Age, Species, and Sex Determination of Four North American Hummingbirds

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The identification of female and immature Costa's (*Calypte costae*), Anna's (*Calypte anna*), Ruby-throated (*Archilochus colubris*), and Black-chinned (*Archilochus alexandri*) hummingbirds is one of the more difficult taxonomic problems among the Trochilidae. Ridgway (1892) and Coues (1903) were among the first to provide basic insights into the problem, but their analyses lacked many of the essential quantitative data. Subsequent works by Williamson (1956), Banks and Johnson (1961), Short and Phillips (1966), Stiles (1971), Leberman (1972), Phillips (1975, 1982), Wells et al. (1978), and Baldridge (1983) all furthered our knowledge. Nonetheless, all failed in one way or another to identify, quantify, and/or to compare differences between species, age groups, or sexes. The present paper, while acknowledging the contributions of the former workers, identifies and quantifies numerous additional heretofore undescribed identification traits.

A comprehensive key, with attendant supporting data, is presented that allows virtually any specimen of these species to be correctly assigned to one of three age categories (adult–older than ca. 10 months, subadult–postfledging age greater than 1 month but less than 10 months, and juvenile–postfledging age less than 1 month), the appropriate species, and the proper sex. Statistically significant differences demonstrate that species, age groups, and sexes are quite distinct and thus separable from one another. The existence of a diminutive race of the Black-chinned Hummingbird (see Phillips 1982) is confirmed, although in the present paper this is discussed only within the context of the problem this presents in identification.

Methods

A total of 821 specimens from throughout the ranges of the four species was examined. Feathers that were damaged or otherwise "ruffled" were first "smoothed" into natural position prior to measuring. The methodology for aging hummingbirds developed by Ortiz-Crespo (1972), which is based upon the presence or absence of bill corrugations, has been refined to produce three age categories (adult, subadult, and juvenile) rather than just two (immature vs adult). The presence of bill corrugations and the degree to which they occur throughout the length of the bill are the primary criteria used for aging, although these are supplemented to some extent by plumage characteristics. The assignment of an individual to a particular age class is therefore based primarily on maturity rather than plumage.

Measurements were made using 10-cm dial calipers, accurate to the nearest 0.05 mm. Differences among species and between males and females of the same age were analyzed by subjecting all data to one-way analyses of variance (UNIVAR–D. M. Power, unpubl.). When the group F-statistic for a particular measure was significant, the sums of squares simultaneous test procedure (Gabriel and Sokal 1969) was used to determine maximally non-significant subsets. In addition, 95% confidence intervals about the mean were calculated for each character. Variations in numerous qualitative characteristics, when relevant to identification, are presented as percentages of the sample population.

In Figure 1, quantitative measurements of primary importance used in this study are depicted, many of which are described in Baldwin et al. (1931). Length of exposed culmen (1A) was measured from the point where the tips of the feathers of the forehead impinge upon the culmen to the tip of the culmen. Length of wing chord (1B) was measured from the farthest anterior point on the anterior edge of the wrist joint to the tip of the longest primary (#10), without attempting to flatten the curve of the primaries. Maximum width of the 5th rectrix (1C) was measured at the widest point from one edge of the feather to the other, at right angles to the shaft. Length of white at the tip of the 5th rectrix (1D) was measured along the rachis to the tip. Tail length (1E), only to the nearest mm, was measured from the insertion of the two middle rectrices to the longest tail feather of the unspread tail. Length of white at the tip of the 3rd rectrix (1F) was measured in the same manner as that for the 5th rectrix.

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The maximum width of the inner web of primary 10 (outermost–1G) was obtained by first establishing the area within 5 mm of the tip (as measured along the rachis) and then measuring the maximum width of the inner web within this area at an angle perpendicular to the rachis. The maximum width of white at the tip of the 3rd rectrix (1H) was simply measured from edge to edge (not necessarily perpendicular to the rachis or other portions of the feather). "Area" of white at the tip of the 3rd rectrix (a derived character not depicted) was calculated by multiplying the length of white (1F) by its maximum width (1H).

