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# Sexual Size Dimorphism and Assortative Mating in Razorbills (*Alca torda*)

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Razorbills (*Alca torda*) are relatively well-studied seabirds, but detailed morphometric data are lacking. Like other members of the Alcidae, the sexes are similar in size and indistinguishable in plumage, making it difficult to obtain measurements of live birds of known sex. The size of individuals has been reported from several museum collections of skins from diverse populations (Cramp 1985), samples of which should not be combined because of clinal variation (Bedard 1985). Hope Jones et al. (1985) measured a large number of corpses that were retrieved along the British coast but only reported bill and wing lengths of specimens of undetermined sex. Lloyd (1976) reported two body-size variables of live birds from a single population of Razorbills in Wales, but the sample sizes were small, and the sex of most individuals was unknown. My primary aim here is to report the first large data set of live, known-sex Razorbills and to identify the degree of sexual size dimorphism in a number of body measurements.

This study is part of a wider project on mating behavior of Razorbills based on color-banded breeding pairs (Wagner 1992). Morphometric data of pairs can provide the answer to a second question, namely whether Razorbills mate assortatively by some aspect of body size. Before I began measuring Razorbills, I was especially interested in bill depth because it coincides with one of the striking physical features of the species, namely its mainly black bill, which is indented by three or four grooves, the largest of which is white-colored. The decorative appearance of this marking suggests that the white coloration of the groove is a sexually selected ornament. In sexually monomorphic species, Darwin (1871) suggested that ornaments are produced by mate choice by both sexes, as has been illustrated by another alcid, the Crested Auklet (*Aethia cristatella*), in which both males and females are attracted to each other's identical ornaments (Jones and Hunter 1993).

*Methods.*—I measured Razorbills in the Basin study colony on Skomer Island, Wales (51°40′N, 05°15′W), in 1987 and 1988. To avoid disturbance during the prelaying period, almost all breeders were trapped late in incubation or during the nestling period, which occurred in June and July. Most birds were trapped in mist nets attached to a pair of 9-m aluminum poles at the bottom of the Basin; pulleys were attached to the top of each pole, and the nets were raised by ropes hoisted by two persons at the cliff top. All Razorbills were color banded, and sex was determined by subsequent observations of copulations. Although males often mounted other males (Wagner 1996), females never mounted individuals of either sex. Thus, all individuals that performed mountings were identified as males, and their mates as females.

I used dial calipers for all linear measurements (±0.1 mm) except wing chord, for which I used a stop-ended wing ruler. I measured unflattened wing chord (±1 mm); bill length (culmen), from the end of feathering on the upper mandible to the tip of the bill; bill depth, from the highest point of the upper mandible to the lowest point of the lower mandible; gape length, from the corner of the mouth to the tip of the upper mandible; gonys length, (the lowermost ridge of the lower mandible), from the end of feathering to the tip of the lower mandible; head length, from the most distal point behind the head to the tip of the upper mandible; head width (the widest part of the head), from the edges of a pair of supraorbital ridges; tarsus length, distance between the patella and the tarsometatarsus (including the depth of the tarsometatarsus); and middle toe length, from where the toe meets the tarsometatarsus up to but excluding the claw. I also weighed each individual (±2 g) using a 1,000-g Pesola spring balance.

*Results.*—I measured 165 live Razorbills, of which I determined the sex of 65 males and 57 females. The sample of sexed individuals excluded subadults (i.e. <4 years old; Lloyd and Perrins 1977) that were not observed copulating or breeding. Slight but highly significant differences (all $t > 3.0$, $P < 0.003$) between sexes occurred in eight of the nine linear measurements (Table 1). With the exception of wing length, which was similar between the sexes ($t = 0.50$, $P = 0.36$), males were larger than females in culmen, bill depth, gonys, head length, head width, gape, tarsus, and toe. In these measurements, males ranged from being 1.9% larger than females in tarsus length to 5.5% larger in gonys length. Males were

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TABLE 1. Morphometric data from male and female Razorbills captured in Wales.

| Sex | $\bar{x} \pm$ SD | Range | *n* | CV | Dimorphism index[a] |
|---|---|---|---|---|---|
| | | **Culmen length (mm)** | | | |
| F | 32.6 ± 1.3 | 305 to 361 | 57 | 3.9 | 95.6 |
| M | 34.1 ± 1.2 | 314 to 369 | 64 | 3.6 | |
| | | **Bill depth (mm)** | | | |
| F | 20.4 ± 0.8 | 184 to 226 | 57 | 4.0 | 96.2 |
| M | 21.2 ± 0.7 | 193 to 226 | 64 | 3.5 | |
| | | **Gonys length (mm)** | | | |
| F | 18.0 ± 1.0 | 161 to 203 | 56 | 5.3 | 94.5 |
| M | 19.0 ± 1.1 | 163 to 219 | 62 | 5.7 | |
| | | **Head length (mm)** | | | |
| F | 89.3 ± 2.4 | 852 to 955 | 46 | 2.7 | 97.3 |
| M | 91.7 ± 2.3 | 855 to 969 | 48 | 2.5 | |
| | | **Head width (mm)** | | | |
| F | 33.5 ± 1.1 | 312 to 356 | 52 | 3.3 | 97.4 |
| M | 34.4 ± 1.3 | 323 to 371 | 50 | 3.8 | |
| | | **Gape length (mm)** | | | |
| F | 52.2 ± 1.8 | 488 to 558 | 56 | 3.4 | 96.9 |
| M | 53.9 ± 1.9 | 485 to 575 | 61 | 3.5 | |
| | | **Tarsus length (mm)** | | | |
| F | 39.6 ± 1.1 | 367 to 439 | 52 | 2.7 | 98.1 |
| M | 40.3 ± 1.3 | 369 to 431 | 51 | 3.2 | |
| | | **Toe length (mm)** | | | |
| F | 39.7 ± 2.0 | 352 to 442 | 56 | 5.0 | 97.4 |
| M | 40.8 ± 1.8 | 367 to 440 | 62 | 4.4 | |
| | | **Wing length (mm)** | | | |
| F | 198.8 ± 4.9 | 183 to 210 | 57 | 2.5 | 100.4 |
| M | 198.0 ± 4.7 | 182 to 206 | 64 | 2.4 | |
| | | **Body mass (g)** | | | |
| F | 596 ± 45 | 505 to 730 | 56 | 7.6 | 95.0 |
| M | 622 ± 46 | 530 to 720 | 64 | 7.4 | |

