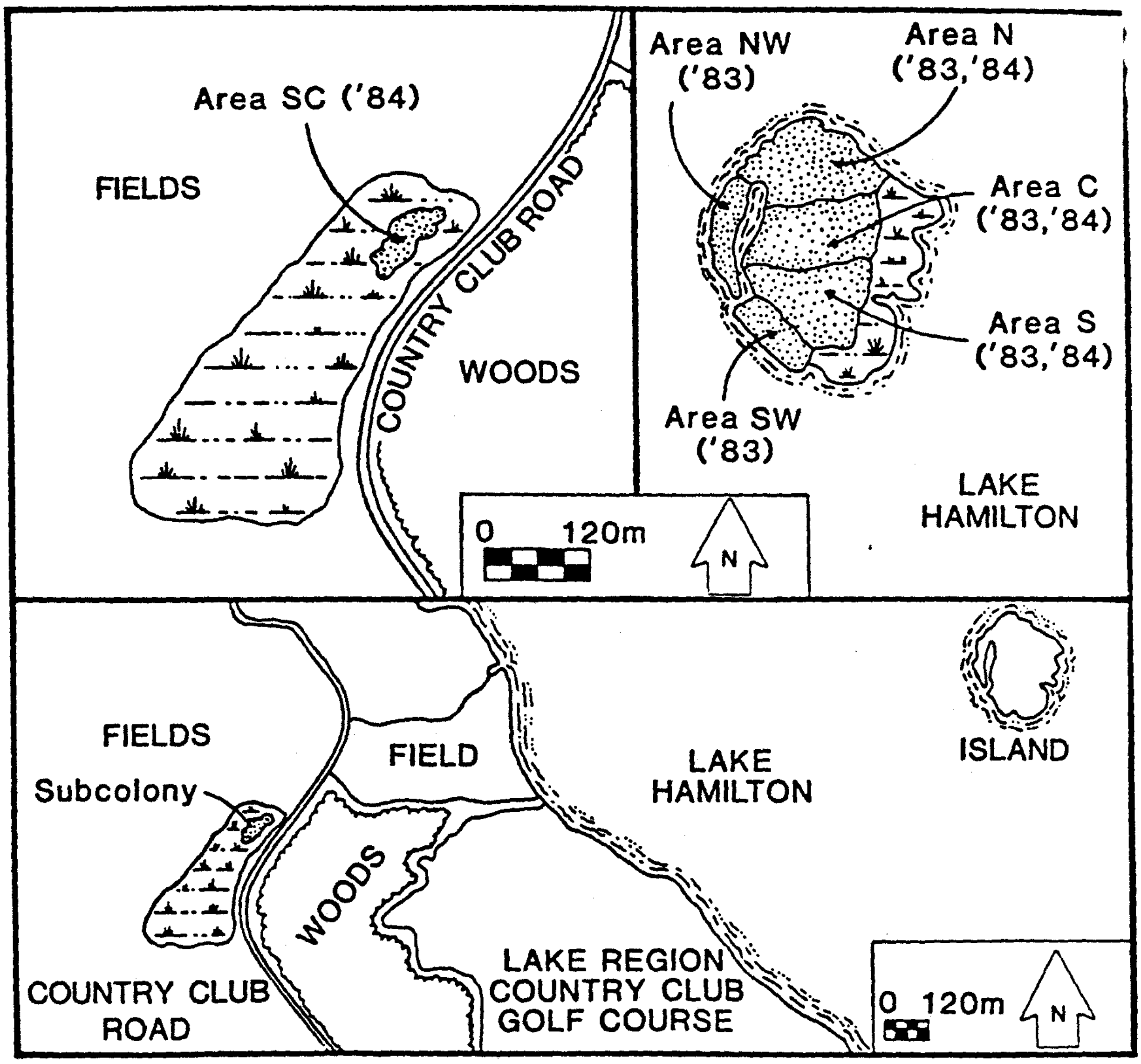


Figure 20. Control colony and subcolony locations and nesting areas (stipled regions) used as breeding sites in 1983 and 1984.

The type of nesting substrate used by the breeding birds differed by site. Wax myrtle was the primary nesting substrate at the treatment site in both study years whereas elderberry and willow were the primary nesting substrate on the control island in those years. In 1984, wax myrtle was the primary nesting substrate selected by birds breeding in the control subcolony.

Research Procedures

During the 1983 and 1984 breeding seasons researchers visited each study colony twice weekly to collect breeding ecology data in the early morning after which they entered an elevated blind to record military overflights (treatment colony) and make behavioral observations.

Military Overflights

A list of F-16 training flights scheduled for IR-046 was provided weekly by Airspace Management and/or Scheduling at MacDill AFB. Under normal conditions these flights are made at 420 knots indicated airspeed at 82-84% maximum rpms and typically are flown at 500 ft above ground level. Only flights estimated to be within 805 m of the treatment colony were recorded as overflights.

Overflying aircraft could potentially produce auditory, visual or tactile (vibrational) stimuli which would be perceived through the hearing, sight and Herbst corpuscles, respectively, of avian species. The first stimulus could be measured in the field; however, the second was considered difficult to measure under field conditions. In addition, neither the sensitivity nor the response of birds to the third stimulus are well understood (Schwartzkopff 1973). Sound was, therefore, the only aircraft generated stimulus monitored.

During each overflight the peak noise level was recorded using a Quest-215 sound level meter with an accompanying peak hold module. Birds, in general, are sensitive to sound frequencies (40 H_z to 21 kH_z) similar to man's (15 H_z to 20 kH_z) but are less sensitive to higher and lower tones within their hearing range (Schwartzkopff 1973). The dBA scale, thus, was selected as a measure of the sound intensity experienced by the study subjects and for comparability to other studies. No data were available for ardeids, specifically; therefore, it was assumed that their hearing sensitivity was similar to that of other avian species.

Behavioral Observations

During behavioral observations responses to overflights, aggressive encounters, adult attendance at the nest and chick feeding rates were monitored. Responses to overflights were recorded for breeding adults throughout the nesting cycle and for nestlings after 2 wks post-hatching. During overflights each observer watched approximately 6 individuals and recorded their location (in nest or out of nest) and response (after Kushlan 1979b): (1) exhibited no response; (2) head movement/looking up; (3) changed position (stood, crouched); (4) walked from its nest but returned within 5 mins; (5) flew from its nest but returned within 5 mins; and (6) left nest and did not return within 5 mins. Any aggressive encounters involving the selected individuals were noted during the 1 min. post-overflight. Comparable response data were gathered at random times in the control colony and statistical comparisons were made using the Wilcoxon's signed rank test and Kruskal-Wallis test for ordinally measured data (Siegel 1956).

During afternoon observations (typically 1200-1800) each observer watched 3 nests and recorded adult attendance and chick feeding rates. Adult attendance was recorded as the time during which one adult, both adults or neither adult were within 10 m of the nest in selected phases of the nesting cycle. The length of chick feeding periods was defined as the time during which the adult was involved in chick feeding activity and/or the time in which chicks were feeding. Since feeding rates may increase towards dawn or dusk (J. Wiese, pers. comm.), feeding rates reported in this study should be considered conservative estimates, but comparable between colonies. Only observations of at least 3 hrs duration are included in analyses, and specific analyses are indicated as results are presented.

Breeding Ecology

During visits to the study colonies researchers monitored reproductive success, nestling survival and mortality, evidence of predation and disease, researcher and non-researcher induced human disturbance, nest heights and density, nestling weight gains and nesting chronology. Chick feeding rates were recorded during behavioral observations, as previously described; and, weather data were compiled from NOAA climatic stations nearest the study colonies (NOAA 1982, 1983).

To minimize researcher disturbance during pair-formation and nest-building, colonies or portions of colonies were entered when most breeding pairs were in late egg-laying or early to mid incubation. Nests found with one or more eggs were considered to be active and as many Great Egret, Snowy Egret, Tricolored Heron and Little Blue Heron nests as possible, were tagged. Since Cattle Egrets were so numerous and often spatially and temporally separated from other breeders, only Cattle Egret nests on 2 m wide randomly selected transects were tagged and monitored. The fate of eggs and subsequently individually marked nestlings was followed to 2 wks (Snowy Egret, Tricolored Heron, Little Blue Heron, Cattle Egret) or 3 wks (Great Egret) at which time nestlings became increasingly mobile, easy to disturb and difficult to monitor.

The nesting cycle was divided into laying, incubation and nestling periods. The laying period was defined as the number of days from the day the first egg was laid to the day the last egg was laid. The incubation period extended from the day after the last egg was laid to the day before hatching of the first egg. The nestling period extended from the date the first egg hatched (hereafter referred to as "hatching") to 14 or 21 days from that date.

Since surveys were conducted every 3rd or 4th day, particular events (i.e. hatching losses) or days of interest (i.e. 7th, 14th, 21st day after hatching) often fell between survey days. In the case of hatching, losses that occurred between surveys could have been either egg or nestling losses so all losses during that period were classified simply as hatching losses. When the 7th, 14th or 21st day after hatching fell between two visits in which the number of nestlings decreased, the mean number of chicks on those two surveys was recorded for the day of interest. This methodology was preferred to omitting data for the nests affected, since dropping such data resulted 46% (N=11 data sets) of the time in estimates outside of the minimum or maximum number of chicks known present. Nest history parameters (i.e. clutch size, number of young at 7, 14, 21 days etc.)

were analyzed using Statistical Analysis System (SAS) programs (Ray 1982): specific analyses are indicated as results are presented.

The nest success of the five study species were compared using the Mayfield method (Mayfield 1961, 1975) which incorporates the time (nest days) over which nests are observed together with nest losses to estimate a daily survival probability ($\hat{p}$) for a given period of the nest cycle. An estimated success probability for the period ($\hat{p}^J$ where J is the number of days in a period) can then be derived and an overall estimate of success for the entire nest cycle calculated by the equation $\hat{s}=\hat{p}_1^{J1}\hat{p}_2^{J2}\hat{p}_3^{J3}$. In analyses presented in this report the periods as previously defined are: p_1=egg-laying, p_2=incubation and p_3=nestling. The length of these periods in days are: $J_1=6$, $J_2=17$, $J_3=14$ for Snowy Egrets, Tricolored Herons, Little Blue Herons and Cattle Egrets and $J_1=6$, $J_2=21$ and $J_3=21$ for Great Egrets. J_1 and J_2 were derived from laying intervals and incubation periods reported for the study species (Jenni 1969, Maxwell and Kale 1977) and from data for the 1983 breeding season. In cases where egg-laying was not observed (i.e. Great Egret at Mascotte in 1983), the nest success estimate for that species is derived by an overall success probability $\hat{s}=\hat{p}^{\Sigma Ji}$ where p is the daily success probability for the entire nesting cycle and Ji is the number of days in the entire nesting cycle (Hensler, in press).

The Mayfield method assumes: 1) nesting periods of equal length for all nests considered; 2) a constant unknown probability of a nest surviving a nesting period; and 3) a fixed unknown probability of finding a nest on any day of a nesting period. If these model assumptions are met, the Mayfield estimate should reduce the bias of the traditional method ($\overline{Y}$=proportion of observed nests which were successful) which overestimates nest success unless most nests are found on the first day of the nesting period. In addition, Hensler and Nichols (1981) have shown that the Mayfield estimate is a maximum likelihood estimator for which a variance can be estimated and tests of significance are appropriate.

Problems can arise when nest contents are lost either in an undeterminable nesting phase (i.e. "between" two phases) or before the nesting species has been identified. In the former case, for example, suppose a nest is found containing 2 eggs. Three days later it contains 3 eggs and 4 days later it is empty. Since 3 eggs could be an incomplete or full clutch, the nest could have been lost in either the laying or incubation phase. In this study such losses were divided between nesting phases based on the proportion of nest days in the two periods in question. To assign losses in this manner, one must assume a constant rate of loss for each period; however, an error from this assumption is presumed less than the error incurred from omitting the nests altogether. The second problem arises from nests of the smaller herons (Snowy Egret, Tricolored Heron, Little Blue Heron, Cattle Egret) which are undifferentiable prior to hatching. To assign losses of these nests randomly among the smaller species based on their relative abundance, one would have to assume a constant rate of nest loss among species. Since this assumption would be false, we rejected this method of dealing with unidentified nests. Of the unidentified nests lost during incubation in 1983, 83% (39 of 47) at Mascotte and 70% (16 of 23) at Hamilton were nests on the Cattle Egret transects. All of these nests were thought to be Cattle Egret nests and were, thus, added to the nest success data of that species. The remaining unidentified nests (1983- 8 at Mascotte, 7 at Hamilton; 1984- 5 at Mascotte, 6 at Hamilton) were not included in the analyses and, therefore, success estimates for the small herons may be slightly biased upward.

During nest surveys we used Pesola scales to weigh all siblings in broods with a known-age chick, one found pipping (day -1) or wet and matted (day 0). The ages of siblings of known-age chicks were estimated using the known hatching order and assuming a 2 day hatching interval. While this assumption may not be correct in all cases, estimated chick ages should be accurate to within ± 1 day. If weight gains of known versus estimated-age chicks differed significantly ($p \leq .05$), then only known-age chick weights were used in further analyses. Data were analyzed using analysis of covariance (SAS, Ray 1982) to test for colony differences in weight gains within year and by species. Regression analyses were used to fit data to linear, quadratic or cubic functions and curves then were plotted for significant regressions. Data for chicks that later died were excluded from analyses.

The time researchers spent in each area of the colony was recorded during each survey. In addition, nest heights were measured from ground level; and, nest densities were recorded on three 2 m wide randomly selected transects in each area.

Results

Wading Bird Responses to Military Overflights

During the 1983 and 1984 breeding seasons, 57 Air Force overflights were recorded at the treatment colony (Table 9). Since observers were present on only 40% (2 of 5) of the flight days (weekdays) per week and since flight frequency is generally consistent among weekdays, a total of 143 flights was estimated to have occurred at the treatment colony. This flight frequency (1-2 flights per day: each flight with 2-4 aircraft) was assumed to represent the typical overflight exposure to be expected at any specific locality beneath one of several centerlines of a frequently flown route.

Noise levels recorded during military overflights ranged from 55 to 100 dBA, a range spanning about a 16-fold increase in loudness since 10 dBAs equal a doubling in perceived sound intensity. Sound levels recorded below overflying aircraft may vary with ground topography, atmospheric conditions, aircraft speed, power setting and orientation. For example, craft just over a small hill from the 1984 colony produced reduced noise levels, and craft that were turning rather than cruising overhead produced increased noise levels. Noise levels within a colony can reach 64 dBA during nest-building, feeding sessions, etc. (Wiese 1978) and, thus, may equal or surpass noise levels during some overflights. The loudest overflights, however, were 4 times louder than any recorded noises near the study colonies (Table 10) excluding airboats.

There was a significant difference ($P < .001$, Wilcoxon's signed rank test) between responses recorded at the treatment and control

Table 9. Date, time and recorded noise levels of 57 Air Force overflights within 805 m (½ mile) of the treatment colony in 1983 and 1984.

Year	Overflight Number	Date	Time of Day	Recorded Noise Level (dBA)
1983				
	1	10 Mar	1139	--
	2	10 Mar	1256	--
	3	14 Mar	1319	--
	4	21 Mar	0840	--
	5	31 Mar	1206	74
	6	31 Mar	1325	90
	7	4 Apr	1100	--
	8	7 Apr	1130	--
	9	11 Apr	0805	--
	10	14 Apr	0952	--
	11	14 Apr	1329	--
	12	18 Apr	0956	--
	13	18 Apr	1023	--
	14	18 Apr	1410	55
	15	21 Apr	1325	84
	16	21 Apr	1326	86
	17	21 Apr	1425	88
	18	21 Apr	1426	84
	19	21 Apr	1511	86
	20	21 Apr	1512	88
	21	25 Apr	1725	86
	22	28 Apr	1629	88
	23	28 Apr	1630	91
	24	2 May	1640	66
	25	9 May	1427	80
	26	16 May	1730	92
	27	19 May	1428	64
	28	19 May	1401	62
	29	9 Jun	1646	94
	30	23 Jun	1336	--
	31	27 Jun	1328	72
1984	32	10 Apr	1443	--
	33	13 Apr	1438	56
	34	13 Apr	1459	56
	35	17 Apr	1025	82
	36	7 May	1256	58
	37	7 May	1257	55
	38	7 May	1508	56
	39	10 May	1353	62
	40	17 May	1330	54
	41	21 May	1320	52
	42	21 May	1335	52
	43	24 May	1425	55
	44	31 May	1225	--
	45	4 Jun	955	--
	46	7 Jun	1328	63

Table 9 (continued)

Year	Overflight Number	Date	Time of Day	Recorded Noise Level (dBA)
	47	7 Jun	1431	61
	48	11 Jun	1111	84
	49	11 Jun	1112	92
	50	11 Jun	1428	88
	51	11 Jun	1429	100
	52	12 Jun	1104	90
	53	12 Jun	1106	96
	54	13 Jun	1102	92
	55	13 Jun	1103	94
	56	18 Jun	1035	55
	57	18 Jun	1355	54

Table 10. Non-military sound sources and levels recorded in and near the treatment and control colonies in 1983 and 1984.

Colony	Sound source	Location	Recorded sound level (dBA)
Treatment	Power saw	adjacent field	52
	Bulldozer	adjacent field	72
	Helicopter	100 m	65-75
	Ultralight aircraft	100 m	74
	Prop planes/crop duster	150-600 m	54-74
	Airboat	colony edge	85-90[a]
Control	Motorboat	island edge	57-90
	Pontoon plane	100-150 m	58-72
	Airboat	colony edge	85-90[a]

[a]Airboat noise levels were estimated.

sites (Table 11): birds in the treatment colony looked up (34% of responses) and changed position (18% of responses) significantly more than those in the control colony (1% and 3%, respectively). While the difference in responses was significant, the levels of responses at the treatment colony were not severe. These responses were limited to no response, looking up or changing position (usually to an alert posture): no walking or flushing from the nest was observed.

During F-16 overflights, birds began looking up as noise levels reached 60-65 dBA and began changing position at 70-75 dBA. From 75-100 dBA birds exhibited no response, looked up, and changed position at each sound level recorded. Responding birds typically resumed their normal position or moved out of an alert posture 1-2 mins after an overflight. Additionally, no increase in aggressive encounters was observed following overflights.

At the treatment site there was a significant difference ($\underline{P} < .01$, 6 df, Kruskal-Wallis test) among species in response to military overflights: Great Egrets looked up more than any other species (Table 11). This differential response may be related to the high nest placement (Table 12) and open, accessible nest sites (McCrimmon 1978, Burger 1978) of Great Egrets and their resulting exposure to both auditory and visual stimuli during jet overflights.

Adult Great Egrets and Cattle Egrets responded to overflights significantly differently ($\underline{P} < .05$, 1 df, Wilcoxon's signed rank test and $\underline{P} < .0001$, 1 df, Wilcoxon's signed rank test, respectively) than did their nestlings (Table 13). In both cases, nestlings looked up and changed position proportionately more than did adults. Based on responses to overflights with noise levels $\geq$ 80 dBA, adults appeared

Table 11. Percentage of responses in each disturbance class[a] as recorded for species observed during overflights at the treatment colony and at random times in the control colony in 1983 and 1984.

Colony[b]	Species	% of responses in each disturbance class						n	Maximum noise level (dBA)
		1	2	3	4	5	6		
Treatment[c]	Great Egret	36	46	18				179	94
	Snowy Egret	80	20					41	94
	Cattle Egret	51	28	21				199	100
	Tricolored Heron	100						4	64
	Little Blue Heron	100						2	62
	White Ibis	67	33					3	94
	Anhinga	100						2	56
All	Species, $\bar{x}$	48	34	18				430	
Control	Great Egret	94	3	3				179	
	Snowy Egret	93		7				68	
	Cattle Egret	97	1	1		1		88	
	Tricolored Heron	100						14	
	Little Blue Heron	97		3				38	
All	Species, $\bar{x}$	95	1	3		1		387	

[a] 1 = no response
2 = head movement/look up
3 = change position
4 = walked from its nest but returned within 5 mins.
5 = flew from its nest but returned within 5 mins.
6 = left nest and did not return in 5 mins. (after Kushlan 1979b)

[b] *P* < .0001; Wilcoxon's signed rank test comparing responses of combined species in treatment versus control colony.

[c] *P* < .01, df = 6; Kruskal-Wallis test comparing responses of species within the treatment colony.

Table 12. Nest heights of study species in the treatment colony in 1983 and 1984.

	1983		1984	
	Nest height (m)		Nest height (m)	
Species	n	$\bar{x} \pm SE$	n	$\bar{x} \pm SE$
Great Egret	42	1.48 ± .05	18	1.58 ± .12
Cattle Egret	77	1.35 ± .03	60	1.48 ± .03
Snowy Egret	23	1.24 ± .05	16	1.38 ± .09
Tricolored Heron	10	1.23 ± .10	15	1.38 ± .05
Little Blue Heron			11	1.38 ± .06

Table 13. Percentage of responses in each disturbance class[a] as recorded for Great Egret and Cattle Egret adults and chicks[b] observed during overflights at the treatment colony in 1983 and 1984.

Species	Age class	% of responses in each disturbance class 1	2	3	4	5	6	n	% of responses when noise levels were 80 dBA
Great Egret[c]	Adult	69	19	12				32	59
	Chick	28	52	20				147	83
Cattle Egret[d]	Adult	76	21	3				82	70
	Chick	33	33	33				117	75

[a] See Table 11, subscript a, for class descriptions.
[b] Responses of adults were recorded throughout the nesting period. Responses of chicks were recorded after they were 2 weeks old.
[c] $\underline{P} < .05$, df = 1; Wilcoxon's signed rank test comparing responses of adults and chicks.
[d] $\underline{P} < .0001$, df = 1; Wilcoxon's signed rank test comparing responses of adults and chicks.

less easily disturbed during certain phases of the nesting cycle, especially during incubation (Fig. 21, a). In the 2-3 wks when adults were present at the nest with young nestlings, they often appeared "relaxed" (i.e. preening, standing in or beside the nest, shading chicks, etc.) and were more responsive to overflights (Fig. 21, b). Later when adults returned to the nest only to feed chicks, they again appeared very stimulated by activity at the nest and less responsive to overflights. For instance, an adult Great Egret feeding a chick did not interrupt this activity during a 92 dBA overflight. Thus, in the case of adults it is difficult to identify habituation to overflights since responses varied with adult activity. Chicks spent the majority of the nestling period lying, sitting or standing in or around the nest, gradually investigating the nest and nest surroundings and, as older chicks, eventually moving into the tree-tops above their nest, if nests were relatively low. Nestlings were very aware of and responsive to changes in their surroundings including the occurrence of jet overflights (Fig. 21, c). There was no clear evidence of habituation to overflights by chicks since they showed similar response patterns even as they got older (Fig. 22).

During 1,011 nest-hours of observation (Table 14), adult Great Egrets and Snowy Egrets demonstrated similar overall patterns of nest attendance when compared by species between sites (Fig. 23 and Fig. 24, respectively). During the nestling period, significant differences did occur between sites for Great Egrets at 2-4 wks (X^2=49.0, 1df, $\underline{P} < .00001$) and for Snowy Egrets at 2-3 wks (X^2=13.4, 1df, $\underline{P} < .001$) and 3-4 wks (x^2=72.2, 1df, $\underline{P} < .00001$). During these time periods (3-4 wks for Great Egrets and 2-3 wks for Snowy Egrets),

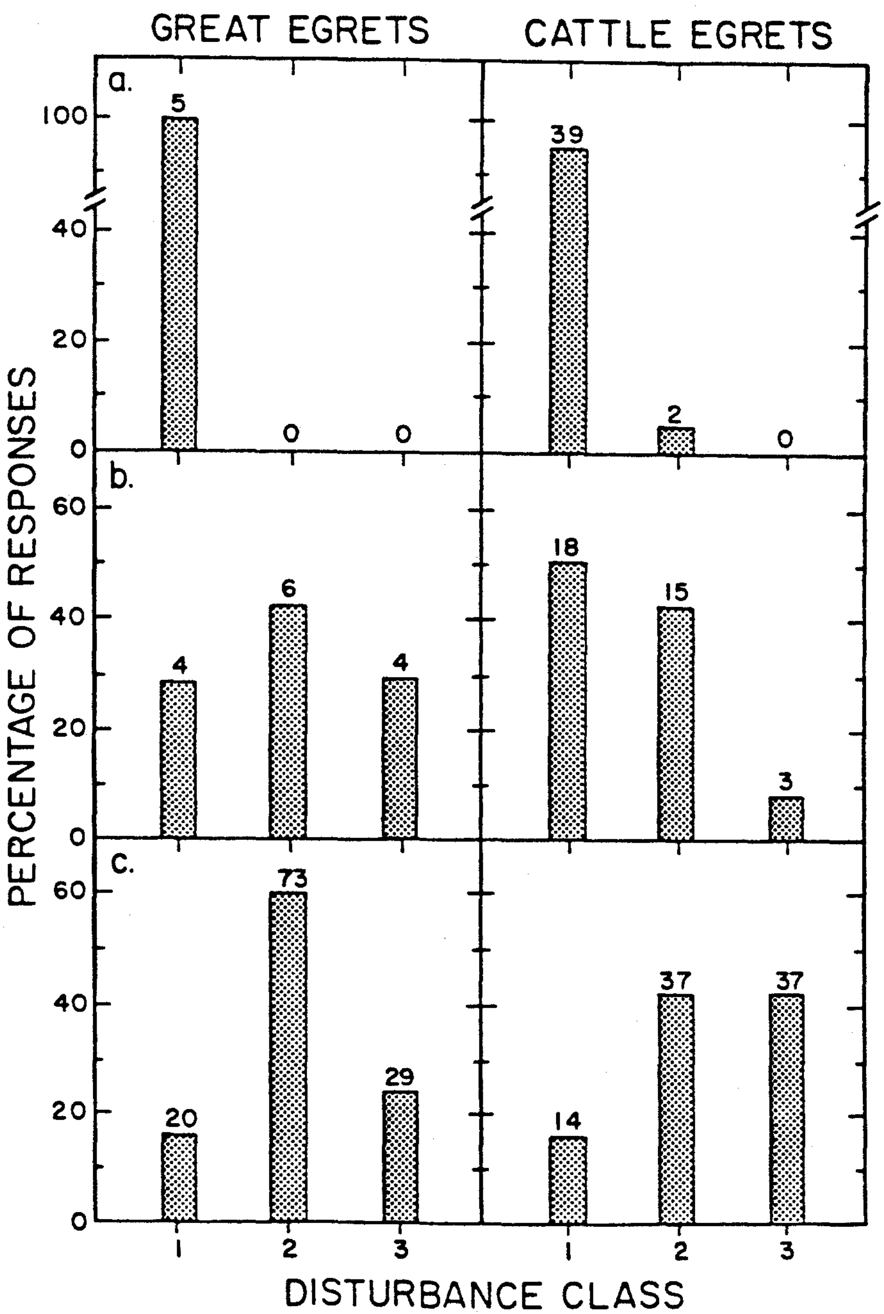


Figure 21. Percentage of responses in three disturbance classes for Great Egret and Cattle Egret a) adults during incubation, b) adults during chick-rearing, and c) nestlings during chick-rearing as recorded during F-16 overflights with noise levels $\geq$ 80 dBA.

