SEX RATIOS AND BILL GROWTH IN NESTLING BLACK-CHINNED HUMMINGBIRDS

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Implicit in the analysis of sex ratios in wild bird populations is the assumption that equal numbers of males and females are conceived, hatched, and fledged. Sex ratios biased in favor of females have been reported for the Broad-tailed Hummingbird (*Selasphorus platycercus*) by Calder et al. (1983) and Calder (1990) and the Ruby-throated Hummingbird (*Archilochus colubris*) by Mulvihill et al. (1992) and Bill Hilton (in litt.). Our data for the Black-chinned Hummingbird (*Archilochus alexandri*) are, to our knowledge, the first attempt at providing empirical support for sex ratios in hummingbirds being equal at conception, hatching, and fledging. Validating this assumption is an important first step in examining the phenomenon of biased sex ratios in adults. In addition, our data show that bill length can be useful in determining the age of nestlings.

METHODS

Most Black-chinned Hummingbird nestlings we studied were received by Elliston through Wildlife Rescue Inc. of New Mexico after their mothers had abandoned them. Others were examined after the limb to which their nest was attached had been sawed down. In these cases, after the adult female was located, the nests were wired back into the tree and the female continued to care for her young. Elliston successfully reared most orphaned birds, though occasionally birds were dead upon arrival or did not survive. These were autopsied, sexed, and preserved as voucher specimens. Less than 10% of our data are from birds that Baltosser obtained in the field during other hummingbird investigations, some dating back to 1976 (e.g., Baltosser 1986, 1989).

Hummingbirds invariably lay two eggs (Skutch 1973, Johnsgard 1983). Since sibling pairs constitute a brood, data on them are separated from other data (i.e., birds of uncertain relationship received by Wildlife Rescue) to make this subset clearly visible. For the purpose of assessing sex ratios, however, all available information has been used. The 15 birds of unknown sex (8.5% of the total) were ultimately allocated equally between males and females, but only after we determined that apportioning them otherwise did not alter the statistical significance (P 0.05).

Birds in the non-paired data set have been assigned to one of three age categories on the basis of bill length and growth curves: pre-fledgling nestlings (bill 13.0 mm), fledglings (bill > 13.0 mm 17.0 mm), and post-fledgling juveniles (bill > 17.0 mm). This system supplements Ortiz-Crespo (1972) and Baltosser (1987) by extending the use of the bill in aging to birds in even earlier stages of development.

Bill-growth rates were determined from orphaned and displaced Black-chinned Hummingbirds brought to Wildlife Rescue of New Mexico over eight years. Elliston took daily bill measurements from the bird's receipt to its release. As the day of hatching of most birds was unknown, an age of 21 days was assigned to each on the day of first flight (Bene 1945, Bent 1940, Cogswell 1949, Skutch 1973, Tyrrell 1985). The age at each previous measurement was then established after the date of fledging became evident. At the beginning of the study, we used vernier calipers accurate to the nearest 0.1 mm. Since 1991 we have adopted digital calipers accurate to 0.02 mm.

Characteristics of wing and tail feathers were the primary means of sex determination (Baldridge 1983, Baltosser 1987). Birds having a notch at the tip of the sixth primary, a pointed and angular fifth rectrix, and a reduced amount of white at the tip of the third rectrix were classified as male. Nestlings lacking these feather specializations and having large amounts of white at the tip of the third rectrix were classified as female.

The data set representing complete two-chick broods may be minimal from a statistical standpoint (N = 36 nests, 72 individuals—including 2 individuals of unknown sex). When combined with the non-paired data (105 individuals—including 13 individuals of unknown sex), however, the data are sufficiently robust to sustain the validity of our conclusion. Data sets were statistically analyzed with G tests of independence in conjunction with Williams' correction (Sokal and Rohlf 1981). The former statistically compares our observed ratio of males to females to the theoretically expected ratio of one male to every female.

