

## NOTES

Interspecific Interactions of Breeding Piping Plovers:  
Conservation Implications

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**Abstract.**—I recorded interspecific agonistic interactions ( $n = 578$ ) and opportunities for interactions ( $n = 1,550$ ) of Piping Plovers (*Charadrius melodus*) during incubation and brood-rearing periods at Lake of the Woods, Minnesota to determine whether interactions (chases, balanced agonistic encounters, fights) were potentially detrimental to Piping Plover reproductive success. Piping Plovers interacted with 16 species, but five (Common Tern [*Sterna hirundo*], Ring-billed Gull [*Larus delawarensis*], Spotted Sandpiper [*Actitis macularia*], Semipalmated Sandpiper [*Calidris pusilla*], Killdeer [*Charadrius vociferus*]) accounted for 88.6% of male and 92.7% of female interactions. Interaction opportunities and interactions peaked during the brood-rearing period. Several species (Common Tern, Franklin's Gull [*L. pipixcan*], Spotted Sandpiper, Semipalmated Sandpiper) posed a low risk of direct negative effects on reproduction, ignoring Piping Plover chicks when they were in close proximity. Piping Plovers responded intensely to three potential predators (Ring-billed Gull, American Crow [*Corvus brachyrhynchos*], Common Grackle [*Quiscalus quiscula*]). Killdeers had the highest interaction indexes and under certain circumstances posed a threat of physical harm to Piping Plover adults and chicks. This method of quantifying interactions could be used at other Piping Plover breeding sites to help identify problem species and facilitate development of site-specific management strategies to reduce detrimental aggressive interactions. Received 17 November, 1999, accepted 1 February, 2000.

**Key words.**—Aggression, *Charadrius melodus*, *Charadrius vociferus*, interspecific interactions, Killdeer, Minnesota, Piping Plover, predation.

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Piping Plovers (*Charadrius melodus*) have been reported to have interspecific agonistic interactions with a variety of bird species including Killdeers (*C. vociferus*), Ring-billed Gulls (*Larus delawarensis*), and Herring Gulls (*L. argentatus*) in Manitoba (Haig 1992) and Wilson's Plovers (*C. wilsonia*), American Oystercatchers (*Haematopus palliatus*), Willets (*Catoptrophorus semipalmatus*), Semipalmated Sandpipers (*Calidris pusilla*), and Dunlins (*C. alpina*) in Virginia (Bergstrom and Terwilliger 1987). While monitoring Piping Plover populations and reproductive success in northwestern Minnesota during 1988-1994, I opportunistically noted 18 agonistic interactions with Killdeers. However, with few exceptions (Bergstrom and Terwilliger 1987), interspecific interactions have not been systematically quantified.

The Piping Plover is classified as threatened or endangered throughout its range (Haig 1992). Factors often cited as contributing to poor reproductive success include hu-

man disturbance, habitat degradation or loss, predation, and adverse weather (e.g., Haig 1992). Whether interspecific agonistic interactions are directly or indirectly detrimental to Piping Plover reproductive success has not been studied. At any given location, the number and intensity of interspecific interactions will likely vary, depending on the mix of species present and also the stage of the breeding cycle (e.g., Pickett *et al.* 1988) of Piping Plovers as well as that of other species.

My objective was to quantify interspecific interactions of Piping Plovers during the incubation and brood periods and to determine whether these interactions were likely to be detrimental to Piping Plover reproductive success.

