

Nest Site Characteristics and Reproductive Parameters of Grey Herons *Ardea cinerea* in Korea

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(Accepted January 6, 2009)

Jungsoo Kim and Tae-Hoe Koo (2009) Nest site characteristics and reproductive parameters of Grey Herons *Ardea cinerea* in Korea. *Zoological Studies* 48(5): 657-664. We studied the breeding ecology of Grey Herons *Ardea cinerea* in 3 mixed-species heronries in Pyeongtaek, Gyeonggi-do, Korea during 2000 and 2001. Nest site characteristics such as the height and distance of Grey Heron nests from the tree trunk did not differ when nesting alone or in combination with other heron and egret species. The mean clutch size, initial brood size, and final brood size did not significantly differ between years. The initial brood size significantly differed among clutch sizes in 2001 (ANOVA, $p < 0.01$). The final brood size differed among clutch sizes in both years (ANOVA, $p < 0.01$). Comparing the final brood size per nest, clutch size had a significant effect on the initial brood size in 2001 and final brood sizes in 2000 and 2001, but the initial brood size had no effect on the final brood size in either year. Clutch size, initial brood size, and final brood size were within the ranges reported by other studies. Mass and culmen-length growth rates of Grey Heron chicks did not differ between years, but wing and tarsus-length growth rates differed between years. <http://zoolstud.sinica.edu.tw/Journals/48.5/657.pdf>

Key words: Grey Herons, Nest site characteristics, Clutch size, Initial and final brood sizes, Growth rate.

In mixed-species heronries, hundreds or thousands of breeding birds coexist, leading to dense nesting and partitioning of the available space (Jenni 1969, Maxwell and Kale 1977, Parsons 1995). Nest site selection is known to influence reproductive success of wild birds (Buckley and Buckley 1980, Burger and Gochfeld 1988). Interactions of colonial birds at their nest sites are well documented for species nesting in trees. Nesting habitat provides protection against predators (e.g., mammals, humans, birds of prey, etc.), offers adequate stability and materials to support and construct the nest, and is accessible to abundant feeding areas within the foraging range (Fasola and Alieri 1992, Hafner 1997, Lamsiri and Gale 2008). Birds possibly nest in colonies to decrease the probability of nest depredation (Brown and Brown 1996). The size, structure, shape, and orientation of the nest site are important in

providing shelter against adverse weather, particularly high winds, gales, and storms (Kim et al. 1998).

The clutch size of herons may differ between years (Custer et al. 1983) or it may remain constant (Tremblay and Ellison 1980). In herons and egrets, fledging success per egg laid is not significantly related to clutch size (Pratt and Winkler 1985), and growth rates of the young are often correlated with nestling survival (Spahn 1997).

The reproductive success of long-legged wading birds is of considerable interest to wildlife and land managers because these species are useful indicators of wetland productivity, trophic structure, human disturbance, and contamination of wetlands (Custer and Osborn 1977). Their reproductive parameters may be the most sensitive bioindicators of the population, community, and ecosystem because they reveal primary responses

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to environmental changes (Temple and Wiens 1989).

Grey Herons *Ardea cinerea* migrate to Korea to breed in late Mar. and early Apr., and then return to the Philippines, Indonesia, and Malaysia in late Sept. and early Oct. During the breeding season, they feed on fish, amphibians, reptiles, and invertebrates in Korean agricultural areas, streams, and rivers.

We investigated the nest site characteristics, clutch size, reproductive success, and growth rate of Grey Herons in Pyeongtaek, Gyeonggi-do, Korea in 2000 and 2001. Our objectives were to estimate differences in nest site characteristic of solitary or co-nesting species in trees and the effect of year on clutch size, reproductive success, and growth rate of Grey Herons.

MATERIALS AND METHODS

Study area

Data were gathered in Pyeongtaek City (37° 02'N, 127°02'E), Gyeonggi-do, Korea, where Black-crowned Night Herons *Nycticorax nycticorax* and Little Egrets *Egretta garzetta* frequently nest in the same colony with Grey Herons (Fig. 1). The elevation of the breeding area is about 55 m above sea level, and the areal extent is 9000 m². This breeding site hosted Black-crowned Night Herons, Little Egrets, and Grey Herons in 2000, and Black-crowned Night Herons and Grey Herons in 2001.