RESULTS AND DISCUSSION

Bill Growth

Figure 1 shows the growth of the bill in young birds from a length of less than 4 mm at hatching to over 13 mm at the end of 21 days, the usual age at fledging (average increment = 0.51 mm/day). The variability between day 1 and day 17 may have been influenced by several conditions. Few very young birds came to Wildlife Rescue, and those that did were growing on an artificial diet, perhaps not as conducive to optimal growth as a natural diet. Since growth of very young birds is rapid, even slight variability in the intervals of measurement can result in proportionately large changes in bill length. Additionally, because of poor feather condition, birds orphaned very young and raised on an artificial diet sometimes were unable to fledge, making estimates of their age, back-dated from time of first flight, unreliable. The bill lengths of birds acquired from the wild at over two weeks of age varied less.

The bills of fledglings continue to grow at a rate just slightly less (0.44 mm/day) than the nestlings' rate for about 2 weeks after fledging (Figure 1). The growth rate of juveniles diminishes (0.04 mm/day) over the next 14 days (weeks 6 and 7) as bills attain their full length. Male and female Black-chinned Hummingbirds are sexually dimorphic (Stiles 1971, Baltosser

1987), and this dimorphism becomes evident in bill length at about the time of fledging (Figure 2).

We devised predictive equations based on bill length to estimate a young Black-chinned Hummingbird's age. The 21-day data set yielded the following, where x represents bill length and y represents age: $y = 1.96x - 3.94$. That is, every 1 mm increase in bill length takes 1.96 days, a daily increase of ca. 0.51 mm/day. The 35-day data set yielded $y = 2.02x - 4.43$. The r-square values for these equations are 0.98 and 0.99, respectively. In other words, 98 to 99% of the variation in age can be explained (predicted) on the basis of the variation in bill length.

Sex Ratios

Even though most nestlings brought to Wildlife Rescue were reared under artificial conditions, this should not bias our conclusions concerning sex ratios at conception or hatching. We also believe that sex ratios of fledglings are similar to those of birds reared in the wild. Our logic stems from research conducted by Baltosser (1986), which revealed that between 32 and 47% of all Black-chinned nests that fail because of predation are lost early, to predation on eggs rather than on chicks. An additional 2 to 6% of nests containing eggs are lost to other causes. Mortality ascribed to predation of nestlings ranges from 10 to 19%, with an additional 2 to 10% lost to
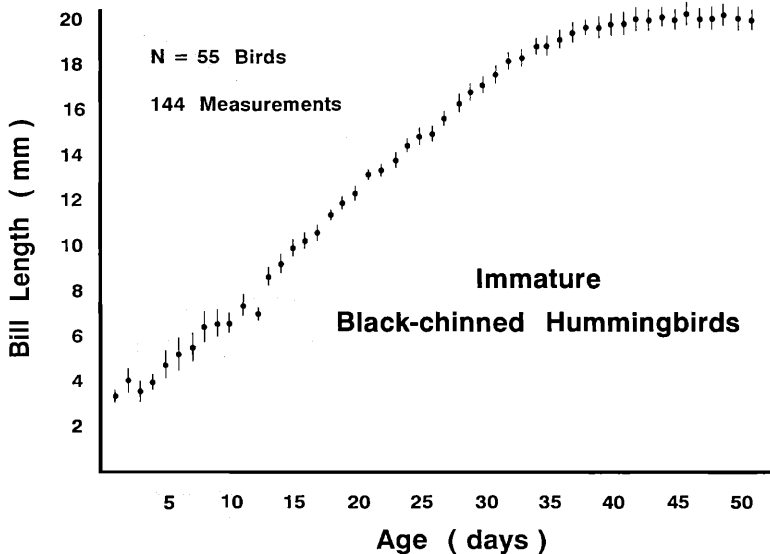

Figure 1. Bill length vs. age in young Black-chinned Hummingbirds (circle, mean; vertical bar, standard deviation), from 144 measurements of 55 birds. Data set includes 14 birds of unknown sex.

other miscellaneous causes affecting both young equally. Loss of the chicks within about 1 week of hatching is minimal, generally affecting both young when it does occur.