## STUDY AREA

The study was conducted at Pine and Curry Island Scientific and Natural Area (48°51'N, 94°45'W), a narrow, 6.4 km long barrier island near the south shore of Lake of the Woods, Minnesota where Piping Plovers tra-

ditionally breed (Wiens 1986; Haig and Oring 1987). At this site, Common Terns (*Sterna hirundo*), Spotted Sandpipers (*Actitis macularia*), and Killdeers often breed in close proximity to the Piping Plovers. Ring-billed Gulls, Franklin's Gulls (*L. pipixcan*), and a variety of migrant shorebirds are often present on beaches. Herring Gulls, American Crows (*Corvus brachyrhynchos*), Common Grackles (*Quiscalus quiscula*), Yellow-headed Blackbirds (*Xanthocephalus xanthocephalus*), Red-winged Blackbirds (*Agelaius phoeniceus*), Brown-headed Cowbirds (*Molothrus ater*), Song Sparrows (*Melospiza melodia*), and Purple Martins (*Progne subis*) were among other species sometimes present.

Management activities at this site include controlling mammalian predators, placing wire mesh predator enclosures (Melvin *et al.* 1992) around plover nests, and using elevated-string gull deterrents (Maxson *et al.* 1996) near plover nests. Protected nests have high hatching success, yet typically fewer than half the chicks fledge (Maxson and Haws, unpubl. data); during most years, fledge rates are below that needed to maintain a stable population (Ryan *et al.* 1993; Plissner and Haig 2000).

#### METHODS

I recorded interspecific interactions of individually color-banded Piping Plovers during 30-min samples during plover incubation and brood-rearing periods. During incubation, I recorded which bird was incubating during samples and when changeovers occurred. For analysis, incubation was subdivided into incubating and non-incubating periods. Observations were made with 10× binoculars from a boat anchored offshore or from land, using a 20-60× spotting scope. Both members of a breeding pair were observed simultaneously (until females departed the island during the brood period). On rare occasions, the non-incubating or non-brood-tending member of the pair was out of view for a short period, but the open habitat allowed virtually 100% visibility of the adult tending eggs or chicks. I observed a pair for two consecutive samples and then switched to another pair. Samples were obtained during 8 June-21 July 1995 and between 0600-2010 h (CST).

Interspecific interactions were defined as an aggressive encounter between a Piping Plover and another bird species. Interactions were subdivided into chasing, being chased, balanced agonistic encounters (BAE), and fights. BAEs included face offs, distracting behaviors, and confrontations in which a Piping Plover rushed up to another, usually larger, bird that showed little response. An encounter between two individuals sometimes resulted in multiple interactions. Because no interactions can occur unless other species are present, I also recorded opportunities to interact. I defined an interaction opportunity as occurring any time a Piping Plover was within five m of another species. During the brood period, I noted when Piping Plover chicks were within two m of another species and whether any interactions occurred. These distances were arbitrary and conservative as some interactions were initiated at greater distances (e.g., see description of plover responses to American Crows and Common Grackles below). In the relatively open habitat occupied by Piping Plovers, birds within five m should have been aware of each other and close enough to perceive each other as a possible threat. At a distance of two m, other birds should have been aware of a plover chick (these were instances where

chicks were active, not immobile and hiding) and close enough to constitute an immediate threat.

Low Piping Plover populations (four pairs) necessitated repeated samples of individual plovers. Because the sample was small and both sexes appeared to participate similarly in interspecific interactions, I chose to pool data for males and females. I used an interaction index (total interactions/total opportunities) to quantify the likelihood of an interaction occurring between Piping Plovers and another species. Characterization of the intensity of interactions was subjective and based on how excited or aggressive the plover appeared, its rapidity of movement, and the duration of the interaction.

#### RESULTS

I conducted 111 30-min samples (incubation period = 47, brood period = 64). Because all females had abandoned broods by 13 July, a total of 25 samples was obtained on females during the brood period. I recorded 1,550 opportunities to interact and 578 interspecific interactions.

Overall, Piping Plovers interacted with 16 species. Five species (Common Tern, Ring-billed Gull, Spotted Sandpiper, Killdeer, Semipalmated Sandpiper) accounted for 88.6% of male and 92.7% of female interactions.

