Notes

Sexual Size Dimorphism and Bohemian Waxwings, *Bombycilla garrulus*

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Sexual size dimorphism is common among birds, with males generally being larger than females. Sexual size dimorphism is typically more extreme in polygynous species; socially monogamous males are typically only 5% larger than females. However, cryptic sexual size dimorphism has been found in some socially monogamous species. I used standard external measurements as well as two internal measurements (keel length and pectoral muscle mass) to determine whether, or to what extent, Bohemian Waxwings (*Bombycilla garrulus*) exhibit sexual size dimorphism. Males were only slightly larger than females in all of the characters measured except keel and tarsus length. Keel and tarsus length were 0.6% and 1% longer, respectively, in females than in males. The similar size exhibited by males and females may be related to the amount of parental care provided by males. Smaller body size in males may reflect a trade-off between selection for increased male size and energetic constraints imposed by parental care.

Key Words: Bohemian Waxwing, *Bombycilla garrulus*, sexual size dimorphism, Saskatchewan.

Sexual size dimorphism is common among birds, with males generally being larger than females (Murphy 2007). Sexual selection theory is often used to explain sexual size dimorphism in birds and other animals (Hendrick and Temeles 1989). If competition is greater in one sex than the other, sexual selection should result in a larger body size in the more competitive sex (Székely et al. 2000; Kissner et al. 2003). For example, if successful competition for females is partially determined by body size, then larger males will obtain more mates, thus selecting for larger body size in males (Webster 1992). The type of mating system strongly influences sexual dimorphism in general, with polygynous species often exhibiting extreme cases of sexual dimorphism (Dunn et al. 2001). In contrast, sexual dimorphism in monogamous species is rare and subtle (Webster 1992). Sexual size dimorphism may also arise through natural selection via ecological differences between the sexes. For example, if both parents tend the nest, selection could result in different sizes between the sexes in order to reduce intra-pair competition for food and other resources (Andersson and Norberg 1981; Székely et al. 2000). In general, the effects of sexual and natural selection are often related and difficult to separate, so it is likely that sexual size dimorphism results from a combination of these two factors.

Among socially monogamous species, males are on average ~5% larger than females (Murphy 2007). However, it is possible that socially monogamous species are more sexually size dimorphic than initially assumed. For example, extensive analyses of bird body components revealed that the socially monogamous Eastern Kingbird (*Tyrannus tyrannus*) exhibits cryptic sexual size dimorphism, despite the fact that there are no sexual differences in body mass or standard external measurements (Murphy 2007). Clearly, a re-evaluation of the current contention that sexual size dimorphism is rare or subtle in socially monogamous species is required. The objective of this study was to determine the extent of sexual size dimorphism in the socially monogamous Bohemian Waxwing (*Bombycilla garrulus*). Although females are slightly smaller, there is no significant difference in the body mass or standard external measurements of male and female Bohemian Waxwings (Witmer 2002).

Materials and Methods

I obtained Bohemian Waxwing specimens from the Royal Saskatchewan Museum (RSM), Regina, Saskatchewan, in September 2007. Total sample size consisted of 19 wild birds donated to the museum over the past two decades from locations throughout the province. Birds were aged and sexed based on plumage (Pyle 1997), and sex was confirmed upon dissection. In order to reduce any size variation due to age, I used only adult birds; all birds available were able to be included. I measured external and internal characteristics to compare the sexes. External measurements included body mass, wing chord, tail length, tarsus length, bill height, and bill width. Tarsus length, bill height, and bill width were measured using digital calipers to a precision of 0.01 mm; wing chord and tail length were measured with a 15.24 cm and 1 m

TABLE 1. Comparisons of body mass, lengths of external and internal characters, and oven-dried pectoral muscle mass (ODPMM),in male (n = 10) and female (n = 9) Bohemian Waxwings.

Character	Male (mean ± SE)	Female (mean ± SE)	t (P)	Sexual size dimorphism index	Percentage difference	Male Confidence interval lower	Male Confidence interval upper	Female Confidence interval lower	Female Confidence interval upper
Body mass (g)	57.8 ± 2.4	56.4 ± 1.3	0.63	0.024	2	53.10	62.50	53.85	58.95
Wing chord (mm)	116.6 ± 0.8	114.4 ± 1.1	0.14	0.019	2	115.03	118.17	112.24	116.56
Tail length (mm)	63.8 ± 1.2	60.8 ± 1.1	0.09	0.047	5	61.45	66.15	58.64	62.96
Tarsus length (mm)	24.90 ± 0.64	25.17 ± 0.73	0.79	−0.011	1	23.65	26.15	23.74	26.60
Bill height (mm)	6.00 ± 0.17	5.79 ± 0.26	0.51	0.036	4	5.67	6.33	5.28	6.30
Bill width (mm)	11.15 ± 0.65	10.58 ± 0.22	0.44	0.051	5	9.88	12.42	10.15	11.01
Keel length (mm)	30.21 ± 0.54	30.4 ± 0.56	0.83	−0.006	0.6	29.15	31.27	29.30	31.50
ODPMM (g)	3.9 ± 0.2	3.9 ± 0.1	0.81	0.0	0	3.61	4.19	3.70	4.10

ruler, respectively. Internal measurements included the length of the keel and the pectoral muscle mass. Keel length was measured from the base of the furcular depression to the base of the sternum. The pectoral muscles were removed and placed in a drying oven for 48 hours to reduce any variability due to moisture content. The oven temperature was 450°C for the first 24 hours, then 500°C for the next 24 hours. All samples were weighed with a triple beam balance to a precision of 0.01 g to obtain oven-dried pectoral muscle mass (ODPMM) values for each bird.

