J. Field Ornithol., 69(2):228–234

CHICK BEHAVIOR, HABITAT USE, AND REPRODUCTIVE SUCCESS OF PIPING PLOVERS AT GOOSEWING BEACH, RHODE ISLAND

MERYL R. GOLDIN[1] AND JONATHAN V. REGOSIN
The Nature Conservancy
45 South Angell Street
Providence, Rhode Island 02906 USA

Abstract.—We studied Piping Plovers (*Charadrius melodus*) at Goosewing Beach, Rhode Island during 1993 and 1994. Broods with access to salt-pond mudflat habitat experienced higher fledging success (3.0 fledglings/brood) than broods limited to ocean beachfront habitat (1.4 fledglings/brood). This difference may be attributed to greater survivorship among chicks with access to mudflat habitat. Broods using pondshore mudflat habitat spent less time responding to human disturbance (1.6%) than chicks using ocean beachfront habitat (17.0%). The difference in time spent feeding between pondshore (77.5%) and ocean beachfront (51.2%) habitats approached statistical significance. Salt pond water levels were artificially manipulated to increase availability of mudflat habitat for plover chicks, though the effect of such manipulation on Piping Plover reproductive success remains unclear.

CONDUCTA DE PICHONES, USO DE HABITAT Y ÉXITO DE ANIDAMIENTO DE INDIVIDUOS DE *CHARADRIUS MELODUS* DE LA PLAYA GOOSEWING, RHODE ISLAND

Sinopsis.—Durante el 1993 y 1994 se estudiaron individuos de *Charadrius melodus* en la playa Goosewing, Rhode Island. Camadas con acceso a lodazales de charcas de sal fueron más exitosas (3.0 volantones/camada) que aquellas que estuvieron limitadas a frentes de playas (1.4 volantones/camada). Esta diferencia puede ser atribuida a una mayor supervivencia de pichones que tuvieron acceso a lodazales. Las camadas que utilizaron este tipo de habitat tomaron menor tiempo para responder a disturbios por parte de humanos (1.6%) que los pichones que utilizaron frentes de playas (17%). La diferencia en tiempo utilizado para alimentarse en lodazales (77.5%) y frentes de playas (51.2%) se acerca a diferencias estadisticas significativas. Los niveles de agua de las charcas de sal fueron manipulados artificialmente para incrementar la disponibilidad de lodazales para los polluelos, aunque el efecto de dicha manipulación en el éxito reproductivo de la especie no queda del todo claro.

The Piping Plover, a threatened shorebird, breeds on open beaches and sandflats on North America's northern Great Plains, Great Lakes, and Atlantic Coast (Haig 1992). Numbers of Piping Plovers have declined over the past 50 years (U.S. Fish and Wildlife Service 1988), resulting in the placement of this species on the U.S. Endangered and Threatened Species List (U.S. Fish and Wildlife Service 1985). Several factors including direct human disturbance on the breeding grounds (Burger 1987, Cairns 1982, Elias-Gerkin 1994, Flemming et al. 1988, Goldin 1993, Strauss 1990), habitat destruction through development, water level regulation, and predation have been suggested as contributing factors to the decline of this ground-nesting species (Haig 1992).

Atlantic Coast Piping Plovers forage in a number of habitats including ocean beach, ocean intertidal zone, bay beach intertidal zone, shoreline of ephemeral pools and salt ponds, overwash area, wrack, and dunes (Elias-Gerkin 1994, Goldin 1993, Hoopes 1993, Loegering and Fraser 1995).

[1] *Current address: P.O. Box 4423, Pago Pago, American Samoa 96799 USA.*

However, Piping Plovers with access to mudflat, bay-beach, and ephemeral pool habitats may disproportionately use these habitats, and enjoy reproductive advantages (Elias-Gerkin 1994, Hoopes 1993, Loegering and Fraser 1995, Patterson et al. 1991). Hypothesized sources of these advantages include decreased human disturbance rates (Elias-Gerkin 1994, Goldin 1993), or a particularly rich food resource for Piping Plover chicks (Elias-Gerkin 1994, Hoopes 1993, Loegering and Fraser 1995).