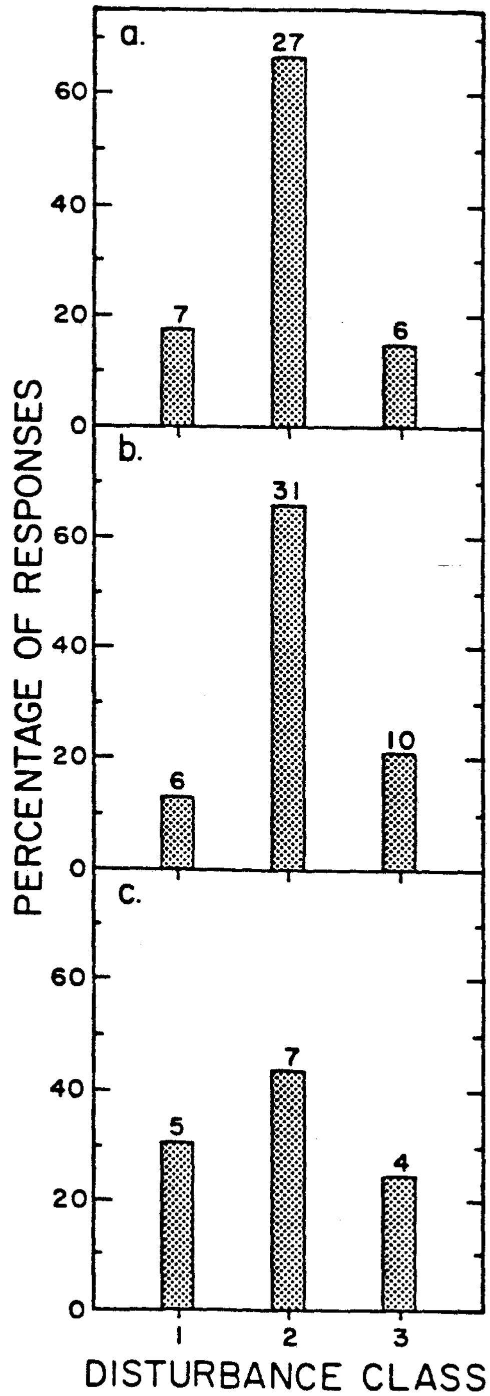


Figure 22. Percentage of responses in three disturbance classes for Great Egret chicks at a) 2-4 wks, b) 4-6 wks, and c) 6-8 wks of age as recorded during F-16 overflights with noise levels $\geq$ 80 dBA.

Table 14. Number of nest-hours of behavioral observations conducted to record adult attendance at Great Egret and Snowy Egret nests in the treatment and control colonies in 1983 and 1984.

	Treatment Colony		Control Colony	
Species	# nests observed	Nest-hours of observation	# nests observed	Nest-hours of observation
Great Egret	11	398	14	292
Snowy Egret	6	182	8	139

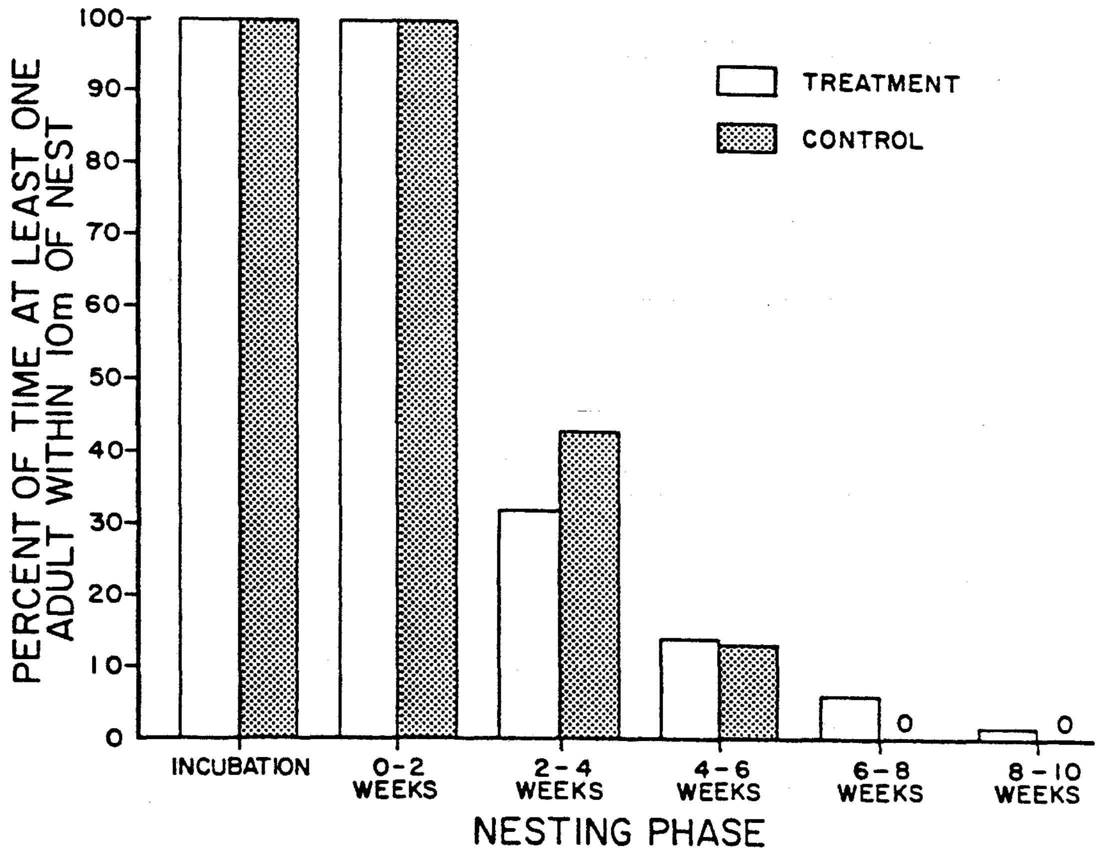


Figure 23. Percentage of time at least one Great Egret adult was within 10 m of its nest during incubation and chick-rearing at the treatment and control colonies in 1983 and 1984.

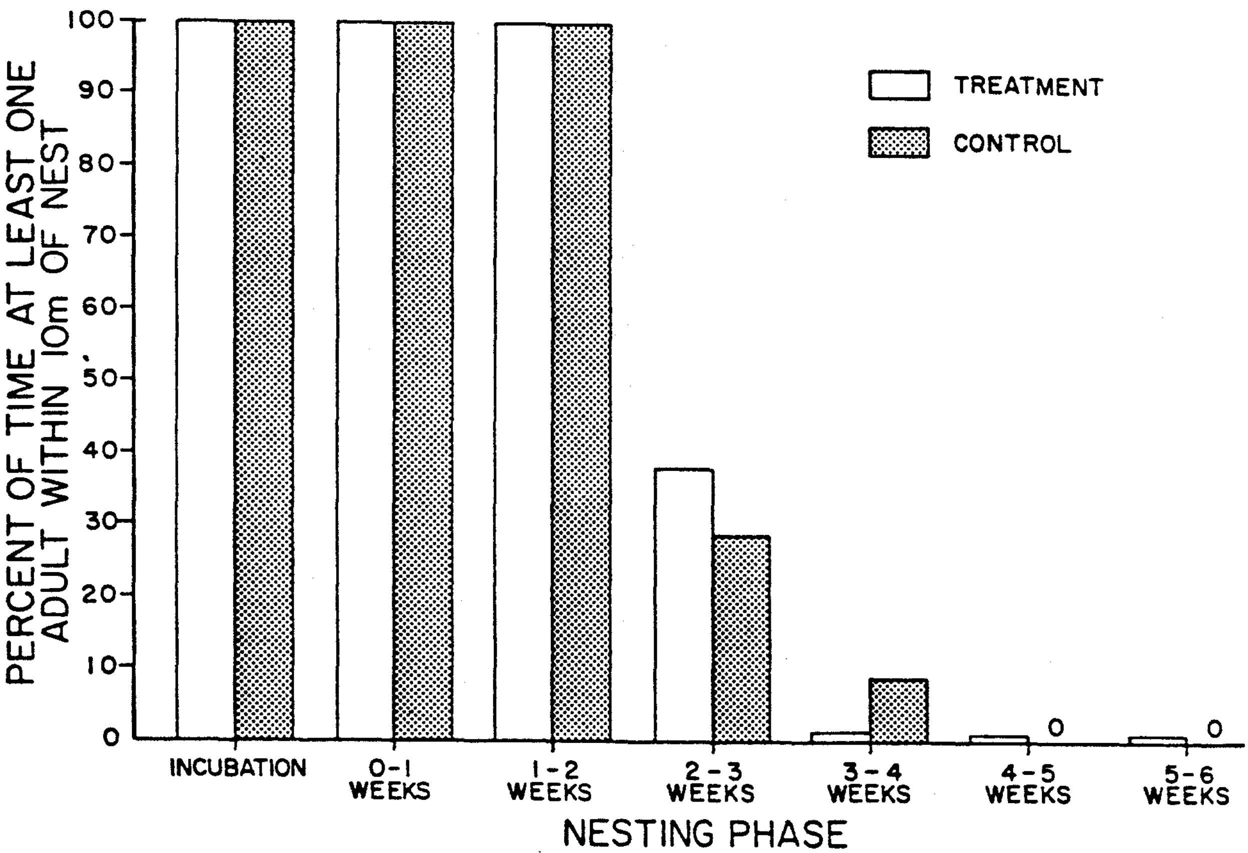


Figure 24. Percentage of time at least one Snowy Egret adult was within 10 m of its nest during incubation and chick-rearing at the treatment and control colonies in 1983 and 1984.

adults are beginning to leave chicks unattended at the nest; however, adults exhibited considerable individual variation in the initiation and length of these departures. Thus, individual variation in adult presence during these periods is the probable cause of colony differences; and, since no consistent differences occurred at the two sites, it is unlikely these results could be attributable to military overflights at the treatment site. In addition, although the defined nest attendance (an adult within 10 m of the nest) is at best a coarse measure of parental care, the actual behavior of adults in incubating eggs, brooding and/or shading chicks, nest maintenance, etc. also did not appear to differ in any consistent manner between the treatment and control colonies.

Reproductive Success in the Study Colonies

Breeding Pairs/Clutch Sizes/Nest Success/Nestling Survival

Breeding pair estimates for the treatment and control colonies were derived from both ground and aerial surveys and represent estimates for the entire breeding season (Tables 15 and 16). Nests of species other than the study species (Great Egret, Snowy Egret, Tricolored Heron, Little Blue Heron, Cattle Egret) were tagged incidentally and followed: results for those species are not presented in this report.

From the total nests tagged during the 1983 breeding season (214 treatment, 271 control), some nests (6 treatment, 19 control) were dropped from the survey since relocating them was not possible or monitoring them adversely disturbed nearby young. Excluding nests

Table 15. Heron, egret, ibis, and anhinga breeding pairs at the treatment and control colonies in 1983.

	Treatment - Mascotte		Control - Lake Hamilton	
	Tagged	Estimated total	Tagged	Estimated total
Great Egret	49	55	141	200
Snowy Egret	28	35	14	20
Cattle Egret	77	1000-1400	62	700-1100
Tricolored Heron	10	20	18	25
Black-crowned Night-Heron	1	3	4	10
Little Blue Heron	0	15	0	0
Great Blue Heron	0	0	0	5
White Ibis	7	100-150	1	1
Glossy Ibis	0	0	0	1
Anhinga	0	0	8	25
Unknown[a]	47		23	
TOTAL	219		271	

[a] Unsuccessful nests where species identification was not possible.

Table 16. Heron, egret, ibis, and anhinga breeding pairs at the treatment and control colonies in 1984.

	Treatment - Mascotte		Control - Lake Hamilton	
	Tagged	Estimated total	Tagged	Estimated total
Great Egret	20	25	10	15
Snowy Egret	16	25	21	35
Cattle Egret	60	1200-1450	25	35[b]
Tricolored Heron	16	20	19	30
Black-crowned Night-Heron	2	5	2	10
Little Blue Heron	11	25	17	30
Great Blue Heron	0	0	0	3
White Ibis	5	125-150	0	0
Glossy Ibis	2	3	0	1
Anhinga	1	20	0	35
Unknown[a]	5		6	
TOTAL	138		100	

[a] Unsuccessful nests where species identification was not possible.

[b] This value is an underestimate since it does not include Cattle Egrets that began nesting on the control island in early to mid-June.

that were incidentally tagged (8 treatment, 5 control) or of unidentified species (47 treatment, 23 control - discussed in methods) 158 treatment nests and 216 control nests were tagged, identified, and used in analyses. In 1984, the total nests tagged (138 treatment, 100 control) minus incidentally tagged nests (10 treatment, 2 control) and nests of unidentified species (5 treatment, 6 control) resulted in 123 treatment nests and 92 control nests that were used in analyses.

When compared by species, clutch sizes did not differ significantly ($\underline{P}$ >.05) between sites in either 1983 (Table 17) or 1984 (Table 18). From 1983 to 1984, however, there was a significant reduction in the clutch sizes of Great Egrets, Snowy Egrets and Tricolored Herons but not Cattle Egrets (Table 19). Despite these yearly differences, the clutch sizes reported here for Snowy Egrets, Tricolored Herons and Little Blue Herons are among the highest reported in Florida (Table 20) and are closest to those reported by Jenni (1969) in another freshwater marsh. A freshwater-estuarine gradation in clutch size, if such exists, is less apparent for Great Egrets and doubtful for Cattle Egrets (Table 20).

The overall nest success of species studied in both years was greater at the treatment site than at the control site, and in 3 of 4 species these differences were significant (Table 21). This same pattern was evident and consistent within years. For instance, in 1983 the nest success of all species (except Cattle Egrets plus unidentified nests) was greater at the treatment site and, in two cases, Snowy Egrets and Great Egrets, these differences were significant (Table 22). Snowy Egrets at the control colony nested in low numbers over a long breeding season (3 hatching peaks from 29

Table 17. Clutch sizes of selected species from the study colonies in 1983.

Species	Colony	# nests	Clutch size $\bar{x} \pm SE$	$\underline{P}$[a]
Great Egret	Treatment	12	3.17 ± .11	N.S.
	Control	60	3.02 ± .08	
Cattle Egret	Treatment	77	3.03 ± .08	N.S.
	Control	60	3.13 ± .11	
Snowy Egret	Treatment	24	4.13 ± .14	N.S.
	Control	11	4.00 ± .19	
Tricolored Heron	Treatment	10	3.90 ± .10	N.S.
	Control	13	3.77 ± .17	

[a]Student's t-test

Table 18. Clutch sizes of selected species from the study colonies in 1984.

Species	Colony	# nests	Clutch size $\bar{x} \pm SE$	$\underline{P}$[a]
Great Egret	Treatment	20	2.55 ± .15	N.S.
	Control	8	2.50 ± .19	
Cattle Egret	Treatment	60	2.88 ± .10	N.S.
	Control	19	3.10 ± .11	
Snowy Egret	Treatment	10	3.40 ± .27	N.S.
	Control	19	3.37 ± .14	
Tricolored Heron	Treatment	11	3.45 ± .16	N.S.
	Control	15	3.33 ± .13	
Little Blue Heron	Treatment	8	3.63 ± .26	N.S.
	Control	17	3.65 ± .12	

[a]Student's t-test

Table 19. Results of analysis of variance comparing clutch sizes of four study species by colony and by year.

Species	Source	Degrees of freedom	Sum of squares	F value	*P*
Great Egret	Colony	1	0.20[a]	0.55	.46
	Year	1	4.70[b]	12.67	.0006
	Colony*year	1	0.04	0.10	.75
Snowy Egret	Colony	1	0.09[a]	0.21	.65
	Year	1	6.46[b]	14.12	.0004
	Colony*year	1	0.03	0.07	.79
Tricolored Heron	Colony	1	0.19	0.76	.39
	Year	1	2.36	9.43	.0036
	Colony*year	1	0.00	0.00	.97
Cattle Egret	Colony	1	0.97[a]	1.70	.19
	Year	1	0.56[b]	0.99	.32
	Colony*year	1	0.13	0.23	.63

[a]Type II - effect of colony after adjustment of year but excluding interaction.
[b]Type I - effect of year after adjustment of colony but excluding interaction.

Table 20. Comparative clutch sizes of selected wading birds in Florida.

Species	Clutch size	n	Habitat type	Latitude	Source
Cattle Egret	3.5 ± .07	85	Freshwater	29°N	Jenni 1969
	3.13 ± .11	60	Freshwater	28° 03'N	This study - Hamilton 83
	3.10 ± .11	77	Freshwater	28° 34'N	This study - Mascotte 83
	3.03 ± .11	19	Freshwater	28° 03'N	This study - Hamilton 84
	3.0 ± .13	31	Estuarine	27° 35'N	Maxwell + Kale 1977
	2.88 ± .10	60	Freshwater	28° 34'N	This study - Mascotte 84
	2.86	36	Freshwater	28° 56'N	Weber 1975
Tricolored Heron	4.1 ± .11	36	Freshwater	29° N	Jenni 1969
	3.90 ± .10	10	Freshwater	28° 34'N	This study - Mascotte 83
	3.77 ± .17	13	Freshwater	28° 03'N	This study - Hamilton 83
	3.45 ± .16	11	Freshwater	28° 34'N	This study - Mascotte 84
	3.33 ± .13	15	Freshwater	28° 03'N	This study - Hamilton 84
	3.1 ± .05	79	Estuarine	27° 35'N	Maxwell + Kale 1977
	3.0 ± .5	64	Estuarine	28° 31'N	Girard + Taylor 1979
	2.79 ± .10	109	Estuarine	27° 55'N	Rodgers 1980b
Little Blue Heron	3.7 ± .10	58	Freshwater	29° N	Jenni 1969
	3.65 ± .12	17	Freshwater	28° 03'N	This study - Hamilton 84
	3.65 ± .26	8	Freshwater	28° 34'N	This study - Mascotte 84
	3.3 ± .16	21	Estuarine	27° 35'N	Maxwell + Kale 1977
	2.91 ± .09	219	Estuarine	27° 55'N	Rodgers 1980a
Snowy Egret	4.13 ± .14	24	Freshwater	28° 34'N	This study - Mascotte 83
	4.00 ± .19	11	Freshwater	28° 03'N	This study - Hamilton 83
	3.9 ± .07	102	Freshwater	29° N	Jenni 1969
	3.40 ± .27	10	Freshwater	28° 34'N	This study - Mascotte 84
	3.37 ± .14	19	Freshwater	28° 03'N	This study - Hamilton 84
	3.15 ± .15	41	Estuarine	27° 55'N	Rodgers 1980b
	3.0 ± .56	60	Estuarine	28° 31'N	Girard + Taylor 1979
	2.9 ± .6	77	Estuarine	27° 35'N	Maxwell + Kale 1977

Table 20 (continued).

Species	Clutch size	n	Habitat type	Latitude	Source
Great Egret	3.17 ± .11	12	Freshwater	28° 34'N	This study - Mascotte 83
	3.02 ± .08	60	Freshwater	28° 03'N	This study - Hamilton 83
	3.00	29	Freshwater	30° 05'N	Wiese 1975
	2.8 ± .17	13	Estuarine	27° 35'N	Maxwell + Kale 1977
	2.55 ± .15	20	Freshwater	28° 34'N	This study - Mascotte 84
	2.50 ± .19	8	Freshwater	28° 03'N	This study - Hamilton 84
	2.40 ± .62	45	Estuarine	28° 31'N	Girard + Taylor 1979

Table 21. Results of paired comparisons between colonies and between years of the nest success of selected species as calculated using the Mayfield method.

Species	Factor	$Z_{\alpha/2}$	P[a]
Great Egret	Colony	3.38	.001
	Year	3.43	.001
Cattle Egret	Colony	7.52	< .0001
	Year	10.77	< .0001
Snowy Egret	Colony	1.97	.05
	Year	2.86	.01
Tricolored Heron	Colony	1.10	N.S.
	Year	2.45	.05

[a]Paired comparisons were made using the test statistic $\frac{Za + Zb}{\sqrt{2}} = Z\alpha/2$ with a = treatment and b = control for colony comparisons and a = 1983 and b = 1984 for year comparisons.

Table 22. Nest success of selected species from the study colonies in 1983 as calculated using the Mayfield method.

Species	Colony	Nests observed	Overall[a] success	$\underline{P}$[b]
Great Egret	Treatment	46	.7698	.05
	Control	125	.3819	
Cattle Egret	Treatment	77	.8029	N.S.
	Control	60	.6998	
Snowy Egret	Treatment	25	1.0000	.001
	Control	14	.5435	
Tricolored Heron	Treatment	10	1.0000	N.S.
	Control	17	.7781	
Cattle Egret[c]	Treatment	116	.4777	N.S.
	Control	76	.5549	

[a]The estimated overall success probability is derived by the formula $\hat{s} = \hat{p}1^{J1}\hat{p}2^{J2}\hat{p}3^{J3}$ for species except Great Egrets whose total nest success is derived by the formula $\hat{s} = \hat{p}^{2J}$ (Hensler, in press). See text for discussion.

[b]Results of standard normal test using the statistic $\frac{(S1 - S2)}{V_{s1} + v_{s2}}$. N.S. = nonsignificant at the .05 level.

[c]Cattle Egret nest data plus nest data for all unidentified nests on Cattle Egret transects. See text for discussion.

April through 10 June), whereas Snowy Egrets at the treatment colony, although also breeding in relatively low numbers, hatched out in a single peak from 26 April to 8 May. Great Egret nest success also differed significantly between colonies in 1983; however, if the main colony (Area C) at the control colony is compared to the treatment colony, there is no significant difference ($Z=.082$, $P > .05$) in nest success (main colony at control, 75% (n=40): treatment colony 77% (n=46)). Great Egrets in the main colony at the control site nested earlier and at significantly greater ($t=2.48$, $P < .05$) nest heights (main colony 1.37 ± .05 m, other areas 1.22 ± .04 m) and greater nest densities (main colony .21 nests/m^2, Area N .11 nests/m^2, Area S .03 nests/m^2) than less successful Great Egrets nesting outside of the main colony. In 1984, all study species had greater or equal nest success in the treatment colony when compared to the control colony; and, again, for Great Egrets and Cattle Egrets, these differences were significant (Table 23). Great Egrets at the control site nested in very low numbers, unaccompanied by other species, and at low nest heights (1.09 ± .06 m) and nest densities (Area C .01 nests/m^2, Area S .01 nests/m^2). In the case of Cattle Egret nest success, raccoons and other predators are believed responsible for the loss of almost all (24 of 25) nests in the control subcolony by 2 wks post-hatching. This possibility will be discussed later with other sources of egg and nestling loss.

The overall nest success of each study species was significantly greater in 1983 than in 1984 (Table 21), a pattern further evidenced when comparisons are made within site by species (i.e. comparing Tables 22 and 23). In only two cases, Cattle Egrets at the treatment

Table 23. Nest success of selected species from the study colonies in 1984 as calculated using the Mayfield method.

Species	Colony	Nests observed	Overall[a] success	$\underline{P}$[b]
Great Egret	Treatment	20	.4299	.05
	Control	8	.0725	
Cattle Egret	Treatment	60	.8459	.0001
	Control	25	.0393	
Snowy Egret	Treatment	16	.7011	N.S
	Control	21	.5754	
Tricolored Heron	Treatment	16	.9312	N.S.
	Control	19	.6745	
Little Blue Heron	Treatment	11	1.0000	N.S.
	Control	17	1.0000	

[a]The estimated overall success probability is derived by the formula $\hat{s} = \hat{p}1^{J1}\hat{p}2^{J2}\hat{p}3^{J3}$ for species except Great Egrets whose total nest success is derived by the formula $\hat{s} = \hat{p}^{\Sigma J}$ (Hensler, in press). See text for discussion.

