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# Clutch size, reproductive success, and growth rate of the Little Egrets *Egretta garzetta*

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We studied clutch size, reproductive success and growth rate of the Little Egrets *Egretta garzetta* in three mixed species heronries in Pyongtaek, Korea, 2000. The mean clutch size of the Little Egrets was $3.48 \pm 0.93$ eggs, and the mean initial brood size was $2.65 \pm 1.90$ chicks, and mean final brood size was $2.86 \pm 0.90$ chicks. The initial brood size was highly significant between clutch sizes (ANOVA, $p < 0.01$), and final brood size was high difference not only between clutch sizes but also between initial brood sizes (ANOVA, $p < 0.01$). Hatching success and fledging success was highly significant between clutch sizes (ANOVA, $p < 0.01$). Growth rate between initial brood sizes, weight (ANOVA, $p < 0.05$), culmen length (ANOVA, $p < 0.01$) and wing length (ANOVA, $p < 0.01$) had significantly different. Between hatching orders per nest, culmen (ANOVA, $p < 0.05$) and wing (t–test, $p < 0.05$) length has significantly different in initial brood size 3 and in initial brood size 2, respectively. However, tarsus–length growth rate was not significant between hatching orders, and between initial brood sizes.

## INTRODUCTION

Collnially nesting wading birds (Ciconiiformes) have been identified as one potential bioindicator group by a number of researchers (Erwin *et al.*, 1996). Measures of reproductive success in Ciconiiformes are known to vary widely depending on species, location, degree of predation, and environmental conditions (Bildstein *et al.*, 1990). Their reproductive parameters may be the most sensitive bioindicators of the population, community, and ecosystem because they reveal primary responses to environmental changes (Temple and Wiens, 1989). Therefore, nesting success and other measures of reproductive performance of Ciconiiformes can be a bioindicator of effect for certain ecosystem conditions (Fox *et al.*, 1991).

The reproductive parameters were affected by prey abundance, density or availability (Frederick and Spalding, 1994), by predation by a variety of mammals, reptiles and birds (Frederick and Collopy, 1989; Kim *et al.*, 1998), as well as by human disturbance (Parsons and Burger, 1982), and by disease (Wiese *et al.*, 1977).

The Little Egrets *Egretta garzetta* migrates to Korea for breeding in late March or in early April, and then returns to the Philippines, Indonesia, and Malaysia for wintering in late September or in early October. They feed on food such as fish, amphibians, reptiles, and invertebrates in farming area, stream, and river (Won, 1981). However, a number of wintering Little Egrets is increasing after 1990's with southern of Korea in the center.

We investigated the clutch size, reproductive success, and growth rate of the Little Egrets in Pyongtaek city, Gyeonggi–Do, Korea in 2000. This breeding site was three mixed species heronry (Black–crowned Night Herons *Nycticorax nycticorax*, Little Egrets and Grey Herons *Ardea cinerea*) in 2000. This research was carried out to inform possibility as bioindicator of Little Egrets in ecosystem.

## STUDY AREA AND METHODS

Our data were gathered at the Pyongtaek city (37°02'N, 127°02'E), Gyeonggi–Do, Korea, where the Black–crowned Night Herons and Grey Herons nest in the same colony. The elevation of breeding area is about 55 m, and width is 9,000 $m^2$.

Rice paddy field surrounds the colony. The distance from breeding site to foraging sites is 3.9 km to Jinwee stream, and 6.8 km to Anseong and Jinwee stream confluence area, respectively.

The colony is dominated by the Oriental Chestnut Oaks *Quercus acutissima* (>70%), and the Pitch Pines *Pinus rigida*, the Red Larches *Larix leptolepis*. The majority of the Little Egrets nests were 7–9 m high from ground level in trees.

Since Ardeid nests are most susceptible to disturbance in the nest–building to egg laying period (Tremblay and Ellison, 1979), we limited our visits to one early in the period (mid–April) and then two per week from late incubation (>25 April) onward.

Clutch size and initial brood size were determined by looking into openly visible nests on trees. The final brood size was determined when chicks were 4 weeks old after hatching. We considered chicks as successfully fledged when they were more than 4 weeks old after hatching because they were old enough to fly across open spaces to trees away from the nests. We calcu-

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lated the hatching and fledging success per nest.