Results and Discussion

Virtually all specimens examined in this study could easily be aged, identified to species, and sexed using the key that follows. Approximately 90% could be correctly classified using only the first two or three phrases within each couplet of the key. The additional phrases (condensed print) are nonetheless provided to identify the remaining 10%, which for one reason or another were not otherwise separable. Characteristics that are of prime importance include: (1) the presence or absence of corrugations on the bill (viewed under 10X magnification) in

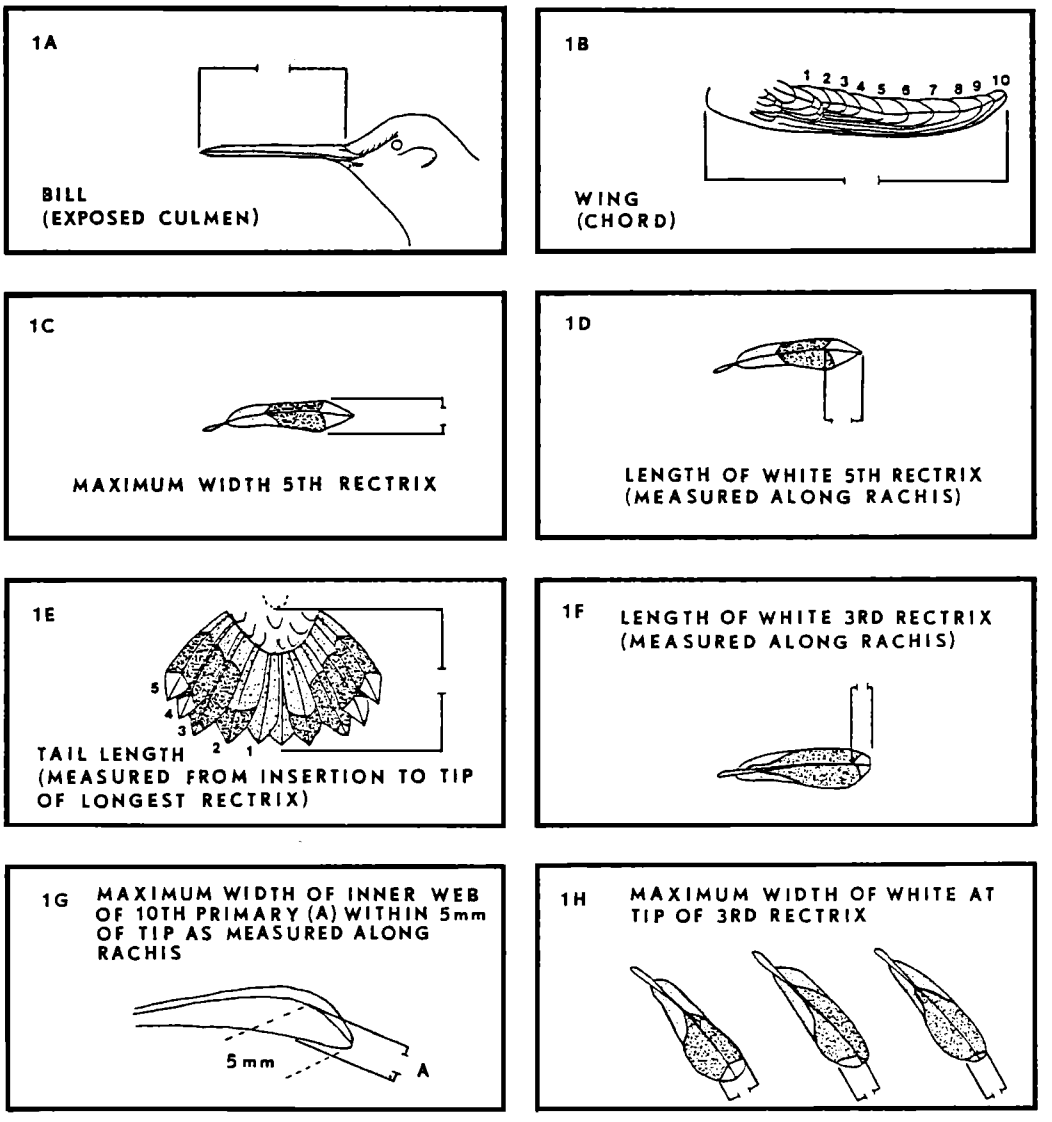
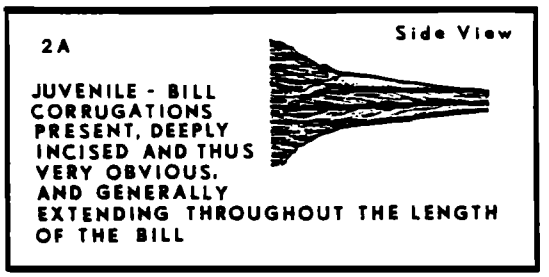


