

# Aspects of the population biology of *Fregata magnificens* in Belize

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The males' scarlet gular sac, inflated during the breeding season, can measure up to 7–8 inches in diameter. Photo/O.S. Pettingill.

**T**HE POPULATION BIOLOGY OF ALL five species of frigatebirds except, surprisingly, the Magnificent Frigatebird (*Fregata magnificens*) has received some detailed study. Eisenmann (1962) provided the best description of the breeding biology of *F. magnificens*, but exposed noticeable gaps in our knowledge.

Most of the known detail about the nesting of *F. magnificens* was reviewed in Nelson (1975) and was largely a result of Diamond's (1972, 1973) work at one colony of about 2500 nesting pairs on Barbuda, Lesser Antilles. Although the

**A regularly occurring species in the Caribbean and eastern Pacific Ocean, the breeding habits of the Magnificent Frigatebird have not been extensively studied.**

species occurs in both the Caribbean and the eastern tropical Pacific, not all known breeding colonies are documented in published sources. It would be beneficial to have a greater data base describing the population biology of this species from more than one breeding colony, because this species, like many others, may be negatively affected one day as a result of human activity.

Diamond (1972) reported that the inshore feeding habits of *F. magnificens* may provide it with a substantially greater food base during the nesting season than that of other frigatebirds



and, therefore, may make it possible for females to feed older juveniles without the help of males. He suggested that this appeared to be the case at Barbuda, and further that an excess of females in the population at Barbuda reflected the evolution of an uneven sex ratio. Males are able to breed each year while females breed only every other year. Thus, the uneven sex ratio tends to insure that a larger part of a population would be egg-laying females than if the sex ratio were 1:1. Diamond quantitatively demonstrated that this would result in increased productivity per individual in a population. It would be useful to know if the population characteristics of the Barbuda colony also occur at other colonies.

Our observations occurred on five short but intensive one-day visits to a small nesting colony on Man-O-War Caye (Bird Island) off Belize, Central America. According to Eisenmann, surprisingly few published nesting sites have been studied along the coast of

*Magnificent Frigatebirds hardly ever land on water, preferring to soar on 7-8 foot wing spans. Their graceful flight, huge wingspan and piratical habit of stealing food from other seabirds earned them the nickname "man-o-war" birds. For its weight, this bird has the largest wings of any living bird. Photo/James W. Parker.*

