

Responses of Shorebirds to Disturbance at Roosting Sites

Kim, Hwa-Chung* and Jeong-Chil Yoo

Korea Institute of Ornithology, Kyung Hee University, Seoul 130-701, Korea

ABSTRACT: The sources and the frequency of disturbances and the responses of shorebirds to disturbances were studied at four roosting sites on Ganghwa Island and Yeongjong Island. The mean frequency of disturbance to roosting shorebirds was 2.7 per hour. Human activities contributed to the disturbance in 65% of all cases. Disturbance frequencies in salt pans were higher than those in the upper tidal zone, fishponds and salt marshes. Response patterns of shorebirds to disturbances were associated with the source of the disturbance. Disturbance caused shorebirds to change their behavior and to reduce roosting time at their roosting sites. Four patterns of responses by roosting shorebirds to disturbance were found, including: (1) leaving the roosts, (2) changing their location within the site, (3) leaving and returning, and (4) remaining in place. In the latter three response patterns, the birds tended to remain in their initial roosting sites, in contrast with the leaving pattern, which involved departing from the roosting area. Factors affecting these response patterns were time from high tide and time of day. When the time from high tide was greater, and the time of day was later, more birds stayed at the roost. The absence of sufficient alternative roosts in the study areas forced the birds to choose between tolerating the current disturbance, or moving to distant roosts.

Key words: Behavior, Disturbance, Roosts, Shorebirds

INTRODUCTION

Human activities can affect shorebirds feeding on tidal flats and roosting during high tides (Burger 1986, Cayford 1993, Davidson and Rothwell 1993, Thomas et al. 2003). Large flocks in the upper tidal zone and coastal wetlands encounter human beings and their facilities, and human activities usually threaten the gregarious birds. Since shorebirds are the most vulnerable group of coastal birds in terms of their immediate behavioral reactions to disturbance (Burger 1981, Kirby et al. 1993, Smit and Visser 1993), they can be an indicator of wetland conditions as waterbird habitat.

Birds can move temporarily or permanently away from roosting areas when they were disturbed. Frequent disturbance at roosts is likely to deprive the birds of resting opportunities and their traditional high-tide roosts (Burger 1981, Pfister et al. 1992, Kirby et al. 1993, Smit and Visser 1993). Repeated disturbances can reduce the roost quality and are implicated in long-term declines in shorebird abundance (Meire 1991, Pfister et al. 1992). Thus mitigating the effects of disturbance is important for the conservation of shorebirds and their habitat.

Different shorebird species in roosting flocks have different susceptibility to disturbance (Furness 1973, Burger 1981, Pfister 1992, Kirby et al. 1993, Fitzpatrick and Bouchez 1998, Lafferty 2001a). A better understanding of species-typical responses to disturbance

will improve the ability of conservation managers to conserve specific birds and manage wetlands. In particular, it is important that we understand which species are most seriously threatened, and what kinds of disturbances affect these species.

Roost selection by shorebirds is affected by tide level, distance from the feeding area, site fidelity, and roost quality (Furness 1973, Cornelius et al. 2001). Shorebirds are pushed to the upper tidal zone by the incoming tide and form an assemblage. When the tidal zone is all flooded, they have no remaining flat, so they move to adjacent wetlands. How can disturbances at the roost affect roosting birds if the area has few or no alternative roosting sites? If there is no suitable habitat nearby, disturbance force them to fly, but if suitable alternative roosts are available, then they can also be used (Smit and Visser 1993, Gill et al. 2001).

This study focused on the sources of disturbance and the responses of shorebirds to disturbances. We examined the effect of disturbance on roost site selection by shorebirds and provided information about aspects of disturbance such as disturbance frequency, species susceptibility and factors affecting responses to disturbance.

MATERIALS AND METHODS

Study Sites

The study sites were the coastal zones of southern Ganghwa Island (N 37°35'~37°36', E 126°23'~126°32') and southern Yeong-

* Corresponding author; Phone: +82-2-961-0727, e-mail: waders@hanmail.net

jong Island (N 37°27'~37°33', E 126°29'~126°35'), which are important stopover sites for migrating shorebirds on the west coast of South Korea. Yeongjong Island is adjacent to reclaimed area for Incheon International Airport and Ganghwa Island is located to the north of Yeongjong Island (Fig. 1).