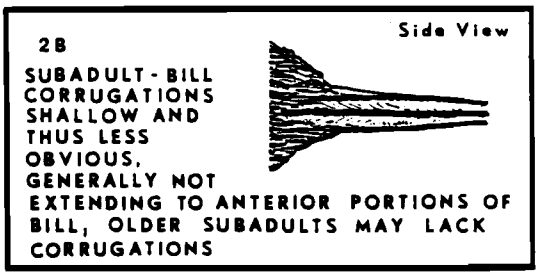
Figure 1. Measurements used throughout the key

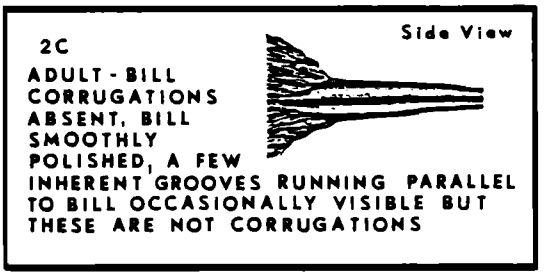
determining age; (2) the shape of the tip and width of the inner six primaries in species and sex determinations; (3) the maximum width of the 5th rectrix, whether the dark rachis extends into the white tip, and the shape of the tip in species and sex determinations; and (4) the amount of white at the tip of rectrix 3 in sex determination. Differences in the amount of white at the tip of rectrix 3 between juveniles and subadults of the same sex are, nonetheless, largely artifacts of wear since the rectrices acquired in the nest are usually retained until adult plumage is acquired at an age of about 10-11 months (Nancy Newfield in litt.). Occasionally, however, juvenile rectrices are lost prematurely and they are replaced with adult rectrices, even in very young birds (Nancy Newfield in litt. and present study).

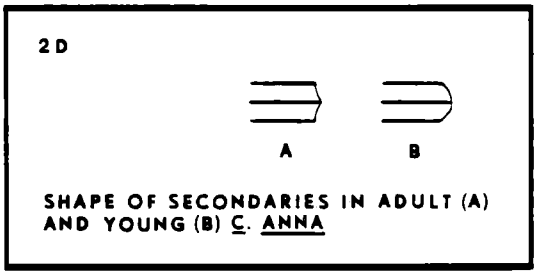
The former characters and those depicted in Figure 1, in conjunction with those depicted and explained in Figure 2 that are more species and/or age specific, form the basis for the following key. Statistics pertaining to the characters used in the key are presented in Appendices A-J. Specimens upon which the key is based are from throughout the entire ranges of the four species and thus the key should be relatively free of geographic or seasonal bias. A listing of the specimens upon which the key is based is available from the author upon request.

Key to Age, Species, and Sex Determination of Four North American Hummingbirds









1a. Bill corrugations deeply incised throughout the length of bill (Fig. 2A); feathers on nape and back extensively edged with buffy or grayish–*JUVENILE BIRDS* 18

1b. Bill corrugations either absent or shallow and restricted to posterior portion of bill 2

2a. Bill corrugations at least faintly visible (Fig. 2B)–*SUBADULT BIRDS* 11

2b. Bill corrugations absent (Fig. 2C) 3

3a. Despite the absence of bill corrugations, portions of plumage not that of an adult (i.e., birds that have been out of the nest in excess of three months but have not assumed full adult plumage; see condensed print under 3b for adult traits)–*SUBADULT BIRDS* 11

3b. Plumage that of an adult (see condensed print below)–*ADULT BIRDS* 4

Adult plumage with regard to males includes fully feathered metallic crown in *Calypte costae* and *C. anna*, fully feathered metallic gorget in the former two species and in *Archilochus colubris* and *A. alexandri*, and in males of all four species the outer rectrices not tipped with white.