I used two-tailed, two sample t-tests assuming equal variance in order to compare mean values between the sexes. I also calculated 95% confidence intervals for the mean of each trait to determine whether any overlap occurred between males and females. I calculated a sexual size dimorphism index (SSDI) for each trait by dividing the size of the trait in the larger sex by the size of the trait in the smaller sex, then subtracting one from the quotient (Lovich and Gibbons 1992). The SSDI indicates the degree of difference between the sexes.

Results and Discussion

Of the 19 birds, there were 9 females and 10 males. Specimens were primarily collected from Regina (50°27'N, 104°37'W), with some from Fort Qu'Appelle (50°77'N, 104°28'W) and Whitewood (50°20'N, 102°15'W); data on collection location were not available for all specimens.

Overall, I found that males were larger than females, but females had slightly longer keels and tarsi (Table 1). However, the difference between males and females was typically < 5%, similar to that found for other socially monogamous birds (Murphy 2007).

Sexual size dimorphism is reduced in males that play a substantial role in parental investment because a smaller body size is less energetically costly and should be favoured by selection (Mosher and Matray 1974; Hughes and Hughes 1986; Jönsson and Alerstam 2008). Male Bohemian Waxwings contribute substantial amounts of parental care, so it is reasonable that males are not much larger than females. Males deliver food to the female during the incubation and early nestling period, and both parents feed the young (Semenchuk 1992; Witmer 2002). Thus, a smaller body size minimizes the male's metabolic needs, thereby enhancing his ability to provide for the female and chicks and potentially increasing his reproductive success as a result.

Sample size was limited to the number of birds available from the RSM. Although juveniles were excluded, a difference in size due to age likely still affected the results. A larger sample size would have allowed further division based on age (i.e., second-year and after-second-year birds). The result may also be biased due to collecting, specifically, if smaller or less fit males are more likely to be collected, then only small males would have been compared with females. It would be interesting to investigate this topic further to determine whether age-related size differences influence the degree of sexual size dimorphism in Bohemian Waxwings, as well as other birds.

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Literature Cited

Andersson, M., and **R. A. Norberg.** 1981. Evolution of reversed sexual size dimorphism and role partitioning among predatory birds, with a size scaling of flight performance. Biological Journal of the Linnean Society 15: 105-130.

Dunn, P. O., L. A. Whittingham, and **T. E. Pitcher.** 2001. Mating systems, sperm competition, and the evolution of sexual dimorphism in birds. Evolution 55: 161-175.

Hendrick, A. V., and **E. J. Temeles.** 1989. The evolution of sexual dimorphism in animals: hypotheses and tests. Trends in Ecology & Evolution 4: 136-138.

Hughes, A. L., and **M. K. Hughes.** 1986. Paternal investment and sexual size dimorphism in North American passerines. Oikos 46: 171-175.

Jönsson, P. E., and **T. Alerstam.** 2008. The adaptive significance of parental role division and sexual size dimorphism in breeding shorebirds. Biological Journal of the Linnean Society 41: 301-314.

Kissner, K. J., P. J. Weatherhead, and **C. M. Francis.** 2003. Sexual size dimorphism and timing of spring migration in birds. Journal of Evolutionary Biology 16: 154-162.

Lovich, J. E., and **J. W. Gibbons.** 1992. A review of techniques for quantifying sexual size dimorphism. Growth, Development & Aging 56: 269-281.

Mosher, J. A., and **P. F. Matray.** 1974. Size dimorphism: a factor in energy savings in broad-winged hawks. The Auk 91: 325-341.

Murphy, M. T. 2007. A cautionary tale: cryptic sexual size dimorphism in a socially monogamous passerine. The Auk 124: 515-525.

Pyle, P. 1997. Identification guide to North American birds. Slate Creek, Bolinas, California.

Semenchuk, G. P., *Editor.* 1992. The atlas of breeding birds of Alberta. Federation of Alberta Naturalists, Edmonton, Alberta, Canada.

Székely, T., J. D. Reynolds, and **J. Figuerola.** 2000. Sexual size dimorphism in shorebirds, gulls, and alcids: the influence of sexual and natural selection. Evolution 54: 1404-1413.

Webster, M. S. 1992. Sexual dimorphism, mating system and body size in New World Blackbirds (Icterinae). Evolution. 46:1621-1641.

Witmer, M. C. 2002. Bohemian Waxwing (*Bombycilla garrulus*). Number 714 *in* The Birds of North America Online. *Edited by* A. Poole. Cornell Lab of Ornithology, Ithaca; retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/714.

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