

## Wing areas and other dimensions of Greater and Lesser Flamingos

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Wing areas and other dimensions for seven Greater and eight Lesser Flamingos are presented. Indices of aspect ratio and wing loading and estimates of the costs of flapping flight (Masman & Klaassen 1987) were calculated for each bird. Greater Flamingos apparently incur higher costs in flight than Lesser Flamingos, while flight costs for males of both species are probably lower than for females.

### INTRODUCTION

There are no published data, as far as we know, on the wing areas of Greater *Phoenicopterus ruber* and Lesser Flamingos *P. minor*. This paper presents these and other measurements recorded on seven Greater Flamingos and eight Lesser Flamingos collected on the Ekuma River (18° 35'S; 16° 03'E) in the Etosha National Park, South West Africa/Namibia. The specimens are now preserved in the State Museum, Windhoek.

### METHODS

The following measurements were recorded: (a) Body Mass (g) recorded using a Pesola scale accurate to about 1%. (b) Wing Area (cm<sup>2</sup>) measured from tracings of one extended wing and doubled for the area of both wings. The wing was flattened onto paper and extended so that the leading edge formed as straight a line as possible. Our wing areas exclude the area of the body and tail. (c) Wing Span (cm), the maximum distance between the tips of the extended wings. (d) Wing Length (mm), the standard measurement of the flattened wing from the wrist (carpometacarpal joint) to the tip of the longest primary feather. (e) Secondary Length (mm), the length of the most distal secondary remex, flattened and measured from the wrist to the tip of the feather. (f) Ulnar Length (mm) from the folded wrist to the inner side of the elbow joint, actually to the inner side of the distal humerus and thus an index of the length of the ulnar. (g) Tail Length (mm) from the tip of the longest rectrix to the posterior base of the uropygial gland. (h) Tarsus (tarsometatarsus) Length (mm) from the posterior centre of the tibiotarsal-

tarsometatarsal joint to the base of the hind toe. (i) Culmen Length (mm) from the tip of the culmen to the suture at the skull-bill junction. (j) Total Body Length (cm) from the tip of the culmen to the tip of the longest claw, the body being fully extended. Sex was determined by inspection of the gonads.

The following ratios and indices were calculated for each bird: (a) Aspect Ratio (wing span<sup>2</sup>/wing area), (b) Mass Loading (body mass/wing area, i.e. g/cm<sup>2</sup>) and (c) Linear Loading (cube root of mass/square root of wing area, g<sup>0.33</sup>/cm) (see Jakšić & Carothers 1985). We also estimated the costs of flapping flight for each bird from a multiple regression of body mass, wing area and wing span to predict the cost (in Watts) of flight (Masman & Klaassen 1987).

### RESULTS & DISCUSSION

The Appendix lists the original measurements for each individual bird. Table 1 compares the dimensions of the two species by combining data for both sexes. Greater Flamingos were larger in all measurements. The costs of flapping flight for Greater Flamingos were probably about 39% greater than those for Lesser Flamingos, perhaps in relation to the higher absolute wing loading (see Mass Loading) of Greater Flamingos. However, they carry relatively lighter loads (Linear Loading) and their aspect ratios were similar to those of Lesser Flamingos.

Males were significantly larger than females in both species, except for body mass and length in Lesser Flamingos and culmen length in Greater Flamingos (Table 1). Although their wing

TABLE 1. Means, standard deviations and sample sizes of various measurements and indices (see text) of Greater and Lesser Flamingos. The first section compares the two species while males and females of each species are compared in the second and third sections. Students t-tests: NS—not significant, \* —  $p < 0.05$ , \*\* —  $p < 0.025$ , \*\*\* —  $p < 0.01$ , \*\*\*\* —  $p < 0.005$ .