A roost is a place where birds rest or sleep. Shorebirds use their roosts during high tides. Neap-tide roosts of shorebirds were on upper tidal zones, but spring-tide roosts were distributed in coastal wetlands such as drained fishponds, rice fields, and salt pans. Observations were conducted at two roosts in Ganghwa Island and two roosts in Yeongjong Island (Fig. 1). Habitat types at these four roosts were as follows: fishpond, upper tidal zone, salt marsh and saltpan. The upper tidal zone used as a neap-tide roosting area was in the Yeocha-ri mudflat of southwestern Ganghwa Island. The fishpond (46.9 ha) was located near the upper flat zone in Yeocha-ri, southern Ganghwa Island. The salt marsh (71.3 ha) in Unnam of southern Yeongjong Island was a mudflat enclosed by banks with sluices. The active salt pans (40.1 ha) were adjacent to the salt marsh. The fishpond and salt pans were used by shorebirds as traditional spring-tide roosts during the study period.

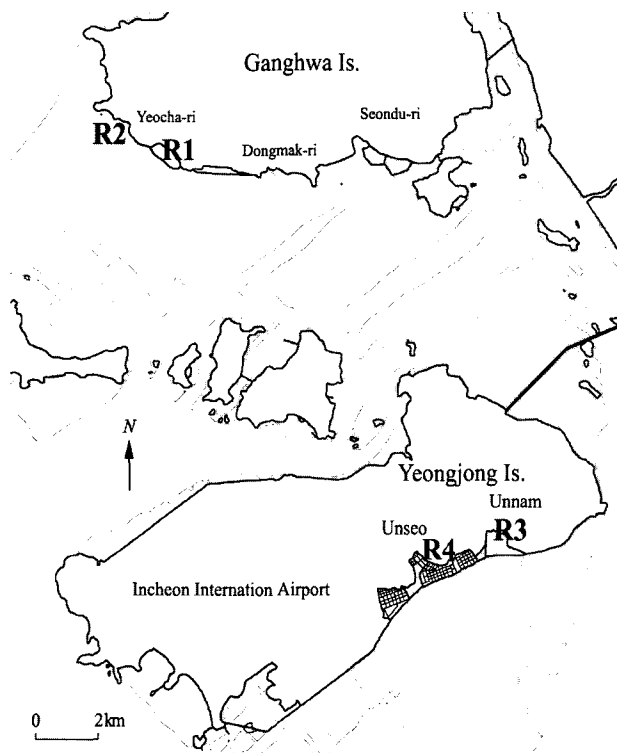


Fig. 1. Roosting sites of shorebirds on Ganghwa and Yeongjong Islands, near the West Coast of South Korea. The four roosting habitat types were: fishpond (R1), upper tidal zone (R2), salt marsh (R3) and saltpan (R4). Shaded areas indicate the flat zone at low tide.

Disturbance by human beings such as visitors, residents, bird-watchers and salt workers may affect roosting shorebirds and occur mostly in daytime in the study area, because access to the shoreline was restricted at night. Hunting of wild birds is strictly prohibited in Ganghwa Island all year-round. The roosts were partially exposed to residents along the road. Three of the roosts (fishpond, salt marsh and saltpan) were adjacent to paved roads and their borders were unpaved roads impassable by vehicles. The western and southern sides of the roosts were bounded by paved roads frequently traversed by fast-moving automobiles. All study areas were covered with small (<5%) patches of reedbed *Phragmites communis*.

SURVEYS

Disturbances were recorded during the peak migration period of shorebirds in August-September 2001 and March-October 2002. All observations were made during high tide periods when shorebirds were using the roosts. The observations were conducted from a distance (100~500 m) so as not to disturb the roosting birds. The observation points were selected at places providing a good view of the roosts. The time shorebirds flocks were present at roosts during each observation period was recorded. Roosting shorebirds were observed for 2,315 minutes (38.6 hours) at various tide levels at the four roost sites. To assess the impact of disturbance, when birds were disrupted by a disturbance, the shorebird species and the number of individuals whose activities were disturbed were recorded. The causes of disturbance, whether by human activities or the natural causes such as predators, were identified and recorded.

The responses of shorebirds to disturbance were divided into two categories, alerting and flying behaviors, to assess the impact of disturbance. Alerting behaviors were defined as raising their heads simultaneously and walking, when disturbed. Flying behaviors could occur at once, or after a delay. The disturbance source, time of day, flock size and the proportion of the flock taking flight were also recorded. The time spent flying by disturbed shorebirds was measured with a stopwatch, until they landed again in their initial roosts.