Rice paddy fields surround the colony where many herons forage. Distances from the breeding

site to additional foraging sites are 3.9 km to Jinwee stream and 6.8 km to the confluence area of Anseong and Jinwee streams.

Because herons and egrets nests are most susceptible to disturbance when the birds are building the nest and laying eggs (Tremblay and Ellison 1979), we limited our visits to 1 in the early period (mid-Apr.) and then 2 per wk from late incubation (from 25 Apr.) onward.

We used a measuring tape (0.01 m) and a laser rangefinder (0.01 m) to determine the position of the nest site. The distance of the nest from the tree trunk was measured from the center of the tree trunk to the nest, and nest height was measured from the ground surface to the bottom of the nest (Fig. 2). Nest site characteristics were measured in trees with different combinations of herons and egrets: (1) Grey Herons only, (2) Black-crowned Night Herons and Grey Herons, and (3) Black-crowned Night Herons, Little Egrets, and Grey Herons.

The clutch size, initial brood size, and final brood size were determined by examining openly visible nests on trees. A ladder was used to view nests not visible from the ground. The average clutch size, initial brood size, and final brood size were compared between years. For fledglings, we considered chicks as having successfully fledged when they were more than 4 wk post-



Fig. 1. Survey site for breeding ecology of Grey Herons, Pyeongtaek, Korea.

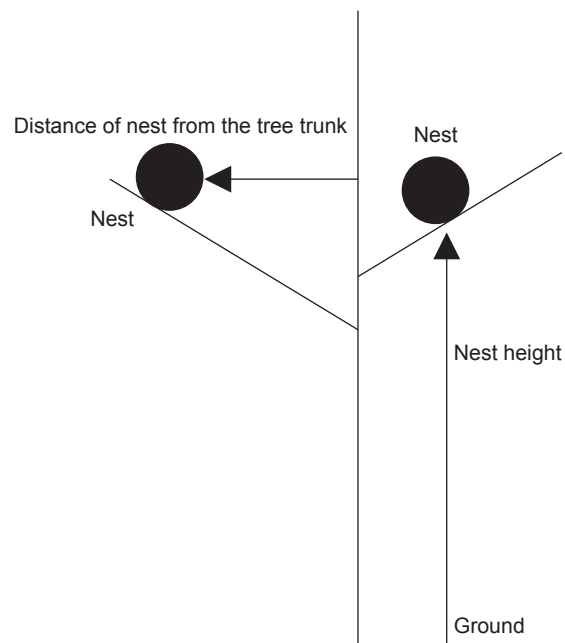


Fig. 2. Measurement of a nest site in a tree.

hatching, because they were then old enough to fly across open spaces to trees away from the nest. Hatching and fledging success rates were determined on a per-nest basis.

Hatching order was assigned to chicks based on the observed hatching dates, or for unknown dates, we used the relative size (length of the bird's culmen; Custer and Peterson 1991). We assigned the chick order by birth dates using a colored plastic band. A-chicks were the first hatched, B-chicks the second hatched, etc, and a number was added after the letter to indicate the total number of hatchlings per nest. For example, hatchling A 4 indicated it was the first hatchling in a nest of 4 total hatchlings. For each chick, the body mass and lengths of the culmen, wing, and tarsus were measured every 3-4 d according to the methods of Baldwin et al. (1931). On every visit, a chick's mass was measured using an Ohaus electronic balance (to the nearest 0.1 g; OHAUS Corp.). Culmen, wing, and tarsus lengths were measured using vernier calipers (to the nearest 0.01 mm). These growth factors were measured for chicks from 5 to 28 d after hatching.

A *t*-test, 1-way analysis of variance (ANOVA), and Bonferroni's test for the statistical analyses were used with SPSS 12.0 (SPSS Korea).

RESULTS

Nest site

Nest height and distance of the nest from the tree trunk for Grey Herons did not differ when they nested alone or in combination with other herons and egrets (Table 1).