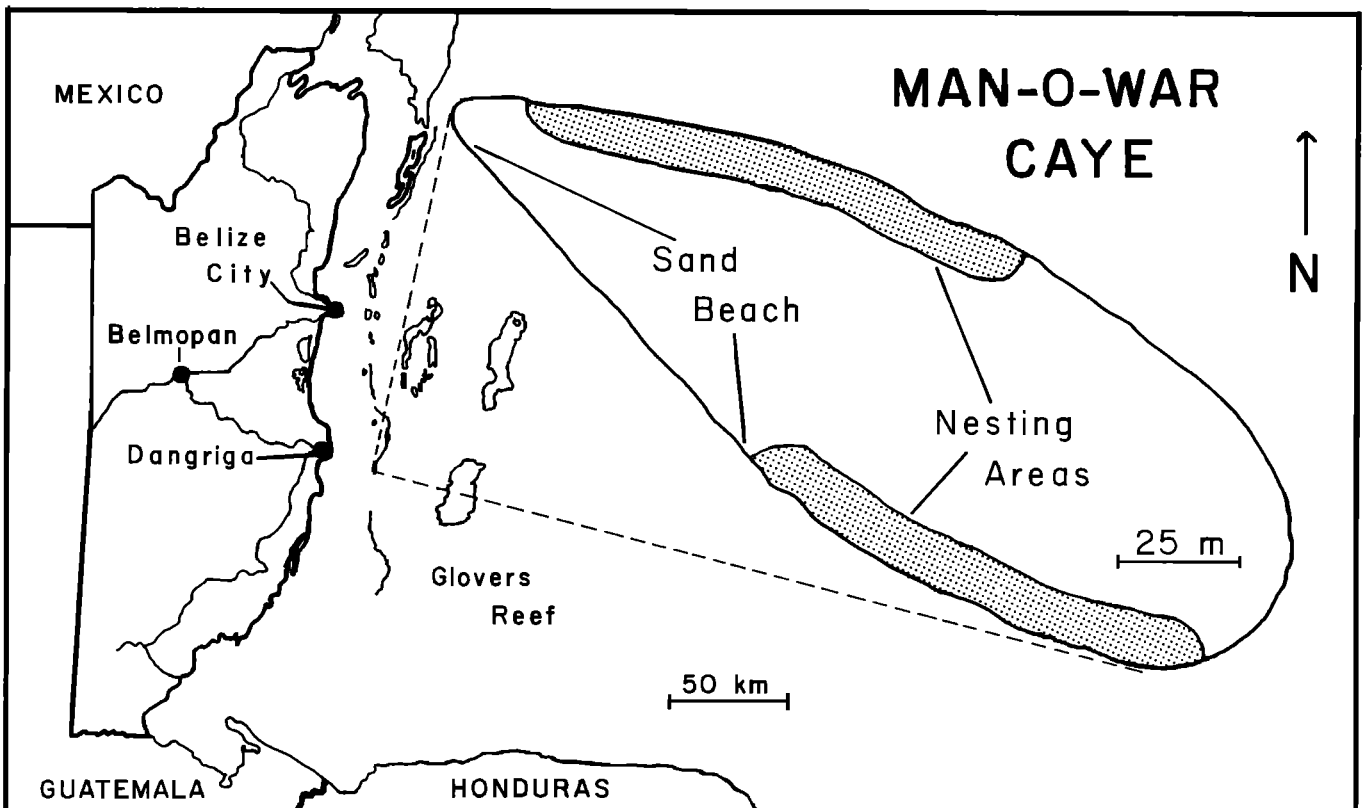


Figure 1. Man-O-War Caye and its location on the barrier reef off Belize, Central America.



*A tangle of trees and bushes, Man-O-War Cay provides nesting and loafing sites for the Magnificent Frigatebirds. Their inshore fishing habits may give the birds a greater food base than other seabirds with more specialized diets. Photo/James W. Parker.*



When not breeding, feeding or flying, this gregarious species roosts together in large numbers. Females seem to outnumber the males. Their sedentary habits and isolation on islands has led this species to the formation of small, distinct, widely spaced populations. Photo/James W Parker.

Central America. Verner (Eisenmann 1962) provided information about frigatebirds nesting off the Belize coast. Eisenmann listed another colony ("off Turneffe"), which he called Man-O-War Caye, that may have been an early reference to our study site, but the specific locality was not given. Our data set is not large, but may contribute to future studies of this and other nesting colonies. We also briefly document another (apparently unreported) colony on the Pacific Coast of Costa Rica.

#### Methods and study area

Man-O-War Caye (Fig. 1) is a 0.8-hectare mangrove island lying at 16°50'N, 88°04'W, and 8 kilometers northwest of Southwater Caye, the latter a 5-hectare coral sand island 24 kilometers off Dangriga (Stann Creek Town), Belize. Southwater Caye is 1.5 kilometers north of Carrie Bow Caye, the site of many studies by personnel of the Smithsonian Institution (Rutzler and MacIntyre 1982). All of these islands are on a coastal barrier reef of about 300 kilometers in length and the second largest in the world. As yet, this reef ecosystem has suffered compara-

tively little impact from human use and development, and small-scale commercial fishing is productive. Judging from Hartshorn *et al.* (1984), Man-O-War Caye is one of seven Crown Reserve Bird Sanctuaries established at the request of the Belize Audubon Society in 1977. However, the frigatebird nesting colony was not specifically identified as one of the reserves.

Most of Man-O-War Caye is covered by tall Red Mangroves (*Rhizophora mangle*) with about 0.5 meters of standing water around most of the periphery. The interior is very wet, and a dry coral sand beach exists only on about 35 meters of the southwest shore. We did extensive photography of the island.

Our five visits spanned almost five years. The first, January 13, 1982, was brief, and served only to orient us to the general characteristics of the island and to allow a count of the birds. One year later, January 8, 1983, we spent six hours counting all nests, censusing frigatebirds, photographing flocks, collecting food samples and carcasses, and observing bird behavior. No attempts were made to examine nest contents, but we flagged nest trees on the south

side of the island. Fifty days later, February 27, 1983, a two-hour visit allowed us to recensus some of the island, locate new nests, check on nesting progress, and make additional collections. We were able to examine the contents of a small number of nests during this visit. The fourth visit, January 12, 1985, allowed us to tally birds and nests once again, check nesting phenology, and collect additional food items, carcasses, and eggshell fragments. Food items were those regurgitated by frigatebirds. The visit on January 28, 1987, was made to confirm tree cutting and to reassess the size of the colony.