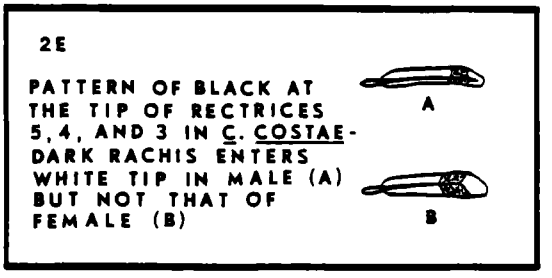
Adult plumage in female birds, particularly as compared to older subadults (i.e., those lacking bill corrugations), is less easily discerned because subadult and juvenile birds all resemble adult females (i.e., not as above). *UNTIL ONE BECOMES FAMILIAR WITH THE KEY*, treat all birds lacking bill corrugations and not exhibiting the following traits as adults, rather than subadults:

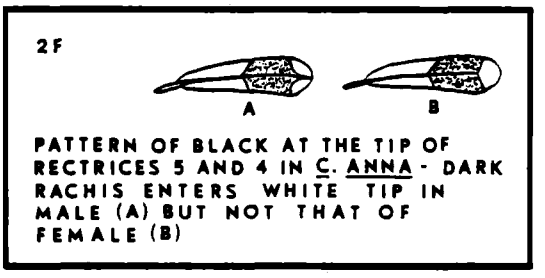
(1) Rounded secondaries (Fig. 2D) are indicative of subadult and juvenile aged birds in *C. anna*.

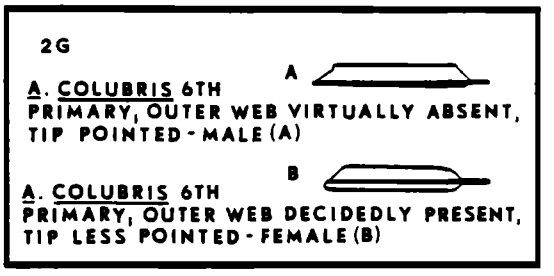
(2) Scattered metallic feathers in the crown and the extension of the dark rachis into the white tips of the outer rectrices (Figs. 2E and 2F) of *C. costae* and *C. anna* are indicative of young males.

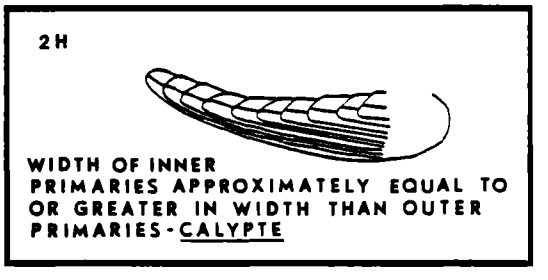
(3) Scattered metallic reddish/gold feathers on the throat and the shape of primary 6 (Fig. 2G) in *A. colubris* are indicative of young males.

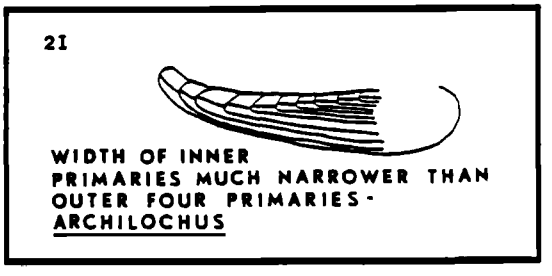
(4) Completely black and metallic purple feathers scattered throughout the throat are indicative of young male *A. alexandri*; scattered purple feathers in the











absence of solid black feathers are indicative of young male *A. alexandri* or adult female and young male *C. costae*.

ADULT BIRDS

4a. Crown and throat covered completely by metallic purple/violet or reddish/magenta feathers **5**

4b. Crown not as above; throat may or may not be covered completely by metallic feathers **6**

5a. Crown and throat covered completely by metallic purple/violet feathers–Adult Male *Calypte costae*.

5b. Crown and throat covered completely by metallic reddish/magenta feathers–Adult Male *Calypte anna*.

6a. Entire throat either metallic reddish/gold or black edged with metallic purple feathers **7**

6b. Throat may or may not possess metallic feathers; if metallic feathers are present, then they never completely cover throat to produce a true gorget; if throat lacks metallic feathers, then throat may totally lack markings or possess varying degrees of streaking **8**

7a. Throat completely covered with metallic reddish/gold feathers–Adult Male *Archilochus colubris*.

7b. Throat black on anterior half to two-thirds and metallic purple on posterior portions–Adult Male *Archilochus alexandri*.