Clutch size, initial brood size, and final brood size

The mean clutch sizes of Grey Herons were 3.44 ± 0.77 eggs in 2000 and 3.36 ± 0.68 eggs in 2001, and did not differ between years. The initial brood sizes averaged 2.93 ± 1.01 chicks in 2000 and 2.96 ± 0.85 chicks in 2001, and did not differ between years. The final brood sizes averaged 2.14 ± 1.04 chicks in 2000 and 2.00 ± 0.91 chicks in 2001, and did not differ between years (Table 2).

Reproductive success

The initial brood size significantly differed by clutch sizes in 2001 but did not in 2000 (ANOVA, $F = 6.70$, $p < 0.01$). The final brood sizes differed among clutch sizes in both 2000 (ANOVA, $F = 7.22$, $p < 0.01$) and 2001 (ANOVA, $F = 18.1$, $p < 0.01$). However, the final brood size did not differ by the initial brood sizes between years. Comparing the final brood size per nest, clutch size had a significant effect on the initial brood size in 2001 and the final brood sizes in 2000 and 2001, but the initial brood size had no effect on the final brood size in either year.

In separate analyses by brood size, Grey Herons of all brood sizes showed no significant year effect. The initial brood size of 1 was excluded from the analysis because of small sample sizes (Table 3).

Growth rates

Growth rates of Grey Heron chick weight and culmen length did not differ between 2000 and 2001; however, wing (*t*-test, $t = 2.93$, $p < 0.01$)

Table 1. Nest height and distance of the nest from the tree trunk (mean \pm SD) of Grey Herons when nesting alone or in combination with Black-crowned Night Herons (BCNH) or Little Egrets (LE) in Pyeongtaek colony, Korea

	<i>n</i>	Nest height (m)	Distance of nest from the tree trunk (m)
Nesting without conspecifics	9 ^a , 21 ^b	8.42 \pm 0.57	0.27 \pm 0.19 ^b
	range	7.22 - 9.37	0.00 - 0.70
Nesting with BCNH	10, 20	8.46 \pm 1.09	0.39 \pm 0.30
	range	6.88 - 10.10	0.00 - 1.10
Nesting with LE and BCNH	5, 7	8.74 \pm 1.03	0.31 \pm 0.22 ^b
	range	7.38 - 10.00	0.00 - 0.60
<i>p</i> value		NS	NS

^aNumber of trees; ^bnumber of nest; NS, Not significant between years.

and tarsus (t -test, $t = 2.55$, $p < 0.01$) lengths were significantly greater in 2001 than in 2000.

The weight and tarsus growth rates did not differ among initial brood sizes in either 2000 or 2001. The culmen length differed among initial brood sizes in 2001 but not in 2000 (ANOVA, $F = 3.16$, $p < 0.05$). Wing length significantly differed among initial brood sizes in 2000 (ANOVA, $F = 5.73$, $p < 0.01$) but not in 2001.

Growth rates of the weight, culmen length, wing length, and tarsus length of Grey Heron chicks did not differ in relation to hatching order for any initial brood sizes in either 2000 or 2001 (Table 4).

DISCUSSION

In heronries, herons and egrets nest close to one another and partition the available space (Jenni 1969, Maxwell and Kale 1977, Parsons 1995, Kazantzidis et al. 1997). Interactions result in both horizontal and vertical stratification, in which vegetation type and structure were found to be very important in nest site selection (McCrimmon 1978, Beaver et al. 1980). Nest site selection (Frederick and Collopy 1989) and timing of clutch initiation (McNiel and Leger 1987) in heronries can affect breeding success of herons and egrets.

Table 2. Grey Heron clutch size, initial brood size, and final brood size in 2000 and 2001

	<i>n</i>	No. of eggs or chicks					Mean \pm SD	
		0	1	2	3	4		5
Clutch size ^{NS}								
2000	43			4	16	21	2	3.44 \pm 0.77
2001	45			5	19	21		3.36 \pm 0.68
Initial brood size ^{NS}								
2000	43	2	1	8	19	13		2.93 \pm 1.01
2001	45	1	1	8	24	11		2.96 \pm 0.85
Final brood size ^{NS}								
2000	43	3	7	18	11	4		2.14 \pm 1.04
2001	45	2	10	21	10	2		2.00 \pm 0.91

^{NS}, Not significant between years.

