

EFFECTS OF THE 1982-83 EL NIÑO EVENT ON BLUE-FOOTED AND MASKED BOOBY POPULATIONS ON ISLA DAPHNE MAJOR, GALÁPAGOS¹

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El Niño events have negative effects on seabird populations in the equatorial Pacific, including the Galápagos Islands, by causing reductions in food supplies (Murphy 1936, Boersma 1978, Nelson 1978, Schreiber and Schreiber 1984). However, the nature and magnitude of such effects are poorly understood because detailed information on population sizes and reproductive characteristics of well-defined seabird colonies immediately before, during, and after El Niño events are rare. Here we report on (1) sizes of breeding populations, (2) clutch sizes and degree of breeding synchrony, and (3) availability of nesting habitat for Blue-footed Booby (*Sula nebouxi*) and Masked Booby (*S. dactylatra*) populations on Isla Daphne Major, Galápagos, from 1982 to 1984. This period included the El Niño event of 1982-83 (Cane 1983, Robinson and del Pino 1985), which has been described as the most severe oceanographic disturbance of its type in the Western Pacific of this century (Cane 1983).

METHODS

Isla Daphne Major is a small island (40 ha in area) located in the middle of the Galápagos archipelago. In most years, large numbers of Blue-footed and Masked boobies breed on the island (Nelson 1978). There is strong spatial separation in the nesting habitat of these species on the island (Duffy 1984). Most Blue-footed Booby pairs (>95% based on census data) nest on the floor of one of either of two extinct volcanic craters. The lower crater is about five times greater in surface area than the upper crater. In contrast, Masked Boobies nest exclusively on the rims of both craters and on the outer slope of the island.

We were present on Daphne from January to May 1982, December 1982 to July 1983, and December 1983 to May 1984. During these periods we censused

booby populations by counting the number of Blue-footed pairs nesting in the upper and lower craters and Masked Booby pairs nesting on the entire island. For each nest, we determined clutch size, brood size, and estimated chick age, based on plumage characteristics described by Nelson (1978). Nest scrapes tended by one or more birds were considered to represent one reproductively active pair; pairs of this type were rare, making up between 0% to 10% of all nesting pairs in censuses when nesting was observed.

In 1982, we censused each booby population once; the Blue-footed Booby population was counted on 12 April and the Masked Booby population was counted on 12 February. We checked for breeding activity in 1983 during island-wide searches once every three days. Following El Niño, we censused Blue-footed Booby populations monthly, from December 1983 to April 1984 ($n = 5$) and counted Masked Booby nests once on 12 December 1983. We also calculated the area of each crater floor available for nesting by Blue-footed Boobies, prior to and following El Niño when the growth of vegetation had substantially altered the physiognomy of these areas.

RESULTS AND DISCUSSION

The El Niño event of 1982-1983 resulted in a dramatic increase in ocean temperatures and rainfall in the Galápagos archipelago from December 1982 until September 1983 (Robinson and del Pino 1985). Ocean temperatures remained above 25°C around Daphne during the entire eight months of our stay on the island, reaching a peak of 30°C in April 1983. Total rainfall on the island was 1,359 mm or 10 times the previously recorded maximum (Gibbs et al. 1984).

We counted 620 pairs of Blue-footed Boobies nesting in the upper and lower craters combined in April 1982 and 348 pairs of Masked Boobies on the whole island in February 1982. The onset of El Niño resulted in a complete cessation of the reproductive activity of these normally continuously breeding populations: no individuals of either species were observed breeding on the island from December 1982 to July 1983. Breeding population sizes showed a rapid recovery immediately following the 1982-1983 event, although total numbers were lower than in 1982: Blue-footed Booby populations averaged 69% and Masked Booby populations

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TABLE 1. Numbers of Blue-footed and Masked booby pairs on Isla Daphne before, after, and during the 1982–83 El Niño event.

Period of observation	Before El Niño: February and April 1982	During El Niño: December 1982 to July 1983	After El Niño: December 1983 to May 1984
Pairs of Blue-footed Boobies ¹	620	0	425 ± 66 ³
Pairs of Masked Boobies ²	348	0	135

¹ Number of pairs in the upper and lower crater.² Number of pairs on the entire island.³ Mean ± SE.

39% of pre-Niño levels in late 1983 and early 1984 (Table 1).

Clutch sizes of both booby species were smaller in post-Niño populations. We estimated frequencies of different clutch sizes for Blue-footed Boobies in 1984 by combining data from December, February, and April censuses to avoid recounting the same nests in consecutive months. A significantly greater proportion of Blue-footed Booby nests had larger clutch sizes in 1982 (clutch size [% total nests]: 1 [17%]; 2 [75%]; 3 [8%]; $n = 446$ total nests) than in 1984 (1 [40%]; 2 [60%]; $n = 110$; $G = 22.9$, $df = 2$, $P < 0.001$). Masked Boobies showed a similar pattern. In both years, all clutches consisted of one or two eggs. In 1982, 53% of all nests had two eggs ($n = 36$ total nests) while only 27% had clutches of two in 1984 ($n = 34$; $G = 5.1$, $df = 1$, $P = 0.024$). Clutch sizes may have been smaller in 1984 because a Niño-induced change in the age structure of both populations resulted in more young, inexperienced birds breeding in 1984 or because food supplies remained low following the 1982–1983 event.