[b]Results of standard normal test using the statistic $\frac{(S1 - S2)}{\sqrt{V_{S1} + V_{S2}}}$. N.S. = nonsignificant at the .05 level.

[c]Cattle Egret nest data plus nest data for all unidentified nests on Cattle Egret transects. See text for discussion.

site and Snowy Egrets at the control site, was nest success greater in 1984 and in both cases this difference was by only 4% (Cattle Egrets, .8029 vs .8459; Snowy Egrets, .5438 vs .5754).

Nest success values as calculated using the Mayfield method ($\hat{P}^J$ - overall success) were equal to or slightly lower than the traditional estimate ($\overline{Y}$ - proportion successful) for all species except Great Egrets (Appendix 7, Tables 1-20). The Mayfield estimate was markedly lower than the traditional estimate of nest success for Great Egrets, a species with a long nesting cycle and an associated greater divergence in the two estimates (Hensler and Nichols 1981).

The survival of nestlings (the number of young per active nest at 2 or 3 wks) of each species was greater overall at the treatment site than at the control site and in 3 of 4 species these differences were significant (Table 24). This same pattern was evident within years (Tables 25 and 26) with significant colony differences recorded for Cattle Egrets and Snowy Egrets in 1983 and for Cattle Egrets in 1984.

Overall nestling survival was greater for each study species in 1983 than in 1984 and for 2 species, Great Egrets and Cattle Egrets, these differences were significant (Table 24). For each species at each site nestling survival was greater in 1983 than in 1984 (Table 25 compared to Table 26) except in the case of Cattle Egrets at the treatment site where the difference was slight (.17 chicks/nest) though reversed.

Patterns of nestling survival generally followed the reported patterns of nest success, as one might expect. One point should be considered, however, in regard to both parameters. Since young herons and egrets become increasingly difficult to monitor after 2-3 wks,

Table 24. Results of analysis of variance comparing the number of young per active nest at 3 weeks for Great Egrets and 2 weeks for other species by colony and by year.

Species	Source	Degrees of freedom	Sum of squares	F value	$\underline{P}^a$
Great Egret	Colony	1	2.45[b]	5.90	.02
	Year	1	1.75[c]	4.21	.04
	Colony*year	1	0.00	0.00	.95
Snowy Egret	Colony	1	1.89[b]	6.55	.013
	Year	1	0.03[c]	0.09	.77
	Colony*year	1	0.25	0.87	.35
Tricolored Heron	Colony	1	0.56[b]	2.27	.14
	Year	1	0.00[c]	0.00	.95
	Colony*year	1	0.00	0.01	.92
Cattle Egret	Colony	1	16.21[d]	70.21	.0001
	Year	1	1.84[d]	7.99	.0051
	Colony*year	1	4.68	20.28	.0001

[a]Analysis of variance comparing the arcsine square root transformation of the proportion of young per active nest.
[b]Type II - effect of colony after adjustment of year but excluding interaction.
[c]Type I - effect of year after adjustment of colony but excluding interaction.
[d]Type III - effect of colony or year after adjustment for the other source and interaction.

Table 25. Comparisons of the number of young per active nest at 3 weeks for Great Egrets and 2 weeks for other species between study colonies in 1983.

Species	Colony	# nests	# young	# young per nest ± SE	P[a]
Great Egret	Treatment	35	87	2.49 ± 0.12	N.S.
	Control	108	151	1.40 ± 0.18	
Cattle Egret	Treatment	77	131	1.70 ± 0.12	.001
	Control	60	66	1.10 ± 0.11	
Snowy Egret	Treatment	25	78	3.12 ± 0.17	.05
	Control	14	22	1.57 ± 0.43	
Tricolored Heron	Treatment	10	28	2.80 ± 0.25	N.S.
	Control	17	37	2.17 ± 0.35	

[a] Student's t-test comparing the arcsine square root transformation of the proportion of young per active nest. These time frames are referenced from the estimated or known hatching date of the oldest chick in each brood.

Table 26. Comparisons of the number of young per active nest at 3 weeks for Great Egrets and 2 weeks for other species between study colonies in 1984.

Species	Colony	# nests	# young	# young per nest ± SE	P[a]
Great Egret	Treatment	20	24	1.20 ± .25	N.S.
	Control	8	5	0.63 ± .32	
Cattle Egret	Treatment	60	112	1.87 ± .12	.0001
	Control	22	1	0.04 ± .04	
Snowy Egret	Treatment	16	37	2.31 ± .36	N.S.
	Control	21	38	1.81 ± .35	
Tricolored Heron	Treatment	16	38	2.38 ± .26	N.S.
	Control	19	39	2.05 ± .24	
Little Blue Heron	Treatment	11	37	3.36 ± .20	N.S.
	Control	17	48	2.82 ± .20	

[a]Student's t-test comparing the arcsine square root transformation of the proportion of young per active nest. These time frames are referenced from the estimated or known hatching date of the oldest chick in each brood.

these are the typical time frames used to identify nest "success" and/or nestling "survival". Chicks, however, stay in and around the nest at least twice that length of time and; thus, "success" or "survival" measured at 2-3 wks is an overestimate of actual success or survival at fledging.

Mortality/Predation/Disease

Total mortality as measured by egg and nestling loss from the day found to 2 or 3 wks post-hatching was greater for each species in each year at the control site than at the treatment site (Tables 27 and 28); however, patterns of mortality were quite variable. Great Egrets had high egg losses in both years at both sites and high hatching losses at the control site in 1983 (Fig. 25). In 1983, severe winds (25-40 mph) and rains coincided with the mid-March onset of laying by late-nesting Great Egrets and abandonment of some nests was suspected (see Pratt 1970). In 1984, Great Egret numbers in both colonies were lower than in 1983 and breeding began later. At both sites some pairs abandoned nesting efforts during nest-building, laying or early incubation. These observations were made from outside the colonies before researchers began entering the sites; however, the loss of nests continued during incubation, perhaps, due still to abandonment. Observations during researcher departure or from observation towers indicated that adult birds typically returned to their nests 4-6 mins. after researchers left and, then, resumed "normal" behavior. On subsequent visits, however, some nests would be found empty. It seems unlikely that human disturbance resulted in these nest abandonments, but the cause of these losses is uncertain.

Table 27. Egg and nestling mortality in those identified nests followed during the incubation and nestling phases in 1983.

	Great Egret				Cattle Egret				Snowy Egret				Tricolored Heron			
	Treatment[a]		Control[b]		Treatment[c]		Control[d]		Treatment[e]		Control[f]		Treatment[g]		Control[h]	
	# Lost	%	# Lost	%	# Lost	%	# Lost	%	# Lost	%	# Lost	%	# Lost	%	# Lost	%
Day found to day before hatching	11	28.2	42	23.2	4	1.7	6	3.2	2	2.0	0	0	0	0	5	10.2
Eggs failing to hatch	0	0	2	1.1	8	3.4	8	4.3	2	2.0	4	9.1	2	5.1	1	2.0
Hatching losses	0	0	30	16.6	45	19.3	52	27.7	6	6.1	17	38.6	2	5.1	12	24.5
7th day after hatching	0	0	12	6.6	8	3.4	17	9.0	6	6.1	2	4.5	5	12.8	3	6.1
14th day after hatching	1	2.6	10	5.5	37	15.9	39	35.1	8	8.1	2	4.5	2	5.1	1	2.0
21st day after hatching	1	2.6	8	4.4												
Total egg loss	11	28.2	44	24.3	12	5.2	14	7.4	4	4.0	4	9.1	2	5.1	6	12.2
Total hatching loss	0	0	30	16.6	45	19.3	52	27.7	6	6.1	17	38.6	2	5.1	12	24.5
Total nestling loss	2	5.1	30	16.6	45	19.3	56	29.8	14	14.1	4	9.1	7	18.0	4	8.2
Mortality from found to 14/21 days	13	33.3	105	57.5	102	43.8	122	64.9	24	24.2	25	56.8	11	28.2	22	44.9

[a] n = 13 nests, 39 eggs, 28 nestlings
[b] n = 60 nests, 181 eggs, 107 nestlings
[c] n = 77 nests, 233 eggs, 176 nestlings
[d] n = 60 nests, 188 eggs, 122 nestlings
[e] n = 24 nests, 99 eggs, 89 nestlings
[f] n = 11 nests, 44 eggs, 23 nestlings
[g] n = 10 nests, 39 eggs, 35 nestlings
[h] n = 13 nests, 49 eggs, 31 nestlings

Table 28. Egg and nestling mortality in those identified nests followed during the incubation and nestling phases in 1984.

	Great Egret				Cattle Egret				Snowy Egret				Tricolored Heron				Little Blue Heron			
	Treatment[a]		Control[b]		Treatment[c]		Control[d]		Treatment[e]		Control[f]		Treatment[g]		Control[h]		Treatment		Control	
	# Lost	%	# Lost	%	# Lost	%	# Lost	%	# Lost	%	# Lost	%	# Lost	%	# Lost	%	# Lost	%	# Lost	%
Day found to day before hatching	18	35.3	12	60.0	19	10.9	22	37.3	5	13.2	4	6.3	2	5.3	10	20.0	0	0	1	1.6
Eggs failing to hatch	0	0	0	0	13	7.5	0	0	3	7.9	0	0	1	2.6	0	0	1	3.5	0	0
Hatching losses	0	0	1	5.0	5	2.9	15	25.4	0	0	7	10.9	5	13.1	6	12.0	0	0	4	6.5
7th day after hatching	0	0	0	0	5	2.9	16	27.1	4	10.5	16	25.0	4	10.5	0	0	1	3.5	1	1.6
14th day after hatching	5	9.8	1	5.0	19	10.9	5	8.5	2	5.3	5	7.8	2	5.3	5	10.0	0	0	8	12.9
21st day after hatching	4	7.8	1	5.0																
Total egg loss	18	35.3	12	60.0	32	18.5	22	37.3	8	21.1	4	6.3	3	7.9	10	20.0	1	3.5	1	1.6
Total hatching loss	0	0	1	5.0	5	2.9	15	25.4	0	0	7	10.9	5	13.1	6	12.0	0	0	4	6.5
Total nestling loss	9	17.6	2	10.0	24	13.9	21	35.6	6	15.8	21	32.8	6	15.8	5	10.0	1	3.5	9	14.5
Mortality from found to 14/21 days	27	52.9	15	75.0	61	35.3	58	98.3	14	36.8	32	50.0	14	36.8	21	42.0	2	6.9	14	22.6

[a] n = 20 nests, 51 eggs, 33 nestlings
[b] n = 8 nests, 20 eggs, 7 nestlings
[c] n = 60 nests, 173 eggs, 136 nestlings
[d] n = 19 nests, 59 eggs, 22 nestlings
[e] n = 12 nests, 38 eggs, 30 nestlings
[f] n = 19 nests, 64 eggs, 53 nestlings
[g] n = 11 nests, 38 eggs, 30 nestlings
[h] n = 15 nests, 50 eggs, 34 nestlings
[i] n = 8 nests, 29 eggs, 28 nestlings
[j] n = 17 nests, 62 eggs, 57 nestlings

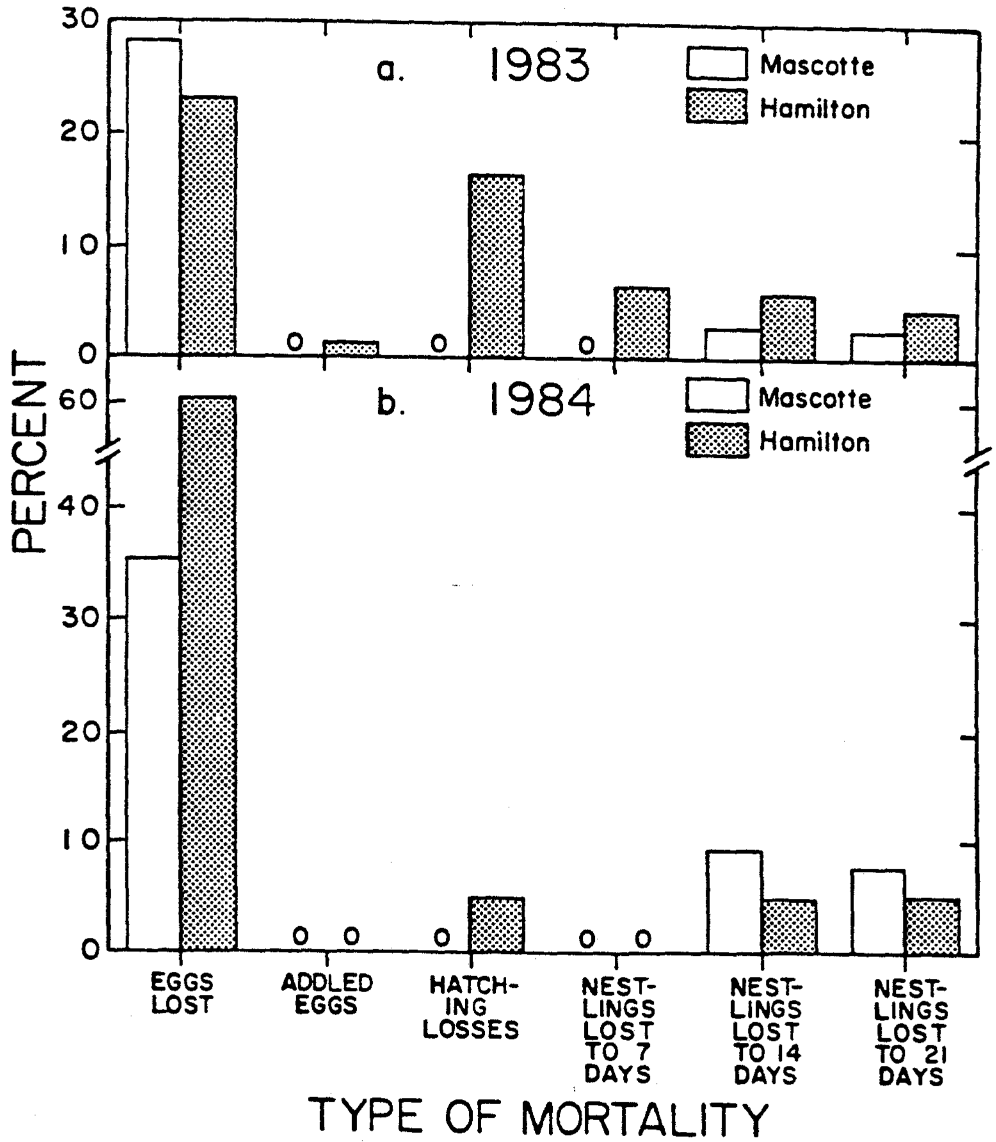


Figure 25. Great Egret egg and nestling mortality in the treatment (Mascotte) and control (Hamilton) colonies in a) 1983 and b) 1984.

Cattle Egrets in 1983 had high hatching losses and nestling losses by 14 d at both sites (Fig. 26, a). At both sites where hatching losses were high, Black-crowned Night-Herons were nesting in association with Cattle Egrets: Black-crowned Night-Herons have been observed taking small Cattle Egret nestlings by working a Cattle Egret nest singly or in pairs (J. Wiese, pers. comm.). The loss of nestlings at 14 d, however, is more likely related to food supply and the starvation of younger, smaller chicks in a brood. In 1984, Cattle Egrets suffered severe losses at the control site including egg, hatching and nestling losses (Fig. 26, b). Cattle Egrets nested later than other species and were still incubating eggs when raccoon tracks first were noted in the colony. Hatching losses and nestling losses to 7 d were believed to result from nocturnal predation since selected observations on consecutive days revealed no diurnal predation but did reveal egg and nestling losses between evening and morning observations. Cattle Egrets had a relatively high proportion of addled eggs at the treatment site in 1984.

In 1983, Snowy Egrets experienced severe hatching losses at the control site and in 1984 hatching losses and nestling losses to 7 d were relatively high (Fig. 26, c, d). In addition, Snowy Egrets had a relatively high proportion of addled eggs at the treatment site in 1984. These patterns of Snowy Egret mortality mirror portions of the mortality of Cattle Egrets with whom late-nesting Snowy Egrets nested.

Tricolored Herons had high hatching losses at the control site in 1983 and high losses of eggs and nestlings to 14 d at the control site in 1984 (Fig. 26, e, f). The egg losses in 1984 occurred only on the control island (100%, 10 of 10) where Tricolored Herons nested in very

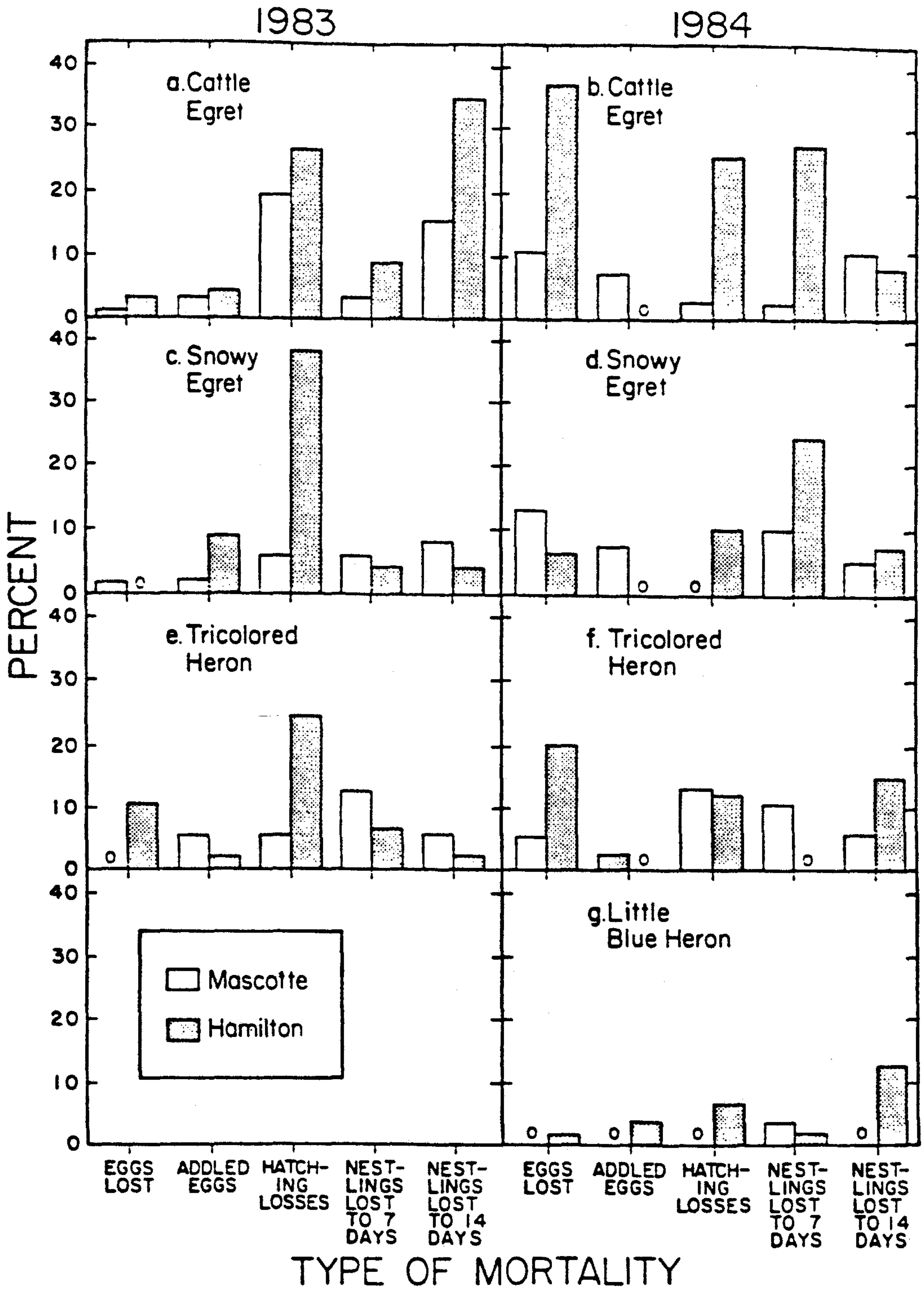


Figure 26. Cattle Egret (a,b), Snowy Egret (c,d), Tricolored Heron (e,f), and Little Blue Heron (g) egg and nestling mortality in the treatment (Mascotte) and control (Hamilton) colonies in 1983 and 1984.

low numbers and at low nest densities (.02 nests/m^2). The losses of nestlings to 14 d occurred primarily in the subcolony (80%, 4 of 5) where overall success and chick survival were high.

Little Blue Herons did not nest in the control colony in 1983 and occurred in very low numbers in the treatment colony in that year. In 1984, they nested in increased numbers at both sites (Table 16) and had very high nest success and nestling survival at both sites. Some mortality was apparent at the control site for nestlings to 14 d (Fig. 26, g).

To summarize, several patterns of mortality were recorded during the study. Egg losses were high for Great Egrets at the control site in 1983 and for Cattle Egrets and Tricolored Herons at the control site in 1984. Great Egret egg losses were believed to be related both to nest abandonment during inclement weather and/or late-breeding and to predation of nests at unusually low nest heights and nest densities outside the main colony. Cattle Egret egg losses were probably the result of raccoon predation and Tricolored Heron losses occurred where adults were nesting in very low numbers at low nest densities.

A relatively high proportion of addled eggs were found in Cattle Egret and Snowy Egret nests at the treatment site in 1984. In the case of Cattle Egrets, 2 instances of egg deposition within 5 days of hatching resulted in 2 nests with eggs that did not hatch. Whether this egg was fertilized or laid by a member of the nesting pair is unknown; however, this pattern of late egg deposition also was noted in 2 Cattle Egret nests at the treatment site in 1983 and has been observed by other researchers monitoring Cattle Egrets (J. Rodgers, pers. comm.). In addition, at the treatment site a Cattle Egret was suspected of dumping one pale egg in a clutch of three medium-blue, Snowy Egret eggs 14 days before the clutch began hatching. This late egg, also, never hatched.

Hatching losses were very high for all study species at the control site in 1983. Since these species (other than Great Egrets) experienced relatively few egg losses during incubation, one might suspect that losses at hatching were nestling rather than egg related. During 501 nest-hours of diurnal observations in this colony, observers saw no predation of newly hatched young, thus, leading to the conclusion that nest loss, if by predation, was occurring crepuscularly or nocturnally. A similar conclusion was reached in regard to Cattle Egret hatching losses at the control site in 1984 and losses to 7 d for Cattle Egrets and Snowy Egrets at the control site in 1984.

Nestling losses to 14 d were relatively high at the control site in 1984 for Tricolored Herons and Little Blue Herons, species which had experienced relatively little egg or nestling loss to that point and in which brood reduction probably was occurring. Of the individually identified nestlings lost during this period at the control site, 100% (4 of 4) of Tricolored Herons and 60% (3 of 5) of Little Blue Herons were the youngest member of the brood. At the control site in 1983, Cattle Egret losses to 14 d were high despite previously high mortality in the nesting cycle: possible cause(s) are uncertain.

Known and suspected predators of ardeid eggs and/or nestlings seen in both study colonies in 1983 and 1984 include Florida watersnakes (Nerodia fasciata), brown water snakes (Nerodia taxispilota), Florida cottonmouths (Agkistrodon piscivorus), American Crows (Corvus brachyrhynchos), Fish Crows (Corvus ossifragus), Boat-tailed Grackles (Quiscalus major), and American alligators (Alligator mississipiensis). Yellow rat snakes (Elaphe obsoleta) and Barred Owls (Strix varia) were seen only in the treatment colony in 1983 and raccoon tracks were seen only in the control subcolony in 1984. Other potential predators seen included Red-tailed Hawks (Buteo jamaicensis) and Red-shouldered Hawks (Buteo lineatus) at the treatment colony in 1983 and 1984, and river otters (Lutra canadensis) at the control colony in 1984. Several hundred Fish Crows roosted within 800 m of both colonies in 1983 in a marsh-side pine stand at the treatment site and in a lake-side Melaleuca stand at the control site. Diurnally, crows occasionally were observed flying over both colonies but were observed taking only one Snowy Egret egg and one Cattle Egret chick in 1,150 nest-hours of observation at the two sites. Since crows and grackles often are cited as egg and nestling predators that follow disturbing intruders into colonies, these species were observed closely during researcher visits in the colony; however, crows were infrequently present below the canopy, and grackles never were observed actually disturbing nest contents during or after researcher visits. Crows at the control site did gather crepuscularly in the colony before roosting in the lake-side roost, and eggs from abandoned nests may have been taken during those periods. River otters are a previously recorded predator of colonially breeding birds (Footlit and Butler 1977, Verbeek and Morgon 1978); however, ardeids usually nest at heights in substrates that would not support the predator's weight. In 1983, however, at the control site Great Egrets nested outside the main colony on very low (<1 m) willow branches and on fallen logs, locations accessible to this predator.

