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Age-related Difference in Bill Length of the Grey Heron *Ardea cinerea jouyi* and Estimation of Prey Size Using Bill Length

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For most birds, direct estimation of ingested prey mass in the field is usually difficult. Therefore, estimating prey size from a comparison with the bill length has often been used. Because this method rarely disturbs birds and is applicable to various field situations, it has been used in studies of many types of birds (*e.g.*, GOSS-CUSTARD 1977, ZWARTS & BLOMERT 1992, EGUCHI 1993). In the case of wading birds such as herons and egrets, it is relatively easy to observe their foraging behavior in the field and the direct estimation method has often been adopted (*e.g.*, RECHER & RECHER 1969, KREBS 1974, RICHNER 1986, DRAULANS 1987). BAYER (1985) pointed out four factors pertinent to this method, which can cause errors in estimating prey length. Three of them, the indistinctness of the exposed culmen's edge, absence of any reference mark on the bill, and casual occurrence of prey longer than the bill, can be overcome by video recording. However, the fourth problem, the individual difference of bill length, still remains a problem. In a field situation, it is usually impossible to know the exact length hence the beforehand knowledge of the mean and the degree of variation in bill length is very important. Here we report the measurements of the bill lengths of the Grey Herons *Ardea cinerea* in Asia, and discuss some implications.

Bill (exposed culmen) lengths were measured from 95 skins (including a few frozen specimens) at 21 museums and 4 live birds captured in Kushiro City, Hokkaido. These samples were originated from various localities in Asia, from Japan, continental China, Korea and Sakhalin. Size difference between sexes and age classes could be the main source of individual size variation. Although for the Grey Heron sex is not distinguishable from its appearance, we could sex 43 of 99 specimens (25 of 65 for adults and subadults) using museums' record. We classified these herons into three age groups (adults, subadults and juveniles) on the basis of plumage coloration (CRAMP & SIMMONS 1977). Pre-fledging juvenile was not included in the samples. The date of death (or measuring) of these juveniles for which data were available, ranged from late June to March of the next year. For our comparison, data for adults and subadults were pooled, because significant difference was not detected between these two age classes (Student's *t*-test, $t=2.32$, $df=63$, $P=0.82$).

Bill lengths of the two age classes are shown in Fig. 1. The average bill length for the sample of Grey Herons in this study was 114 ± 8.08 mm ($N=99$). Average bill length of non-juvenile (adult + subadult) males is larger than that of females (117 mm, $SD=6.67$, $n=15$, vs. 112 mm, $SD=5.08$, $n=10$), but the difference is not significant (Student's *t*-test, $df=23$, $t=1.89$, $P=0.07$), probably due to small sample size. Frequency distributions for both age classes were not significantly deviated from

Fig. 1. Frequency distribution of bill length (mean $\pm$ SD, mm) of Grey Heron. Dotted column denotes subadults. Figures in parentheses indicate sample size and range.

Table 1. Eye-bill tip length and gape length (mean $\pm$ SD, mm) of non-juvenile Grey Heron and their conversions from bill length (BL). We were unable to measure these lengths, gape length in particular, for some skins.

Eye-Bill Tip Conversion	Gape Conversion
140 $\pm$ 8.17	145 $\pm$ 9.54
y=1.13*BL+7.93	y=1.21*BL+3.82
r ² =0.91, n=53	r ² =0.74, n=32

normal distribution (Kolmogorov-Smirnov one sample test, $D=0.05$, $df=64$, $P>0.20$ for non-juvenile, $D=0.21$, $df=33$, $P>0.05$ for juvenile, Fig. 1). Bill length of juveniles was significantly shorter than that of non-juveniles (Student's t -test, $t=5.22$, $df=97$, $P<0.001$). Here we also show eye-bill tip length and gape length of the Grey Heron, which were recommended by BAYER (1985) as more effective indicators in estimating prey size (Table 1). Because eye-bill tip length has less variance than gape length, the former would be suitable if these lengths are used as a prey size indicator following his recommendation.

The Grey Heron is divided into four subspecies, and the one found in Asia, *Ardea cinerea jouyi* Clark, is distinguished from the European nominate *A. c. cinerea* L. (CRAMP & SIMMONS 1977). In the case of the Grey Heron (*A. c. cinerea*) in the Netherlands, the average bill length of adult males (120 mm) is significantly larger than that of adult females (112 mm). For males, the average bill length of *A. c. jouyi* is shorter than that of *A. c. cinerea*, but the difference is not significant (one sample t -test, $t=1.94$, $df=14$, $P=0.07$). Although VOISIN (1991) stated that the difference between the average bill lengths of juvenile and adult Grey Herons is generally not large, we found for the first time a significant difference between these age groups.

The shorter bill of juveniles indicates development during post-fledging period. Although fledging date is variable, regression between bill length (y : mm) and date of death (x : month 6-9) is significantly correlated ($y=7.02 \cdot X + 54.18$, $r^2=0.52$, $n=13$, $p=0.005$). Bill length is estimated at 96, 103, 110 and 117 mm (same size as adult) from June to September, respectively. These estimated lengths would be useful for field study.

Some studies have reported age-related differences in foraging behavior; Young birds are less efficient than adults because of poorer hunting skills, a lower social position and a difference in motivation (e.g., RECHER & RECHER 1969, COOK 1978, DRAULANS 1987, MARCHETTI & PRICE 1989). However, there seems to be no study in which the difference in bill length between adults and juveniles was taken into consideration when discussing the difference in foraging behavior, at least for Ciconiiform birds. The age-related difference in bill size should be kept in mind for some species when using bill size to estimate prey size in the field. If not, prey size captured and hence foraging efficiency could be overestimated for juveniles.

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アオサギの嘴峰長の齢による差と嘴峰長を用いた餌の大きさ判定法。鳥類の場合、その摂取エサ量を嘴峰長との相対サイズから評価する方法があり、この方法はサギ類などでも多く用いられている。より正確な摂取量の評価には、嘴峰長の個体による差を把握する必要がある。日本におけるアオサギ

の嘴峰長の測定結果から、幼鳥は成鳥より有意に嘴峰長が短いことが判った。サギ類の成鳥と幼鳥との採餌行動を比較した研究では、齢による嘴峰長の差を考慮した例はないが、幼鳥の巣立ち後、数カ月間は嘴峰長の差に注意を払う必要があるだろう。

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