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The Relationship between Vegetation Cover and Hatching Success, and Chicks' Survival in Black-Tailed Gulls on Hongdo Island

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ABSTRACT: During the breeding seasons in 2002 and 2003, the influences of vegetation cover on breeding processes of Black-tailed Gulls (*Laurs crassirostris*) were studied on Hongdo Island. We checked clutch sizes, calculated hatching success and survival rates on day 15 and a vegetation cover. There was significant positive relationship between vegetation cover and hatching success, and survival on day 15. In order to analyze the relationship, sample nests were categorized as 'exposed' and 'covered' nests, and the breeding processes at each nest were compared. Hatching success and survival on day 15 in covered nests were significantly higher than ones in exposed nests. However, in clutch size, there was no significant difference. The rate of the hatching and survival failure was different amongst the categorized nests. The primary cause of hatching failure in covered and exposed nests was 'disappeared', and the primary causes of survival failure on day 15 were 'disappeared' and 'killed by adults'. The failure in exposed nests was significantly larger than that of covered nests. In the breeding of Black-tailed Gulls on Hongdo Island, vegetation cover influenced the survival of eggs and chicks as the cover provided shelter against predators and extreme weather.

Key words: Black-tailed Gulls, Hongdo Island, *Laurs crassirostris*, Survival on day 15, Vegetation cover

INTRODUCTION

The success of hatching or fledgling in colonial breeding gulls is influenced by environmental or social factors (Furness and Monaghan 1987, Schreiber and Burger 2001). The environmental factors included habitat features, nest-site characteristics and climate (Burger and Shisler 1980, Yorio et al. 1995). The social factors included predators, parental experiences and parental qualities (Ricklefs 1969, Chastel et al. 1995). Some (Pierotti 1982, Good 2002) suggested that the analysis of the ecological relationship between these factors and survivals was important in nest-site selection. The competition for occupying better places which included better characteristics (e.g. vegetation cover) was indirectly/directly influenced by these factors (Schreiber and Burger 2001). For the reasons the study of nest-site selection was based on the analysis of the ecological meaning of the relationship.

The quality of nest-sites in open habitats was often determined by the extent of shelter for eggs and chicks (Parsons and Chao 1983). In the study on best-site selection by gulls, the role or meaning of shelters was generally defined by vegetation cover (Burger and Gochfeld 1988) in that the cover was relevant to both breeding success and selection of environmental and social factors. Additionally shelters in the form of natural screens at nests can be considered a measure of territory quality. Jenks-Jay (1982) reported that the evaluation of colonies in Least Tern (*Sterna antillarum*) was able to discern whether there were many shelters or not because shelters in breeding periods contributed the survival of chicks. Since gulls are semi-precocial or precocial birds (Schreiber and Burger 2001), especially, it was necessary that the depending mechanism reduced the risk developed from the activity of early chicks (Parsons 1982). Vegetation cover made nests a safe-place because it made activity low. Therefore many studies on nest-site selection focused on vegetation cover.

Black-tailed Gulls (*Larus crassirostris*) are open-nesting birds, and breed colonially on islands and on rocky cliffs (Paek and Yoo 1996). Although Black-tailed Gulls have a broad geographical distribution in Korea, little is known about their habitat requirements and nest-site preferences (Lee et al. 2005). The goals of this study were to measure egg and chick survival, and to examine the influence of vegetation cover on offspring survival in Black- tailed Gulls on Hongdo Island.

METHODS

Hongdo Island (34° 31' 87" N, 128° 43' 88" E) has the largest breeding colony of Black-tailed Gulls in Korea, numbering some 10,000 pairs in 1995 (Paek and Yoo 1996), and is located about

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50.5 km from Tongyeong city, Gyeongsangnamdo, Republic of Korea (Fig. 1). The Island's area is approximately 98,380 m^2. The sedge (*Carex boottiana*) covers the whole island except the rocky cliffs. Cliffs surround the coastline of the island and are inclined over 45°, and the peak point of the island is about 115 m above sea level (Lee et al. 2005). The average air temperature from April to July, covering the breeding period of Black-tailed Gulls, varies between 13.1℃ and 30.5℃. Average annual rainfall varies from 170 to 340 mm (Korea Meteorological Administration 2004).