Kruskal-Wallis tests were used to make comparisons among species and sources of disturbance in the mean numbers of individuals responding in the four roosts. To examine the effects of the independent variables (high-tide level, time to high tide, time of day) on the behavioral response of shorebirds (stay, relocate, return, leave), stepwise regression procedures were conducted, using SAS statistical software. High-tide level was determined by NORI 2001. Time to high tide was calculated by adding or subtracting minutes from the predicted high tide time.

RESULTS

Sources and Frequencies of Disturbance

Roosting shorebirds experienced disturbances from six types of sources (Table 1). Most of these sources (except predators) were related to human activities. In 65% of all cases the roosting shorebirds were disturbed by human beings, and in 12% of cases they were disturbed by automobiles and other machines. Disturbance from avian predators, such as hobbies (*Falco subbuteo*) and goshawks (*Accipiter gentiles*) were observed only in the upper tidal zone.

The mean frequency of disturbance to roosting shorebirds from all sources was in the range of 0.27 to 5.37 events per hour (Table 1). Helicopters were the most frequent source of disturbance in the salt marsh, and human beings were the most frequent source of disturbance in the fishpond and saltpans. Fishery tillers and preda-

Table 1. Mean frequency (\pm SE) per hour of disturbance in all cases and for each sources at the four roosts

	Ganghwa Is.		Yeongjong Is.	
	Fishpond	Upper tidal zone	Saltpan	Salt marsh
Mean freq.	2.13 \pm 0.74	1.73 \pm 0.43	5.09 \pm 2.61	2.59 \pm 1.01
Automobile	0.75 \pm 0.25	–	0.86 \pm 0.64	0.72
Small aircraft	–	0.45	0.45	–
Helicopter	0.27	1.33	–	4.62
Human being	1.97 \pm 1.07	1.21 \pm 0.11	5.37 \pm 3.05	1.71
Fishery tiller	–	5.00	–	–
Predator	–	1.74 \pm 0.14	–	–

Table 2. Responses to disturbance by roosting shorebird species shown as: observation time, frequency of occurrence, and the total responding numbers, mean numbers (N) and percentage of respondent birds (mean \pm SE) of the population

Species	Obs. (min.)	Freq.	Obs. birds	N	% Pop.
<i>Numenius madagascariensis</i>	102.1 \pm 24.8	34	8572	252.1 \pm 36.2	54.4 \pm 5.9
<i>Calidris alpina</i>	117.8 \pm 34.7	20	9693	484.7 \pm 94.3	61.4 \pm 9.2
<i>Pluvialis squatarola</i>	101.4 \pm 33.1	10	3225	322.5 \pm 75.9	61.5 \pm 12.4
<i>Tringa nebularia</i>	130.0 \pm 62.7	7	565	80.7 \pm 23.5	38.3 \pm 13.4
<i>Charadrius mongolus</i>	93.5 \pm 58.5	7	2890	412.9 \pm 55.8	78.3 \pm 10.2
<i>Limosa lapponica</i>	143.8 \pm 71.7	6	2545	424.2 \pm 236.9	67.4 \pm 12.1
<i>Calidris tenuirostris</i>	86.8 \pm 47.5	4	1356	339.0 \pm 200.8	92.7 \pm 7.3

tors in the upper tidal zone and helicopters in the salt marsh disturbed the birds intensively for short periods of time. Shorebirds in the saltpan were disturbed more frequently than those on the fishpond. Shorebirds in the upper tidal zone were disturbed by various sources including fishery tillers and predators.

Shorebird Responses to Disturbance

The percentage of shorebirds responding to disturbance corresponded to 38.3–92.7% of the population at the roost, and significant differences between species were not detected (Kruskal-Wallis test, $\chi^2=9.36$, $df=6$, $P=0.15$) (Table 2). More than 50% of roosting birds of all species except for greenshanks (*Tringa nebularia*: 38.3%) alerted and flew when disturbed. The species with the highest percentage of responding birds was the great knot (*Calidris tenuirostris*).

The mean percentage of shorebirds responding differed significantly among disturbance sources (Flying; Kruskal-Wallis test, $\chi^2=9.41$, $df=4$, $P<0.05$, Alerting; $\chi^2=12.67$, $df=4$, $P<0.01$) (Fig. 2). All the shorebirds in the upper tidal zone responded to fishery tillers and predator. They all alerted or took flight in response to a predator, but they all walked away from a tiller. Disturbance by aircrafts caused over 60% of roosting shorebirds to alert. Disturbance by humans, automobiles and helicopters made over 60% of the roosting birds fly. The mean time flying following a disturbance was 34.3 seconds, and the birds flew in 77.2% of cases.