We cleaned and dried the eggshell fragments we collected. Three thickness measurements of the eggshell and membranes from each egg were taken with a dial caliper, and calibrated to the nearest 0.001 millimeter (Parker 1976). The average measurement for each egg was compared to those of older, pre-pesticide period eggshells which were obtained from three museums.

#### Results and discussion

From our brief contact with the colony in January, 1982, we arrived at a

maximum count (from transparencies) of 145 frigatebirds, although our impression was of a larger number of birds. It is likely that the colony was not significantly different in size than in early 1983 when our maximum count of birds (from transparencies) was 297 in the air and on mangroves. Sometimes far fewer birds were visible. It would have been too difficult to estimate total colony size without the use of photography, but even with the transparencies we probably missed individuals sitting on the far side of the island and a few others perched. Therefore, our best estimate of colony size is 325-350 frigatebirds, a much smaller local population than on Barbuda. The maximum counts of birds in the air in 1985 and 1987 were 223 and 196, respectively. Despite tree cutting, these figures were similar to counts in earlier years and indicative of no major changes in the number of birds using the island.

The estimation of sex and age ratios from direct observations of rapidly milling birds was impossible, as was the case for Diamond (1972). The use of transparencies proved more productive. Even so, aging and sexing proved difficult.

Males with inflated pouches were most easily identified; detecting females was more difficult. Nevertheless, our maximum count in 1983 showed nearly twice as many adult females (23) as



*With iridescent black wings spread, long hooked bill pointing up and crimson pouch inflated like a balloon, a male postures while scanning the sky for a female. When she appears, he shivers violently, rattles his bill and his wings while uttering a high warble to attract her attention. Photo/James W. Parker.*

adult males (12). This suggests an unbalanced sex ratio favoring females as documented for the Barbuda colony by Diamond (1972). This was not conclusive, however, owing to possible differences in behavior between sexes when

photographs were taken. At that stage in the breeding cycle, more males than females were on nests. If an unbalanced sex ratio favoring females were confirmed on Man-O-War Caye, which is an inshore colony with what seems a



*Magnificent Frigatebirds are five to seven years old before they begin breeding. Juvenile birds, distinguished in all *Fregata* species by their white head and neck, usually roost together in "clubs." In sunny sites, they take up a "sunning" posture—wings extended and turned so that the concave surface is exposed—as a means of shedding heat. Photo/James W. Parker.*



*A female Magnificent Frigatebird in flight. Males and females share parental duties, including incubation of their single white egg, brooding, and feeding of young. Photo/James W. Parker.*

relatively substantial food base, it would support Diamond's analysis of a link between food supply and sex ratio.

We were able to count more thoroughly the white-headed immatures, both in flight or perched, but some individuals were probably missed. The maximum of 48 immatures represented about 15% of the colony population. The percentage of immature frigatebirds at Man-O-War Caye was very similar to the percentages reported for colonies on the Gulf Coast of Florida

by Harrington *et al.* (1972). Often several immatures roosted together although we never observed them being fed by females, and most were probably independent birds. Gatherings of immatures may have comprised what Nelson (1983) called "clubs".

Our brief observations of plumage and soft-part colors reinforced general descriptions of the transitions involved in aging (Eisenmann 1962). We saw immature frigatebirds with throats and faces appearing dusky in overall aspect

because of some darker contour feathers. One nesting male with a red gular sac had an upper breast incompletely black with scattered dusky white contours. Adult males resting on nests, but not displaying, generally had red, deflated gular sacs. However, two of the three adult males that we handled had deflated gular sacs that were pale, dull orange suggesting that pouch color may be affected by factors other than age, such as emotional state.

During the first 1983 visit, 54 nests were found in 28 mangrove trees ( $X = 1.9$ ,  $S.D. = 0.9$  nest/tree) on the southeast border of the island. There were 49 other nests that we could not mark or examine, on the north side of the island. The maximum number of nest masses in one tree was 16, more than that reported by Eisenmann. All nest trees stood in shallow water or very wet sediment. No nests were found in trees on the drier, inner areas of the island. The southeast nesting area was recensused 50 days later on the second visit, and 115 nest masses were present ( $X = 4.3$ ,  $S.D. = 3.0$  nest/tree). This represented a 113% increase in the number of nests with an increase to 2.4 nests/tree ( $S.D. = 2.4$ ). One tree in this sample experienced an increase from four to 16 nests. If the number of nests on the north side had increased proportionately, the total number of nests would have been in excess of 200. Not all of these would necessarily have been active, and the breeding population size reflected by the number of nests was consistent with censuses derived from transparencies. The number of nests, 113, found in January, 1985, was similar to the number found about a week earlier in 1983. This suggests neither a significant change in the nesting population, nor in the nesting schedule. The existence of nests on opposite sides of the island supported Diamond's (1973) assessment that frigatebirds do not require nesting to windward on an island to facilitate take off.