The degree of breeding synchrony was similar in pre- and post-Niño populations of both species although most pairs were at different stages of the breeding cycle when censuses were made in 1982 and 1984. For example, in April 1982 77% of all Blue-footed Booby pairs had eggs while in December 1983, 85% of all pairs had chicks six weeks old or younger. Masked Boobies showed a similar pattern of synchrony: 64% had eight- to 12-week-old young in February 1982 while 67% had chicks six weeks old or younger in December 1984. Therefore, because a high degree of synchrony already exists in normal populations, the uniform onset of breeding following a Niño event may not increase synchrony further.

The increase in vegetative cover following El Niño had a demonstrable effect on the availability of nest sites to Blue-footed Boobies in the large crater. Due to the heavy, sustained rainfall during 1982–1983, a large proportion of the lower crater floor was covered in thick vegetation from July 1983 onwards. This vegetation covered 3,595 m² or 46% of the crater floor used by nesting boobies in 1982 and consisted mainly of annual plant species including *Cacabus miersii*, *Heliotropium angiospermum*, *Merremia aegyptica*, *Ipomoea linearifolia*, and *Chamaesyce amplexicaulis*. Plants, previously absent, also grew on the floor of the upper crater; however, they were sparsely distributed and did not decrease the availability of nest sites. The difference in cover between the craters provided a natural experiment with which to examine the effect of

the growth of vegetation on breeding populations of Blue-footed Boobies. In the upper crater, the numbers of nesting pairs, hence bird density, were remarkably similar in the two years (1982: 104 pairs; 0.061 pairs per m²; 1984: 101.5 pairs ± 7.2 [mean ± SE]; 0.063 pairs per m²). In the lower crater, there were fewer breeding pairs in 1984 than in 1982 (1982: 516 pairs; 1984: 323.3 ± 22.9) but the density of pairs in the nonvegetated area of the crater floor remained almost constant (1982: 0.062 pairs per m²; 1984: 0.069 pairs per m²). Thus, the reduction in the breeding population of Blue-footed Boobies in 1984 was apparently due to nest site limitation caused by changes in the cover of terrestrial vegetation during the 1982–83 El Niño.

Although quantitative data on changes in nest site availability are lacking for Masked Booby populations, the dramatic increases in vegetative cover on the outer slope of the island (Gibbs and Grant, unpubl.) may also account for the post-Niño reduction in breeding populations of this species. In 1984, Masked Boobies were not seen nesting in newly-vegetated areas, where they had previously bred in 1982 (H. L. Gibbs, pers. observ.).

In conclusion, the 1982–1983 event had important short-term effects (cessation of breeding) and potentially long-term effects (smaller clutch sizes and reduced availability of nesting habitat) on booby populations nesting on Daphne. Interruptions in breeding activity have also been reported for other Galápagos seabirds during this (Valle 1985) and other (Boersma 1978) El Niño events. The vegetation in the lower crater has continued to limit the nesting habitat available to Blue-footed Boobies up to January 1986 (H. L. Gibbs, pers. observ.). Further studies should consider the importance of such long-term indirect effects of El Niño on seabird populations nesting in arid regions of the equatorial Pacific.

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CANNIBALISM IN AMERICAN COOTS INDUCED BY SEVERE SPRING WEATHER AND AVIAN CHOLERA¹

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The food habits of American Coots (*Fulica americana*) have been well documented (Jones 1940; Stollberg 1949; Eley and Harris 1976, Ivey 1987). These studies have shown that plant food is the primary component of American Coot diets, although invertebrates are commonly taken. However, coots may occasionally attempt to eat larger vertebrates (McCurdy 1983). Bent (1926) reported that coots have been known to pluck and partially eat dead ducks.

Cannibalism includes both the killing and eating or scavenging of conspecifics and in birds is most commonly reported among raptors, where younger, weaker nestlings are sometimes killed and eaten by siblings or parents to reduce fratricidal strife (Newton 1979). I know of no records of cannibalism in American Coots, although, Castwon (1983) reported it for the closely related Common Moorhen (*Gallinula chloropus*).

On 21 February 1984 at 14:37 I observed two American Coots eating a fresh carcass on ice adjacent to a small open water area on Malheur National Wildlife Refuge (NWR), Harney County, Oregon. Closer examination (from a distance of approximately 25 m)

revealed the carcass was a fresh coot. The sternum and ribs were completely exposed and most of the pectoral muscle tissue had been removed. The cause of death was unknown but since the carcass was beneath a powerline it was assumed that death had resulted from a collision with the overhead wires. The two feeding coots were immediately joined by four others, and the six began vigorously tearing and consuming the remaining muscle tissue and viscera. I returned to the site within 1 hr to continue observations; however, strong winds had broken the ice and the carcass had sunk. The feeding coots had dispersed.

By 22 February the number of dead coots had increased to seven and by 23 February there were 15 dead coots, all near the powerline. I observed no cannibalistic behavior on 22 February but on 23 February I observed two coots separately feeding on two mostly intact coot carcasses. Throughout February and March American Coots continued to die in the few areas of open water. I observed American Coots cannibalizing coot carcasses on five occasions during this period.

By late February it was apparent that not all dead coots could be attributed to powerline collisions because of the widening distribution of carcasses away from the powerline. On 11 March five fresh coot carcasses were collected and sent to the National Wildlife Health Laboratory in Madison, Wisconsin for necropsy. All five birds were diagnosed as dying from avian cholera (*Pasteurella multocida*). Before the epizootic subsided following ice breakup in late March, 317 dead coots were picked up and disposed of. Sixty additional

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