Shorebirds at the roosting area displayed one of the four response patterns; staying, relocating, leaving and returning or leaving the roost. These patterns were related to time to high tide and time of day (Table 3). Time to high tide was a factor affecting the decision to stay or leave. Time of day affected the staying and returning responses. As time from the high tide increased, shorebirds tended to stay at their roosts even when they were disrupted.

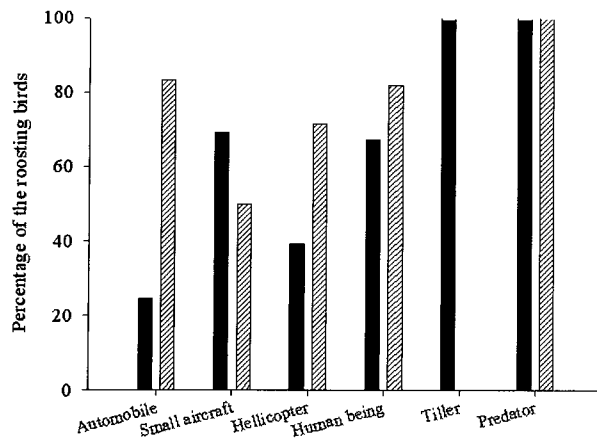


Fig. 2. Percentage of roosting shorebirds responding to various types of disturbance by engaging in alerting behavior (solid bars) and flying behavior (cross-hatched bars).

Table 3. Stepwise regression analysis of responses of shorebirds to disturbance and environmental variables including high-tide level, time to high tide and time of day. R-square (*P*-value)

	Stay	Relocate	Return	Leave
Model				
<i>F</i>	8.80	0.44	2.06	2.79
<i>P</i>	0.001	0.724	0.156	0.057
<i>R</i> ²	0.58	0.06	0.32	0.21
Factors				
Tide level	ns	ns	ns	ns
Time to high tide	0.58***	ns	ns	0.19**
Time of day	0.18*	ns	0.29*	ns

****P*<0.001, ***P*<0.01, **P*<0.05 ; ns, no significant.

DISCUSSION

Disturbances occurred a mean of 2.7 times per hour at all study sites, with different patterns of disturbance among the sites related to different conditions and sources of disturbance. Salt pans with the largest roosting flocks among the four study sites were most frequently disturbed. Large flocks are generally disturbed more easily (Smit and Visser 1993), but the highly predictable disturbance by salt workers did not have severe effects on the large flocks on the salt pan. Roosting birds flushed, but relanded whenever the workers came close to them. They formed large flocks in spite of the frequent disturbance, perhaps because human access to this roost is

restricted except for salt pan workers. Shorebirds in the upper tidal zone close to the sea bank were disturbed by the other five sources, but not by automobiles. Thus, each roost experiences different kinds of disturbance mainly related to human activities. Predation rarely occurred in this study, but the presence of predators had strong impacts on roosting birds for a short period of time. The effects of aircraft and human beings (usually residents) on roosting birds were relatively less pronounced than those of other sources.

We assume that the impact of the disturbance is more serious when the behavioral response to disturbance is stronger. In the studies of coastal birds responding to disturbances, flight to safer roosting areas was a common response to disturbance (Burger 1981, Cornelius et al. 2001). Responses to disturbance can involve different movement patterns, including shifting the roost selection and leaving the area (Pfister et al. 1992, Kirby et al. 1993, Smit and Visser 1993). In this study, shorebirds displayed the responses, staying, relocating, leaving and returning and leaving the roost. Staying at the roost throughout the disturbance, or shifting their location within the roost suggested that they had no choice of other roosts. Roosting shorebirds in the salt pan on Yeongjong Island responded by flying behavior but not by leaving. Salt workers frequently dispelled the large flocks of shorebirds that assembled at high tide. The birds did not have other sites to roost, because most disturbances on the salt pan occurred during the spring tide period in the daytime.

Long-distant migrants require safe roosts to allow them to conserve their fat reserves to prepare for migration (Puttick 1979). In the absence of roosts, they cannot comfortably rest. Disturbances at roosts may therefore force the shorebirds to expend extra energy, as short flights are energetically cost (Nudds and Bryant 2000, Gill et al. 2001). Minimizing unnecessary flight induced by disturbances permits birds to accumulate larger energy reserves. It is thus advantageous for shorebirds to reutilize roosts in which they are not disturbed rather than taking the risk of searching for new roosts which may prove unsuitable (Rehfishch et al. 1996). In cases of disturbance, shorebirds may choose to tolerate disturbance and keep their initial roost, or to avoid the situation by leaving the area.