Although many nestlings were handled for banding, weighing, etc., evidence of disease was limited to abdominal and lower leg lesions believed to be produced by dermestid beetle larvae. Such lesions have been found on Wood Stork, Snail Kite (Rostrhamus sociabilis) and Great Blue Heron nestlings in Florida and Ohio (Snyder et al. 1984) but have not been previously reported occurring on Snowy Egret, Tricolored Heron or Cattle Egret nestlings as found during this study. These lesions were observed on nestlings in two Cattle Egret and one Snowy Egret nests at the treatment site and in one Tricolored Heron nest at the control site in 1983. In 1984, they were noted on nestlings in one Cattle Egret nest at the control subcolony and one Cattle Egret nest at the treatment site.

Non-military Disturbance

Human intrusion into breeding colonies can be detrimental since adult birds flushed from the nest leave eggs and nestlings exposed to temperature fluctuations and predation. In this study researcher visitation, time per nest visited, was consistent by species between sites and similar between years (Tables 29 and 30). In 1983, Great Egret areas had low nest densities (.12 to .16 nests/m^2) relative to Cattle Egrets and required on the average from 2.0 to 2.3 mins per nest visit. Cattle Egret areas had relatively high densities (.68 to .75 nests/m^2) and required on the average from 1.0 to 1.1 mins per nest visit. The area West of Large Pool at the treatment colony was of mixed species and intermediate in both nest density and average

Table 29. Researcher visitation, nest density, and visitation time per nest for selected species in areas[a] of the study colonies in 1983.

	Control					Treatment		
	Area N	Area C	Area S	Area NW	Area SW	NW of Sm Pool	W of Lg Pool	NW of Lg Pool
Predominant species	Great Egret	Great Egret	Great Egret	Cattle Egret	Cattle Egret	Great Egret	Mix	Cattle Egret
Time per nest visited (mins)	2.0	2.2	2.2	1.1	1.0	2.3	1.3	1.0
Nest density (nests/m^2)	.11	.21	.03	.60	.90	.16	.26	.68
Mean survey time (mins)	52	44	33	27	40	75	57	55
Mean # of nests visited per survey	27	20	15	24	41	33	44	57

a See section on colony histories for area locations.

Table 30. Researcher visitation, nest density, and visitation time per nest for selected species in areas of the study colonies in 1984.

	Control				Treatment		
	Area N	Area C	Area S	Area SC	Area A	Area B	Area C
Predominant species	Tricolored Heron	Great Egret	Great Egret	Mix	Cattle Egret	Cattle Egret	Mix
Time per nest visited (mins)	3.6	1.5	1.8	0.9	1.0	1.2	2.0
Nest density (nests/m^2)	.02	.01	.01	.65	1.3	.57	.28
Mean survey time (mins)	20	4	10	38	53	38	14
Mean # of nests visited per survey	6	3	6	40	53	32	7

a See section on colony histories for area locations.

time per nest visit. The mean survey times were long but unavoidable since the breeding area at the treatment site was about 6 ha and that at the control site was about 7 ha. In 1984, average time per nest visited was less (1.5 to 1.8 mins) for Great Egrets since researchers did not weigh and/or band this species in this year. The average time per nest visit was similar between Cattle Egret areas both within 1984 and between 1983 and 1984. The mixed species area (Area C) at the treatment site had an increased average visitation time per nest since portions of this subcolony were accessible only by boat.

Two points should be made as to how visitation actually may affect the birds. Firstly, while visitation time per nest is less for Cattle Egrets the effects of disturbance are potentially worse in an area of high nest density where there is no visual barrier between nests and all nests must be visited before the researcher leaves and adult birds return. In the case of Great Egrets at low nest densities adults could return to a checked nest soon after researchers passed and were hidden by vegetation. Thus, the time per visit was higher for Great Egret nests, but the potential effect per nest was probably less than for Cattle Egrets. Secondly, equal human visitation can have a different effect at two colonies if avian predation pressure differs at those two sites. As mentioned previously, avian predation during and immediately following researcher visits did not appear to play a significant role in egg or nestling loss.

Other potential disturbances observed near the study colonies were variable but generally comparabable between sites. At the treatment colony low flying (~ 100 m) crop dusters and ultralight aircraft were noted on several occassions, however, breeding bird responses were limited to no response, looking up or alert postures. Trucks, tractors, bulldozers, chain-saws and irrigation systems operating in nearby (within 800 m) citrus groves elicited no visible response from breeding birds. Non-researcher human intrusion into this colony was not observed probably due to the difficult access, a bog island substrate, rumored snake populations, etc. On 3 occassions, however, persons in airboats approached colony or subcolony edges and evoked severe flushing and panic flights in the colony. These responses did not subside until airboats either left the colony vicinity or were turned off. At the control site crop dusters/ultralights essentially were replaced by pontoon planes doing "touch and goes" on Lake Hamilton and tractors/bulldozers were replaced by offshore speedboats conducting practice runs in the lake around the island. Both of these activities occurred regularly throughout the breeding season and otherwise habituated birds went into alert posture only when overflights were low and directly overhead or when boat passes approached the island edge. Human intrusion was not observed but was known to occur very infrequently. On 2 occasions an airboat came onto the island and elicited flushing and panic flights which again subsided only after the airboat left. Thus, consistently at both sites the most severe reactions of breeding birds were to humans entering the colony or airboats closely approaching the colony.

Feeding Rates/Weight Gains

Both the number of feedings per hour and the length of feeding sessions decreased at both sites with the increasing age of Great Egret chicks (Fig. 27, a + b). Since the proportions of observations

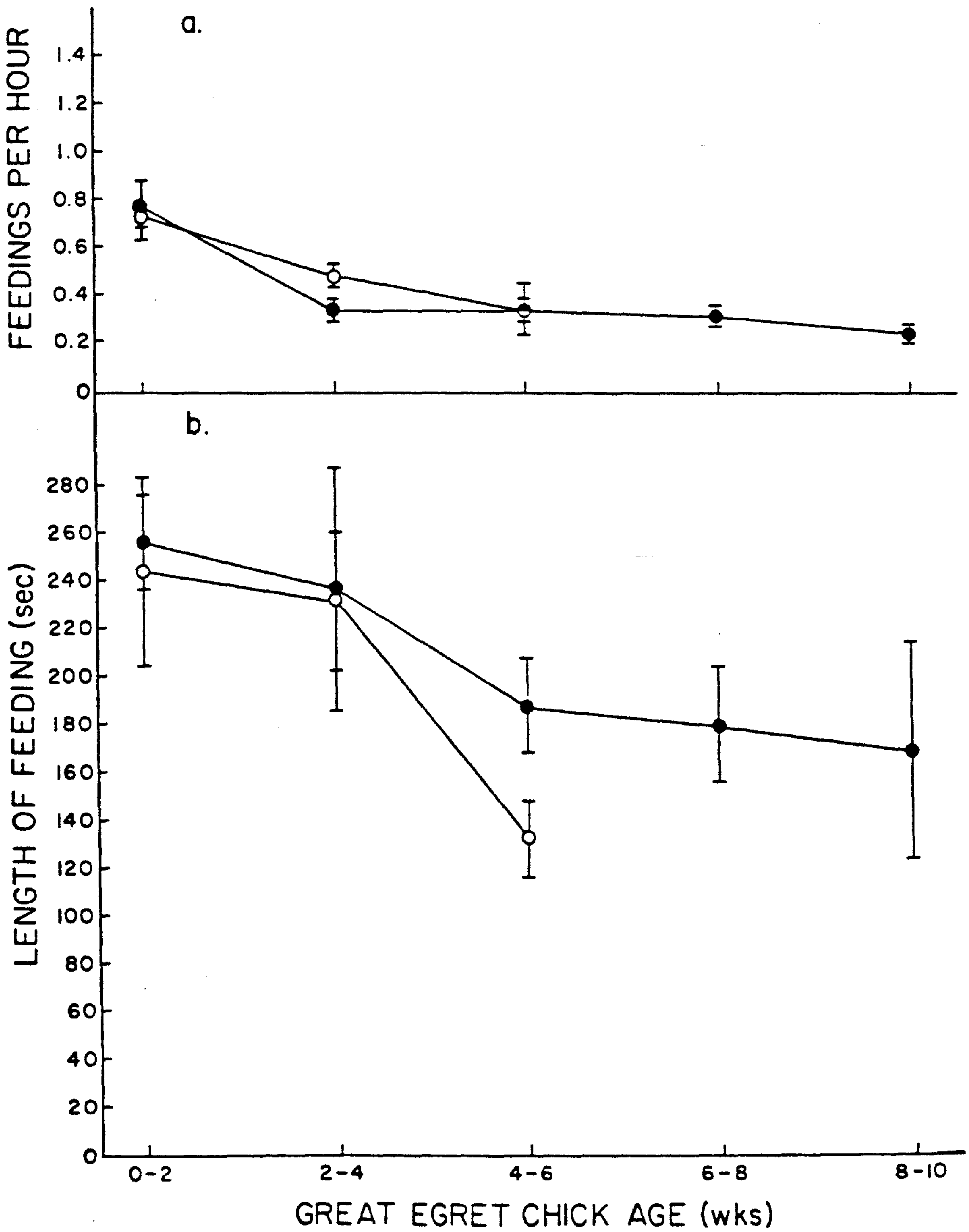


Figure 27. Feedings per hour (a) and length of feeding sessions (b) for Great Egret chicks at the treatment (●) and control (o) colonies in 1983 and 1984.

of 2 and 3-chick broods were similar between sites (Table 31, subscript a), the longer feeding sessions at the treatment site should reflect the delivery of more food to chicks given the assumptions that adults at both sites and chicks by age class at both sites have equal handling time per unit of prey. Site differences in the number of feedings per hour were not consistent; however, overall rates to 6 wks were slightly higher at the control site (Fig. 27, a) and significantly ($P < .0001$) higher there at 2-4 wks (Table 31). Thus, to 6 wks of age Great Egret chicks at the treatment site were fed more food in less frequent feedings whereas chicks at the control site were fed less food in more frequent feedings.

The number of feedings per hour decreased at both sites with the increasing age of Snowy Egret chicks (Fig. 28, a); however, feeding sessions increased in length from 1-2 wks before decreasing thereafter (Fig. 28, b). This increase in feeding session length coincides with that period of chick development when scissor feeding is beginning and may not have been apparent for Great Egrets since data were grouped over 2 wk intervals. Observations of Snowy Egrets were proportionately equal between the two sites for 2 and 3-chick broods with more emphasis on smaller (1-chick) broods at the treatment site and more emphasis on larger (4-chick) broods at the control site (Table 32, subscript a). Given these differences and the previous assumption of equal handling time per prey unit by same-class birds at both sites, the consistently longer feeding sessions at the treatment site should indicate more prey delivered since they cannot reflect an increased time investment by adults attempting to feed larger broods. The number of feedings per hour was consistently greater at the

Table 31. Feeding rates of Great Egret chicks from 0 to 10 weeks of age in the study colonies combining data for 1983 and 1984[a].

Stage of chick-rearing/location	Total observation time (hrs)	# nests observed	# feedings observed	Feeding time (sec)[b] $\bar{X} \pm$ SE	Feedings per hour[c] $\bar{X} \pm$ SE
0-2 wks					
Treatment	38	3	30	257 ± 20	.79 ± 0.12
Control	33	4	24	244 ± 40	.75 ± 0.14
2-4 wks					
Treatment	40	4	14	238 ± 50	.35 ± 0.04****
Control	48	4	22	232 ± 26	.47 ± 0.03
4-6 wks					
Treatment	60	4	21	187 ± 19*	.35 ± 0.03
Control	26	4	10	133 ± 15	.36 ± 0.12
6-8 wks					
Treatment	70	4	23	180 ± 24	.33 ± 0.06
8-10 wks					
Treatment	29	3	7	168 ± 46	.24 ± 0.03

[a]Observations at Mascotte were on 2-chick (56%, 139 hr) and 3-chick (44%, 108 hr) broods. Observations at Lake Hamilton were on 2-chick (58%, 70 hr) and 3-chick (42%, 50 hr) broods.
[b]The length of feedings differed significantly (Z statistic, * = $\underline{P} < .05$) between sites only when chicks were 4-6 wks of age.
[c]Feedings per hour differed significantly (t statistic, **** = $\underline{P} < .0001$) between sites only when chicks were 2-4 wks of age.

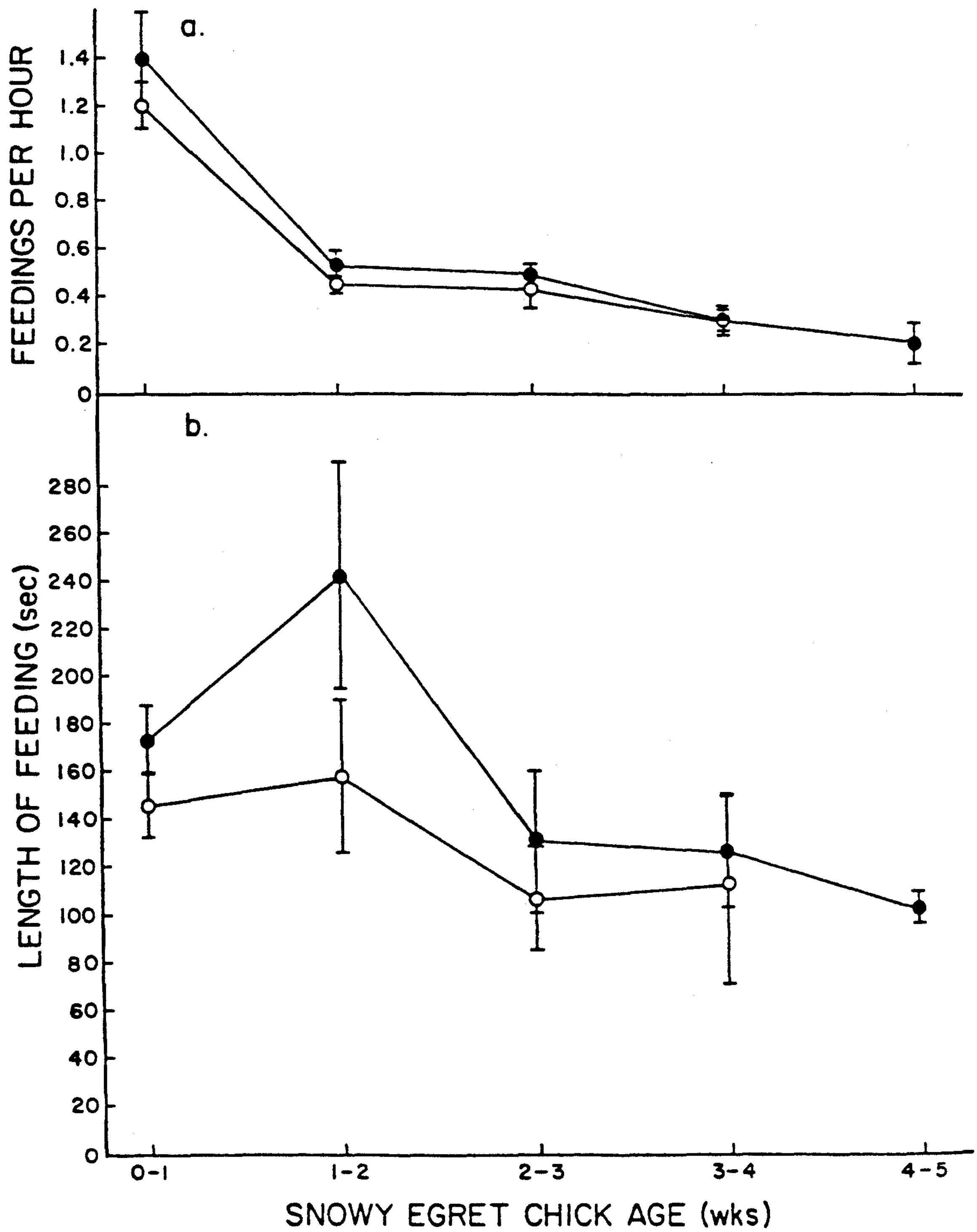


Figure 28. Feedings per hour (a) and length of feeding sessions (b) for Snowy Egret chicks at the treatment (•) and control (o) colonies in 1983 and 1984.

Table 32. Feeding rates of Snowy Egret chicks from 0 to 5 weeks of age in the study colonies combining data for 1983 and 1984[a].

Stage of chick-rearing/location	Total observation time (hrs)	# nests observed	# feedings observed	Feeding time (sec)[b] $\bar{x} \pm SE$	Feedings per hour[c] $\bar{x} \pm SE$
0-1 wks					
Treatment	10	1	14	174 ± 18	1.4 ± 0.2
Control	32	5	37	145 ± 11	1.2 ± 0.1
1-2 wks					
Treatment	28	3	16	243 ± 46	.55 ± 0.09*
Control	19	3	9	158 ± 30	.48 ± 0.05
2-3 wks					
Treatment	28	3	14	131 ± 29	.48 ± 0.12
Control	16	4	8	106 ± 19	.43 ± 0.18
3-4 wks					
Treatment	27	3	8	127 ± 24	.32 ± 0.09
Control	17	2	6	112 ± 42	.34 ± 0.11
4-5 wks					
Treatment	12	1	3	102 ± 7	.20 ± 0.16

[a] Observations at Mascotte were on 1-chick (20%, 26 hr), 2-chick (14%, 18 hr), 3-chick (40%, 52 hr) and 4-chick (26%, 35 hr) broods. Observations at Lake Hamilton were on 1-chick (5%, 3 hr), 2-chick (11%, 7 hr), 3-chick (46%, 30 hr) and 4-chick (38%, 25 hr) broods.

[b] The length of feedings did not differ significantly (Z statistic, $\underline{P} > .05$) between sites at any age.

[c] Feedings per hour differed significantly (t statistic, * = $\underline{P} < .05$) between sites only when chicks were 1-2 wks of age.

treatment site than at the control site (Fig. 28, a) and significantly greater ($\underline{P}$ <.05) when chicks were 1-2 wks of age (Table 32). This trend, also, does not reflect a sampling bias but may reflect either increased prey availability (shorter hunting time) and/or more proximate food resources (shorter travel time) in the vicinity of the treatment colony. Thus, Snowy Egret chicks at the treatment site were fed consistently more food in more frequent feedings than were Snowy Egret chicks at the control site.

Weight gains of Great Egret chicks were significantly greater (Table 33) at the control site than at the treatment site (Fig. 29). Based on the indirect evidence of feeding rates, food resources appeared to be equal or greater at the treatment site though, perhaps, more proximate at the control site. In terms of weight gains, this benefit may have been offset by the mortality-induced, reduced brood sizes at the control site (Table 34) and the resulting division of food resources between fewer individuals per brood at that site. Thus, over most of the nestling period, Great Egrets at the control site produced fewer but heavier young whereas at the treatment site they produced more and lighter young.

Weight gains of Cattle Egret chicks also were signifiantly greater (Table 33) at the control site (Fig. 30) where the average brood size of weighed nestlings was smaller (Table 34). The food resources of this species were noted only incidentally; however, frog remains (pelvic girdles) found in and around nests at the treatment site indicated that such prey were being fed frequently to chicks at that site. Siegfried (1972b) has suggested that the higher proportionate availability of relatively large prey, such as frogs, in

Table 33. Results of analysis of covariance comparing weight gains of selected species from the study colonies in 1983.

Species	Colony	# of chicks weighed	Total # of weights (known age/estimated age)	P
Great Egret[a]	Treatment	8	44 (29/15)	.05
	Control	31	150 (50/100)	
Cattle Egret[a]	Treatment	33	131 (45/86)	.001
	Control	26	67 (31/36)	
Snowy Egret[b]	Treatment	42	160 (49/111)	.05
	Control	26	85 (10/75)	
Tricolored Heron[a]	Treatment	18	75 (21/54)	N.S.
	Control	24	88 (20/68)	

[a]Based on weights of known and estimated age chicks.
[b]Based on weights of known age chicks only.

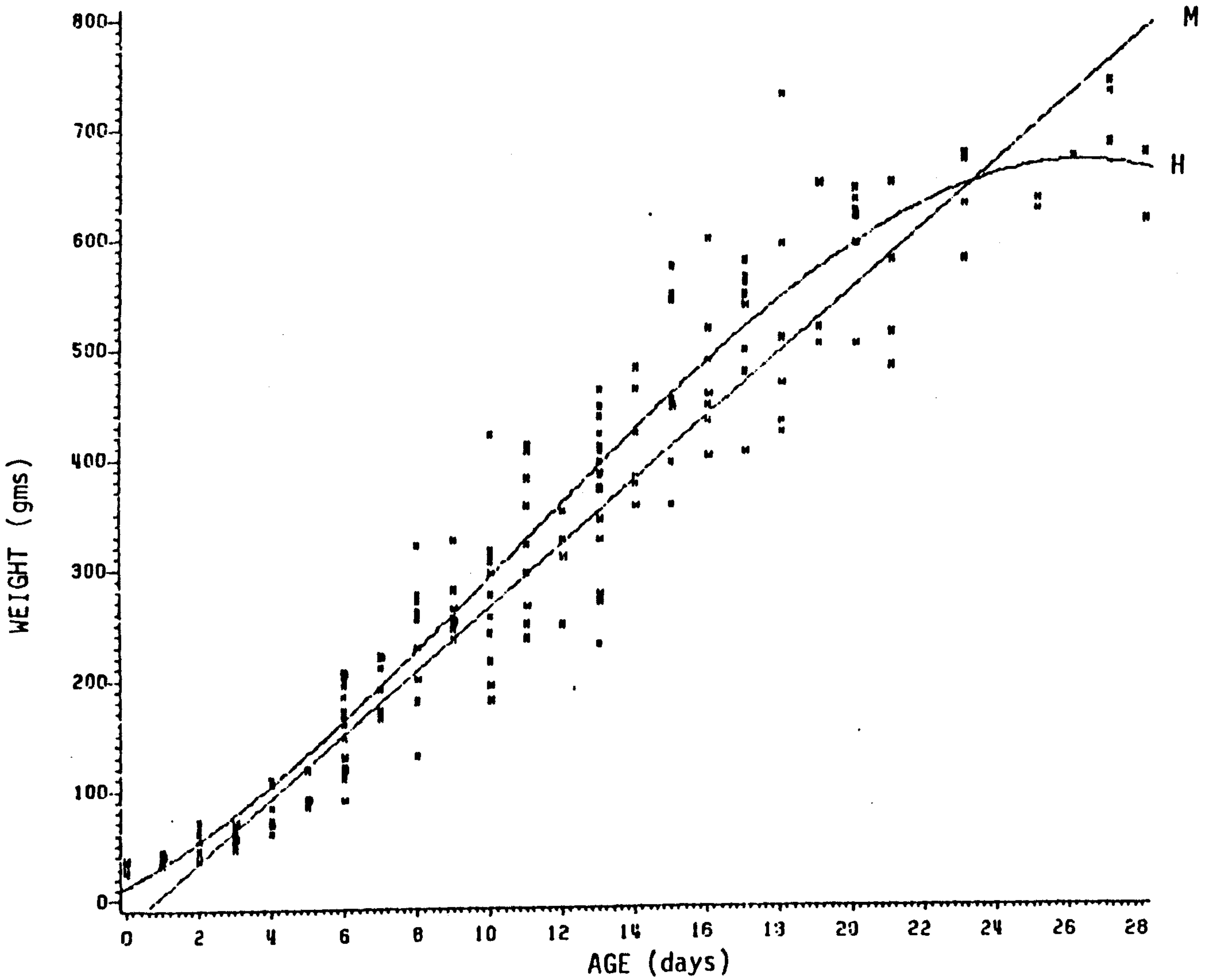


Figure 29. Weight gains of nestling Great Egrets at the study colonies in 1983. M = Mascotte (treatment) H = Hamilton (control).

Table 34. Comparative brood sizes and weight gains at the treatment and control colonies for broods weighed in 1983 and 1984.