Average nest elevation in 1983 was 6.7 meters ( $S.D. = 1.7$  meters) and distance between nearest-neighbor nests averaged 1.2 meters ( $S.D. = 1.4$  meters), both calculated only for subsamples of the 28 nest trees tagged on the first visit. Nearest-neighbor distance was obviously less than this by the time all nests were established. We do not present nest density per  $m^2$ , as did Diamond (1973), but our nearest-neighbor distances indicate a density similar to, or



Prior to the breeding season, the gular pouch shows only as a pale strip of pink flesh. Photo/James W. Parker.

greater than, on Barbuda. The structure and size of active nests were typically as described by Eisenmann, but nests averaged higher in elevation. All were exposed at the upper canopy. A small number of old, partly decomposed nests remained from past years in the mangrove mid-canopy. Presumably, these were inaccessible to the frigatebirds, and may have reflected a long history of nesting on Man-O-War Caye.

In January, 1983, virtually all nest masses in the tagged trees were occupied, 28% by displaying males, 11% by females, 9% by both, and the remainder by birds of unknown sex. By the late February visit, only 16% of the 115 nests in the tagged trees were occupied by males, 43% by females, 8% by both and 34% were unoccupied (and probably failed). Of the 17 nest cups viewed on the latter visit, three held one egg, five contained a single nestling, and nine were empty. The five nestlings were all small with scattered down and no evident contour feather development. They were no more than two weeks old based on estimates of 50+ days required for incubation (Nelson 1975). The first eggs must have been laid before our first (January) visit. The only nest cup examined in January 1985 held one egg, and the January visits of all years dis-

closed fresh eggshell fragments beneath some nests, indicating egg loss.

The period between our 1983 visits apparently saw not only substantial nest construction, but also a great deal of first-egg laying, which quickly follows the period of display by males on nests (Nelson 1975). Allowing for some re-laying, which is usual, the hatching dates on the island probably spanned February to mid-April, or even longer. In general, nesting chronology for Man-O-War Caye appeared consistent from year to year and later than on Barbuda (Diamond 1972, 1973), where there was some bimodality with the early peak of laying in late October. Laying on Man-O-War Caye synchronized more with the second peak of laying on Barbuda.

The high numbers of nests empty or untended on the second visit in 1983 strongly indicate substantial failure, perhaps of 25% or more, of nests during incubation. This is a high rate of nest failure, typical of other frigatebird species, and on the same order of magnitude as that of *F. magnificens* on Barbuda (Diamond 1972). Our presence in the colony in early January might have delayed laying by some birds, or otherwise might have disrupted nesting activity. However, the frigatebirds on nests did not appear to be greatly disturbed

by us; in many cases they did not leave their nests, and we saw no eggs thrown from nests. We did not examine nest contents during our January visits to avoid frightening females from eggs.

We discovered considerable evidence of bird mortality in the colony, including carcasses (skeletons were recovered). Four full-grown frigatebirds were mummified, entangled, and suspended beneath nests on fishing line. One large and one small nestling died similarly. One adult trailing 10 meters of fishing line was observed flying, and a live adult male was released from entanglement on the mangrove edge. Cause of death was undetermined for seven other carcasses, two of which were juveniles and all of which were suspended in branches beneath the top of the canopy.

Eisenmann (1962) noted that frigatebirds have been caught on baited fishline; neither he nor others reported mortality as a result. However, fishing activity along the Belize coast clearly takes its toll of adult and nestling frigatebirds. Similar mortality should be looked for at other colonies or reported by those who might have observed it.