Table 3. Final Grey Heron brood sizes in 2000 and 2001 in relation to the initial brood size

	<i>n</i>	No. of nests with this final brood size					Mean \pm SD	
		0	1	2	3	4		
Initial brood size 1 (no test)								
2000	1		1					1
2001	1		1					1
Initial brood size 2 ^{NS}								
2000	8		2	6				1.75 \pm 0.46
2001	8		4	4				1.50 \pm 0.54
Initial brood size 3 ^{NS}								
2000	19	1	2	10	6			2.11 \pm 0.81
2001	24		4	13	7			2.13 \pm 0.68
Initial brood size 4 ^{NS}								
2000	13		2	2	5	4		2.85 \pm 1.07
2001	11	1	1	4	3	2		2.36 \pm 1.21

^{NS}, Not significant between years.

In the Pyeongtaek heronry, Grey Herons arrived first at the heronry (late Feb.) followed later by Little Egrets and Black-crowned Night Herons (early Apr.). Among these 3 species, the body size of Grey Herons is largest, while they are similar for Black-crowned Night Herons and Little Egrets. In this study, nest height and distance of the nest from the tree trunk of Grey Herons did not differ when nesting alone or combination with Black-crowned Night Herons and Little Egrets. The earliest Grey Herons arriving in the heronry selected the most suitable nest sites, such as the shortest distance from the tree trunk, as this is the place with the highest safety. We suggest that this selection is the result of the early arrival of Grey Herons at the heronry which limits competition for nest sites with other ardeids.

The mean clutch size of herons sometimes shows inter-colony differences in similar habitats

(Custer and Osborn 1977). The mean clutch size (3.36-3.44 eggs) of Grey Herons in our study was similar to clutch sizes in Spain (3.29 eggs, Campos 1984; 3.5 eggs, Fernandez-Cruz and Campos, 1993), but lower than records in England (4.0 eggs, Owen, 1960), Germany (4.3 eggs, Creutz 1981), and Albufera de Valencia (4.23 eggs, Prosper and Hafner 1996) and the Duero River basin (3.8 eggs, Campos and Fraile 1990) in Spain (Table 5). Erwin et al. (1996) and Kim and Koo (2007) found that the clutch size of Black-crowned Night Herons did not significantly change between years; however, variations in clutch size of Snowy Egrets *Egretta thula* were significant (Erwin et al. 1996). In this study, the clutch size of Grey Herons did not significantly differ between 2000 and 2001.

The mean of 2.14 fledglings per successful nest in this colony was lower than records from England (2.9 chicks, Owen 1960), France

Table 4. Mass, culmen, wing, and tarsus growth rates (mean \pm SD) for Grey Heron chicks in 2000 and 2001