Siblings.—Assuming that each nest began with two eggs, three combinations are possible; nest mates are both male, there is one bird of each sex, or both are female. If, as we hypothesized, the ratio between the sexes tends toward 1:1, the ratio of these combinations should be 1:2:1. Our result (11 male/male, 14 male/female, and 10 female/female) does not differ significantly from this ratio ($G = 3.66$, $P > 0.05$).

If we assume that the 36 nests (sex of young in 1 nest not known) were a random, representative sample of the entire population, then the 72 nestlings should be equally divided between males and females. The G-test statistic for the 37 males and 35 females (unknown apportioned equally) is 0.06 ($P > 0.05$). Thus, there is no reason to reject our hypothesized 1:1 ratio.

Nonsiblings.—Data for single birds and pairs for which there was no guarantee of relatedness are shown in Table 1. The sex ratio in this sample varied greatly from year to year. Collectively, however, the data support the hypothesis of equal sex ratios for nestlings ($G = 0.42$, $P > 0.05$) and fledglings ($G = 0.37$, $P > 0.05$). This is not true for post-fledging juveniles ($G = 6.15$, $P < 0.05$), however, as more males than females are brought to Wildlife Rescue for care.
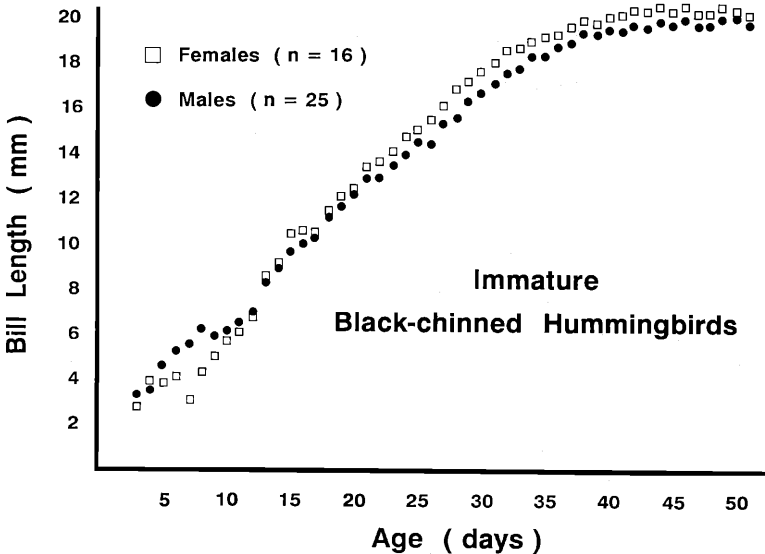

Figure 2. Bill length vs. age in young Black-chinned Hummingbirds. Squares, females ($n = 16$); circles, males ($n = 25$).

Table 1 Numbers of Nonsibling Black-chinned Hummingbirds by Sex and Age

Age (days)	Males	Females	Sex undetermined
Nestlings (1–20)	15	19	4
Fledglings (21–35)	20	16	7
Juveniles (36–49)	17	5	2

CONCLUSIONS

Our observations suggest that bill length, even in very young birds, can be a useful indicator of developmental age from hatching to independence. Similar growth patterns should be investigated in other hummingbird species. In the Black-chinned Hummingbird, the sex ratio of nestlings remains at 1:1 through fledging. Under Mendelian segregation, because birds have discrete sex chromosomes, a 1:1 ratio between males and females is to be expected (see Charnov 1982). Our data, however, suggest the ratio may shift shortly after fledging in favor of females. To our knowledge, this is the first attempt at providing empirical support for sex ratios in hummingbirds being equal at conception, hatching, and fledging.