		Average brood size at 1 wk		Control relative to Treatment	
Year	Species	Control	Treatment	Average brood size at 1 wk	Weight gain
1983	Great Egret	2.5	3.0	<	>
	Cattle Egret	2.4	2.5	<	>
	Snowy Egret	3.3	3.6	<	>
	Tricolored Heron	2.4	2.6	<	≥
1984	Snowy Egret	2.4	2.8	<	>
	Tricolored Heron	2.8	2.3	>	<

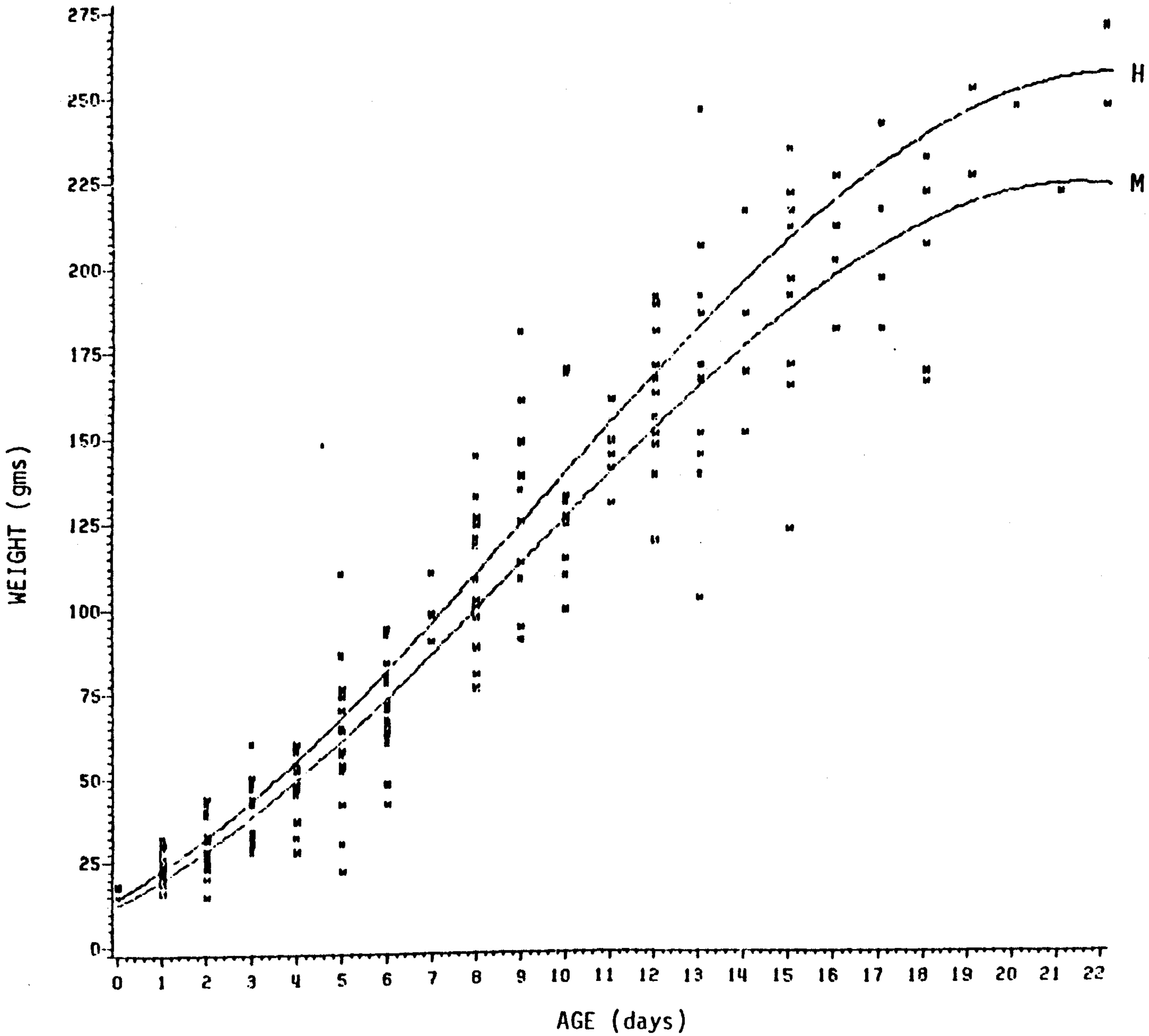


Figure 30. Weight gains of nestling Cattle Egrets at the study colonies in 1983. M = Mascotte (treatment), H = Hamilton (control).

natural areas may yield a more efficient return for equal effort by adult Cattle Egrets feeding young. Cattle Egret weight gains in 1984 were measured only for nestlings at the treatment site (Table 35, Fig. 31) because of the high mortality and loss of nestlings at the control site in that year.

Weight gains of Snowy Egrets were greater in both years at the treatment site (Figs. 32 and 33) and significantly greater at that site in 1983 (Tables 33 and 35). Based on indirect evidence (feeding rates), overall food resources in both years were greater for Snowy Egrets at the treatment site. As in the case of Great Egrets, this benefit in terms of weight gain may have been offset in both years by larger brood sizes at the treatment colony (Table 34): young at the control colony were in smaller broods and averaged greater weight gains. Thus, in both years Snowy Egrets at the treatment site produced more and lighter young whereas Snowy Egrets at the control site produced fewer but heavier young.

Weight gains of Tricolored Heron nestlings in 1983 were similar between sites (Fig. 34, Table 33); however, in 1984 weight gains were significantly greater at the treatment site (Fig. 35, Table 35). In 1983, the average size of weighed broods was slightly greater at the treatment site; however, in 1984, weighed broods on the average were slightly larger at the control site. The latter was the only instance in which average weight gains were significantly greater at the treatment site and the only instance in which the average size of weighed broods was smaller at that site.

<u>Nesting Chronology/Weather</u>

As is typically reported, Great Egrets initiated the breeding seasons at the study sites and were followed by Snowy Egrets,

Table 35. Results of analysis of covariance comparing weight gains of selected species from the study colonies in 1984.

Species	Colony	# of chicks weighed	Total # of weights (known age/estimated age)	P
Cattle Egret[a]	Treatment	38	145 (87/58)	
Snowy Egret[a]	Treatment	19	53 (18/35)	N.S.
	Control	22	59 (14/45)	
Tricolored Heron[a]	Treatment	20	66 (13/53)	.01
	Control	18	61 (24/37)	

[a]Based on weights of known and estimated age chicks.

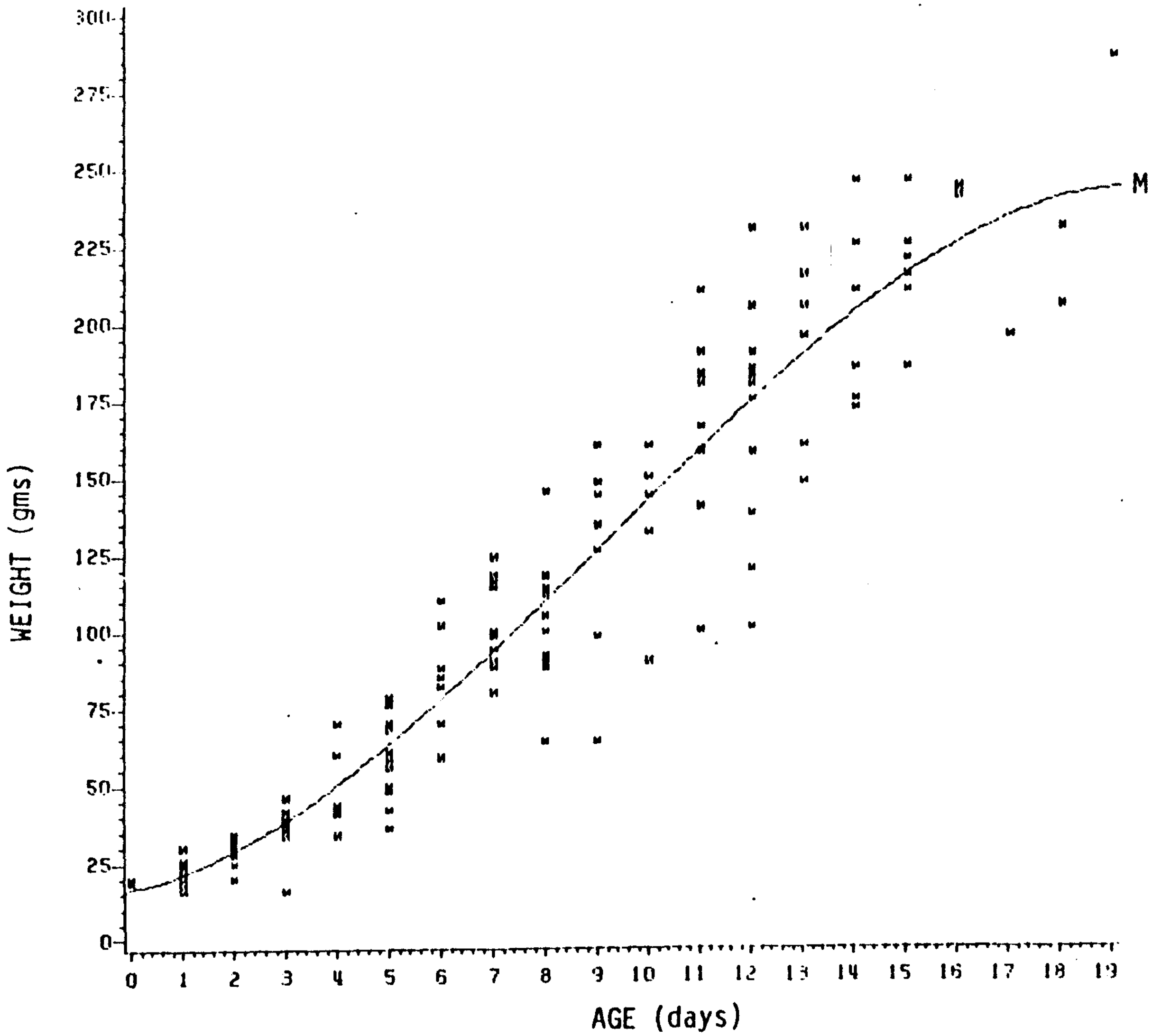


Figure 31. Weight gains of nestling Cattle Egrets at the treatment colony in 1984. M=Mascotte.

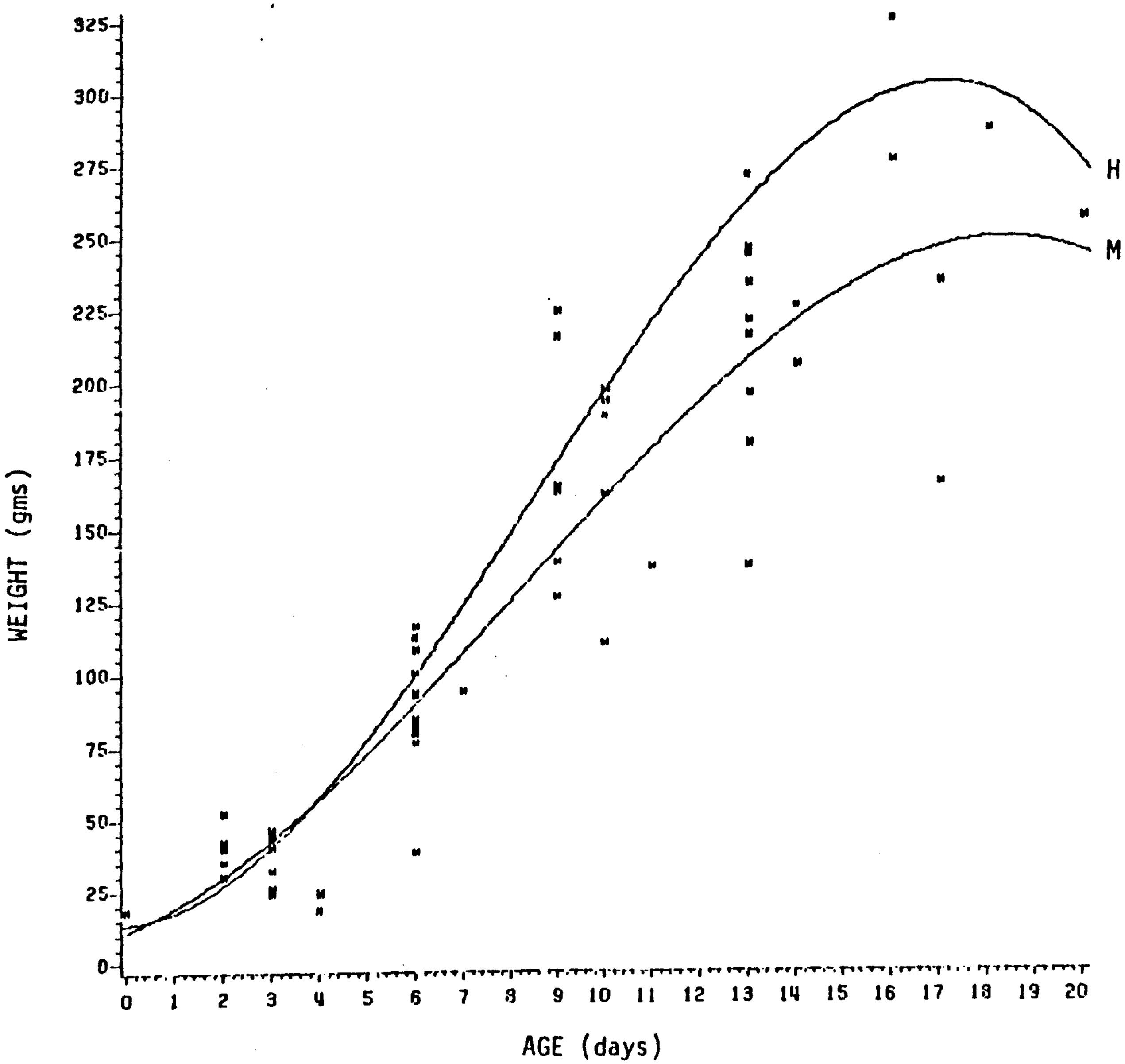


Figure 32. Weight gains of nestling Snowy Egrets at the study colonies in 1983. M = Mascotte (treatment), H = Hamilton (control).

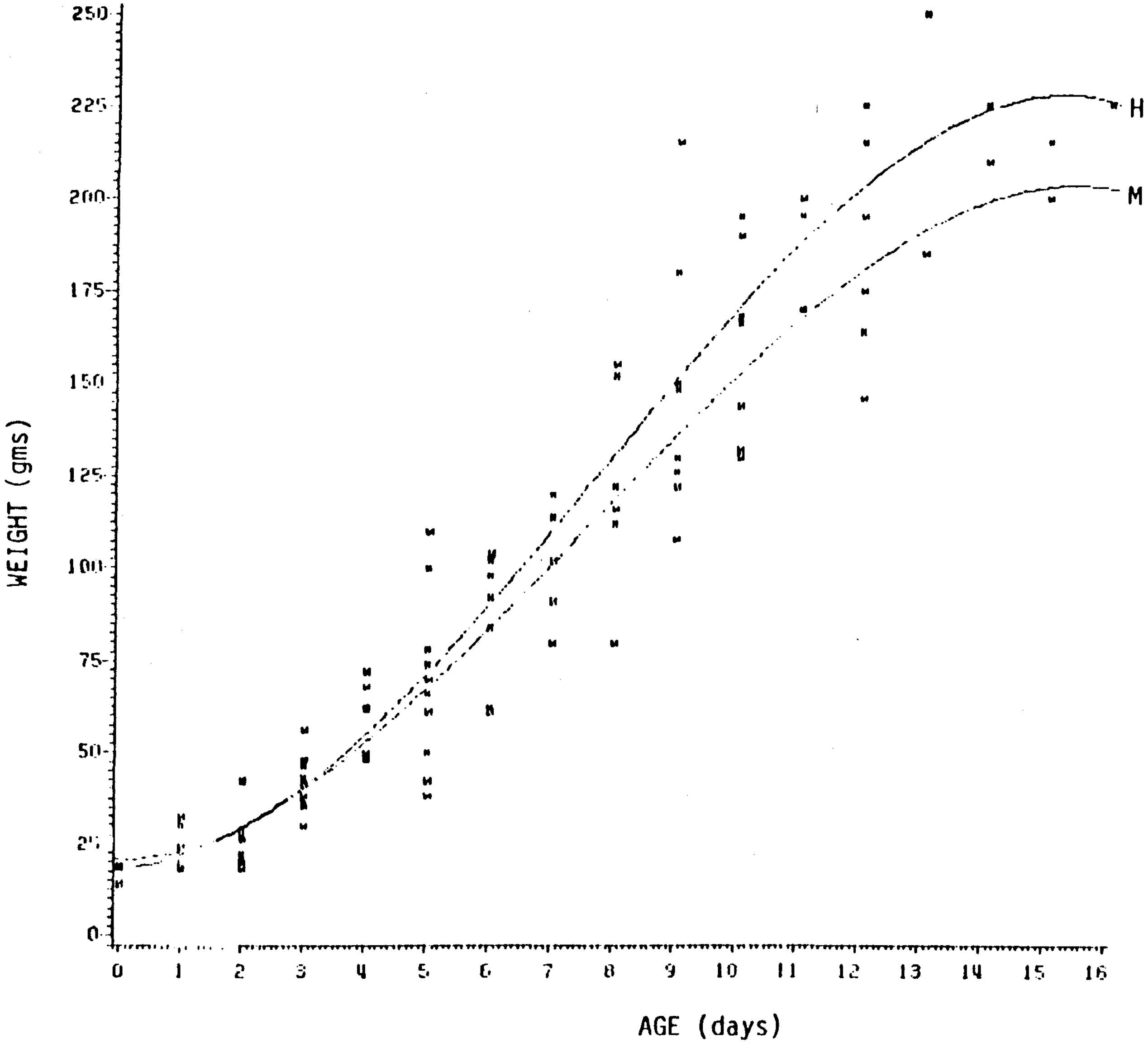


Figure 33. Weight gains of nestling Snowy Egrets at the study colonies in 1984. M = Mascotte (treatment), H = Hamilton (control).

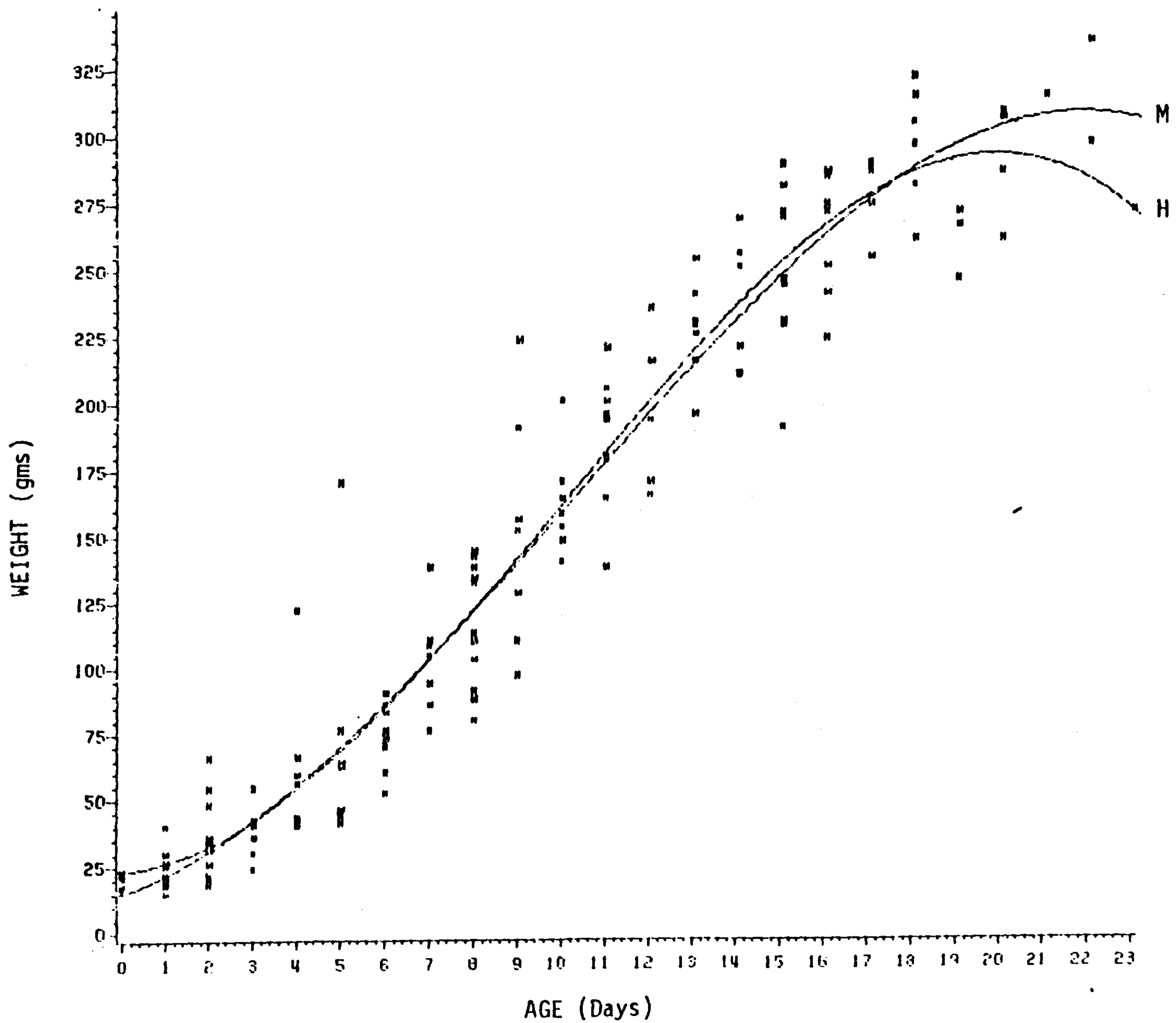


Figure 34. Weight gains of nestling Tricolored Herons at the study colonies in 1983. M = Mascotte (treatment), H = Hamilton (control).

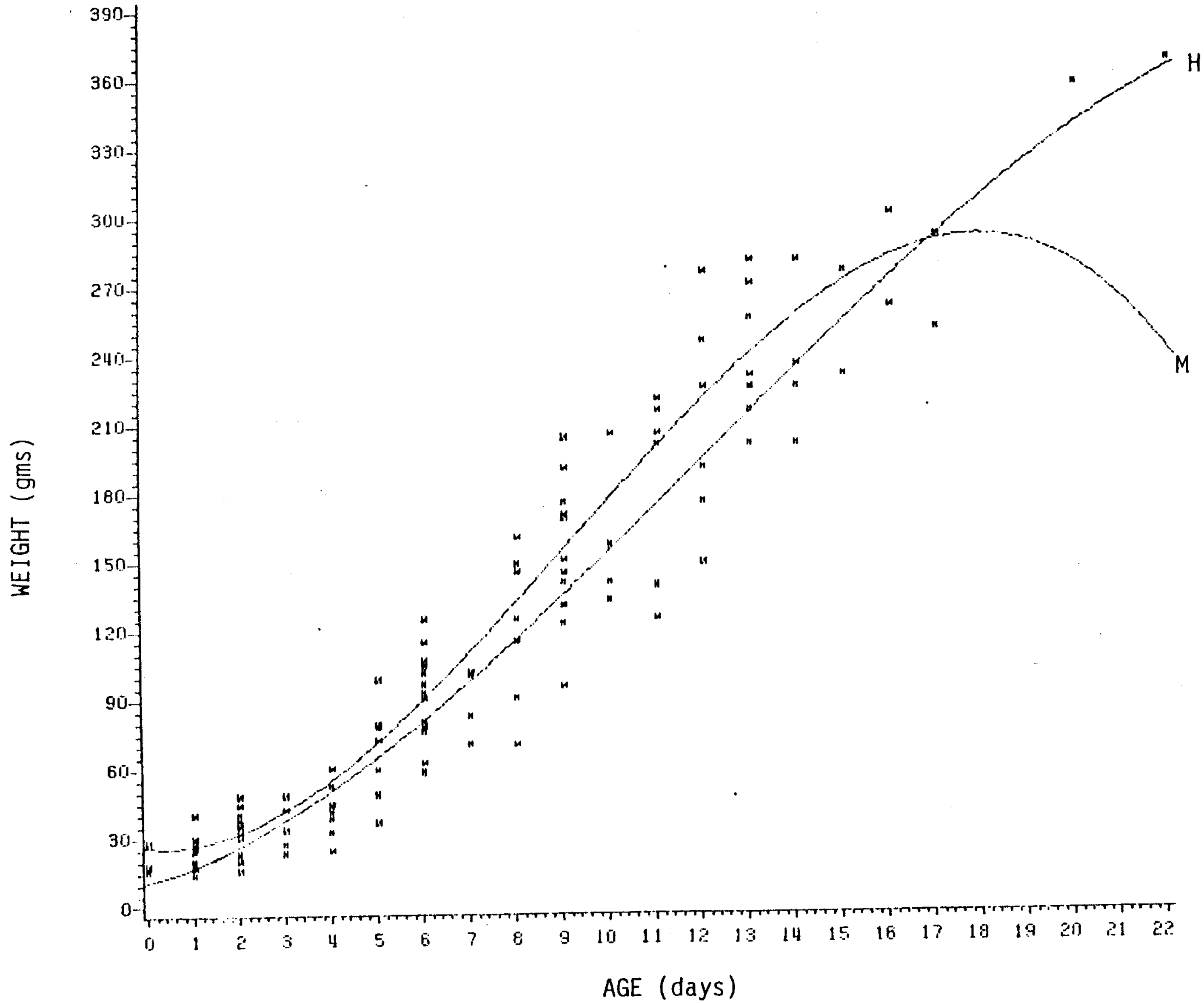
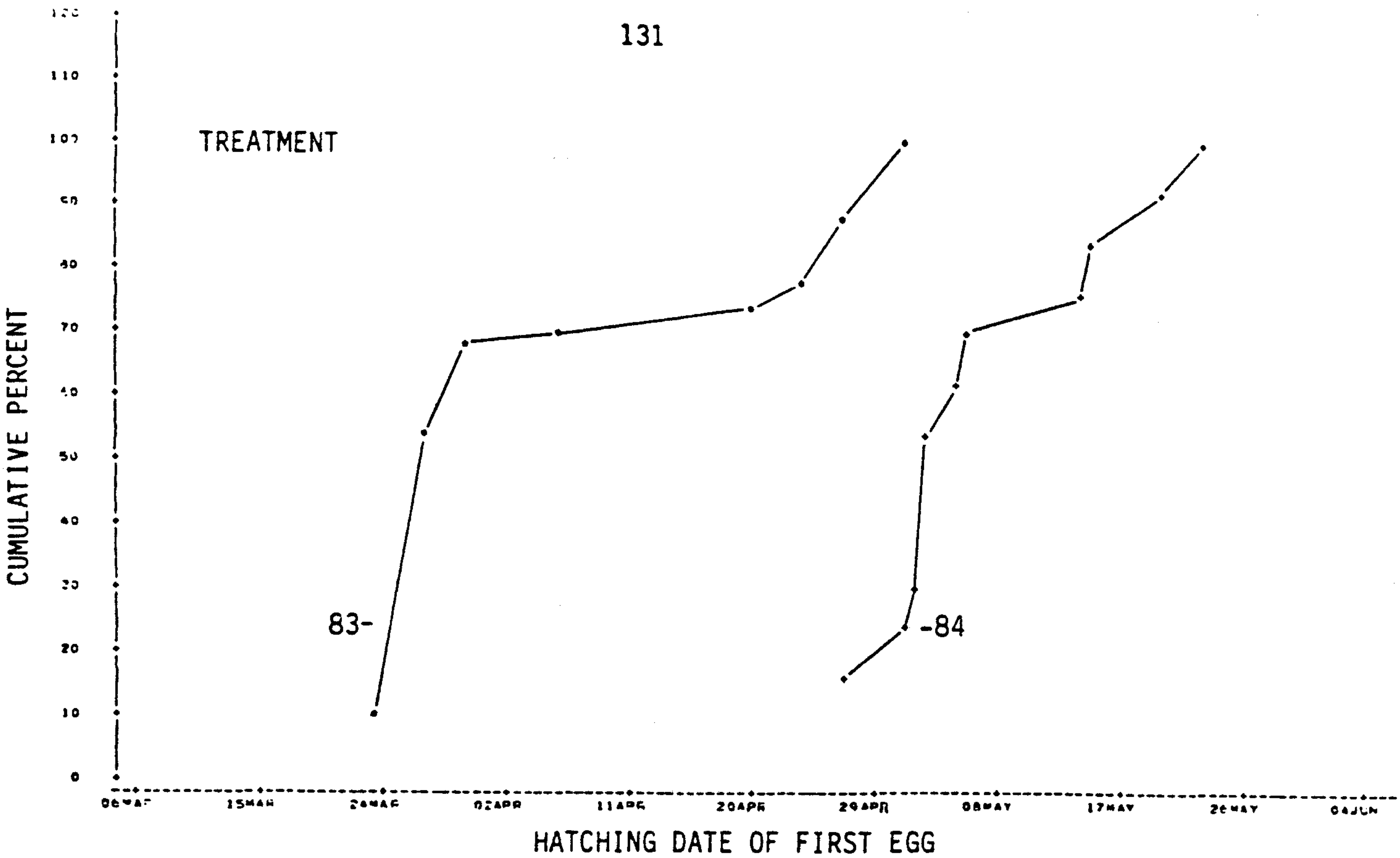


Figure 35. Weight gains of nestling Tricolored Herons at the study colonies in 1984. M = Mascotte (treatment), H = Hamilton (control).