#### Incubation Period

Both sexes shared diurnal incubation duties and nest exchanges were frequent. In 36 of 47 samples, both sexes were involved in incubating. Males averaged 12.6 min (SE = 1.3) and females averaged 16.5 min (SE = 1.3) on the nest per sample. Only ten interactions were recorded while Piping Plovers were incubating, despite 183 opportunities (Table 1). This reflected an apparent reluctance to leave the nest to interact. Spotted Sandpipers presented the most interaction opportunities to both sexes and were observed walking within one m of incubating Piping Plovers, without incident, on several occasions. Ring-billed Gulls elicited responses when they walked directly toward an incubating plover. In such cases, the gull's progress was stopped by the 2.5 m diameter wire mesh predator enclosure surrounding the nest. Otherwise, these nests likely would have been depredated. One Common Tern that landed next to an enclosure was chased. Killdeers did not elicit responses from incubating male Piping Plovers, but a female left the

**Table 1. Interspecific interaction opportunities and interactions of Piping Plovers while incubating.**

Species	No. 30-min samples <sup>1</sup>	Oppor- tunities <sup>2</sup>	Interactions				Total	Interaction index <sup>3</sup>
			Chase	Being chased	BAE	Fight		
Common Tern	15	28	1	0	0	0	1	0.036
Ring-billed Gull	4	27	2	0	3	0	5	0.185
Spotted Sandpiper	25	93	0	0	0	0	0	0.000
Killdeer	11	18	4	0	0	0	4	0.222
Semipalmated Sandpiper	3	10	0	0	0	0	0	0.000
Dunlin	1	1	0	0	0	0	0	0.000
Passerines <sup>4</sup>	6	6	0	0	0	0	0	0.000

<sup>1</sup>Number of samples in which interactions and/or opportunities occurred. Total possible = 83.

<sup>2</sup>An opportunity occurred when a Piping Plover was within 5 m of another species.

<sup>3</sup>Total interactions/total opportunities.

<sup>4</sup>Common Grackle, Yellow-headed Blackbird, Brown-headed Cowbird, Song Sparrow.

nest to chase a Killdeer on 4 occasions. On one occasion, I saw five American Crows land in trees 140 m from a Piping Plover nest. The incubating bird immediately ran about 15 m from the nest, and neither parent returned until after the crows left the area 14 min later. This was a very strong response considering that other Piping Plovers did not leave their nest until a Ring-billed Gull was within three to four m.

I recorded 367 interaction opportunities for non-incubating members of Piping Plover pairs. These birds were much more likely to be involved in interactions (135 record-

ed) than their incubating mates (Table 2). Common Terns presented the most opportunities, but only one interaction ensued. Spotted Sandpipers presented numerous opportunities, and were chased on 43 occasions. Ring-billed Gulls elicited aggressive responses when they approached nests, as described above. The most interactions, as well as the most intense interactions, were with Killdeers. Piping Plovers, even on their own territories, could not always displace the larger Killdeers and one Piping Plover sustained an eye injury during a series of chases.

**Table 2. Interspecific interaction opportunities and interactions of the non-incubating Piping Plover during the incubation period.**

Species	No. 30-min samples <sup>1</sup>	Oppor- tunities <sup>2</sup>	Interactions				Total	Interaction index <sup>3</sup>
			Chase	Being chased	BAE	Fight		
Common Tern	31	116	0	1	0	0	1	0.009
Ring-billed Gull	12	27	6	0	5	0	11	0.407
Franklin's Gull	16	30	1	0	0	0	1	0.033
Spotted Sandpiper	34	94	43	0	0	0	43	0.457
Killdeer	18	58	18	22	10	1	51	0.879
Semipalmated Sandpiper	7	27	19	0	0	0	19	0.704
Marbled Godwit <sup>4</sup>	1	1	0	0	0	0	0	0.000
Passerines <sup>5</sup>	10	14	9	0	0	0	9	0.643

<sup>1</sup>Number of samples in which interactions and/or opportunities occurred. Total possible = 90.

<sup>2</sup>An opportunity occurred when a Piping Plover was within 5 m of another species.