Because increased availability of mudflat habitat may benefit Piping Plovers by providing high-quality foraging habitat and decreased human disturbance, the Atlantic Coast Population Piping Plover Revised Recovery Plan (U.S. Fish and Wildlife Service 1995) encourages the draw-down of coastal ponds, in some cases, to make more feeding habitat available. However, no studies directly demonstrate increased reproductive success for broods with access to coastal pond mudflat habitat. This study tests the hypothesis that broods with access to coastal pond mudflats experience greater survivorship and fledging success than broods that are restricted to ocean beachfront habitat. In addition, we expected broods using mudflats to spend less time responding to human disturbance and more time feeding than broods restricted to the ocean beachfront.

METHODS

We studied Piping Plovers at Goosewing Beach in Little Compton, Rhode Island from April–August 1993 and 1994, as part of The Nature Conservancy's ongoing Piping Plover and Least Tern (*Sterna albifrons*) protection program. Goosewing is a cobbly barrier beach, 1.4-km long, bordered to the north by the shallow, 158-ha Quicksand Pond. The beach typically breaches, forming an outlet to the ocean, as pond water levels rise. In addition, the beach was breached mechanically as a management measure once during each nesting season. Initially, breaching lowers water levels within the pond and allows for water exchange with the ocean. The breach usually closes within 1–2 wk. Thus, throughout the spring and summer, varying amounts of sandy mudflats were exposed along the pond-shore. Piping plover chicks and adults foraged on these mudflats.

Eight and nine pairs of Piping Plovers nested on Goosewing Beach in 1993 and 1994, respectively, accounting for approximately 25% of Rhode Island's Piping Plover population. We monitored plovers daily from a distance of 50–75 m with spotting scopes and binoculars. We surrounded nests containing two or more eggs with a net-topped, wire mesh exclosure to reduce depredation (Melvin et al. 1992). Clutch size, hatching success, and fledging success were recorded for each brood. Chicks observed in flight or reaching 25 days of age (whichever came first) were considered fledged (U.S. Fish and Wildlife Service 1988).

We attempted to count all chicks from all broods daily and to map the location of the brood when counted. Because there is a moratorium on banding Piping Plovers to minimize disturbance, birds were unbanded with few exceptions. Therefore, we noted distinctive neckbands, headbands, and other plumage characteristics. These features, along with plover territoriality and asynchronous hatching of broods, made it possible to identify breeding pairs and their associated broods. Because chicks were usually counted daily, we could determine chick mortality to within 2 days (approx. 36 h) in 14 of 26 (54%) cases. However, not all chicks were counted each day, and mortality could only be determined to within 3 days in eight (31%) cases, and to within 4 days in four (15%) cases.

During 1993 we conducted behavioral observations on plover chicks from 15 June–3 August between 0830–1700 h EST. A subset of broods were randomly selected for sampling each day and sampled in random order. We grouped chick behaviors into four classes: (1) feeding (peck, probe, swallow, walk between pecks or probes); (2) disturbance (freeze, run or walk in apparent response to disturbance); (3) maintenance (bathe, preen, stand, loaf); and (4) other (walk or run in the absence of feeding or disturbance, agonistic behavior, brooding). The first chick encountered in a given brood served as the focal individual and its behavior was continuously recorded for up to 15 min (Martin and Bateson 1986). If the chick disappeared from view, observation was halted, and, if the chick did not reappear within 5 min, the sampling session was aborted. Observation sessions were subsequently conducted for all other chicks present. If no other chicks were encountered within 10 min, data collection began on the next randomly selected brood. Only observation sessions that lasted a full 15 min were included for analysis.

For each behavioral observation we recorded date, time, brood number, chick age, and habitat. For analysis, we divided habitats into two classes: (1) mudflat (wet, sandy, partially organic substrate adjacent to Quicksand Pond) and (2) ocean beach (intertidal zone, beachfront including broad "overwash" areas, and dunes). In addition to recording the actual habitat used by broods during behavioral observations, all broods were divided into two classes: (1) those that were observed using mudflat habitat during the prefledging period, and (2) those that were never observed using mudflats and spent time exclusively on beach habitat.

Because multiple behavioral observations from individual broods lack statistical independence, for each brood we computed the mean time/observation period spent in each behavior as the unit of analysis. For one brood for which behavioral data was available from both habitat types, we computed means for each habitat. We used two sample *t*-tests (Sokal and Rohlf 1981) to test for differences in mean time spent feeding and responding to human disturbance by broods using mudflat versus ocean beach habitats.