We assigned hatching orders to chicks based on observed hatching dates or, for unknown dates, we used relative size (length of the bird's culmen; Custer and Peterson 1991). A–chicks were the first hatched, B–chicks the second hatched, and so on, and we then added a number behind the letter to indicate total number of hatchlings per nest – such that Hatchling A 4 indicated it was the first hatchling in a nest of 4 total hatchlings. For each chick, body weight and length of culmen, wing, and tarsus were measured every 3–4 days according to the methods of Baldwin *et al.* (1931). On every visit, we measured chick mass using an Ohaus electronical balance (unit; 0.1 g). We also measured culmen, wing, and tarsus length using vernier calipers (unit; 0.01 mm). We measured growth rates of chicks from 5 days to 21 days after hatching.

We used t–test and one–way analysis of variance (ANOVA) for statistical analysis by SPSS 10.0 version.

## RESULTS

In 2000, there were 114 pairs of the Black–crowned Night Herons, 98 pairs of the Little Egrets, and 275 pairs of Grey Herons.

The Little Egrets clutch size ranged from 2–6 eggs with 3 and 4 eggs/nest being most common (respectively 38.7%), and the mean clutch size of the Little Egrets was $3.48 \pm 0.93$ eggs. The mean initial brood size was $2.65 \pm 0.90$ chicks, and mean final brood size was $2.86 \pm 0.90$ chicks, and the highest initial brood size (38.7%) and final brood size (51.7%) was 3 chicks (**Table 1**).

**Table 1.** Clutch size, initial brood size, and final brood size analyses for the Little Egrets.

| N | No. of eggs or chicks | | | | | | | Mean±SD |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | |
| Clutch size | | | | | | | | |
| 31 | | | 4 | 12 | 12 | 2 | 1 | 3.48±0.93 |
| Initial brood size | | | | | | | | |
| 31 | 2 | | 8 | 12 | 7 | 2 | | 2.90±1.65 |
| Final brood size | | | | | | | | |
| 29 | | 3 | 5 | 15 | 5 | 1 | | 2.86±0.95 |

N was number of nest.

Comparing chick production per nest (based on successfully hatched nests), the initial brood size was high significant between clutch sizes (ANOVA, $p<0.01$), and final brood size was high significant not only between clutch sizes but also between initial brood sizes (ANOVA, $p<0.01$) (**Table 2**). Therefore, the clutch size and initial brood size had a significant effect on final brood size. Large clutch size had larger initial and final brood size than small clutch size.

The mean hatching success was $85.0 \pm 26.6\%$, and the mean fledging success was $77.4 \pm 27.3\%$ (**Fig. 1**). Hatching success and fledging success were highly significant between clutch sizes (ANOVA, $p<0.01$).

**Table 2.** Initial and final brood size by clutch size of Little Egret.

| Clutch size | N | Initial brood size (mean±SD)** | Final brood size (mean±SD)** |
|---|---|---|---|
| 2 | 4 | 2.00±0.00 | 1.25±0.50 |
| 3 | 12 | 2.67±0.49 | 2.67±0.49 |
| 4 | 12 | 3.08±1.51 | 2.92±1.44 |
| 5 | 2 | 4.00±1.41 | 3.50±0.71 |
| 6 | 1 | 5.00 | 4.00 |