<sup>3</sup>Total interactions/total opportunities.

<sup>4</sup>(*Limosa fedoa*).

<sup>5</sup>Common Grackle, Yellow-headed Blackbird, Brown-headed Cowbird, Song Sparrow.

### Brood Period

Piping Plovers were very defensive of their chicks especially during the early part of the brood period when both parents were present. Females abandoned broods during the second week of July when chicks were 7-17 days old. I recorded the largest number of interaction opportunities (1,000) and interactions (433) during this period (Table 3). Common Terns and their chicks again presented the most opportunities, but no interactions with Common Tern chicks were observed. Most interactions with adult terns resulted from a tern landing near the brood. When terns chased Piping Plovers, the chases were very brief and appeared to have minimal aggressive intent. Franklin's Gulls also presented many interaction opportunities, but few interactions occurred. When Franklin's Gulls chased Piping Plovers, the chases were brief and were in response to being confronted. The most interactions were with Semipalmated and Spotted sandpipers (Table 3). The Semipalmated Sandpipers, assumed to be southward migrants, were repeatedly chased by Piping Plovers, but were never observed being aggressive toward plovers. Spotted Sandpipers also were chased

frequently, but, in a few instances, male Spotted tending broods responded aggressively to Piping Plovers. In one such instance, two brief fights ensued, but the Spotted Sandpiper was quickly displaced. Other migrant shorebirds sometimes chased Piping Plovers, but only after first being confronted or chased.

There were relatively few interactions with Ring-billed Gulls. The most intense interactions were with Killdeers and Common Grackles. While Piping Plovers could quickly displace non-breeding Killdeers, Killdeers tending their own broods were particularly aggressive toward Piping Plovers and often dominated and displaced them during encounters. On one occasion, a pair of Piping Plovers was defeated in interactions with a single Killdeer and retreated, leaving their chicks unguarded between the two species. In another instance, a Killdeer appeared about to attack a plover chick when the parent suddenly intervened. I observed several instances where parent Piping Plovers were temporarily driven from their territories by Killdeers.

Although Common Grackles were seldom seen on beaches occupied by Piping Plovers, the plover's reaction to them, at a

**Table 3. Interspecific interaction opportunities and interactions of Piping Plovers during the brood period.**

Species	No. 30-min samples <sup>1</sup>	Opportunities <sup>2</sup>	Interactions				Total	Interaction index <sup>3</sup>
			Chase	Being chased	BAE	Fight		
Common Tern	49	231	9	6	23	0	38	0.165
Common Tern chick	26	78	0	0	0	0	0	0.000
Ring-billed Gull	11	23	3	0	10	0	13	0.565
Franklin's Gull	20	147	2	4	4	0	10	0.068
Spotted Sandpiper	52	197	128	2	1	2	133	0.675
Spotted Sandpiper chick	9	21	11	0	0	0	11	0.524
Killdeer	15	38	13	19	5	0	37	0.974
Killdeer chick	1	1	1	0	0	0	1	1.000
Semipalmated Sandpiper	22	203	151	0	0	0	151	0.744
Other shorebirds <sup>4</sup>	11	41	17	7	2	0	26	0.634
Passerines <sup>5</sup>	10	20	6	2	5	0	13	0.650

<sup>1</sup>Number of samples in which interactions and/or opportunities occurred. Total possible = 91.

<sup>2</sup>An opportunity occurred when a Piping Plover was within 5 m of another species.

<sup>3</sup>Total interactions/total opportunities.

<sup>4</sup>Lesser Yellowlegs (*Tringa flavipes*), Stilt Sandpiper (*Micropalama himantopus*), Ruddy Turnstone (*Arenaria interpres*), Pectoral Sandpiper (*Calidris melanotos*), Sanderling (*Calidris alba*).