RESULTS

Fledging success and chick survivorship.—Mean fledging success (number of chicks fledged/brood) was 3.0 (SD = 1.6, n = 5) and 3.0 (SD = 1.3, n = 6) for broods with access to mudflats and 1.3 (SD = 1.0, n = 4) and 1.7 (SD = 1.5, n = 3) for broods limited to the ocean beach and dunes in 1993 and 1994, respectively. Because all pairs hatched chicks

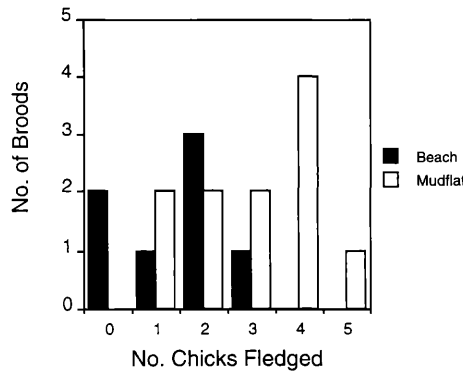

FIGURE 1. Fledging success for Piping Plover broods with and without access to mudflat habitat at Goosewing Beach, Rhode Island. Brood of five chicks resulted from an interpair adoption (see Methods).

and no pairs fledged chicks from more than one brood, these results are equivalent to the mean number of chicks fledged/breeding pair, the standard measure of productivity (U.S. Fish and Wildlife Service 1988, 1995). Combining data from both years, mean fledging success was higher for broods with access to mudflats ($\bar{x}$ = 3.0, SD = 1.3, n = 11) than broods limited to beach and dunes ($\bar{x}$ = 1.4, SD = 1.1, n = 7; t = 2.56, df = 16, P = 0.021; Fig. 1). Neither hatching success (eggs hatched/eggs laid; mudflat: 97.7%, n = 43 eggs; beach: 96.4%, n = 28 eggs; $\chi^2 = 0.10$) nor initial brood size (mudflat: $\bar{x}$ = 3.7; n = 11; SD = 1.0; beach: $\bar{x}$ = 4.0; n = 7; SD = 0.8; t = 0.59; df = 16; P = 0.55) differed for broods from the two habitats. Thus, the difference in fledging success by habitat can be attributed to differences in chick survivorship, with 33 of 41 (80.5%) chicks with access to mudflat habitat surviving to fledging, compared to only 10 of 28 (35.7%) chicks limited to beach habitat (Fig. 2).

Behavioral observations.—Fifty-seven observation sessions were completed on nine broods (one pair was double-brooded). Because we were interested in comparing chick behavior between the mudflat and beach habitats, it was important to sample chicks of comparable ages from the two habitats. Chicks in beach habitat ranged from 1–22-d old when sampled, while chicks in mudflat habitat ranged from 4–27-d old. Because of two interpair chick adoptions, not all chick ages could be precisely determined at the time they were sampled. Nonetheless, the maximum possible age of chicks in mudflat habitat ($\bar{x}$ = 15.7 d, n = 46, SD = 6.6) did not differ significantly from the minimum possible age for chicks using beach habitat ($\bar{x}$ = 13.3 d, n = 11, SD = 5.6; t = 1.14; df = 55; P = 0.256).

In mudflat habitat, broods experienced human disturbance events at an average rate of 1.0/h, as compared with a rate of 7.3/h for ocean beach habitat (t = 3.87, df = 8, P = 0.005). All human disturbances involved pedestrians or joggers. Gulls (*Larus* spp.), terns (*Sterna* spp.), Mute Swans (*Cygnus olor*), Osprey (*Pandion haliaetus*), and American Oys-

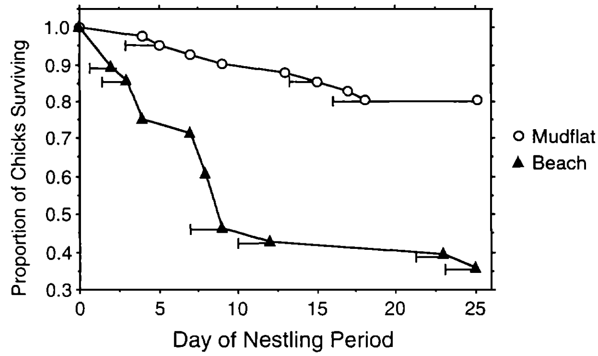

FIGURE 2. Survivorship curves of prefledging Piping Plover chicks with access to mudflat and ocean beach habitat at Goosewing Beach, Rhode Island. Error bars (d) are shown only for mortality events that could not be dated to within two consecutive calendar days.