During the breeding season (April～July), nests were visited every day to determine clutch size and to check egg laying or hatching. We selected samples of 130 and 128 nests in 2002 and 2003 respectively. All sample nests were marked with plastic tags (10×10 cm). Chicks were banded with celluloid bands and National Institute of Environmental Research (NIER) aluminum bands. 'Hatching success' and 'Survival on day 15' were quantified by the following formula (Burger and Gochfeld 1981, Lee 2004):

$$\text{Hatching success}(\%) = \frac{\text{No. of hatched chicks}}{\text{Total number of eggs}} \times 100 \quad (1)$$

$$\text{Survival on day 15}(\%) = \frac{\text{No. of survival chicks on day 15}}{\text{Total number of eggs}} \times 100 \quad (2)$$

When hatching or survival on day 15 was failed, we noted the causes of failure. The causes were separately categorized by the following (Barbour et al. 2000):

Fig. 1. Map of Hongdo Island.

(1) The causes of hatching failure
'Addled' – not hatched, spoil smell or cold eggshell
'Depredated' – found perforated or fractured
'Disappearance' – not found at all or predated signs

(2) The causes of fledging failure
'Killed by adults' – found pecked signs in head or body of dead chicks
'Fate unknown' – no visible wound found on body of dead chicks
'Disappeared' – chicks not found and did not return within 3 consecutive days

Vegetation cover was measured after termination of laying (Martin and Roper, 1988). At each nest, a sampling quadrat (0.5 m^2) was established. Vegetation cover provided by laying down the quadrat frame over each nest and estimating the percentage (0～100 %) of vegetation or bare ground present (Burger and Gochfeld 1988). Pearson correlation was used to examine the relation between vegetation cover and hatching success, and survival on day 15. In order to analyze the relation in more detail, we categorized sample nests as 'exposed' and 'covered,' excluding those sample nests with partial cover. 'Exposed' nests were defined as bare ground or without vegetation cover above them (below 10 % of vegetation cover, n=39). 'Covered' nests were defined as totally protected by vegetation (above 90 % of vegetation cover, n=30) (Parsons and Chao 1983, Yorio et al. 1995).

To compare clutch size, hatching success, and survival on day 15 between 'exposed' and 'covered' nests, we used the Mann-Whitney U-test. Chi-square test was used to compare the failure of hatching and survival on day 15 between covered and exposed nests. All means are represented with standard errors.

RESULTS

There was significant positive correlation of vegetation cover (0～100 %) and hatching success, and survival on day 15 (Table 1).

Table 1. Correlation coefficient between vegetation cover and hatching success, and survival on day 15 in 2002 and 2003

	No. of sample nests	Vegetation cover
Hatching success	258	0.24***
Survival on day 15	207	0.15*

* P<0.05; *** P<0.001 (Pearson correlation).

Table 2. Clutch size, chicks hatched, and survival on day 15 in covered and exposed Black-tailed Gull nests in Hongdo Island during 2002 and 2003

	Covered nests (*n*=39)	Exposed nests (*n*=30)	Difference between covered and exposed nests (*Z*-value)
Clutch size	2.0 ± 0.1	1.9 ± 0.1	−1.08
Hatching success (%)	77.6 ± 6.2	42.2 ± 8.4	−3.28***
Survival on day 15 (%)	68.6 ± 6.3	37.8 ± 7.7	−2.94**

** $P<0.01$; *** $P<0.001$ (Mann-Whitney *U*-test).

Clutch size between covered and exposed nests was not significantly different (Table 2, Mann-Whitney *U*-test, $Z=-1.08$, $P=0.28$). However, hatching success in covered nests was significantly higher than one in exposed nests ($Z=-3.28$, $P<0.001$). Survival on day 15 in covered nests was significantly higher ($Z=-2.94$, $P<0.01$).