One event in January, 1983, indicated that intraspecific hostility in the colony can result in injury and possibly death. As one of us stood quietly in tall

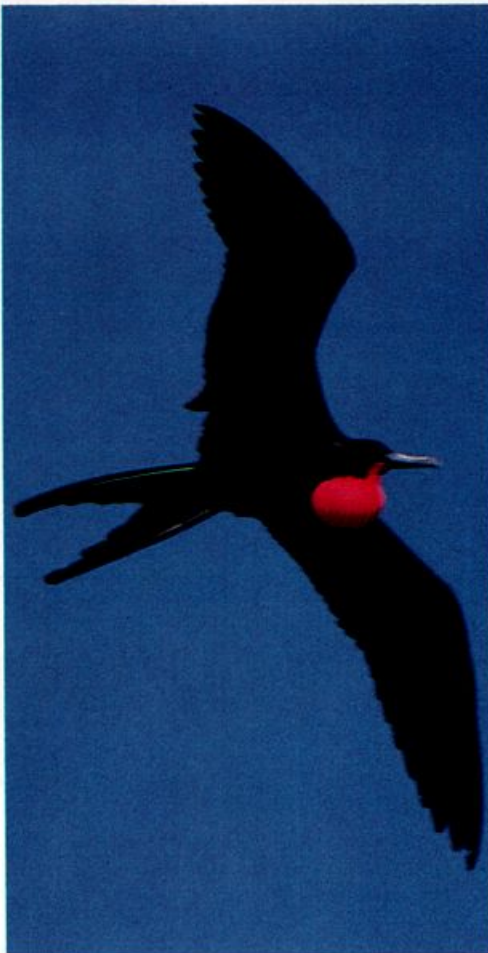
mangroves beneath nests, an adult male fell down through the canopy and landed on several mangrove roots near the water's surface. This bird had a fresh laceration on its pouch, and was more or less immobilized by its position in the mangrove. This predicament might result in death if it stranded a bird sufficiently far from the open edge of the mangrove. Eisenmann reported "considerable mortality" at some colonies from entanglement in branches, and Nelson (1975) also mentioned this. In January 1987, we found another adult male on the ground which may have been a casualty of male hostility. This bird was well-fed and well-muscled, but had a blind left eye. It was uncoordinated and unable to fly. No cause for the bird's predicament could be determined and it died the day it was found.

Eisenmann suggested that limitation of breeding to small islands might demonstrate avoidance of predators by frigatebirds. Our observations suggest details of predator occurrence that could increase mortality and, in some cases, locally affect the distribution of colonies.

F. Dodd (*pers. comm.*) visited a mangrove island, near and similar to Man-O-War Caye, where he found Boa Constrictors (*Constrictor constrictor*) of various sizes, the largest able to eat frigatebird eggs and nestlings. The occurrence of boas probably renders an island unsuitable for nesting by Magnificent Frigatebirds, but this presumably would be less a problem for the other, more pelagic, *Fregata* species.

In January, 1983 and 1987, several large colonies of arboreal, biting ants were encountered. They had advanced high up limbs of the mangroves, and, in two cases, were in and apparently foraging on frigatebird carcasses. Arboreal ants can kill young nestlings of medium sized tree-nesting birds (Parker 1977) and might do so in frigatebird colonies. They probably furnish an additional reason why nesting in the exposed upper canopy is optimal where ant foraging is less likely to occur.

As we expected, there was no evidence of eggshell thinning that might be attributable to pesticide residues. Sixteen recent eggshells showed a mean thickness of 0.382 millimeters (S.D. = 0.028), very similar to a mean of 0.386 millimeters (S.D. = 0.022) for 27 eggshells taken prior to use of pesticides. No statistical test of significance was warranted.



During the courtship phase of the breeding season, males often fly with their crimson gular sac partially inflated. Once incubation begins, this activity will cease. Photo/James W. Parker.

Our observations of food remains or foraging by frigatebirds were minimal. Roosting adult birds often regurgitated food masses, but only of five to ten silver fish (8–10 centimeters in length) in the family *Clupiedae*. Surprisingly, we found no remains of squid (*Exocoetidae*), which Diamond (1983) found common in the diets of Lesser (*F. ariel*) and Great (*F. minor*) frigatebirds. *Fregata magnificens* might be less likely to encounter squid owing to its inshore foraging.

On occasion, frigatebirds foraged at South Water Caye in response to discarded fish offal from the shore. In January, 1983, when males were more numerous on nests, most of the foragers at Southwater Caye were adult females.

The species vulnerable to kleptoparasitism by frigatebirds were not numerous. A few Brown Pelicans (*Pelecanus occidentalis*) were often present, and as many as 20, 50, 40 Brown Boobies (*Sula leucogaster*) were at or near Man-O-War Caye in 1982, 1983, 1987, respec-

tively. However, kleptoparasitic attacks by frigatebirds were rare during our visits.