We hope our work with the Black-chinned Hummingbird will stimulate others to investigate growth and sex ratios in other hummingbird species that can be sexed at an early age. Prime candidates in the western U.S. include the Anna's (*Calypte anna*; see Williamson 1956, Stiles 1971, Baltosser 1987), Costa's (*Calypte costae*; see Stiles 1971, Baltosser 1987), and Calliope (*Stellula calliope*; see Stiles 1971, Baltosser 1994). In the eastern U.S. work should continue (see Southwick and Gates 1975) on the Ruby-throated Hummingbird (see Leberman 1972, Baltosser 1987). Such efforts will ultimately provide a basis from which the phenomenon of female-biased sex ratios in adult birds can be better assessed.

LITERATURE CITED

Baldridge, F. A. 1983. Plumage characteristics of juvenile Black-chinned Hummingbirds. Condor 85:102–105.

Baltosser, W. H. 1986. Nesting success and productivity of hummingbirds in southwestern New Mexico and southeastern Arizona. Wilson Bull. 98:353–367.

Baltosser, W. H. 1987. Age, species, and sex determination of four North American hummingbirds. N. Am. Bird Bander 12:151–166.

Baltosser, W. H. 1989. Nectar availability and habitat selection by hummingbirds in Guadalupe Canyon. Wilson Bull. 101:559–578.

Baltosser, W. H. 1994. Age and sex determination in the Calliope Hummingbird. W. Birds 25:104–109.

Bene, F. 1945. The role of learning in the feeding behavior of Black-chinned Hummingbirds. Condor 47:3–21.

Bent, A. C. 1940. Life histories of North American cuckoos, goatsuckers, humming-birds, and their allies. U.S. Natl. Mus. Bull. 176.

Calder, W. A. 1990. Avian longevity and aging, in Genetic Effects on Aging II (D. E. Harrison, ed.), pp. 185–204. Telford Press, Caldwell, N.J.

Calder, W. A., Waser, N. M., Hiebert, S. M., Inouye, D. W., and Miller, S. 1983. Site-fidelity, longevity, and population dynamics of Broad-tailed Hummingbirds: A ten-year study. Oecologia 56:689–700.

Charnov, E. L. 1982. The Theory of Sex Allocation. Princeton Univ. Press, Princeton, N.J.

Cogswell, H. L. 1949. Alternate care of two nests in the Black-chinned Humming-bird. Condor 51:176–178.

Johnsgard, P. A. 1983. The Hummingbirds of North America. Smithsonian Inst. Press, Washington, D.C.

Leberman, R. C. 1972. Identify, sex, and age it. Key to age and sex determination of Ruby-throated Hummingbirds in autumn. Inland Bird Banding News 44:197–202.

Mulvihill, R. S., Leberman, R. C., and Wood, D. S. 1992. A possible relationship between reversed sexual size dimorphism and reduced male survivorship in the Ruby-throated Hummingbird. Condor 94:480–489.

Ortiz-Crespo, F. I. 1972. A new method to separate immature and adult humming-birds. Auk 89:851–857.

Skutch, A. F. 1973. The Life of the Hummingbird. Crown, New York.

Sokal, R. R., and Rohlf, F. J. 1981. Biometry. W. H. Freeman, New York.

Southwick, E. E., and Gates, D. M. 1975. Energetics of occupied hummingbirds nests, in Perspectives of Biophysical Ecology (D. M. Gates and R. B. Schmerl, eds.), pp. 417–430. Springer-Verlag, New York.

Stiles, F. G. 1971. On the field identification of California hummingbirds. Calif. Birds 2:41–54.

Tyrrell, E. Q., and Tyrrell, R. A. 1985. Hummingbirds, Their Life and Behavior. Crown, New York.

Williamson, F. S. L. 1956. The molt and testis cycle of the male Anna Hummingbird. Condor 58:342–366.