Tricolored Herons, and finally Cattle Egrets. In 1984, Little Blue Herons nested at the same time as Snowy Egrets, and at the treatment site in both years White Ibis nested late in the season after Cattle Egrets. Other than these differences, Great Egrets, Snowy Egrets, and Tricolored Herons shared similar patterns of nesting chronology that differed markedly from the patterns of Cattle Egrets. Great Egrets, Snowy Egrets, and Tricolored Herons had an earlier breeding cycle at both sites in 1983 than in 1984, began nesting earlier in both years at the control colony than at the treatment colony, and in both years had shorter, more synchronized breeding cycles at the treatment site than at the control site (Figs. 36, 37, 38). Cattle Egrets demonstrated reverse patterns in each case: they had an earlier breeding season at both sites in 1984 than in 1983, began nesting earlier in both years at the treatment colony than at the control colony and in both years had shorter, more synchronized breeding cycles at the control site (Fig. 39).

The years preceding each breeding season of the study may be characterized as wetter than average. The year preceding the 1983 season, however, was closer to the 30 year mean than the year preceding the 1984 season (Table 36). In addition, precipitation during those years was slightly closer to average at the treatment site than at the control site. During the 1983 breeding season, precipitation at both sites was average-to-wet during January, February and March, average-to-dry during April and May, and wet during June (Table 37). In 1984, precipitation at both sites was average-to-dry during January, February, March and April.



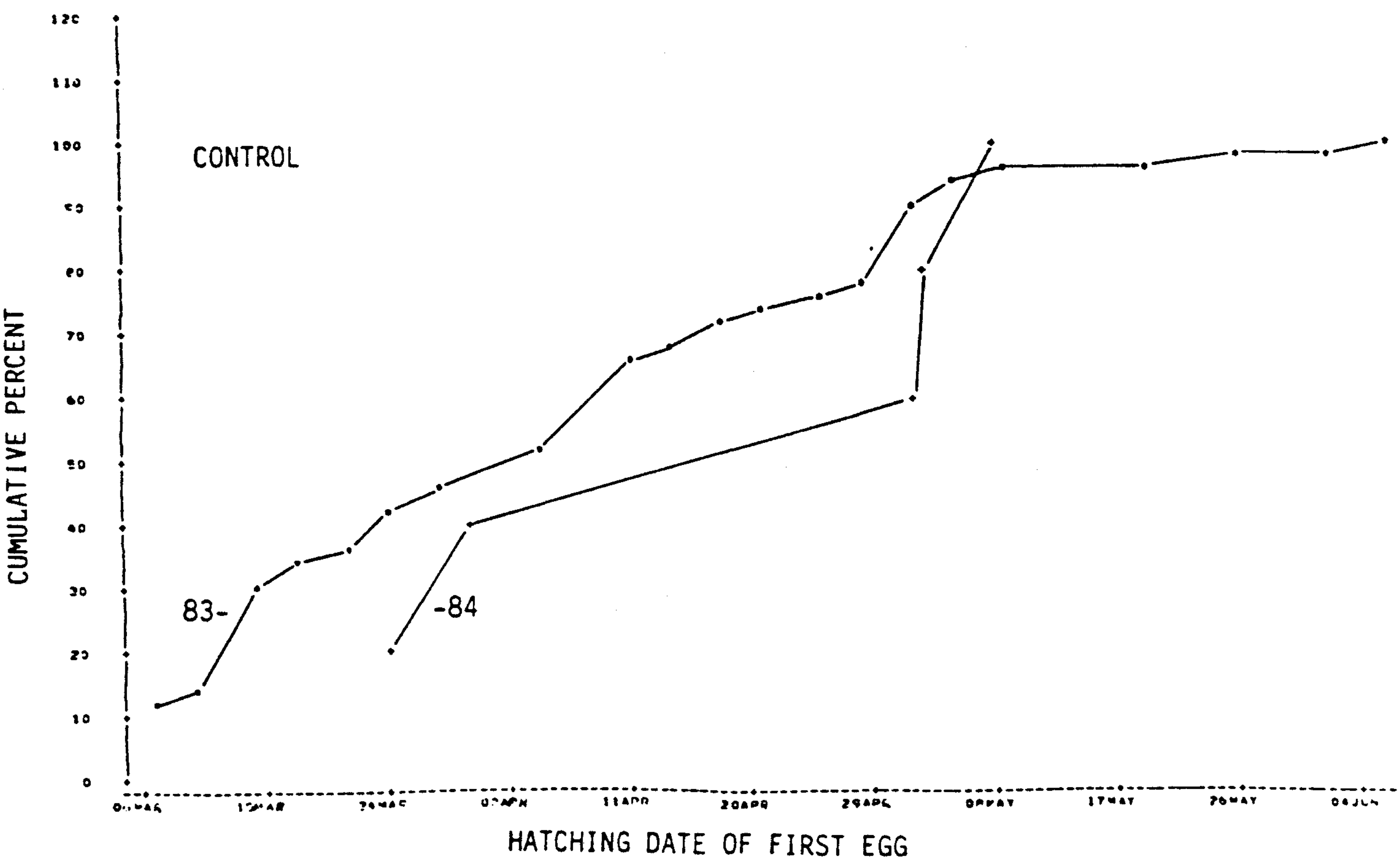


Figure 36. Cumulative percentage of Great Egret nests with the first egg hatching in 1983 (*) and 1984(+) at the treatment (above) and control (below)

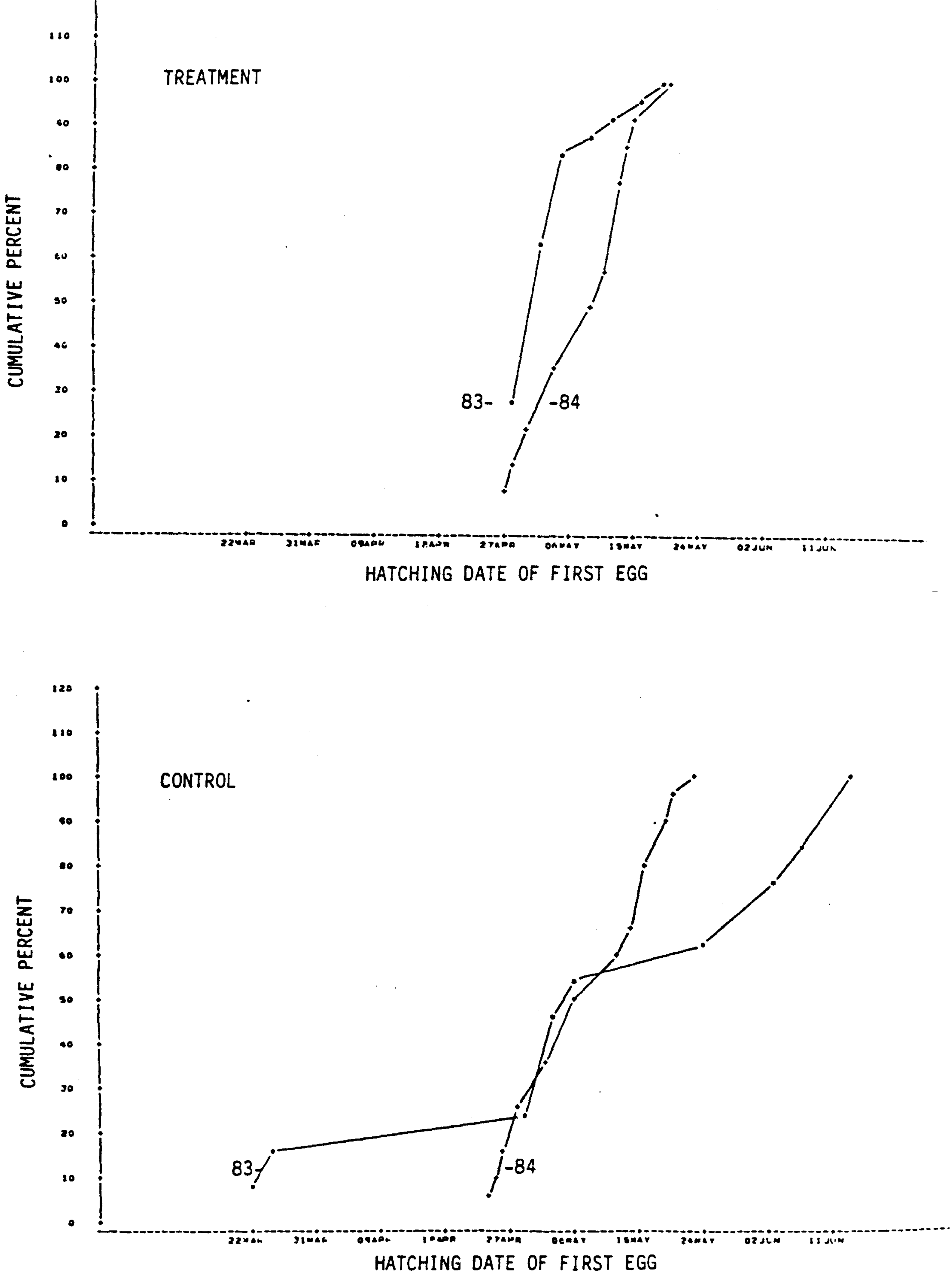


Figure 37. Cumulative percentage of Snowy Egret nests with the first egg hatching in 1983 (*) and 1984 (+) at the treatment (above) and control (below) colonies.

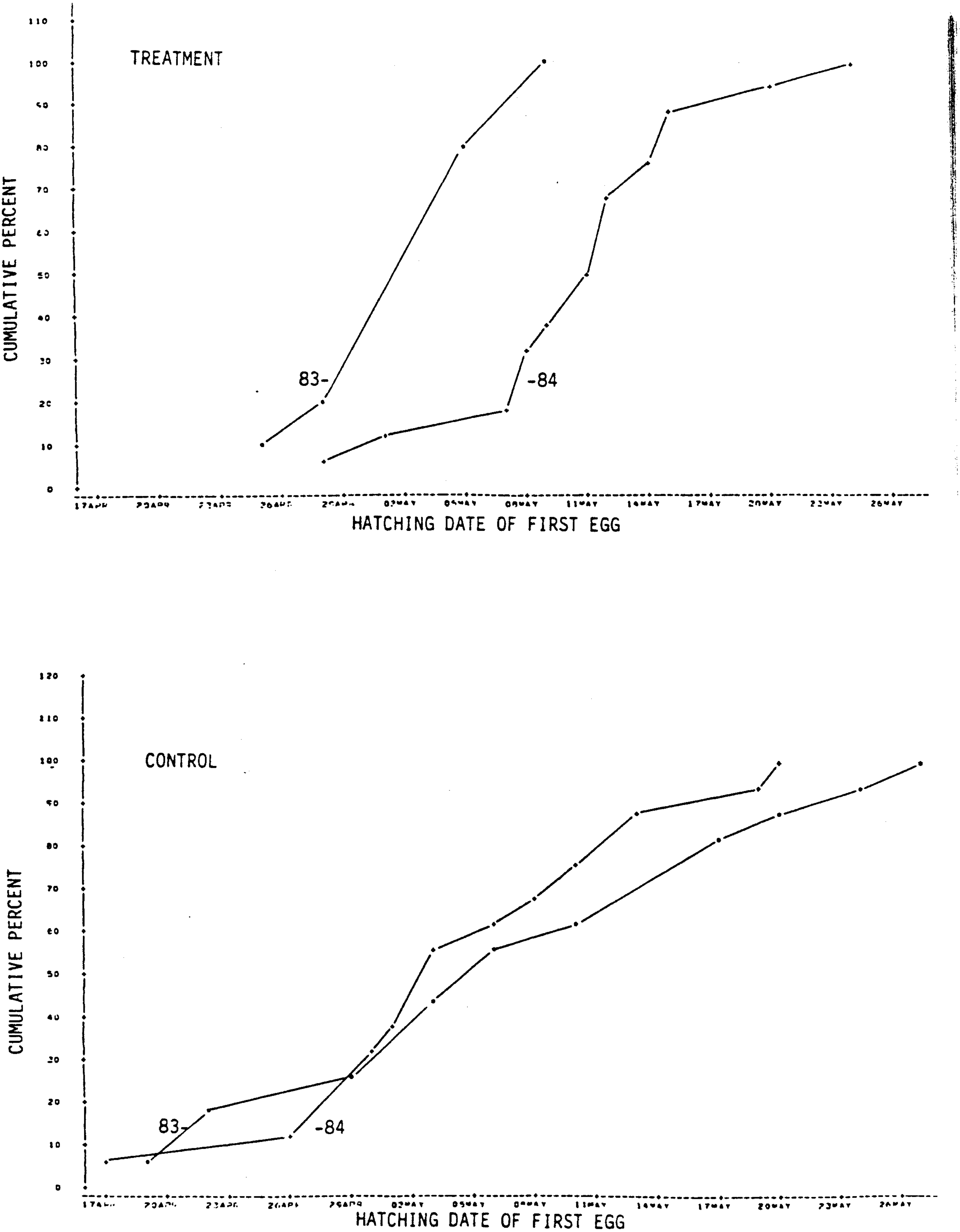


Figure 38. Cumulative percentage of Tricolored Heron nests with the first egg hatching in 1983 (*) and 1984 (+) at the treatment (above) and control (below) colonies.

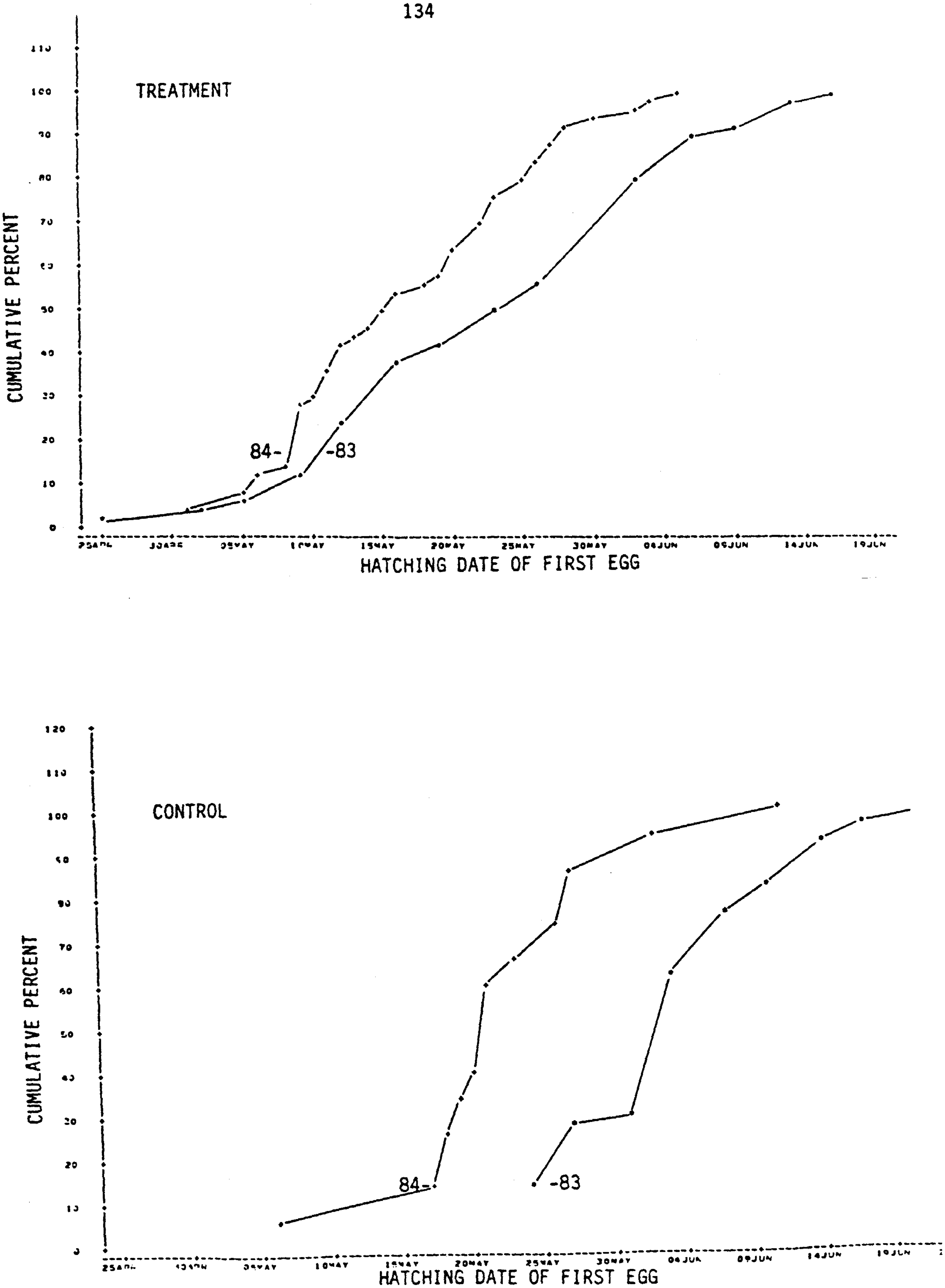


Figure 39. Cumulative percentage of Cattle Egret nests with the first egg hatchi in 1983 (*) and 1984 (+) at the treatment (above) and control (belo colonies

Table 36. Total annual precipitation and departure from the 30 year mean at NOAA climatic stations nearest the treatment and control colonies in the years preceeding the 1983 and 1984 breeding seasons.

Year	Weather station (colony)	Annual precipitation (inches)	Departure from normal (inches)
1982	Clermont (Treatment)	53.87	+ 2.47
	Winter Haven (Control)	62.10	+ 10.10
1983	Clermont (Treatment)	57.70	+ 6.48
	Winter Haven (Control)	68.76	+ 18.03

Table 37. Monthly precipitation and departure from the 30 year mean at NOAA climatic stations nearest the treatment and control colonies in the spring of 1983 and 1984.

		Total precipitation (departure from normal) in inches	
Year	Month	Clermont (Treatment)	Winter Haven (Control)
1983	Jan	2.43 (.02)	1.94 (-.41)
	Feb	7.64 (4.47)	8.42 (5.05)[a]
	Mar	7.31 (3.76)	7.00 (3.68)[a]
	Apr	3.24 (.54)	.87 (-1.38)
	May	2.42 (-1.23)	2.72 (-2.01)
	Jun	8.51 (1.53)	8.35 (2.23)
1984[b]	Jan	2.12 (-.29)	1.62 (-.73)
	Feb	3.01 (-.16)	3.69 (.63)
	Mar	.92 (-2.63)	1.73 (-1.71)
	Apr	2.76 (.06)	2.52 (.28)

[a]Data for Winter Haven were missing, thus, data from the Bartow station were used.
[b]Data for May and June not yet available.

Discussion

F-16 flights at 500 ft above ground level and up to 100 dBA were not observed to greatly or adversely alter reproductive behavior in the treatment colony. Breeding wading birds responded to military overflights in ways both similar to and different from those reported for other species subjected to similar sound stimuli. The birds in this study responded significantly differently during F-16 overflights with noise levels ranging from 55 to 100 dBA than they did during the absence of overflights. The responses to overflights, however, were not severe and were limited to no movement, head movement or in-place body movement (usually to an alert posture). These responses are similar to those reported for Great Egrets and Black-crowned Night-Herons (Grubb 1978) and for seabirds and raptors (Dunnett 1977, Ellis 1981) subjected to similar sound stimuli (range 61-110 dBA) by overflying aircraft. Differences in species' responses reported by other investigators (Cottereau 1978) also were noted in this study. High-nesting Great Egrets were more responsive and engaged in proportionately fewer "no responses" and more "position changing", a pattern also recorded by Kushlan (1979b) during surveys by low flying aircraft. These results concur with Casady's and Lehmann's (1967 in Cottereau 1978) suggestion that species subjected to auditory as well as visual stimuli may exhibit enhanced responses. Heinemann (1969) reported that domestic chicks responded more than adults during overflights with noise levels from 84-140 dB. In this study Great Egret and Cattle Egret nestlings responded significantly more to F-16 overflights than did the adults of their respective species.

Differences between responses reported in this and previous studies are three-fold. Firstly, responses in this study were less severe than those reported for Herring Gulls during 101-116 dBA overflights (Burger 1981): no flushing or increase in aggressive encounters were observed. Secondly, differential responses that vary with nest phase but result from similar stimuli have not been reported previously. For example, both adult Great Egrets and Cattle Egrets responded to overflights more during nest attendance in early chick-rearing and less during incubation and when feeding older young. Such differences may reflect the focus of adult "attention" during particular nesting activities. Thirdly, evidence of habituation to stimuli as reported by other investigators (Cottereau 1978, Grubb 1978) was not evident in regard to F-16 overflights. This lack of habituation may result from the short duration, spatial proximity and/or relative infrequency of such overflights as compared to operating tractors, distant speedboats, bulldozers, etc., to which the birds did appear habituated.

F-16 overflights were not found to influence either adult attendance at the nest or the rates or length of time adults spent feeding chicks. These activities, however, were interrupted by the two most detrimental colony disturbances observed, humans entering the colony and airboats approaching the colony edge.

Reproductive success in the treatment colony was independent of military overflights but reproduction at both sites did vary among species and between years. For each species, nest success and nestling survival were similar or greater in the treatment colony than in the control colony, and in 1983 than in 1984. Since clutch sizes within years were similar between sites, the treatment - control differences in nestling survival resulted from differing overall egg and nestling mortality which was consistently greater at the control site than at the treatment site. Factors associated with comparatively high egg and nestling mortality at the control colony included inclement weather, nest abandonment, unusually low nest placement, suspected nocturnal predation possibly by raccoons, Black-crowned Night-Herons, Barred Owls or snakes and starvation of the youngest sibling. Similar clutch sizes between sites and greater mortality at the control site are inconsistent with productivity-limiting effects induced by F-16 overflights through reduced egg production or increased mortality due to altered adult attentiveness in incubating eggs or guarding and feeding young. In addition, such effects would be unexpected in light of the non-severe responses to military overflights by the study species in the treatment colony.

One mortality category, addled eggs, was comparatively greater at the treatment site than at the control site. Hatching failures for colonial birds have been associated with extreme sound perturbations (Robertson 1970); however, this is not suspected to be the case in this study. The increase in non-viable Cattle Egret and Snowy Egret eggs at the treatment site was associated with late egg deposition intraspecifically (egg may or may not have been produced by the breeding pair) and egg dumping interspecifically (egg laid in the nest by another species), as also reported by other researchers. Although these occurrences do not account entirely for the high proportion of non-viable eggs in the treatment colony, reduced hatchability from F-16 overflights was not recorded in 1983 and would be unexpected since sound levels to 96 dBA inside and 131 dBA outside of an incubator produced no damaging effects to domestic chicken eggs (Stadelman 1957).

Non-military disturbances were similar between colonies in each year. Researcher visitation was consistent by species between sites and during researcher departure and subsequent blind observations, such visitation was not observed to influence avian predation at either site. Schreiber and Schreiber (1980) concluded that high-level sonic booms were less disturbing to colonial seabird colonies than were investigators. Similarly, in this study human intrusion into the colony was far more disturbing than F-16 overflights and equaled only in adverse effect by airboats.