We made limited observations of behavior and vocalizations at nests, but they matched those of Nelson (1975), Diamond (1973), and Eisenmann (1962). We heard an abundance of Diamond's (1973) "drumming" and "reeling" calls and we did observe one female behavior that was doubted by Nelson (1975). An adult female landed in front of an adult male who enlarged his gular sac, drummed, and showed spreading motions typical of courtship. The female then stroked or "caressed" the male's pouch repeatedly from side to side with her head and beak while twittering and holding her wings partly extended. Both then settled with wings left open.

Nelson (1975) said that, except in the Caribbean, *magnificens* breeds at stations few and far between. In fact, Eisenmann's (1962) map showed only three breeding sites for all of the Pacific coast of Central America and extreme southern Mexico. Therefore, we report here an additional breeding colony, ostensibly the first for the Pacific coast of Costa Rica, off Puerto Soley near La Cruz in Bahía de Salinas near the Nicaraguan border. Bonaccorso visited this small island December 24, 1983, and found at least 85 adult and 20 immature frigatebirds perching and nesting on tall, unidentified fig trees well above the shore to an elevation of about 100 meters. We know of no name for the island.

In February 1985, F. Dodd (*pers. comm.*) encountered two fisherman cutting trees at Man-O-War Caye. Dodd observed many broken eggs and dead nestlings on the ground and in shallow water and estimated that as many as 30 nests had been destroyed before the fisherman were persuaded to leave the island.

The government of Belize has been unable to provide enforcement protection for any of the Crown Reserve Sanctuaries because of meager financial resources. Since their establishment in 1977, most have either been destroyed or disturbed (Hartshorn *et al.* 1984).

Stumps of cut mangroves were obvious in 1987, but the frigatebird population did not seem reduced. Nevertheless, Man-O-War Caye is clearly vulnerable and the government of Belize should be encouraged to provide effective surveillance and protection and assisted if necessary.

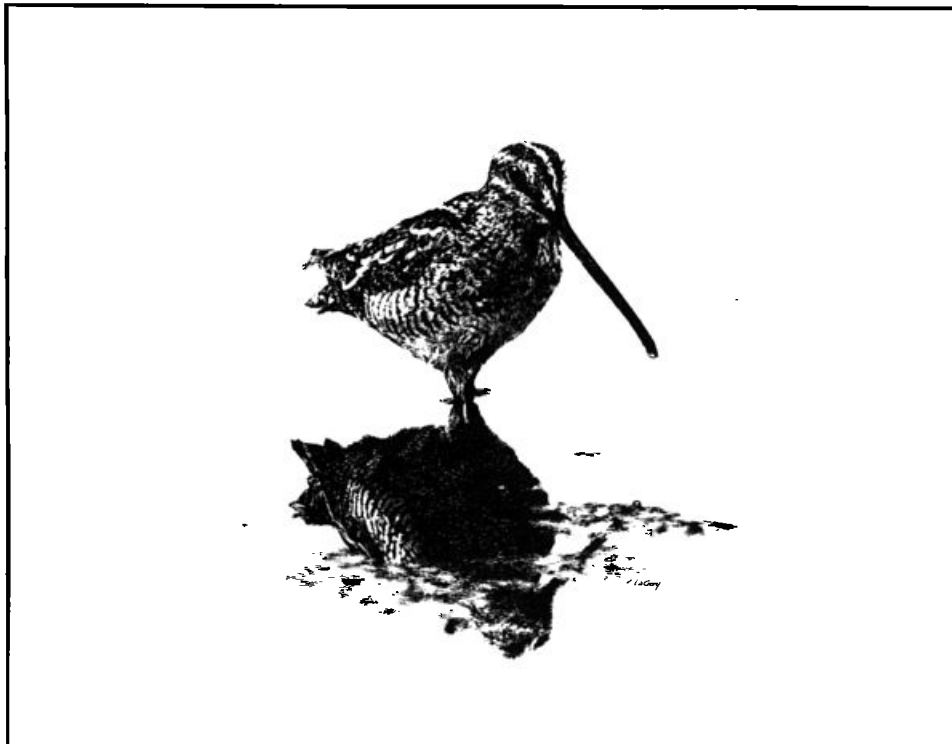


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*Common Snipe (Gallinago gallinago). Illustration/Michelle LaGory.*