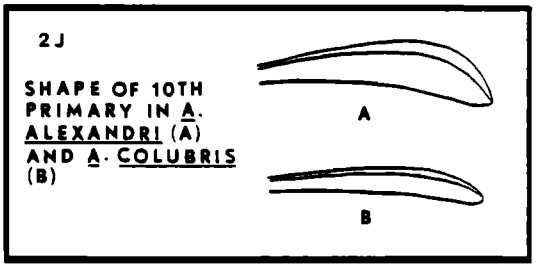
8a. Inner primaries approximately equal to or greater in width than outer primaries (Fig. 2H)–Genus *Calypte* **9**

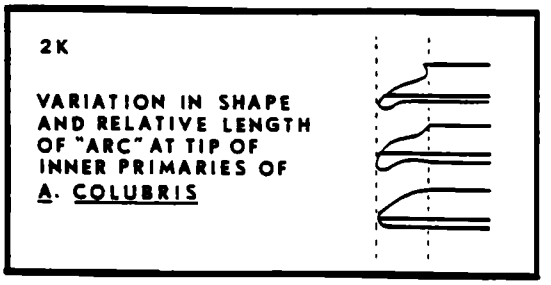
8b. Inner six primaries much narrower than outer four (Fig. 2I)–Genus *Archilochus* **10**

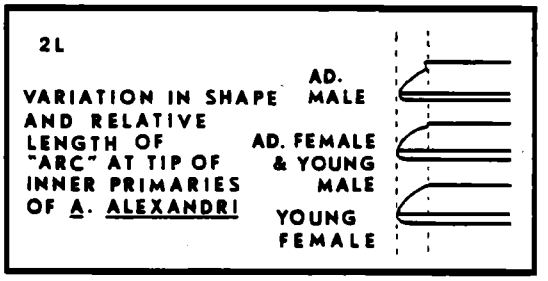
9a. Maximum width of rectrix 5 usually between 3.57 and 3.75 mm, ranging from 2.90 to 4.25 mm (Appendix A); throat of many individuals (56%) lacks purple/violet metallic feathers, although in an almost equal number (44%) such feathers are present–Adult Female *Calypte costae*.

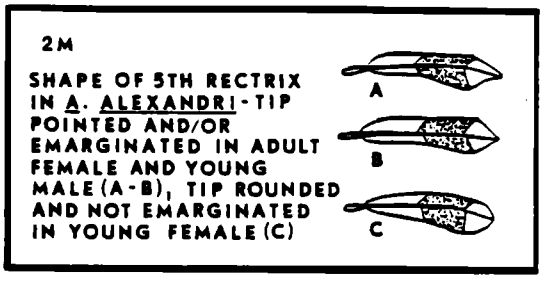
Excluding metallic purple/violet feathers, throat generally (89%) lacks markings, but in a limited number of individuals (11%) throat contains a few isolated greenish/brown feathers; wing length usually between 44.38 and 44.90 mm, ranging from 42.30 to 46.60 mm (Appendix A).

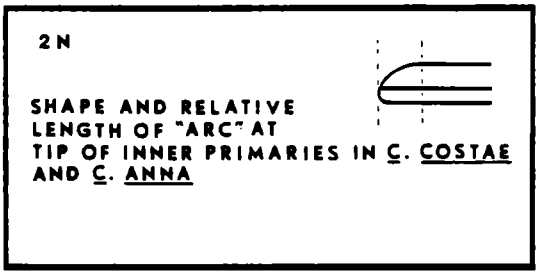
9b. Maximum width of rectrix 5 usually between 5.54 and 5.72 mm, ranging from 4.90 to 6.75 mm (Appendix A); throat usually contains at least a few metallic reddish/magenta feathers, or if not, then at least a few relatively broad greenish/brown feathers are present–Adult Female *Calypte anna*.











Throat only rarely (15%) lacks either metallic reddish/magenta or broad greenish/brown feathers; wing length usually between 49.39 and 49.85 mm, ranging from 47.05 to 51.85 mm (Appendix A).

10a. Maximum width of inner web of primary 10 within 5 mm of tip generally between 2.05 and 2.20 mm, ranging from 1.60 to 2.50 mm (see Figs. 1G and 2J); forehead and crown generally greenish; exposed culmen generally between 17.19 and 17.53 mm, ranging from 15.05 to 19.30 mm (Appendix A)–Adult Female *Archilochus colubris*.