tercatchers (*Haematopus palliatus*) also elicited disturbance responses from Piping Plover chicks. Some, but not all of these species are potential predators of plover chicks. The rates of nonhuman disturbance in mudflat (5.8/h) versus ocean beachfront (2.0/h) habitat did not differ significantly (t = 1.75, df = 8, P = 0.117). The duration of human disturbances ($\bar{x}$ = 62 s, SD = 69, n = 28) was greater than the duration of nonhuman disturbances ($\bar{x}$ = 25 s, SD = 27, n = 31; t = 2.75, df = 57, P = 0.008).

Broods with access to mudflats spent less time responding to human disturbances than broods limited to beach habitat (t = 2.44, df = 8, P = 0.040, Table 1). The observed difference in time spent feeding in the two habitats (Table 1) approaches statistical significance (t = 2.06, df = 8, P = 0.073).

DISCUSSION

Chick survivorship and fledging success were higher for broods with access to salt-pond mudflats, supporting the Piping Plover Recovery Team

TABLE 1. Mean percentage time spent in various activities for Piping Plover broods using mudflat and ocean beach habitats, Goosewing Beach, Rhode Island.

	Mudflat (n = 6)		Beach (n = 4)		
Activity	Mean	SD	Mean	SD	P[a]
Feeding	77.5	15.8	51.2	25.0	0.073
Maintenance	16.9	13.9	13.2	8.3	
Disturbance (human)	1.6	1.7	17.0	15.8	0.040
Disturbance (nonhuman)	0.8	0.8	3.7	2.6	
Other	3.1	3.2	14.9	14.1	

[a] t-tests performed on feeding and human disturbance behaviors only (see Methods).

recommendation to consider coastal pond draw-down as a Piping Plover management tool (U.S. Fish and Wildlife Service 1995). Fledging success at Goosewing beach continued to be higher for mudflat habitat in 1995 (mudflat: $\bar{x}$ = 2.4, SD = 1.5, n = 5; beach: $\bar{x}$ = 1.3, SD = 1.5, n = 4; Campellone and Hadjian, unpubl. data) and 1996 (mudflat: $\bar{x}$ = 3.0, SD = 0.0, n = 3; beach: $\bar{x}$ = 0.7, SD = 1.0, n = 7; Fontes, unpubl. data). Further evidence that mudflats are, in fact, preferred brood-rearing habitat is offered by observations of breeding pairs at Goosewing Beach moving their broods over considerable distances through dense vegetation in order to gain access to the pondshore.

Findings from this study are consistent with other research that has shown higher chick survivorship for chicks using bay-beach island interior, and ephemeral pool habitats (Elias-Gerkin 1994, Loegering and Fraser 1995). Furthermore, we found that chicks utilizing pondshore habitat spent less time responding to human disturbance, and possibly more time foraging. Though we were unable to draw a direct connection between increased human disturbance and decreased foraging time, human disturbance has been found to decrease time chicks devoted to feeding at other sites (Fleming et al. 1988, Strauss 1990).

The observed reduction in human disturbance associated with salt-pond habitat may have contributed to the observed increase in reproductive success. However, other studies have shown that mudflat habitat may be a particularly rich food resource for Piping Plover chicks (Elias-Gerkin 1994, Hoopes 1993, Loegering and Fraser 1995). While the cause of the observed increase in chick survivorship associated with mudflats remains unclear, the magnitude of the effect suggests that augmentation of mudflats through control of water levels may be a powerful management technique at a number of salt pond breeding sites, especially in southeastern Massachusetts, Rhode Island, and Long Island. Artificial breaching of salt ponds may also benefit migrating shorebirds and some anadromous fish species such as Alewife (*Alosa pseudoharengus*).

However, two cautions are in order. First, while water levels were manipulated on a limited basis at Quicksand Pond, it is unclear the extent to which artificially increased availability of mudflat habitat, over and above the mudflats that would have been available under natural conditions, contributed to increased survivorship. Second, salt pond manipulation through artificial breaching can have multiple affects on salt pond ecology (Lee 1980). Changes in water level and salinity may affect submerged aquatic vegetation as well as a wide variety of animal species. The establishment of permanent breachways in many of Rhode Island's larger salt ponds has caused major, unforeseen changes in these ecosystems (Lee 1980). Since the potential long term affects of regular artificial breaching are not well understood, managers would be well advised to consider all potential long term costs and benefits before undertaking salt pond manipulation to benefit Piping Plovers.