The minimization of disturbance, allowing the birds to rest comfortably, should be a primary goal for conservation of roosting habitat (Burger 1981). More birds are expected to use refuges offering safe, undisturbed roosting sites than will use adjacent disrupted areas (Cornelius et al. 2001). Indeed, frequent disturbance can make roosting shorebirds leave an area, especially if there are undisturbed areas nearby (Smit and Visser 1993, Stock 1993).

Traditional roosts should be protected for shorebirds and designated as refuges. Human accessibility to these areas should be limited, and buffer zones should be designated around important roosting areas (Korschgen and Dahlgren 1992, Pfister et al. 1992,

Lafferty 2001b). If the designated roosts are large enough to allow managers to redirect human visitors, or to keep them at a sufficient distance from high-tide roosts, shorebirds will be able to rest undisturbed, and to reduce the energetic costs associated with disturbance, or searches for new roosting areas.

LITERATURE CITED

- Burger J. 1981. The effect of human activity on birds at a coastal bay. *Biol Conserv* 21: 231-241.
- Burger J. 1986. The effect of human activity on shorebirds in two coastal bays in the northeastern United States. *Environ Conserv* 13: 123-130.
- Cayford J. 1993. Wader disturbance: a theoretical overview. *Wader Study Group Bull* 68: 3-5.
- Cornelius C, Navarrete SA, Marquet PA. 2001. Effects of human activities on the structure of coastal marine bird assemblages in central Chile. *Conserv Biol* 15: 1396-1404.
- Davidson NC, Rothwell PI. 1993. Human disturbance to waterfowl on estuaries: conservation and coastal management implications of current knowledge. *Wader Study Group Bull* 68: 97-105.
- Fitzpatrick S, Bouchez B. 1998. Effects of recreational disturbance on the foraging behavior of waders on a rocky beach. *Bird Study* 45: 157-171.
- Furness RW. 1973. Roost selection by waders. *Scottish Birds* 7: 281-287.
- Gill JA, Norris K, Sutherland WJ. 2001. Why behavioral responses may not reflect the population consequences of human disturbance. *Biol Conserv* 97: 265-268.
- Kirby JS, Clee C, Seager V. 1993. Impact and extent of recreational disturbance to wader roosts on the Dee estuary: some preliminary results. *Wader Study Group Bull* 68: 53-58.
- Korschgen CE, Dahlgren RB. 1992. Human disturbance of waterfowl: causes, effects, and management. *Waterfowl Management Handbook*. Fish and Wildlife Leaflet 13.2.15.
- Lafferty KD. 2001a. Birds at a southern California beach: seasonality, habitat use and disturbance by human activity. *Biodiversity and Conservation* 10: 1049-1062.
- Lafferty KD. 2001b. Disturbance to wintering western snowy plovers. *Biol Conserv* 101: 315-325.
- Meire PM. 1991. Effects of a substantial reduction in intertidal area on numbers and densities of waders. *Acta Int Ornithol Congr XX*: 2219-2227.
- NORI-National Oceanographic Research Institute. 2001. 2002 Tide tables (Coast of Korea). NORI, Incheon.
- Nudds RL, Bryant DM. 2000. The energetic cost of short flights in birds. *J Exp Biol* 203: 1561-1572.
- Pfister C, Harrington BA, Lavine M. 1992. The impact of human disturbance on shorebirds at a migration staging area. *Biol Conserv* 60: 115-126.
- Puttick GM. 1979. Foraging behaviour and activity budgets of Curlew Sandpipers. *Ardea* 67: 111-122.
- Rehfish MM, Clark NA, Langston RHW, Greenwood JJD. 1996. A guide to the provision of refuges for waders: an analysis of 30 years of ringing data from the Wash, England. *J Appl Ecol* 33: 373-687.
- Smit C, Visser JM. 1993. Effects of disturbance on shorebirds: a summary of existing knowledge from the Dutch Wadden Sea and Delta area. *Wader Study Group Bull* 68: 6-19.
- Stock M. 1993. Studies on the effects of disturbances on staging Brent Geese: a progress report. *Wader Study Group Bull* 68: 29-34.
- Urft AJ, Goss-Custard JD, Durell SE, Ale Vdit. 1996. The ability of oystercatchers *Haematopus ostralegus* to compensate for lost feeding time: field studies on individually marked birds. *J Appl Ecol* 33: 873-883.

(Received February 4, 2007; Accepted February 17, 2007)