<sup>5</sup>Common Grackle, Brown-headed Cowbird, Song Sparrow, Purple Martin.

distance of 15 m, was immediate and very intense. Adult plovers rushed to confront grackles, but a single bird seemed unable to displace a foraging grackle by direct means. One plover used injury-feigning displays to lead a grackle away from the brood. In another instance, two adult plovers simultaneously interacted with a grackle and caused it to gradually move away from the brood.

On 50 occasions, I observed Piping Plover chicks within two m of other species (Common Tern = 18, Franklin's Gull = 7, Spotted Sandpiper = 11, Semipalmated Sandpiper = 13, Song Sparrow = 1). The only interaction noted was a large plover chick briefly chasing a Semipalmated Sandpiper.

#### Interaction Indexes

The interaction index for all species peaked during the brood period (Tables 1-3) reflecting the increased aggressiveness of Piping Plovers after chicks hatched. During incubating, non-incubating, and brood periods, Killdeers had the highest interaction index, indicating that they were the most likely, of the frequently occurring species, to elicit an agonistic response. This was especially true during the brood period (Table 3) when the two species failed to interact at only one opportunity. Ring-billed Gulls, Spotted Sandpipers and Semipalmated Sandpipers had moderately high indexes during both non-incubating and brood periods (Tables 2 and 3). On the other hand, Common Terns and Franklin's Gulls had very low indexes during all periods. With the exception of several instances when Ring-billed Gulls walked directly toward a plover nest or Common Terns landed next to Piping Plovers, Killdeers were the only species I observed initiating interactions with Piping Plovers. All other interactions were initiated by Piping Plovers.

#### DISCUSSION

At Lake of the Woods, breeding Piping Plovers interacted aggressively with a variety of bird species. These interactions varied in frequency and intensity depending on the species involved and whether Piping Plovers

were incubating or tending chicks. Aggressiveness in shorebirds typically peaks during the brood period (Gochfeld 1984; Pickett *et al.* 1988), as was the case for Piping Plovers.

Species having a low interaction index are not likely to have significant negative effects, via aggressive interactions, on Piping Plover reproductive success. On the other hand, a high interaction index indicated that aggressive interactions between the two species were likely to occur when opportunities arose. Detrimental effects of interspecific interactions can be direct, such as a threat of predation on nests or chicks. This could be expressed, in part, by BAEs as plovers confronted or attempted to distract a potential predator. Other direct negative effects involved fighting, with the associated risk of injury, or being repeatedly chased by a dominant species, which could lead to loss of a favorable territory or foraging location.

Some species posed a low risk of direct negative effects on Piping Plover reproduction in this study. Common Terns were encountered by Piping Plovers in a higher proportion of 30-min samples than any other species except Spotted Sandpipers, but I recorded only 40 interactions, none of which was very intense. Common Terns ignored plover chicks when they were in close proximity. Similarly, Bergstrom and Terwilliger (1987) reported that Piping Plovers did not interact aggressively with Least Terns (*S. albigifrons*). It is not uncommon for Piping Plovers to nest in association with tern colonies (Haig 1992), as did two of the four pairs I observed, and plovers may benefit from this association through the terns' mobbing of predators. In my study, American Crows and diurnal raptors were driven off by terns before they could closely approach the tern colony.

Franklin's Gulls presented many interaction opportunities during the brood rearing period, but had a very low interaction index. Clearly, Piping Plovers did not appear to view these gulls as a serious threat to their chicks. This is supported by the fact that Franklin's Gulls ignored plover chicks when they were in close proximity. Further, Franklin's Gulls have not been reported to prey on birds

(Burger and Gochfeld 1994). Spotted Sandpipers were frequently encountered by Piping Plovers during this study and had one of the higher interaction indexes; however, almost all interactions were totally one-sided in favor of Piping Plovers. Spotted Sandpipers, which vigorously attack and sometimes kill conspecific chicks (Maxson and Oring 1980; Oring *et al.* 1983), ignored Piping Plover chicks. Semipalmated Sandpipers also had a high interaction index, but were never observed to exhibit any aggression toward Piping Plover adults or chicks. Other migrant shorebirds did not arrive until plover chicks were about two weeks old and did not initiate interactions with Piping Plover adults or chicks.