** was $p<0.01$, ANOVA. When statistical analyzing, except clutch size 6 because of sample size was small.

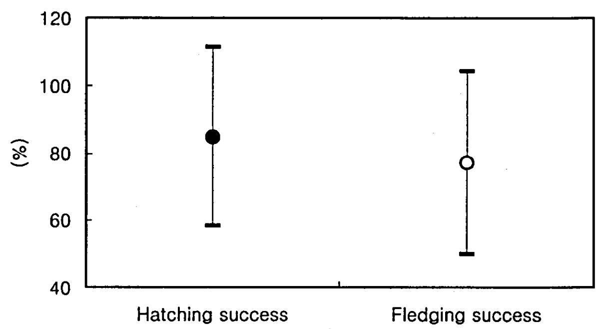


**Fig. 1.** Hatching and Fledging success (mean±SD) of the Little Egrets.

**Table 3.** The final brood size by initial brood size of the Little Egrets

| N | Number of nest with final brood size | | | | | | Mean±SD |
|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | |
| Initial brood size 2 | | | | | | | |
| 8 | | 3 | 5 | | | | 1.63±0.52 |
| Initial brood size 3 | | | | | | | |
| 12 | | | | 12 | | | 3.00±0.00 |
| Initial brood size 4 | | | | | | | |
| 7 | | | | 2 | 5 | | 3.71±0.49 |
| Initial brood size 5 | | | | | | | |
| 2 | | | 1 | | | 1 | 4.00±1.41 |

N was number of nest.

We evaluated growth rate of chicks that to know initial brood size and hatching order had an effect on it. The Little Egret chicks showed the highest growth rate on A–chick of all initial brood size. Between initial brood sizes, weight (ANOVA, $p<0.05$), culmen length (ANOVA, $p<0.01$) and wing length (ANOVA, $p<0.01$) were significantly difference but tarsus length was not (**Table 4**).

For hatching order in an initial brood size, weight and wing length were not difference in all initial brood size. However, culmen length (ANOVA, $p<0.05$) and wing length (t–test, $p<0.05$) were significantly difference in initial brood size 3 and initial brood size 2, respectively but other initial brood sizes were not difference (**Table 4**).

**Table 4.** Weight, culmen, wing, and tarsus growth rates (mean±SD) for the Little Egrets chicks.

| Initial brood size | Chick order | Weight*,[a] (g) | Culmen** (mm) | Wing** (mm) | Tarsus (mm) |
|---|---|---|---|---|---|
| | A | 18.98±7.65 | 1.97±0.81 | 3.15±1.20* | 2.97±1.09 |
| 2 | B | 13.88±7.80 | 1.42±0.82 | 1.58±0.83 | 1.93±1.24 |
| | Mean | 17.12±7.75 | 1.77±0.82 | 2.58±1.31 | 2.59±1.20 |
| | A | 29.29±31.00 | 1.72±0.13 *,[b] | 13.03±9.96 | 3.78±2.59 |
| | B | 26.83±15.89 | 1.53±0.33 | 11.52±4.59 | 3.68±1.02 |
| 3 | C | 20.05±17.09 | 0.68±0.55 | 11.43±1.13 | 2.59±1.20 |
| | Mean | 28.78±22.91 | 1.21±0.61 | 12.14±6.67 | 3.73±1.77 |
| | A | 23.70±21.90 | 1.61±0.60 | 7.34±7.41 | 4.65±4.87 |
| | B | 21.55±20.48 | 1.57±0.82 | 7.24±6.79 | 4.36±4.86 |
| 4 | C | 20.07±20.03 | 1.54±0.73 | 5.22±4.86 | 4.11±3.81 |
| | D | 13.26±7.89 | 1.39±0.63 | 3.83±2.79 | 3.29±2.83 |
| | Mean | 19.93±18.63 | 1.53±0.69 | 6.02±5.87 | 4.00±3.98 |
| | A | 20.55±8.09 | 2.52±0.57 | 8.24±4.44 | 3.79±1.20 |
| | B | 19.76±10.11 | 2.06±0.33 | 7.54±3.97 | 3.21±1.00 |
| 5 | C | 16.47±5.25 | 2.03±0.33 | 4.70±1.80 | 2.80±0.93 |
| | D | 15.62±10.21 | 1.86±0.31 | 3.77±0.84 | 2.77±0.81 |
| | E | 7.11±3.86 | 2.26±1.77 | 3.50±2.19 | 2.40±0.98 |
| | Mean | 16.67±8.60 | 2.13±0.70 | 5.73±3.41 | 3.05±1.01 |

In all initial brood size, number of nests was 3–4.
* was $p<0.05$, ** was $p<0.01$ (one-way ANOVA) except wing length in initial brood size 2 (t-test).
[a] was statistical analysis between initial brood size.
[b] was statistical analysis for hatching order in an initial brood size.