Chick	<i>n</i>	Year	Mass (g)	Culmen (mm)	Wing (mm)	Tarsus (mm)
A	3	2000	41.9 \pm 27.0 ^{NS}	2.82 \pm 2.64 ^{NS}	8.76 \pm 6.69 ^{NS}	4.59 \pm 2.01 ^{NS}
	3	2001	45.4 \pm 18.1 ^{NS}	2.16 \pm 0.71 ^{NS}	10.00 \pm 3.40 ^{NS}	4.00 \pm 0.94 ^{NS}
B	3	2000	37.4 \pm 27.5	1.80 \pm 0.99	6.29 \pm 5.10	3.72 \pm 2.44
	3	2001	43.3 \pm 17.5	2.24 \pm 0.46	9.36 \pm 3.49	3.80 \pm 1.03
mean		2000	39.7 \pm 21.9	2.53 \pm 1.04	7.53 \pm 5.86	4.15 \pm 2.19
		2001	44.4 \pm 17.6	2.20 \pm 0.59	9.67 \pm 3.34	3.89 \pm 0.97
A	4	2000	38.0 \pm 12.9 ^{NS}	2.70 \pm 0.78 ^{NS}	11.10 \pm 4.59 ^{NS}	4.20 \pm 1.55 ^{NS}
	4	2001	61.9 \pm 16.4 ^{NS}	2.54 \pm 0.74 ^{NS}	9.42 \pm 2.97 ^{NS}	4.41 \pm 2.10 ^{NS}
B	4	2000	32.0 \pm 17.4	2.56 \pm 1.34	9.68 \pm 3.02	3.89 \pm 1.27
	4	2001	55.1 \pm 24.4	2.54 \pm 0.74	9.42 \pm 2.97	4.33 \pm 1.76
C	4	2000	33.2 \pm 21.7	2.51 \pm 1.04	6.49 \pm 2.50	2.31 \pm 1.74
	4	2001	41.3 \pm 15.8	2.02 \pm 1.02	6.99 \pm 5.81	3.63 \pm 1.94
mean		2000	35.7 \pm 16.0	2.59 \pm 0.96	9.10 \pm 3.80	3.47 \pm 1.67
		2001	50.7 \pm 21.1	2.32 \pm 0.78	8.38 \pm 4.47	4.13 \pm 1.94
A	4	2000	47.6 \pm 16.5 ^{NS}	3.12 \pm 1.40 ^{NS}	6.63 \pm 4.22 ^{NS}	3.73 \pm 1.57 ^{NS}
	4	2001	52.0 \pm 20.9 ^{NS}	3.02 \pm 1.06 ^{NS}	10.25 \pm 4.31 ^{NS}	5.16 \pm 1.91 ^{NS}
B	4	2000	46.9 \pm 25.6	2.72 \pm 1.19	4.52 \pm 4.35	2.53 \pm 1.79
	4	2001	52.2 \pm 24.7	2.27 \pm 0.56	11.93 \pm 2.49	3.15 \pm 4.34
C	4	2000	45.8 \pm 11.5	2.59 \pm 1.64	2.19 \pm 0.95	3.15 \pm 2.21
	4	2001	49.3 \pm 6.5	3.02 \pm 2.04	12.90 \pm 5.48	4.34 \pm 1.64
D	4	2000	34.9 \pm 8.4	1.98 \pm 1.09	2.17 \pm 1.05	2.05 \pm 1.54
	4	2001	51.8 \pm 14.8	2.52 \pm 0.62	8.37 \pm 4.11	4.77 \pm 1.05
mean		2000	43.8 \pm 17.5	2.60 \pm 0.24	3.88 \pm 1.90	2.87 \pm 1.31
		2001	51.6 \pm 17.5	2.70 \pm 1.05	9.77 \pm 4.94	4.65 \pm 1.50
Between years			NS	NS	<i>p</i> < 0.01	<i>p</i> < 0.01
Among initial brood sizes		2000	NS	NS	<i>p</i> < 0.01	NS
		2001	NS	<i>p</i> < 0.05	NS	NS

n, Number of nests. ^{NS}, Not significant

(2.34-2.85, Thomas and Hafner 2000; 2.6 chicks, Marion 1980), Germany (3.6 chicks, Creutz 1981), Belgium (3.1 chicks, van Vessem and Draulans 1986b), Albufera de Valencia, Spain (3.56 chicks, Prosper and Hafner 1996), western Spain (2.6 chicks, Fernandez-Cruz and Campos 1993), and Poland (3.4-3.7 chicks, Jakubas 2005), but was similar to that of the Duero River basin in Spain (2.32 chicks, Campos 1984; 2.2 chicks, Campos and Fraile 1990) (Table 5). As was found in this study, mean brood size did not differ between years at Carmague, France (Thomas and Hafner 2000). However, brood size differed in relation to nesting habitat such as in reedbeds and trees (Thomas and Hafner 2000).

In North America, clutch size and chick fledging success of herons and egrets decrease as the season progresses (Erwin et al. 1996). This suggests that local prey abundance within the foraging range of the colony influences reproductive activities early and throughout the season, and also a mild winter can influence the reproductive success (Prosper and Hafner 1996). Probable factors affecting reproductive success include predation by birds, mammals, and reptiles; weather conditions such as gales and storms; food availability; disease; pollutants; disturbance by humans; sibling aggression; the number of feeding visits; and heronry size (Parson and Burger 1982, Stotskaja 1984, Frederick and Collopy 1989, Butler et al. 1995, Yu and Hahm 1997, Kim et al. 1998, Jeong and Won 1999, Jakubas 2005, Kim et al. 2006, Gilbert et al. 2007, Kim and Koo 2007). For these reasons, siblicide is an important contributing factor to reproductive failure of Grey