[a] Female mean/male mean × 100.

also significantly heavier, weighing 5% more than females. I also obtained data from 28 to 37 pairs and performed correlation analyses between mates; the only significant linear measurement was bill depth (Fig. 1, Table 2). Body mass was also significantly positively correlated between mates (Table 2).

*Discussion.*—My main aim is to report morphometric data for Razorbills, whose sexual size differences have not been documented in detail. My other aim is to determine whether Razorbills pair assortatively by size, especially by bill depth, which is made conspicuous by a striking white groove. The bill depths of mates were positively correlated (Fig. 1), whereas no other linear measurement was significant. Thus, it is possible that mate choice is influenced by this feature, although I cannot exclude other possible causes of this relationship.

To my knowledge, only one previously reported example of positive assortative mating by an aspect of bill size exists for a charadriiform. In Common Terns (*Sterna hirundo*), the bill length of mates is significantly correlated (Coulter 1986). The same relationship probably exists in Atlantic Puffins (*Fratercula arctica*), for which Corkhill (1972) reported morphological data but did not examine whether assortative mating occurs. When I examined Corkhill's measurements of 10 mated pairs, however, I found a significant relationship for bill length ($r$ = 0.65, $P$ = 0.031) but not for bill depth.

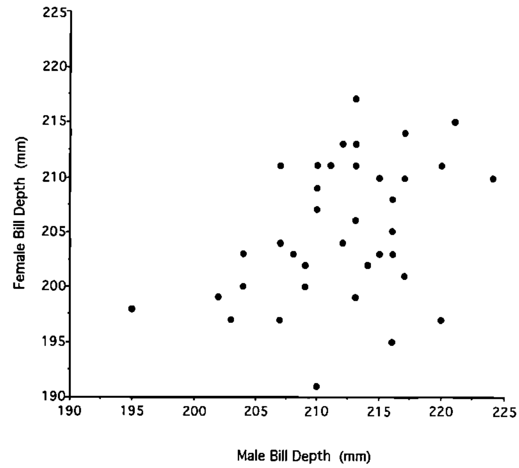


FIG. 1. Bill depth of males plotted against that of females in mated pairs of Razorbills. The significant correlation ($r$ = 0.39, $n$ = 37, $P$ = 0.017) indicates positive assortative mating.

Mate choice is one possible explanation for assortative mating by bill depth. Another possible explanation is that Razorbills pair assortatively by age, and bill depth increases (or decreases) with age, producing the pattern as a byproduct. This is unlikely, because adult Razorbills of known age (i.e. those that had been banded as nestlings or juveniles; Wagner 1992), show no relationship between age and bill depth ($r$ = 0.25, $n$ = 15, $P$ = 0.36).

The body masses of mates were also positively correlated (Table 2). Body mass, however, is generally a relatively inaccurate variable in birds because it

TABLE 2. Correlations between measurements of mated pairs of Razorbills.

| Variable | *r* | *n* | *P* |
|---|---|---|---|
| Culmen length | 0.11 | 37 | 0.52 |
| Bill depth | 0.39 | 37 | 0.017 |
| Gonys length | 0.24 | 35 | 0.16 |
| Head length | 0.08 | 28 | 0.68 |
| Head width | 0.01 | 31 | 0.93 |
| Gape length | 0.13 | 35 | 0.45 |
| Tarsus length | 0.19 | 32 | 0.30 |
| Toe length | 0.00 | 35 | 0.98 |
| Wing length | 0.08 | 37 | 0.64 |
| Body mass | 0.38 | 36 | 0.02 |

tends to fluctuate throughout the breeding cycle (Moreno 1989), as has been described in four alcids: Common Murres (*Uria aalge;* Harris and Wanless 1988), Thick-billed Murres (*Uria lomvia;* Croll et al. 1991), Ancient Murrelets (*Synthliboramphus antiquus;* Gaston and Jones 1989), and Least Auklets (*Aethia pusilla;* Jones 1994). When I weighed individual Razorbills at various stages of their reproductive cycle, body mass declined with date ($r = 0.69$, $n = 106$, $P < 0.001$), as occurs in many other species. Given that mates often were captured on approximately the same dates, the correlation of body mass of mates could be an artifact of seasonal mass changes that may be roughly synchronous between mates. However, the data are insufficient to examine this issue in detail.

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