Hatching failure in exposed nests was higher than one in covered nests (Table 3, Chi-square test, $\chi^2 = 8.26$, df = 2, $P<0.05$). The causes of hatching failure at each nest were; 'Disappeared' (covered=63.6 %, exposed=82.1 %) as the highest rate, and then 'Addled' (covered=27.3 %, exposed=14.3 %), and finally 'Depredated' (covered=9.1 %, exposed=3.6 %). The survival failure until day 15 in exposed nests was higher than one in covered nests (Table 4, $\chi^2 = 10.50$, df = 2, $P<0.01$). The causes of the survival failure until day 15 at each nest were that 'Disappeared' (covered=42.9 %, exposed=54.6 %) was the highest rate, and then 'Killed by adults' (covered=57.1 %, exposed=36.4 %), and 'Fate unknown' (covered=0 %, exposed=9.1 %).

DISCUSSION

The survival of eggs or chicks within breeding colonies in gulls was influenced by nest-site characteristics (Lack 1968) which were vegetation cover, the nearest distance, slope, and nest-wall (Burger and Shisler 1980, Lee 2004). The choice of the characteristics was related to predator, weather, or density of breeding pairs (Ricklefs 1969, Butler and Trivelpiece 1981). Therefore the choice which provided positive benefits (e.g. the protection from the weather effects) was important for increasing breeding success. For instance, the vegetation or rock cover which is one of nest-site characteristics was used as major materials for making nests or concealing eggs and chicks. Good (2002) showed the strong positive relationship between vegetation cover and chick survival in Western Gull (*Larus occidentalis*) and Glaucous winged Gull (*Larus glaucescens*) because vegetation covers provided the concealment as protection from a hawk. Our result also showed the positive relationship between vegetation cover and hatching success, and survival on day 15 (Table 1). And hatching success and survival on day 15 in covered nests was significantly higher than ones in exposed nests (Table 2). The eggs and chicks of Black-tailed Gulls which bred on Hongdo Island had two major predators, Peregrine falcon (*Falco peregrinus japonensis*) and conspecific adults (Lee 2004). The falcon mainly preyed upon adults and chicks and conspecific adults pecked chicks or preyed upon eggs (Kwon 2004). Eventually, the positive relation between vegetation cover and hatching success, and survival on day 15 meant that Black-tailed Gulls like the other gulls used the vegetation as concealments for protecting from the predator. And the protection using vegetation cover positively influenced on the survival of eggs and chicks during breeding periods.

Nest-spacing in Black-tailed Gulls on Hongdo Island was very narrow (Lee et al. 2005), and declined from 114.3 cm in 1996 (Kwon 1998) to 91.3 cm in 2003 (Lee 2004). Namely the breeding density on Hongdo Island was probably increased even though we did not show the evidence. The high density was able to bring about increasing the competition for foods and the frequency of aggression within conspecific (Furness and Monaghan 1987, Schreiber and Burger 2001). The defence of the competition or aggression was able to occupy good nest-sites and increase the survival of chicks. Table 2 showed that survival on day 15 in covered nests was significantly higher than in exposed nests. Black-tailed Gulls are semi-precocial species so chicks were able to come in and out nests after one or two days (Yoo and Kwon 1997). This movement of chicks brought about decreased or increased risk factors according to circumstances (Schreiber and Burger 2001). When the temperature is higher, for instance, chicks probably came to the covered nests or shelters. The probability of movement in exposed nests may be higher than in covered nests and the movement may bring about the high probability of keeping away from predators. In the cause of survival failure on day 15 (Table 4), the major causes were 'Disappeared' and 'Killed by adults'. Kwon (1998) reported that the primary cause of disappeared chicks at nests was 'Killed by adults' after chicks broke away natal nests. In other words, the meaning of 'Disappeared' included 'Killed by adults' even though we didn't show the evidence. Yorio et al. (1995) found Kelp Gulls (*Larus dominicanus*) at Punta León preferred nest-sites which were covered or were close to vegetation cover because the chicks in exposed nests were easily detected by