| SPECIES                  | BODY MASS (g) | WING AREA (cm <sup>2</sup> ) | WING SPAN (cm) | WING LENGTH (mm) | SECONDARY LENGTH (mm) | ULNAR LENGTH (mm) | TAIL LENGTH (mm) | TARSUS LENGTH (mm) | CULMEN LENGTH (mm) | BODY LENGTH (cm) | ASPECT RATIO | FLIGHT COST (Watts) | MASS LOADING | LINEAR LOADING |
|--------------------------|---------------|------------------------------|----------------|------------------|-----------------------|-------------------|------------------|--------------------|--------------------|------------------|--------------|---------------------|--------------|----------------|
| Greater Flamingo         | AVERAGE       | 2661.00                      | 161.11         | 409.14           | 220.00                | 229.71            | 130.00           | 289.29             | 123.57             | 12.36            | 9.98         | 92.75               | 1.059        | 0.274          |
|                          | SD            | 171.98                       | 9.69           | 16.90            | 9.77                  | 13.86             | 11.34            | 19.98              | 3.29               | 0.33             | 0.96         | 16.18               | 0.086        | 0.010          |
| Lesser Flamingo          | AVERAGE       | 1685.71                      | 122.29         | 333.50           | 184.13                | 180.75            | 103.38           | 191.38             | 97.50              | 9.75             | 9.31         | 66.63               | 0.944        | 0.284          |
|                          | SD            | 119.30                       | 11.93          | 14.64            | 12.18                 | 10.54             | 6.28             | 15.91              | 6.10               | 0.61             | 0.92         | 14.65               | 0.063        | 0.008          |
| Greater Flamingo Males   | AVERAGE       | 2751.00                      | 169.17         | 419.75           | 227.75                | 239.75            | 157.50           | 303.75             | 125.25             | 12.53            | 10.67        | 81.94               | 1.043        | 0.271          |
|                          | SD            | 140.15                       | 4.29           | 12.95            | 2.86                  | 5.72              | 9.01             | 11.10              | 1.48               | 0.15             | 0.88         | 12.01               | 0.102        | 0.011          |
| Greater Flamingo Females | AVERAGE       | 2481.00                      | 150.43         | 395.00           | 209.67                | 216.33            | 140.00           | 270.00             | 121.33             | 12.13            | 9.07         | 108.96              | 1.092        | 0.280          |
|                          | SD            | 29.00                        | 1.02           | 9.63             | 4.99                  | 9.57              | 4.08             | 10.80              | 3.68               | 0.37             | 0.01         | 0.22                | 0.009        | 0.001          |
| Lesser Flamingo Males    | AVERAGE       | 1690.00                      | 139.20         | 353.00           | 196.00                | 195.00            | 110.00           | 217.00             | 107.00             | 10.70            | 10.47        | 52.69               | 0.915        | 0.277          |
|                          | SD            | 90.00                        | 0.80           | 4.00             | 14.00                 | 0.00              | 4.00             | 7.00               | 1.00               | 0.10             | 0.27         | 0.35                | 0.083        | 0.010          |
| Lesser Flamingo Females  | AVERAGE       | 1560.00                      | 116.65         | 327.00           | 180.17                | 176.00            | 101.17           | 182.83             | 94.33              | 9.43             | 8.84         | 72.21               | 0.955        | 0.287          |
|                          | SD            | 102.17                       | 7.90           | 10.55            | 8.35                  | 7.62              | 5.27             | 5.43               | 3.04               | 0.30             | 0.63         | 13.84               | 0.048        | 0.004          |

proportions were similar, males have higher aspect ratios (i.e. relatively narrower wings than females). This might explain the apparent lower costs of flight for males (the difference was almost significant for Lesser Flamingos [ $P < 0.1$ ]) since their wing loadings were similar. Female Lesser Flamingos, however, carry relatively heavier loads than males.

Our measurements from Etosha were similar to most of those published by Gallet (1950), Cramp & Simmons (1977) and Brown *et al.* (1982). Small differences in linear measurements were perhaps because of differences in measuring techniques. The only substantial difference was in body mass of male Greater Flamingos. Gallet's figures ( $\bar{x} = 3579$ ,  $SD = 340$ ,  $n = 13$ ) were much higher ( $p < 0.005$ ). Fat reserves carried by flamingos probably vary markedly during the year and body mass would change as a result. Such changes will affect their flight costs. For example, if Gallet's (1950) flamingos had similar wing areas and spans to those from Etosha (as the measurements suggest), their flight costs would

have been 26% greater. Flamingos are known to move very great distances and it remains to be seen how the timing of these flights may relate to changes in body mass and flight costs.

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#### APPENDIX: Measurements of seven Greater and eight Lesser Flamingos collected in the Etosha National Park, S.W.A./Namibia.

| SEX              | BODY MASS (g) | WING AREA (cm) | WING SPAN (cm) | WING LENGTH (mm) | SECONDARY LENGTH (mm) | ULNA LENGTH (mm) | TAIL LENGTH (mm) | TARSUS LENGTH (mm) | CULMEN LENGTH (mm) | BODY LENGTH (cm) |
|------------------|---------------|----------------|----------------|------------------|-----------------------|------------------|------------------|--------------------|--------------------|------------------|
| Greater Flamingo |               |                |                |                  |                       |                  |                  |                    |                    |                  |
| M                | 2800          | 2932           | -              | 430              | 230                   | 235              | 170              | 289                | 123                | 161              |
| M                | 2630          | 2820           | 169            | 405              | 223                   | 240              | 145              | 298                | 127                | 166              |
| M                | 2990          | 2696           | 164            | 435              | 230                   | 235              | 160              | 310                | 125                | 165              |
| M                | 3000          | 2556           | 175            | 409              | 228                   | 249              | 155              | 318                | 126                | 172              |
| F                | 2700          | 2452           | 149            | 382              | 203                   | 221              | 145              | 255                | 121                | 144              |
| F                | 2720          | 2510           | 151            | 405              | 215                   | 225              | 135              | 275                | 126                | 158              |
| F                | 2300          | -              | 151            | 398              | 211                   | 203              | 140              | 280                | 117                | 136              |
| Lesser Flamingo  |               |                |                |                  |                       |                  |                  |                    |                    |                  |
| M                | 1600          | 1922           | 140            | 349              | 210                   | 195              | 106              | 210                | 90                 | 122              |
| M                | 1780          | 1784           | 138            | 357              | 182                   | 195              | 114              | 224                | 95                 | 121              |
| F                | 1480          | 1644           | 126            | 345              | 187                   | 177              | 100              | 181                | 93                 | 110              |
| F                | 1600          | 1628           | 112            | 328              | 166                   | 189              | 107              | 185                | 95                 | 126              |
| F                | 1470          | 1580           | 119            | 316              | 172                   | 178              | 106              | 185                | 100                | 123              |
| F                | 1440          | 1552           | 117            | 328              | 182                   | 169              | 105              | 182                | 93                 | 106              |
| F                | 1750          | 1690           | 124            | 332              | 189                   | 178              | 96               | 191                | 108                | 108              |
| F                | 1620          | -              | 102            | 313              | 185                   | 165              | 93               | 173                | 106                | 104              |