ACKNOWLEDGMENTS

We thank The Nature Conservancy, the town of Little Compton, E. Lawrence, the Oliver S. and Jennie R. Donaldson Charitable Trust, and numerous volunteer wardens for protecting Piping Plovers on Goosewing Beach and making this research possible. Special thanks to E. Rowland, E. Stephens, and T. Santiago for assistance in the field, and to T. Bear, R. Berkowitz, V. Carpenter, A. Leviton, G. Venator, and four anonymous reviewers for their encouragement and comments on earlier versions of the manuscript.

LITERATURE CITED

BURGER, J. 1987. Physical and social determinants of nest site selection in Piping Plover in New Jersey. Condor 89:881–918.

CAIRNS, W. E. 1982. Biology and behavior of breeding Piping Plovers. Wilson Bull. 94:531–545.

ELIAS-GERKEN, S. 1994. Piping Plover habitat suitability of central Long Island, New York, Barrier Islands. M.S. thesis. Virginia Polytechnic Institute and State University, Blacksburg, Virginia. 247 pp.

FLEMMING, S. P., R. D. CHIASSON, P. C. SMITH, P. J. AUSTIN-SMITH, AND R. P. BANCROFT. 1988. Piping Plover status in Nova Scotia related to reproductive and behavioral responses to human disturbance. J. Field Ornithol. 59:321–330.

GOLDIN, M. R. 1993. Effects of human disturbance and off-road vehicles on Piping Plover (*Charadrius melodus*) reproductive success and behavior at Breezy Point, Gateway National Recreation Area, New York. M.S. thesis. University of Massachusetts, Amherst, Massachusetts. 143 pp.

HAIG, S. M. 1992. Piping Plover (*Charadrius melodus*). No. 2, *in* A. Poole, P. Stettenheim, and F. Gill, eds. The birds of North America. Academy of Natural Sciences, Philadelphia and American Ornithologists' Union, Washington, D.C. 18 pp.

HOOPES, E. M. 1993. Relationships between human recreation and Piping Plover foraging ecology and chick survival. M.S. thesis, Univ. of Massachusetts, Amherst, Massachusetts. 106 pp.

LEE, V. 1980. An elusive compromise: Rhode Island coastal ponds and their people. Coastal Resources Center, Marine Technical Report 73. University of Rhode Island, Narragansett, Rhode Island. 82 pp.

LOEGERING, J. P., AND J. D. FRASER 1995. Factors affecting Piping Plover chick survival in different brood-rearing habitats. J. Wildl. Manage. 59:646–655.

MARTIN, P., AND P. BATESON. 1986. Measuring behaviour. Cambridge Univ. Press, Cambridge, United Kingdom. 200 pp.

MELVIN, S. M., L. H. MACIVOR, AND C. R. GRIFFIN. 1992. Predator exclosures: a technique to reduce predation at Piping Plover nests. Wildl. Soc. Bull. 20:143–148.

PATTERSON, M. E., J. D. FRASER, AND J. W. ROGGENBUCK. 1991. Factors affecting Piping Plover productivity on Assateague Island. J. Wildl. Manage. 55:525–531.

SOKAL, R. R., AND F. J. ROHLF. 1981. Biometry. W. H. Freeman and Co., New York. 859 pp.

STRAUSS, E. 1990. Reproductive success, life history patterns, and behavioral variation in a population of Piping Plovers subjected to human disturbance. Ph.D. diss. Tufts University, Medford, Massachusetts. 143 pp.

U.S. FISH AND WILDLIFE SERVICE. 1985. Determination of endangered and threatened status for the Piping Plover. Federal Register 50:50720–34.

———. 1988. Atlantic coast Piping Plover recovery plan. U.S. Fish and Wildlife Service, Newton Corner, Massachusetts. 77 pp.

———. 1995. Piping Plover (*Charadrius melodus*) Atlantic coast population revised recovery plan. U.S. Fish and Wildlife Service, Hadley, Massachusetts.

Received 8 Jan. 1997; accepted 28 Apr. 1997.