Reproductive success in the study colonies was thought to be influenced primarily by ecological factors related to colony location, colony characreristics, and climatology. McCrimmon (1980) identified three major factors affecting the reproductive success of colonially nesting waterbirds including time of breeding, nest dispersion and habitat. These factors are discussed below as they relate to consistent or major trends in this study.

Given the fact that clutch sizes were similar between sites for each species within each year, the reproductive success of Great Egrets, Snowy Egrets, and Tricolored Herons in each year was greater at the site where the breeding season was shorter and more synchronized. Conversely, mortality was greater for each of these species at the site where the breeding season was more extended. The nest success and nestling survival of these three species also were greater in the year when the nesting cycle was initiated earlier

(1983), and earlier nesting Great Egrets (Area C-control) had significantly better nest success and greater nestling survival than late nesting Great Egrets (Areas S and N-control) in that year. Although nesting in only one year, Little Blue Herons also experienced lower mortality at the site (treatment) where the breeding season was more synchronized; however, Cattle Egrets did not follow this pattern. This species experienced greater mortality at the site (control) where its breeding was more synchronized; however, in both years this breeding was initiated markedly later than at the treatment site where Cattle Egrets bred more in concert with other species.

Areas of relatively low nest density experienced high mortality especially from egg loss apparently due to nest abandonment and/or predation. This pattern was noted at the control site for Great Egrets nesting outside of the main colony in 1983, for all Great Egrets at that site in 1984, and for Tricolored Herons on the control island in 1984: in this study no areas of unusually low nest density had high reproductive success. The converse, however, was not consistently recorded. For example, Cattle Egrets breeding at high nest densities also experienced high mortality though from qualitative observation this mortality occurred most frequently in areas of open canopy or in open areas next to the waters edge.

Respective treatment versus control habitat differences included an apparently higher versus lower availability of suitable nest sites, natural versus man-maintained hydrologic conditions, and a higher versus lower frequency of subcolony formation over time. At the treatment colony no nesting at very low nest heights or very low nest densities were recorded even for late-nesting individuals. In addition, based on indirect evidence (length of feedings sessions for like-size broods of Great Egrets and Snowy Egrets), food availability was greater in the treatment colony vicinity, a natural freshwater marsh. Finally, birds breeding in this marsh system have selected at least 7 "new" (not used in the previous year) subcolony sites over a period of 9 years indicating that in most years such a marsh system provides adequate nesting and feeding habitat to support a breeding wading bird population. At the control site suitable nest sites were not available for all Great Egrets forcing late-breeders into suboptimal (low and dispersed) nest sites. In addition, food availability (again based on indirect evidence for Snowy Egrets and Great Egrets) was slightly lower at this site; however, the significance of this difference is confounded by smaller surviving broods which gained weight faster than the larger broods at the treatment site. Finally, birds breeding at this site have formed subcolonies only 3 times in 9 years of survey. This tenacity to a site with limited suitable habitat may indicate limited nesting habitat nearby, as also suggested by the selection in 1983 of a subcolony site, an island in an artifical wetland, that was 30 m from land and accessible to raccoons.

The reader should bear in mind that generalizations from results gathered over only a two-year period should be interpreted cautiously. Speculation relating various factors to reproductive success and mortality is based on observed patterns: underlying causative processes cannot always be defined. Discussion of such patterns, however, should stimulate further thinking and help to identify directions and points of departure for future research.

Based on the responses of approximately 220 individuals during 57 overflights, F-16's at 500 ft above ground level and up to 100 dBA were not observed to greatly or adversely alter reproductive behavior or success of study species in the treatment colony. Flights by these craft at these standard speeds, rpms, and altitude should represent the impact to be expected from Air Force training squadrons flying F-16's in Florida since members of training squadrons are not authorized to fly below 500 feet above ground level. It is unknown, however, if local disturbances occur at certain colony sites below route segments used for very low (< 500 feet) flight training or below route segments used by military training squadrons flying louder aircraft at 500 feet above ground level. Wading bird responses to louder and/or lower military aircraft have not been tested.

SUMMARY AND CONCLUSIONS

Based on the indirect evidence of colony distribution and colony turnover rates in relation to military training routes (≤ 500 feet above ground level) and military operations areas, there was no demonstrated effect of military activity on wading bird colony establishment or size on a statewide basis. Colony distributions and turnover rates were independent of military activity but were related to the amount and type (estuarine or freshwater) of wetland, respectively.

Based on the responses of approximately 220 individual birds during 57 overflights, F-16's at 420 knots indicated airspeed, 82-84% rpm, 500 ft above ground level and up to 100 dBA were not observed to greatly or adversely alter the reproductive behavior of study species in the treatment colony. Wading bird responses to F-16 overflights were not severe or productivity-limiting: these responses were limited to no response, head movement or in-place body movement (usually to an alert posture). Differential responses that were noted included increased responses overall by high-nesting Great Egrets, significantly greater responses by Great Egret and Cattle Egret nestlings than by adults of the respective species, and reduced adult responses during incubation and late chick-rearing. No habituation to overflights was noted. During the study, the most severe and potentially productivity-limiting responses noted were elicited by humans entering the colony or airboats approaching the colony vicinity. Both disturbances induced panic flights that subsided only after the intruder retreated.

The reproductive success of study species in the treatment colony was independent of F-16 overflights. Reproductive success in both study colonies, however, was related to influential ecological factors including colony location, colony characteristics, and climatology.

Results of this study, thus, indicate that in Florida the establishment and size of wading bird colonies is independent of military activity on training routes designated to 500 feet or less above ground level and in military operations areas and that reproductive success in wading bird colonies is independent of low level training flights by F-16's at 420 knots indicated airspeed, 82-84% rpm, 500 feet above ground level and up to 100 dBAs. Flights by these craft at these standard speeds, rpms and altitude should represent the impact to be expected from Air Force training squadrons flying F-16's in Florida since members of training squadrons are not authorized to fly below 500 feet above ground level. The responses to and effects of F-16 overflights, as reported here, should not be considered representative of military aircraft at lower altitudes or greater noise levels.

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APPENDICES

Appendix 1. Wading bird colonies[a] found in U.S. Air Force MOAs or on low flight training routes in Florida and the number of breeding pairs surveyed in those colonies in 1976, 1977 and 1978.

County	Colony	Military Activity	Number of Breeding Pairs 1976	1977	1978
Brevard	612010	MOA	508		
"	612004	"	1482	1225	2113
"	612009	"		95	800
"	612007	"	2717	1900	
Citrus	611009	IR 046 B-C	1000	1025	1500
Collier	619028	VR 1087 B-C	35	0	
"	619024	IR 034 D-E	8300	1000	1750
"	619030	VR 1087 A-B	1650	400	130
"	619017	VR 1088 A-B		2550	2500
Desota	616013	MOA	415	0	54
"	616011	"			2000
"	616012	IR 049 D-E			33
Dixie	605015	VR 1006 P-Q		5000	175
"	605016	"		175	0
"	605014	"			550
Flagler	606005	VR 1009 B-C			10
Glades	619032	IR 034 F-G		2700	2000
"	619031	IR 050 D-F			50
"	619033	VR 1088 C-D	1500		
"	619034	"			90
Hamilton	593001	VR 1002 J-K	225	0	0
"	593002	VR 1001 J-K		7825	275
"	593003	MOA		100	230
Hardee	616016	MOA	1600	1575	700
"	615006	IR 050 A-B			50
Hendry	619035	IR 034 E-F	1500	0	0
"	619037	VR 1088 B-C		255	
Hernando	611016	IR 046 B-C		750	300
"	611011 (3)	"	100	52	171
"	611011 (2)	"	10	0	50
"	611011 (1)	"	110	55	333
"	611014	IR 046 A-B	400	375	500

Appendix 1. (cont.)

County	Colony	Military Activity	Number of Breeding Pairs 1976	1977	1978
Highlands	616019	MOA	3025	2950	3800
"	616020	"	256	202	1870
"	616017	"	2050	3000	6350
"	616018	IR 049 D-E			2000
Indian River	616021	VR 1006 J-K		6	0
	616023	VR 1089 B-C		1150	700
Jefferson	593005	VR 1001 H-I	50	6	0
Lafayette	593006	MOA	26	11	450
Lake	612029	IR 046 C-D	400	1510	2000
Levy	605021	VR 1006 N-O		175	26
Martin	616027	IR 051 F-G	200	100	0
"	616026	"		5750	10050
Monroe	620048	IR 053 A-B	1	0	8
"	620005	"	73	33	46
"	621007	"	65		
"	621018	"	256		
Okeechobee	616029	MOA	300		0
"	616030	"	1600	180	0
"	616031	VR 1098 E-F	1550	0	0
"	616028	IR 056 F-G	6300	6350	2820
Orange	612038	VR 1007 E-F	300	130	250
Osceola	616032	MOA	2800	2500	5350
Pinellas	611025	IR 046 A-B	160	40	100
"	611026	"	1150	150	700
Polk	612047	IR 046 C-D	1250	0	0
"	612044	"	500		0
"	612045	MOA	4300	4050	3155
"	616036	"	20	8	45
"	616040	"	2151	0	0
"	616041	"		3000	5050
"	616037	"		3	40
"	616034	"			1000
St. Lucie	616049	IR 056 G-H			35
"	616047	IR 051 F-G	4115	2400	2260

Appendix 1. (cont.)

County	Colony	Military Activity	Number of Breeding Pairs 1976	1977	1978
Sumter	611031	IR 046 B-C		43	0
"	611029	IR 046 C-D	1500	3506	4007
"	611030	"			850
Suwannee	593012	MOA		1500	350
Taylor	593010	VR 1005 D-E		137	0
Volusia	612001	MOA	1118	1500	225
Wakulla	592006	IR 015 C-D	21	8	70
"	592005	IR 015 B-C	147	375	100
TOTALS			57236	67830	70071

[a]Colony number designations and the number of breeding pairs are from the Florida Atlas of Breeding Sites for Herons and their Allies: 1976-78 (Nesbitt et al. 1982).

Appendix 2. Common and scientific names of bird species found in Florida wading bird colonies (Nesbitt et al. 1982) and their legal status as of February 1983 (FGFWFC 1983).

Common Name	Scientific	Legal Status[a] FGFWFC[b]	USFWS[c]	CITES[d]
Eastern Brown Pelican	(*Pelecanus occidentalis*)	T	E	
Magnificent Frigatebird	(*Fregata magnificens*)			
Double-crested Cormorant	(*Phalacrocorax auritus*)			
Anhinga	(*Anhinga anhinga*)			
Great Blue Heron	(*Ardea herodias*)			
Great White Heron	(*A. h. occidentalis*)			
Green-backed Heron	(*Butorides striatus*)			
Little Blue Heron	(*Egretta caerulea*)	SSC		
Cattle Egret	(*Bubulcus ibis*)			
Reddish Egret	(*Dichromanassa rufescens*)	SSC	UR	
Great Egret	(*Casmerodius albus*)			
Snowy Egret	(*Egretta thula*)	SSC		
Tricolored Heron	(*Egretta tricolor*)	SSC		
Black-crowned Night-Heron	(*Nycticorax nycticorax*)			
Yellow-crowned Night-Heron	(*Nyctanassa violacea*)			
Least Bittern	(*Ixobrychus exilis*)			
Wood Stork	(*Mycteria americana*)	E	UR	
Glossy Ibis	(*Plegadis falcinellus*)			
White Ibis	(*Eudocimus albus*)			
Scarlet Ibis	(*Eudocimus ruber*)			
Roseate Spoonbill	(*Ajaia ajaja*)	SSC		
American Flamingo	(*Phoenicopterus ruber*)			

[a]E=Endangered; T=Threatened; SSC=Species of Special Concern; UR=Under Review (for possible listing).
[b]Florida Game and Fresh Water Fish Commission.
[c]U.S. Fish and Wildlife Service.
[d]Convention on International Trade in Endangered Species of Wild Fauna and Flora.

Appendix 3

Brown Pelicans Breeding in U.S. Air Force Military Areas in Florida

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Interim Report

prepared for

United States Air Force
Department of Command Natural Resources
Headquarters Tactical Air Command
Langley Air Force Base, VA 23665
(Reimbursable Agreement No. 14-16-0009-82-1885)

and

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The Brown Pelican (*Pelecanus occidentalis*) was placed on the Endangered Species List of the U.S. Department of the Interior in 1974 as a result of drastic population declines in Louisiana and Texas and unusual reproductive failure in California (Schreiber 1978). The Florida breeding population of the Eastern Brown Pelican (*Pelecanus occidentalis carolinensis*) has remained relatively stable since 1968 (Table 1) and recent analyses of tissues from Brown Pelicans in Florida have revealed residue levels lower than those attendant to reproductive stress and failure (Nesbitt et al. 1981). The Brown Pelican is presently listed as threatened by the State of Florida.

Brown Pelicans nest in coastal areas primarily on islands (Palmer 1976); however, they are infrequent breeders in coastal U.S. Air Force military areas (MOA's and low flight training routes (≤ 05 AGL)) in Florida (Table 2). Since the estimate for Florida's Brown Pelican population is somewhat less than 30,000 birds (Schreiber 1978), the proportion of the population (450 pair) breeding in coastal U.S. Air Force military areas (MOA's and low flight training routes (≤ 05 AGL)) is only 3-4% of the State's total population. These 450 pair represent 5-6% of the State's estimated breeding population of 8,000 pair.

Brown Pelicans were recorded breeding in a total of 50 colonies in the state during the 1976-78 survey (Nesbitt et al. 1982); however, only 3 (6%) of these colonies were in military areas. Of these 3 colonies (#612001, 611025, 620005 Nesbitt et al. 1982) only 1 was used by breeding Brown Pelicans in all 3 years of the survey. The colony (#612001) is located on Bird Island (also referred to as "Crane Island" in the literature), Mosquito Lagoon, Volusia County, FL in the Shiloh MOA. No low flight training routes enter the Shiloh MOA and according to NASA's public affairs office, this MOA is a buffer zone for the John Kennedy Space Center. Only sporadic operations occur in this area as jets, prop jets or the shuttle transport jet arrive or depart from the NASA Shuttle Landing Facility on Merritt Island. This airfield is located 11 nautical miles from colony #612001.

During a program undertaken by the Louisiana Wildlife and Fisheries Commission and the Florida Game and Fresh Water Fish Commission to restock Brown Pelicans in Louisiana, Bird Island, Volusia Co., was selected as 1 of 3 stable Florida colonies from which to take nestling Brown Pelicans (Nesbitt et al. 1978). This colony has remained relatively stable since 1971 (Table 3).

A Brown Pelican colony located in Tampa Bay, FL in neither a MOA nor on a low flight training route ($\leq$ 05 AGL) has come to our attention due to its location within 5 nautical miles of MacDill AFB. This colony (#615007, Alafia, Nesbitt et al. 1982) is part of the National Audubon Society's Tampa Bay Sanctuary. Former sanctuary warden, James A. Rodgers, says that military craft he saw over this area were above 500 ft and reactions from breeding birds to overflights were limited to head movements. The present sanctuary warden, Richard T. Paul, followed Rodgers in 1978 and reports that aircraft are usually 1000 to 2000 ft, but suspects some flights may be as low as 500 ft. He reported no reactions from the birds and said that the population of breeding Brown Pelicans continues to increase from the 500 breeding pair in 1976-78 to 650-700 breeding pair in 1980 and 1981. Aircraft flying over the Alafia Banks from MacDill AFB are traveling towards IR-047 which has a beginning altitude of 50-90 MSL (5,000 to 9,000 ft above mean sea level). These craft climb to 1600 feet within two or three miles from take-off and are then assigned higher altitudes.

To summarize, Brown Pelicans are infrequent breeders in military areas (MOA's or low flight training routes ($\leq$ 05 AGL)) in Florida. Only one consistently active colony ($\simeq$450 pairs) exists in such a military area and it is a stable colony located in a MOA with no training routes and only sporadic operations. A Brown Pelican colony is located 5 nautical miles from MacDill AFB but should not be affected by military activity based on warden observations and the assigned altitudes of aircraft in that area.

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Table 1. Estimated pairs of Brown Pelicans nesting in Florida since 1968 as reported in Nesbitt et al. 1981.

Year	Number of Pairs
1968	6936
1969	6133
1970	7690
1971	5923
1972	7990
1973	6010
1974	6090
1975	5950
1976	5491
1977	6532
1978	7780
1979	8442
1980	8095

Table 2. Breeding pairs of Brown Pelicans in the 16 colonies affected by U.S. Air Force activity on the Florida coast.[a,b]

Colony	Survey Year 1976	1977	1978
612008	0	0	0
612001	338	450	300
612010	0		
612004	0	0	0
612009	0	0	0
612007	0	0	0
611011(1)	0	0	0
611011(2)	0	0	0
611011(3)	0	0	0
611025	+	+	0
611026	0	0	0
529005	0	0	0
620048	0	0	0
620005	30	0	0
621007	0		
621018	0		
TOTAL	368	450	300

[a]Data from Nesbitt et al. (1982)

[b]Blanks indicate no survey was conducted that year. A "+" means the species was present but the number of pairs could not be estimated.

Table 3. Estimated numbers of Brown Pelican nests or breeding pairs on Bird Island, Volusia Co., FL, from 1971 to 1978 as reported in Nesbitt et al. 1977 and Nesbitt et al. 1982.

Year	Number of Nests or Breeding Pairs
1971	500
1972	500
1973	250
1974	350
1975	350
1976	325
1977	450
1978	300

Appendix 4. Vegetation found in the treatment colony at Mascotte, FL during the 1983 breeding season. Species list and site description compiled by A.A. Tiller[a].

Vegetation Type	Family	Scientific Name	Common Name
Trees and shrubs	Caprifoliaceae	Sambucus simpsonii Rehd.	Florida elderberry
	Salicaceae	Salix caroliniana Michx.	willow
	Rubiaceae	Cephalanthus occidentalis L.	common buttonbush
	Aceraceae	Acer rubrum L.	red maple
	Myricaceae	Myrica cerifera L.	wax myrtle
	Onagraceae	Ludwigia peruviana (L.) Hara.	primrose willow
		Ludwigia leptocarpa (Nutt.) Hara.	
Forbs, grasses, sedges/ emergent or terrestrial	Anthocerataceae	Anthocerus sp.	hornwort
	Osmundaceae	Osmunda regalis L. var. spectabilis (Willd.) Gray	royal fern
		Osmunda cinnamomea L.	cinnamon fern
	Onagraceae	Ludwigia arcuata Walt.	
	Umbelliferae	Hydrocotyle umbellata L.	water pennywort
		Hydrocotyle ranunculoides L.f.	
	Pontederiaceae	Pontederia cordata var. lancifolia (Muhl.) Torrey	pickerelweed
	Solanaceae	Solanum americanum Miller	nightshade
	Phytolaccaceae	Phytolacca americana L.	pokeweed
	Haemodoraceae	Lachnanthes caroliniana (Lam.) Dandy.	red-root
	Alismataceae	Sagittaria lancifolia L.	arrowhead
		Sagittaria sp.	
	Commelinaceae	Commelina communis Michx.	dayflower
	Vitaceae	Parthenocissus quinquefolia (L.) Planchon	Virginia creeper
		Vitis rotundifolia L.	muscadine grape
	Scrophulariaceae	Micranthemum umbrossum (J.F. Gmel.) Blake	baby's tears
	Caprifoliaceae	Lonicera sempervirens L.	coral honeysuckle
	Typhaceae	Typha sp.	cattail
	Eriocaulaceae	Eriocaulon sp.	bog buttons
	Compositae	Eupatorium capillifolium (Lam.) Small	dog-fennel
		Eupatorium serotinum Michx.	thoroughwort, boneset
		Cirsium sp.	plume thistle

		Mikania scandens (L.) Willd.	climbing hempweed
	Poaceae	*Panicum* sp.	panic grass
	Cyperaceae	*Cyperus odoratus* L.	flatsedge
		Fuirena scirpoidea Michx.	umbrella-grass
		Cladium jamaicense Crantz	saw-grass
		Eleocharis equisetoides (Ell.) Torr.	spikerush
Forbs/submergent	Lentibulariaceae	*Utricularia inflata* Walt.	bladderwort
Forbs/floating or floating-leaved	Salviniaceae	*Salvinia rotundifolia* Willd.	common salvinia
		Azolla caroliniana Willd.	mosquito fern
	Lemnaceae	*Lemna* sp.	duckweed
	Nymphaeaceae	*Nymphaea odorata* Ait.	fragrant white water-lily
		Numphar luteum (L.) Sibth. and Sm.	spatter-dock
	Menyanthaceae	*Nymphoides* sp.	floating-hearts

[a] Taxonomic sources: Godfrey and Wooten (1979, 1981) and Radford et al. (1976).

Appendix 5. Vegetation found in the control colony at Lake Hamilton, FL during the 1983 breeding season. Species list and site description compiled by A.A. Tiller[a].

Vegetation Type	Family	Scientific Name	Common Name
Trees and shrubs	Salicaceae	*Salix caroliniana* Michx.	willow
	Caprifoliaceae	*Sambucus simponsii* Rehd.	Florida elderberry
	Rubiaceae	*Cephalanthus occidentalis* L.	common buttonbush
	Onagraceae	*Ludwigia peruviana* (L.) Hara.	primrose-willow
		Ludwigia leptocarpa (Nutt.) Hara.	
	Euphorbiaceae	*Sapium sebiferum* (L.) Roxb.	Chinese tallow-tree
	Compositae	*Baccharis* sp.	groundsel-tree
	Myrtaceae	*Melaleuca quinquenervia* (Cav.) Blake	bottle-brush, punk-tree
Forbs, grasses,sedges/ emergent	Amaranthaceae	*Alternanthera philoxeroides* (Mart.) Griseb.	alligator weed
	Polygonaceae	*Polygonum punctatum* Ell.	knotweed
	Umbelliferae	*Hydrocotyle umbellata* L.	water pennywort
		Hydrocotyle ranunculoides L.f.	
	Alismataceae	*Sagittaria lancifolia* L.	arrowhead
	Typhaceae	*Typha* sp.	cattail
	Compositae	*Eupatorium capillifolium* (Lam.) Small	dog-fennel
		Mikania scandens (L.) Willd.	climbing hempweed
		Pluchea rosea Godfrey var. *rosea*	marsh-fleabane
	Poaceae	*Brachiaria purpurascens* (Raddix) Henr.	para grass
		Panicum hemitomum Schult.	maidencane
	Cyperaceae	*Scirpus* sp.	bulrush
		Cladium jamaicense Crantz	saw-grass
Forbs/floating or floating-leaved	Ricciaceae	*Ricciocarpus natans* (L.) Corda	liverwort
	Salviniaceae	*Salvinia rotundifolia* Willd.	common salvinia
		Azolla caroliniana Willd.	mosquito fern
	Lemnaceae	*Lemna* sp.	duckweed
		Wolffia sp.	water-meal
		Wolfiella sp.	mud-midget
	Araceae	*Pistia stratiotes* L.	water-lettuce
	Pontederiaceae	*Eichhornia crassipes* (Mart.) Solms	water-hyacinth

[a]Taxonomic sources: Godfrey and Wooten (1979, 1981) and Radford et al. (1976).

Appendix 6. Number of breeding pairs and nesting stages of wading birds censused in the treatment (Mascotte) and control (Lake Hamilton) colonies from 1976 to 1984. Data from 1976-82 are from National Audubon Society's research department files and data from 1983-84 are from both that source and this study.

Colony	Month	Year	Great Egret	Cattle Egret	White Ibis	Tricolored Heron	Snowy Egret	Little Blue Heron	Great Blue Heron	Miscellaneous (Group)[a]
Mascotte	June	1976		450/sm-md-lg yg		0/lg yg; flg yg				
	April	1977	15/eggs	1250/eggs	500/early; eggs					
	April	1978		1100/early; eggs						
	July	1978		2000/flg yg						
	April	1980	53/early; eggs	290/early; eggs			98/early; eggs		1/eggs	800/early; eggs (IE+CS)
	July	1980	25/nr	1325/eggs; sm-md yg; lg yg	650/sm-md yg/ lg yg		75/nr	100/lg yg		150/nr (LL)
	April	1981	2/eggs							
	July	1981		300/lg yg						200/lg yr (CS)
	July	1982	0/lg yg	600/sm-md yg; lg yg; fly yg	150/lg yg; flg yg		0/seen flying	0/seen flying		
	April	1983	55/sm-lg yg	1000/early; eggs		20/eggs	35/eggs	15/eggs		
	July	1983		600/lg yg	100/eggs; sm yg					
	April	1984	10/eggs	800/early;eggs		20/eggs	25/eggs	25/eggs		
Hamilton	April	1976	300/eggs; sm-md yg	1000/eggs	500/eggs					0/seen fly (GI)
	June	1976	100/sm-md yg	1000/eggs; sm-md yg	200/flg yg					
	April	1977	50/nr	3000/eggs; sm-md yg	1500/eggs				0/lg yg	
	April	1978	150/eggs; sm-md yg	2000/eggs	1000/early; eggs				8/lg yg	
	July	1978	0/lg yg	2500/eggs; lg yg	250/eggs; sm-md yg				0/lg yg	50/hr (GI)
	April	1980	58/eggs							150/nr (CS)
	July	1980	30/lg yg	250/eggs; lg yg			0/lg yg			
	April	1981	75/early; eggs							
	July	1981	6/lg yg							200/eggs; lg yg (CS)
	July	1982	50/lg yg	425/eggs; lg yg				25/seen flying		
	April	1983	200/eggs; sm-lg yg			25/eggs	15/eggs		2/lg yg	
	July	1983	30/lg yg	400/lg yg						
	April	1984	10/eggs	25/early; eggs		30/eggs; sm yg	35/eggs; sm yg	30/eggs; sm yg	2/lg yg	

[a]Miscellaneous species: IE = WI/SE/CE/LB, LL = CE/LA/LB; CS = CE/SE; GI = Glossy Ibis.