## DISCUSSION

The clutch sizes of the Little Egrets vary 2～6 eggs, rarely 8, but are most often 5 eggs in temperate, 3 in tropical zone (Hancock and Elliott, 1978). This study was 2～6 eggs, and the most incidence were 3 and 4 eggs. Our mean clutch size was smaller than Jeong's (**Table 5**). The mean clutch size sometimes shows inter-colony differences in similar habitats (Custer and Osborn, 1977). The clutch size variation was a result of differences in food availability, and available energy within the foraging range of colony (Eldridge and Krapu 1988), distance from breeding site to foraging site (Rudegeair, 1975). Be deteriorated wetland condition, these factors bring about low average clutch sizes in herons, survival and fledging success (per hatched egg) may also be reduced (Erwin *et al.*, 1996).

In this study, initial brood number was 2.90±1.65 (ranged from 0 to 5), was lower than 4.3±1.0 (1982), 3.5±1.6 (1986) in Japan (Fujioka, 1989) and 4.2±0.9 in Korea (Jeong, 1998). Our young fledged from successful nests was 2.86±0.95, and was considerably higher than 1.10～2.00 (Baxter, 1994), 1.47～2.70 (Maddock and Baxter, 1991) in a Australian study, but was lower than 3.5±1.3 in Korean study (Jeong, 1998), however was in similar to 2.95 in a Japanese study (Inoue, 1985). In this study, produced young was more in large clutch size than in small. This study showed that the clutch size affected to initial brood size, and final brood size was affected to clutch size and initial brood size. We suggest that in two Korean studies, difference of initial brood size and final brood size was attributed to clutch size.

**Table 5.** Published arithmetic mean clutch size, initial brood size and final brood size of the Little Egrets

| Area | Clutch size | Initial brood size | Final brood size | Source |
|---|---|---|---|---|
| Japan | | | 2.95 | Inoue 1985 |
| Japan | – | 4.3±1.0<br>3.5±1.6 | – | Fujioka 1989 |
| Australia | – | – | 2.09±0.84 | Maddock and Baxter 1991 |
| Australia | – | – | 1.10~2.00 | Baxter 1994 |
| Korea | 4.5±0.9 | 4.2±0.9 | 3.5±1.3 | Jeong 1998 |
| Korea | 3.48±0.93 | 2.90±1.65 | 2.86±0.95 | This study |

Maddock and Baxter (1991) suggested that mean fledging success was not affected to climate variation such as rainfall, wet and dry condition for breeding season, but it was affected to position of natal tree in a colony (Baxter, 1994). Probable factors affecting reproductive success was predation by birds, mammals, and reptiles (Kim *et al.*, 1998), weather condition such as a gale and heavy rain (Kim *et al.*, 1998), starvation by food availability (Fujioka, 1989), disease, pollutant (Kushlan, 1989), and disturbance by man (Parson and Burger, 1982). Fledging success of the Little Egrets was affected to predator and weather condition such as a gale and heavy rain in Pyongtaek. Predators of the Little Egrets were the Black-billed Magpies *Pica pica*, and Raccoons *Nyctereutes procyonoides* in Pyongtaek. The former was egg predators, and the latter was chick predators. We suspect that the Black-crowned Night Herons might be predated the Little Egrets chicks because confirmed the Little Egret chicks in the Black-crowned Night Herons regurgitation.

Asynchronous hatching in Ardeidae, weight gain was the largest senior broodmates because they are superior to younger siblings in food handling and aggressive interactions (Inoue, 1985). Consequent competition among siblings may result in lower growth rate for younger siblings (Werschkul, 1979). In our study, growth rate of weight between siblings was the largest the first hatching chick than other chicks, but was not significantly difference for hatching order in an initial brood size. However, weight gain had significantly different between initial brood sizes.

Breeding success depends not only on a safe nest site but also on the quality of the surrounding feeding areas, conservation attempts need to focus on breeding site protection as well as on large scale habitat preservation near nesting colonies (Kushlan, 1997). In Pyongtaek, the Little Egrets foraging Anseong and Jinwee stream in 4–7 km from breeding site. We suggest that they have bioindicator possibility because foraging not in sea but in fresh water. Becoming worse stream environment, it will be affected to reproductive parameter of the Little Egrets. Therefore, they are probably good bioindicator in fresh water environment for feeding.

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