The intensity of their reactions indicated that adult Piping Plovers perceived three species to pose a threat of predation on their eggs or chicks. Ring-billed Gulls were confronted with high-intensity aggression by Piping Plovers when they approached nests or landed anywhere near plover chicks. Despite the gull's large size, Piping Plovers were able to chase them away on several occasions, although BAEs were more common. Ring-billed Gulls were common on the study area, but the number of interactions observed was rather small due, in part, to our use of elevated nylon string gull deterrents in plover brood-rearing areas (Maxson *et al.* 1996). American Crows, even from a distance of 140 m, caused an intense response by incubating Piping Plovers. Though I only observed one such incident, it strongly suggested that American Crows were serious predators on eggs and chicks of Piping Plovers that were not nesting in association with the Common Tern colony. Piping Plovers with broods were especially distressed by the presence of a foraging Common Grackle within 15 m of the chicks. Common Grackles are known to prey on small shorebird chicks (Maxson 1978; Oring *et al.* 1983) and the parent plover's behavior around grackles could best be described as frantic.

On a day to day basis, Killdeers may pose the biggest threat of direct physical harm to both adult and young Piping Plovers at this site. Killdeers had the highest interaction in-

dex during all three breeding cycle stages sampled. While Piping Plovers could routinely displace non-breeding Killdeers, Killdeers with nests or especially chicks were much more aggressive. Breeding Killdeers were as likely to initiate agonistic encounters as were Piping Plovers and, when both species were equally motivated, the larger Killdeers prevailed. Haig (1992) reported an injury to a Killdeer during a confrontation with a Piping Plover. Based on the level of aggression that I observed, it is conceivable that a brood-rearing Killdeer could attack and kill small Piping Plover chicks. This would most likely occur where Killdeers and Piping Plovers have adjacent or overlapping territories and both species are tending chicks.

In addition to direct negative effects of interspecific interactions on Piping Plovers, there also may be more subtle indirect effects. The presence of a potential predator may result in eggs left unattended or chicks forced to hide, perhaps for extended periods, thereby reducing the time available for chicks to forage or be brooded. Interactions with Killdeers could have these same effects, as well as forcing Piping Plover broods to use less favorable habitat. Franklin's Gulls sometimes caused problems simply by loafing on beaches in large numbers (up to several thousand in this study), thereby preventing Piping Plover broods from using such areas for foraging. Spotted and Semipalmated sandpipers and other shorebirds may compete for food with Piping Plovers. When migrant shorebirds were present, adult Piping Plovers often spent a large proportion of the sample period interacting with them (up to 44 chases/sample). These repeated chases distracted the adult plover from the brood, leaving chicks potentially vulnerable. Further, the energy that adult plovers expended in these interactions required that they later spend additional time foraging which, in turn, reduced time available for guarding chicks.

#### Conservation Implications

Depending on the circumstances at a particular breeding location, several things can be done to reduce potential negative effects

on Piping Plovers of interspecific interactions. Where Ring-billed Gulls present problems, deterrents such as elevated nylon strings (Maxson *et al.* 1996) will usually prevent the gulls from using the area. Brightly-colored strings have been used for eight years at Lake of the Woods and no Piping Plovers have become entangled. The influence of American Crows can be reduced by removing trees or other tall objects that crows use as observation perches. Because Piping Plovers can dominate and displace non-breeding Killdeers, the most serious of the problems with Killdeers could be solved by removing eggs from Killdeer nests in territories immediately adjacent to breeding Piping Plovers.

The method of quantifying interactions employed in this study could be used at other Piping Plover breeding sites to indicate potential avian predators and species that may directly or indirectly affect Piping Plover breeding success via aggressive interactions. This could lead to site-specific management programs for predator removal or management strategies to reduce or eliminate detrimental interspecific interactions.

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