Appendix 7. Nest success of each study species as calculated using the Mayfield method

Appendix 7, Table 1. Nest success of Great Egrets in the treatment colony (Mascotte) in 1983.

	Nesting Period				
	Laying	Incubation	Nestling	Entire Cycle[a]	Overall Success[b]
Expected number of days in period; J	6	21	21	48	
Number of nests; K	0	11	42	46	
Number of successful nests; ΣY_k	0	9	42	42	
Total nest days of observation; ΣT_k	0	113	293	368	
Estimated daily survival probability; $\hat{p}$		.982301	1	.994565	
Estimated standard deviation of $\hat{p}$; $\hat{V}_{\hat{p}}$		.0124039	0.00	.00383251	
Estimated success probability for period; $\hat{p}^J$		.687282	1.000	.769833	C
Estimated standard deviation of $\hat{p}^J$; $\hat{V}_{\hat{p}} J\hat{p}^{J-1}$		.1822	0.00	.1423	C
Proportion of observed nests which were successful; $\bar{Y}$		.8182	1.000	.9130	

[a]Calculated using the formula $\hat{s}=\hat{p}^{\Sigma J}$

[b]Calculated using the formula $\hat{s}=\hat{p}1^{J1}\hat{p}2^{J2}\hat{p}3^{J3}$

[c]No overall success value was calculated since Great Egrets at this site were not observed during egg-laying.

Appendix 7, Table 2. Nest success of Great Egrets in the control colony (Hamilton) in 1983.

	Nesting Period				
	Laying	Incubation	Nestling	Entire Cycle[a]	Overall Success[b]
Expected number of days in period; J	6	21	21	48	
Number of nests; K	31	70	101	125	
Number of successful nests; ΣY_k	28	49	84	84	
Total nest days of observation; ΣT_k	146	973	1244	2065	
Estimated daily survival probability; $\hat{p}$	.979452	.978417	.986334	.980145	
Estimated standard deviation of $\hat{p}$; $\hat{V}_{\hat{p}}$	.0117408	.00465864	.00329167	.00306985	
Estimated success probability for period; $\hat{p}^J$	.882875	.632421	.749045	.381892	.41823
Estimated standard deviation of $\hat{p}^J$; $\hat{V}_{\hat{p}} J \hat{p}^{J-1}$	.0634	.0632	.0524	.0574	.0035
Proportion of observed nests which were successful; $\bar{Y}$	.9032	.7000	.8316	.6720	

[a]Calculated using the formula $\hat{s}=\hat{p}^{\Sigma J}$

[b]Calculated using the formula $\hat{s}=\hat{p}1^{J1}\hat{p}2^{J2}\hat{p}3^{J3}$

Appendix 7, Table 3. Nest success of Cattle Egrets in the treatment colony (Mascotte) in 1983.

	Nesting Period				
	Laying	Incubation	Nestling	Entire Cycle[a]	Overall Success[b]
Expected number of days in period; J	6	17	14	37	
Number of nests; K	52	77	77	77	
Number of successful nests; ΣY_k	52	77	62	62	
Total nest days of observation; ΣT_k	229	1165	964	2358	
Estimated daily survival probability; $\hat{p}$	1.0000	1.0000	.98444	.993639	
Estimated standard deviation of $\hat{p}$; $V_{\hat{p}}$	0	0	.00398624	.00163725	
Estimated success probability for period; $\hat{p}^J$	1.0000	1.0000	.802876	.789685	.80288
Estimated standard deviation of $\hat{p}^J$; $V_{\hat{p}} J_{\hat{p}}^{J-1}$	0	0	.0455	.0481	.0455
Proportion of observed nests which were successful; $\bar{Y}$	1.0000	1.0000	.8052	.8052	

[a]Calculated using the formula $\hat{s}=\hat{p}^{\Sigma J}$

[b]Calculated using the formula $\hat{s}=\hat{p}1^{J1}\hat{p}2^{J2}\hat{p}3^{J3}$

Appendix 7, Table 4. Nest success of Cattle Egrets in the control colony (Hamilton) in 1983.

	Nesting Period				
	Laying	Incubation	Nestling	Entire Cycle[a]	Overall Success[b]
Expected number of days in period; J	6	17	14	37	
Number of nests; K	42	60	60	60	
Number of successful nests; ΣY_k	42	60	42	42	
Total nest days of observation; ΣT_k	195	965	715	1875	
Estimated daily survival probability; $\hat{p}$	1.0000	1.0000	.974825	.9904	
Estimated standard deviation of $\hat{p}$; $V_{\hat{p}}$	0	0	.0058586	.00225185	
Estimated success probability for period; $\hat{p}^J$	1.0000	1.0000	.699801	.699831	.69980
Estimated standard deviation of $\hat{p}^J$; $V_{\hat{p}}J\hat{p}^{J-1}$	0	0	.0588	.0588	.0589
Proportion of observed nests which were successful; $\bar{Y}$	1.0000	1.0000	.7000	.7000	

[a]Calculated using the formula $\hat{s}=\hat{p}^{\Sigma J}$

[b]Calculated using the formula $\hat{s}=\hat{p}1^{J1}\hat{p}2^{J2}\hat{p}s^{J3}$

Appendix 7, Table 5. Nest success of Snowy Egrets in the treatment colony (Mascotte) in 1983.

	Nesting Period				
	Laying	Incubation	Nestling	Entire Cycle[a]	Overall Success[b]
Expected number of days in period; J	6	17	14	37	
Number of nests; K	6	24	25	25	
Number of successful nests; ΣY_k	6	24	25	25	
Total nest days of observation; ΣT_k	23	325	350	698	
Estimated daily survival probability; $\hat{p}$	1.000	1.000	1.000	1.000	
Estimated standard deviation of $\hat{p}$; $\hat{V}_p$	0	0	0	0	
Estimated success probability for period; $\hat{P}^J$	1.000	1.000	1.000	1.000	1.0000
Estimated standard deviation of $\hat{p}^J$; $V_{\hat{p}} J \hat{p}^{J-1}$	0	0	0	0	0
Proportion of observed nests which were successful; $\bar{Y}$	1.000	1.000	1.000	1.000	

[a]Calculated using the formula $\hat{s}=\hat{p}^{\Sigma J}$

[b]Calculated using the formula $\hat{s}=\hat{p}1^{J1}\hat{p}2^{J2}\hat{p}3^{J3}$

Appendix 7, Table 6. Nest success of Snowy Egrets in the control colony (Hamilton) in 1983.

	Nesting Period				
	Laying	Incubation	Nestling	Entire Cycle[a]	Overall Success[b]
Expected number of days in period; J	6	17	14	37	
Number of nests; K	7	11	13	14	
Number of successful nests; ΣY_k	7	10	8	8	
Total nest days of observation; ΣT_k	26	158	142	318	
Estimated daily survival probability; $\hat{p}$	1.0000	.993671	.964789	.981132	
Estimated standard deviation of $\hat{p}$; $\hat{V}_{\hat{p}}$	0	.00630905	.0154672	.00762978	
Estimated success probability for period; $\hat{p}^J$	1.0000	.897684	.605412	.494216	.543469
Estimated standard deviation of $\hat{p}^J$; $\hat{V}_{\hat{p}} J \hat{p}^{J-1}$	0	.0968	.1358	.1422	.3590
Proportion of observed nests which were successful; $\bar{Y}$	1.0000	.9091	.6154	.5714	

[a]Calculated using the formula $\hat{s}=\hat{p}^{\Sigma J}$

[b]Calculated using the formula $\hat{s}=p1^{J1}\hat{p}2^{J2}\hat{p}3^{J3}$

Appendix 7, Table 7. Nest success of Tricolored Herons in the treatment colony (Mascotte) in 1983.

	Nesting Period				
	Laying	Incubation	Nestling	Entire Cycle[a]	Overall Success[b]
Expected number of days in period; J	6	17	14	37	
Number of nests; K	4	10	10	10	
Number of successful nests; ΣY_k	4	10	10	10	
Total nest days of observation; ΣT_k	11	137	140	288	
Estimated daily survival probability; $\hat{p}$	1.000	1.000	1.000	1.000	
Estimated standard deviation of $\hat{p}$; $\hat{V}_{\hat{p}}$	0	0	0	0	
Estimated success probability for period; $\hat{p}^J$	1.000	1.000	1.000	1.000	1.0000
Estimated standard deviation of $\hat{p}^J$; $V_{\hat{p}} J\hat{p}^{J-1}$	0	0	0	0	0
Proportion of observed nests which were successful; $\bar{Y}$	1.000	1.000	1.000	1.000	

[a]Calculated using the formula $\hat{s}=\hat{p}^{\Sigma J}$

[b]Calculated using the formula $\hat{s}=\hat{p}1^{J1}\hat{p}2^{J2}\hat{p}3^{J3}$

Appendix 7, Table 8. Nest success of Tricolored Herons in the control colony (Hamilton) in 1983.

	Nesting Period				
	Laying	Incubation	Nestling	Entire Cycle[a]	Overall Success[b]
Expected number of days in period; J	6	17	14	37	
Number of nests; K	7	13	16	17	
Number of successful nests; ΣY_k	7	12	14	14	
Total nest days of observation; ΣT_k	34	159	196	377	
Estimated daily survival probability; $\hat{p}$	1.000	.993711	.989796	.992042	
Estimated standard deviation of $\hat{p}$; $\hat{V}_{\hat{p}}$	0	.0062695	.00717847	.00457598	
Estimated success probability for period; $\hat{p}^J$	1.000	.898296	.866242	.744079	.77814
Estimated standard deviation of $\hat{p}^J$; $\hat{V}_{\hat{p}} J \hat{p}^{J-1}$	0	.0963	.0879	.1269	.1152
Proportion of observed nests which were successful; $\bar{Y}$	1.000	.9230	.8750	.8235	

[a]Calculated using the formula $\hat{s}=\hat{p}^{\Sigma J}$

[b]Calculated using the formula $\hat{s}=\hat{p}1^{J1}\hat{p}2^{J2}\hat{p}3^{J3}$

Appendix 7, Table 9. Nest success of Cattle Egrets plus unidentified nests on Cattle Egrett transects in the treatment colony (Mascotte) in 1983.

	Nesting Period				
	Laying	Incubation	Nestling	Entire Cycle[a]	Overall Success[b]
Expected number of days in period; J	6	17	14	37	
Number of nests; K	79	107	80	116	
Number of successful nests; ΣY_k	70	77	62	62	
Total nest days of observation; ΣT_k	317	1487	964	2358	
Estimated daily survival probability; $\hat{p}$	.971609	.979825	.98444	.977099	
Estimated standard deviation of $\hat{p}$; $\hat{V}_{\hat{p}}$	.00932841	.00364606	.00398624	.00308051	
Estimated success probability for period; $\hat{p}^J$	.841296	.707173	.00207158	.424357	.47767
Estimated standard deviation of $\hat{p}^J$; $\hat{V}_{\hat{p}} J \hat{p}^{J-1}$	.0485	.0447	.0455	.0495	.0491
Proportion of observed nests which were successful; $\bar{Y}$	.8861	.7196	.7750	.5345	

[a]Calculated using the formula $\hat{s}=\hat{p}^{\Sigma J}$

[b]Calculated using the formula $\hat{s}=\hat{p}1^{J1}\hat{p}2^{J2}\hat{p}3^{J3}$

Appendix 7, Table 10. Nest success of Cattle Egrets plus unidentified nests on Cattle Egrett transects in the control colony (Hamilton) in 1983.

	Nesting Period				
	Laying	Incubation	Nestling	Entire Cycle[a]	Overall Success[b]
Expected number of days in period; J	6	17	14	37	
Number of nests; K	48	76	60	76	
Number of successful nests; ΣY_k	48	60	42	42	
Total nest days of observation; ΣT_k	220	1181	715	1875	
Estimated daily survival probability; $\hat{p}$	1.000	.986452	.974825	.981867	
Estimated standard deviation of $\hat{p}$; $V_{\hat{p}}$	0	.00336394	.0058586	.00308152	
Estimated success probability for period; $\hat{p}^J$	1.000	.793035	.699801	.508093	.55497
Estimated standard deviation of $\hat{p}^J$; $V_{\hat{p}} J \hat{p}^{J-1}$	0	.0459	.0588	.0590	.0568
Proportion of observed nests which were successful; $\bar{Y}$	1.0000	.7894	.7000	.5526	

[a]Calculated using the formula $\hat{s}=\hat{p}^{\Sigma J}$

[b]Calculated using the formula $\hat{s}=\hat{p}1^{J1}\hat{p}2^{J2}\hat{p}3^{J3}$

Appendix 7, Table 11. Nest success of Great Egrets in the treatment colony (Mascotte) in 1984.

	Nesting Period				
	Laying	Incubation	Nestling	Entire Cycle[a]	Overall Success[b]
Expected number of days in period; J	6	21	21	48	
Number of nests; K	5	20	13	20	
Number of successful nests; ΣY_k	5	13	12	12	
Total nest days of observation; ΣT_k	13	235	265	459	
Estimated daily survival probability; $\hat{p}$	1.0000	.97021	.99623	.98257	
Estimated standard deviation of $\hat{p}$; $\hat{V}_{\hat{p}}$	0	.0110896	.00376646	.00610821	
Estimated success probability for period; $\hat{P}^J$	1.0000	.5299	.9237	.4299	.48947
Estimated standard deviation of $\hat{p}^J$; $\hat{V}_{\hat{p}} J \hat{p}^{J-1}$	0	.1272	.0733	.1283	.0154
Proportion of observed nests which were successful; $\bar{Y}$	1.0000	.6500	.9231	.6000	

[a]Calculated using the formula $\hat{s}=\hat{p}^{\Sigma J}$

[b]Calculated using the formula $\hat{s}=\hat{p}1^{J1}\hat{p}2^{J2}\hat{p}3^{J3}$

Appendix 7, Table 12. Nest success of Great Egrets in the control colony (Hamilton) in 1984.

	Nesting Period				
	Laying	Incubation	Nestling	Entire Cycle[a]	Overall Success[b]
Expected number of days in period; J	6	21	21	48	
Number of nests; K	0	8	3	8	
Number of successful nests; ΣY_k	0	3	3	3	
Total nest days of observation; ΣT_k	0	58	63	94	
Estimated daily survival probability; $\hat{p}$		.91379	1.0000	.94681	
Estimated standard deviation of $\hat{p}$; $V_{\hat{p}}$		.0368537	0	.0231467	
Estimated success probability for period; $\hat{p}^J$		.1506	1.0000	.0725	C
Estimated standard deviation of $\hat{p}^J$; $V_{\hat{p}} J \hat{p}^{J-1}$		.1275	0	.0851	C
Proportion of observed nests which were successful; $\bar{Y}$		.3750	1.0000	.3750	

[a]Calculated using the formula $\hat{s}=\hat{p}^{\Sigma J}$

[b]Calculated using the formula $\hat{s}=\hat{p}1^{J1}\hat{p}2^{J2}\hat{p}3^{J3}$

[c]No overall success value was calculated since Great Egrets at this site were not observed during egg-laying.

Appendix 7, Table 13. Nest success of Cattle Egrets in the treatment colony (Mascotte) in 1984.

	Nesting Period				
	Laying	Incubation	Nestling	Entire Cycle[a]	Overall Success[b]
Expected number of days in period; J	6	17	14	37	
Number of nests; K	20	60	53	60	
Number of successful nests; ΣY_k	20	53	52	52	
Total nest days of observation; ΣT_k	76	807	732	1520	
Estimated daily survival probability; $\hat{p}$	1.0000	.99133	.99863	.99474	
Estimated standard deviation of $\hat{p}$; $\hat{V}_{\hat{p}}$	0	.00326425	.00136519	.0018559	
Estimated success probability for period; $\hat{P}^J$	1.0000	.8623	.9810	.8226	.84599
Estimated standard deviation of $\hat{p}^J$; $V_{\hat{p}}J\hat{p}^{J-1}$	0	.0483	.0188	.0568	.0501
Proportion of observed nests which were successful; $\bar{Y}$	1.0000	.8833	.9811	.8667	

[a]Calculated using the formula $\hat{s}=\hat{p}^{\Sigma J}$

[b]Calculated using the formula $\hat{s}=\hat{p}1^{J1}\hat{p}2^{J2}\hat{p}3^{J3}$

Appendix 7, Table 14. Nest success of Cattle Egrets in the control colony (Hamilton) in 1984.

	Nesting Period				
	Laying	Incubation	Nestling	Entire Cycle[a]	Overall Success[b]
Expected number of days in period; J	6	17	14	37	
Number of nests; K	4	21	15	25	
Number of successful nests; ΣY_k	3	12	1	1	
Total nest days of observation; ΣT_k	18	206	99	239	
Estimated daily survival probability; $\hat{p}$	.94444	.95631	.85859	.89958	
Estimated standard deviation of $\hat{p}$; $\hat{V}_{\hat{p}}$	.0539903	.0142414	.0350204	.0194414	
Estimated success probability for period; $\hat{p}^J$	.7096	.4679	.1183	.0199	.03928
Estimated standard deviation of $\hat{p}^J$; $\hat{V}_{\hat{p}} J \hat{p}^{J-1}$	.2434	.1185	.0675	.0159	.0298
Proportion of observed nests which were successful; $\bar{Y}$	.7500	.5714	.0667	.0400	

[a]Calculated using the formula $\hat{s}=\hat{p}^{\Sigma J}$

[b]Calculated using the formula $\hat{s}=\hat{p}1^{J1}\hat{p}2^{J2}\hat{p}3^{J3}$

Appendix 7, Table 15. Nest success of Snowy Egrets in the treatment colony (Mascotte) in 1984.

	Nesting Period				
	Laying	Incubation	Nestling	Entire Cycle[a]	Overall Success[b]
Expected number of days in period; J	6	17	14	37	
Number of nests; K	3	12	14	16	
Number of successful nests; ΣY_k	3	10	13	13	
Total nest days of observation; ΣT_k	15	129	157	294	
Estimated daily survival probability; $\hat{p}$	1.0000	.98449	.99363	.98979	
Estimated standard deviation of $\hat{p}$; $\hat{V}_{\hat{p}}$	0	.0108776	.00634911	.00586119	
Estimated success probability for period; $\hat{P}^J$	1.0000	.7667	.9144	.6842	.70111
Estimated standard deviation of $\hat{p}^J$; $\hat{V}_{\hat{p}} J \hat{p}^{J-1}$	0	.1440	.0818	.1499	.1463
Proportion of observed nests which were successful; $\bar{Y}$	1.0000	.8333	.9286	.8125	

[a]Calculated using the formula $\hat{s}=\hat{p}^{\epsilon J}$

[b]Calculated using the formula $\hat{s}=\hat{p}1^{J1}\hat{p}2^{J2}\hat{p}3^{J3}$

Appendix 7, Table 16. Nest success of Snowy Egrets in the control colony (Hamilton) in 1984.

	Nesting Period				
	Laying	Incubation	Nestling	Entire Cycle[a]	Overall Success[b]
Expected number of days in period; J	6	17	14	37	
Number of nests; K	8	19	20	21	
Number of successful nests; ΣY_k	8	18	13	13	
Total nest days of observation; ΣT_k	31	191	215	428	
Estimated daily survival probability; $\hat{p}$	1.0000	.99476	.96744	.98131	
Estimated standard deviation of $\hat{p}$; $V_{\hat{p}}$	0	.00522188	.0121038	.00654642	
Estimated success probability for period; $\hat{p}^J$	1.0000	.9146	.6291	.4951	.57543
Estimated standard deviation of $\hat{p}^J$; $V_{\hat{p}} J \hat{p}^{J-1}$	0	.0816	.1102	.1228	.1135
Proportion of observed nests which were successful; $\bar{Y}$	1.0000	.9474	.6500	.6190	

[a]Calculated using the formula $\hat{s}=\hat{p}^{\Sigma J}$

[b]Calculated using the formula $\hat{s}=\hat{p}1^{J1}\hat{p}2^{J2}\hat{p}3^{J3}$

Appendix 7, Table 17. Nest success of Tricolored Herons in the treatment colony (Mascotte) in 1984.

	Nesting Period				
	Laying	Incubation	Nestling	Entire Cycle[a]	Overall Success[b]
Expected number of days in period; J	6	17	14	37	
Number of nests; K	5	11	16	16	
Number of successful nests; ΣY_k	5	11	15	15	
Total nest days of observation; ΣT_k	13	156	197	366	
Estimated daily survival probability; $\hat{p}$	1.0000	1.0000	.99492	.99727	
Estimated standard deviation of $\hat{p}$; $\hat{V}_{\hat{p}}$	0	0	.00506324	.00272851	
Estimated success probability for period; $\hat{p}^J$	1.0000	1.0000	.9312	.9037	.931232
Estimated standard deviation of $\hat{p}^J$; $V_{\hat{p}} J \hat{p}^{J-1}$	0	0	.0663	.0915	.0664
Proportion of observed nests which were successful; $\bar{Y}$	1.0000	1.0000	.9375	.9375	

[a]Calculated using the formula $\hat{s}=\hat{p}^{\Sigma J}$

[b]Calculated using the formula $\hat{s}=\hat{p}1^{J1}\hat{p}2^{J2}\hat{p}3^{J3}$

Appendix 7, Table 18. Nest success of Tricolored Herons in the control colony (Hamilton) in 1984.

	Nesting Period				
	Laying	Incubation	Nestling	Entire Cycle[a]	Overall Success[b]
Expected number of days in period; J	6	17	14	37	
Number of nests; K	2	15	16	19	
Number of successful nests; ΣY_k	2	12	16	16	
Total nest days of observation; ΣT_k	11	131	205	330	
Estimated daily survival probability; $\hat{p}$	1.0000	.97709	1.0000	.99091	
Estimated standard deviation of $\hat{p}$; $V_{\hat{p}}$	0	.0130695	0	.00522473	
Estimated success probability for period; $\hat{p}^J$	1.0000	.6745	1.0000	.7133	.674462
Estimated standard deviation of $\hat{p}^J$; $V_{\hat{p}} J \hat{p}^{J-1}$	0	.1534	0	.1391	.1534
Proportion of observed nests which were successful; $\bar{Y}$	1.0000	.8000	1.0000	.8421	

[a]Calculated using the formula $\hat{s}=\hat{p}^{\Sigma J}$

[b]Calculated using the formula $\hat{s}=\hat{p}1^{J1}\hat{p}2^{J2}\hat{p}3^{J3}$

Appendix 7, Table 19. Nest success of Little Blue Herons in the treatment colony (Mascotte) in 1984.

	Nesting Period				
	Laying	Incubation	Nestling	Entire Cycle[a]	Overall Success[b]
Expected number of days in period; J	6	17	14	37	
Number of nests; K	2	8	11	11	
Number of successful nests; ΣY_k	2	8	11	11	
Total nest days of observation; ΣT_k	3	94	148	245	
Estimated daily survival probability; $\hat{p}$	1.0000	1.0000	1.0000	1.0000	
Estimated standard deviation of $\hat{p}$; $\hat{V}_{\hat{p}}$	0	0	0	0	
Estimated success probability for period; $\hat{p}^J$	1.0000	1.0000	1.0000	1.0000	1.0000
Estimated standard deviation of $\hat{p}^J$; $\hat{V}_{\hat{p}} J\hat{p}^{J-1}$	0	0	0	0	0
Proportion of observed nests which were successful; $\bar{Y}$	1.0000	1.0000	1.0000	1.0000	

[a]Calculated using the formula $\hat{s}=\hat{p}^{\Sigma J}$

[b]Calculated using the formula $\hat{s}=\hat{p}1^{J1}\hat{p}2^{J2}\hat{p}3^{J3}$

Appendix 7, Table 20. Nest success of Little Blue Herons in the control colony (Hamilton) in 1984.

	Nesting Period				
	Laying	Incubation	Nestling	Entire Cycle[a]	Overall Success[b]
Expected number of days in period; J	6	17	14	37	
Number of nests; K	6	17	17	17	
Number of successful nests; ΣY_k	6	17	17	17	
Total nest days of observation; ΣT_k	26	210	238	474	
Estimated daily survival probability; $\hat{p}$	1.0000	1.0000	1.0000	1.0000	
Estimated standard deviation of $\hat{p}$; $\hat{V}_{\hat{p}}$	0	0	0	0	
Estimated success probability for period; $\hat{p}^J$	1.0000	1.0000	1.0000	1.0000	1.0000
Estimated standard deviation of $\hat{p}^J$; $\hat{V}_{\hat{p}} J \hat{p}^{J-1}$	0	0	0	0	0
Proportion of observed nests which were successful; $\bar{Y}$	1.0000	1.0000	1.0000	1.0000	

[a]Calculated using the formula $\hat{s}=\hat{p}^{\Sigma J}$

[b]Calculated using the formula $\hat{s}=\hat{p}1^{J1}\hat{p}2^{J2}\hat{p}3^{J3}$