predators. And the chicks in exposed nests were so high temperature at Punta León that they had to found or move concealments. Therefore, the survival of chicks indirectly might be influenced by vegetation cover.

The vegetation did not only indirectly act as a defense but also provided direct defense when avoiding extreme weather (Schreiber and Burger 2001). Burger and Shisler (1978), and Salzman (1982) showed that the heat stresses affected breeding success in gulls. During the incubation period, the maintenance of the nest-microclimate was the most important (Ar and Sidis 2002). The vegetation cover was able to keep the nest warm (cf. the first is parents). Especially, the affects of typhoon/storm on chicks were very dangerous (Schreiber and Burger 2001) because of strong winds and low temperature. Hongdo Island also is famous for the intense heat, the gale of wind and typhoon (Lee 2004). During the breeding period (April～July) in 2003, the maximum air temperatures and wind velocity reached 30.5℃ and 21.0 m/sec. When a typhoon struck 3 times in 2003, 10 % of chicks above day 10 were killed (Lee unpublished data). The typhoon was not a factor of hatching and survival on day 15 in our sampled nests (Table 3 and 4) because the typhoon to hit the breeding colony on Hongdo Island came at a later time. Generally, the breeding pairs which arrived late selected poor nest-sites such as opened areas. The vegetation cover in opened areas was about 0 %. Therefore the defense using vegetation cover did not occur. And the damage was high because the typhoon or extreme weather directly influenced the survival of chicks on Hongdo Island.

The results are consistent with many authors (Vermeer 1970, Burger and Shisler 1978, Winnett-Murray 1979, Jenks-Jay 1982, Yorio et al. 1995) who suggested vegetation cover was the major characteristics for selecting nest-sites. For instance, Winnett-Murray (1979) found that the chicks' survival in Western Gulls on Santa Barbara Island was influenced by vegetation cover. Parsons and Chao (1983) showed that Herring Gulls (*Larus argentatus*) which bred on Clark's Island preferred covered nests or were close to vegetation cover due to provide shelters against predators or extreme weather. The weather condition on Hongdo Island were not good because of strong wind and high temperature. The social condition went from bad to worse due to increase breeding density. Therefore we suggest that vegetation cover provided concealments against a predator of nesting gulls and shelters from heat and wind.

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Table 3. Causes of hatching failure in covered and exposed nests in 2002～2003 (Chi-square test, $\chi^2 = 8.26$, df = 2, $P<0.05$). The percentage of each cause is given in parentheses

Nests	N_t[1)]	N_f[2)]	Causes		
			Disappeared	Addled	Depredated
Covered	78	11	7 (63.6)	3 (27.3)	1 (9.1)
Exposed	56	28	23 (82.1)	4 (14.3)	1 (3.6)

[1)] N_t is the total number of eggs.

[2)] N_f is the number of hatching failure.

Table 4. Causes of the survival failure on day 15 in covered and exposed nests in 2002～2003 (Chi-square test, $\chi^2 = 15.211$, df = 2, $P<0.001$). The percentage of each cause is given in parentheses

Nests	N_t[1)]	N_f[2)]	Causes		
			Disappeared	Killed by adults	Fate unknown
Covered	67	7	3 (42.9)	4 (57.1)	0 (0)
Exposed	28	11	6 (54.6)	4 (36.4)	1 (9.1)

[1)] N_t is the total number of chicks.

[2)] N_f is the number of survival failure on day 15.

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