Hérons (Stotskaja 1984, Jakubas 2005). Jakubas (2005) reported the number of feeding visits, and found that siblicide was a very important reason for mortality of Grey Heron chicks. The number of feeding visits was significantly correlated with the reproductive success of large chicks and fledglings (Jakubas 2005), but sibling aggression was not (Jakubas 2004a). However, in Poland, the distance from the breeding site to the feeding habitat was correlated with siblicide, and in 3 Grey Heron colonies close to feeding habitats, decreased sibling aggression and siblicide were recorded (Jakubas 2005). The decrease in siblicidal behavior was probably an effect of foraging by parent birds in feeding areas close to the colony, with an abundance of high-quality and easily caught prey. As a result, the chick mortality rate was low (Jakubas 2004a b). However, increased distances between heron colonies and the feeding habitats have a negative influence on the number of feeding visits, and decreased feeding visits can result in lower reproductive success of ardeids (Simpson et al. 1987, Frederick and Spalding 1994). In the Pyeongtaek colony, heron and egret individuals decreased from 2000 to 2001 (Kim and Koo 2007), but the reproductive success of Grey Herons did not differ between the 2 yr of this study.

Older Grey Heron chicks are large and formidable to most predators, in contrast to eggs and small chicks (Milstein et al. 1970, van Vassem and Draulans 1986a, Jakubas 2004a). We found that predators at the Pyeongtaek colony included Black-billed Magpies *Pica pica* and the raccoon *Nyctereutes procyonoides*. The former is an egg

Table 5. Clutch size, initial brood size, and final brood size of Grey Herons from previous studies and this study

Site	Clutch size	Final brood size	Source
England	4.0	2.9	Owen 1960
France	-	2.6	Marion 1980
Germany	4.3	3.6	Creutz 1981
Belgium	-	3.1	van Vessem and Draulans 1986b
Spain	3.29	2.32	Campos 1984
	-	2.2	Campos and Fraile 1990
	3.5	2.6	Fernandez-Cruz and Campos 1993
	4.23	3.56	Prosper and Hafner 1996
France	-	2.3 - 2.85	Thomas and Hafner 2000
Poland	-	3.3 - 3.9	Jakubas 2004
Korea	3.44	2.14	This study

predator, and the latter is a chick predator. In Poland, predators of Grey Heron chicks included Ravens *Corvus corax*, Carrion Crows *Corvus cornix*, Black-billed Magpies *Pica pica*, and White-tailed Eagles *Haliaeetus albicilla* (Jakubas 2005). Large birds of prey were reported to be predators of heron chicks in British Columbia, Canada (Butler et al. 1995).

Asynchronous hatching in egrets and herons may result in senior broodmates that are superior to younger siblings in food handling and aggressive interactions (Mock and Parker 1986). Consequent competition among siblings may result in lower growth rates for younger siblings (Werschkul 1979). Many researchers have reported differences in growth rates of herons and egrets in relation to hatching order (McClure et al. 1959, Wolford and Boag 1971, Parsons and Burger 1982, Custer and Peterson 1991, Erwin et al. 1996, Kim et al. 2006, Kim and Koo 2007). In this study, weight gain was the largest for the 1st hatched chick compared to the other chicks.

Breeding success depends not only on a safe nest site but also on the quality of the surrounding feeding areas. Conservation attempts need to protect breeding sites as well as preserve large-scale habitat near nesting colonies (Kushlan 1997). In the Pyongtaek heronry, Grey Herons forage at the Anseong and Jinwee streams within 4-7 km of the breeding site. We suggest that this species can be useful as a bioindicator of freshwater ecosystems because they forage in fresh water not the sea. Deteriorating stream environments used as foraging sites will affect the reproductive parameters of Grey Herons.

Our data suggest that clutch size, reproductive success, and growth rate did not differ between years. Therefore, we concluded that colony changes such as variations in population size and breeding species did not affect clutch size, reproductive success, or the growth rate of Grey Herons.

Acknowledgments: We are grateful to T.W. Custer (USGS) for critically reading and commenting on the manuscript.

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