Throat markings virtually absent (>95%) or when present (<5%) very faint; "arc" formed at tip of inner primaries relatively long and gradual, producing tip that is relatively narrow and pointed (Fig. 2K); at least many of the inner six primaries deeply notched in the majority of individuals (Fig. 2K), or if not, then long-gradual "arc" at tip nonetheless present (Fig. 2K); outer web of primary 6 decidedly present (Fig. 2G); outer three rectrices and sometimes outer four (*AMOUNT OF WHITE AT TIP OF RECTRICES 3 AND 2 NOT CONSISTENT IN ADULTS*) tipped with white.

10b. Maximum width of inner web of primary 10 within 5 mm of tip generally between 3.10 and 3.20 mm, ranging from 2.65 to 3.55 mm (see Figs. 1G and 2J); forehead and crown generally brownish/gray; exposed culmen of most United States specimens generally between 20.24 and 20.54 mm, ranging from 19.00 to 22.05 mm (Appendices A and B); exposed culmen of a diminutive race that occurs primarily in Mexico is generally between 18.56 and 18.92 mm, ranging from 17.80 to 19.40 mm (Appendix B)–Adult Female *Archilochus alexandri*.* (See note at end of key.)

Throat of most individuals faintly streaked (75%), only occasionally (25%) are streaks of moderate to heavy intensity present; metallic throat feathers absent in the vast majority of individuals (95%), although one or two black feathers are present in a limited number of birds (5%) that appear to be very old; slight notch at tip of trailing edge of most inner primaries generally visible, although less discernible than in adult males (Fig. 2L); "arc" formed at tip of inner primaries relatively short and angular, producing tip that is relatively broad and blunt (Fig. 2L); outer three rectrices and sometimes outer four (*AMOUNT OF WHITE AT TIP OF RECTRICES 3 AND 2 NOT CONSISTENT IN ADULTS*) tipped with white; rectrix 5 pointed and/or emarginated at tip (Fig. 2M).

SUBADULT BIRDS

11a. Maximum width of rectrix 5 almost always less than 4.25 mm (Appendix C); inner primaries approximately equal to or greater in width than outer primaries (Fig. 2H); "arc" formed at tip of inner primaries relatively short and rounded with no angular notches (Fig. 2N)–Subadult *Calypte costae* 14

11b. Maximum width of rectrix 5 always greater than 4.45 mm (Appendices D, E, and F); inner primaries may or may not be equal to or greater in width than outer primaries (Figs. 2H and 2I); "arc" formed at tip of inner primaries variable, angular notches may or may not be present (Figs. 2K, 2L, and 2N)...12

12a. Wing length generally less than 46.34 mm, ranging from 40.00 to 48.50 mm (Appendices E and F); inner primaries much narrower than outer four (Fig. 2I). 13

12b. Wing length usually between 49.36 and 50.18 mm, ranging from 47.45 to 52.65 mm (Appendix D); inner primaries approximately equal to or greater in width than outer primaries (Fig. 2H)–Subadult *Calypte anna* **15**

Most secondaries not truncated or pointed centrally (Fig. 2D); throat usually contains at least a few metallic reddish/magenta feathers, or if not, then at least a few rather broad greenish/brown feathers present.

13a. Maximum width of inner web of primary 10 within 5 mm of tip generally less than 2.50 mm (see Figs. 1G and 2J)–Subadult *Archilochus colubris* **16**

"Arc" formed at tip of inner primaries relatively long and gradual, producing tip that is relatively narrow and pointed (Fig. 2K); at least many of the inner six primaries in both males and females deeply notched in the majority of birds (Fig. 2K), or if not, then long-gradual "arc" at tip nonetheless present (Fig. 2K).

13b. Maximum width of inner web of primary 10 within 5 mm of tip generally greater than 2.50 mm (see Figs. 1G and 2J)–Subadult *Archilochus alexandri* **17**

"Arc" formed at tip of inner primaries relatively short and angular, producing tip that is relatively broad and blunt (Fig. 2L); shape of inner six primaries (i.e., notches) not as above.

14a. Outer rectrices resemble those of adult female (i.e., tipped with white); "area" of white at tip of rectrix 3 usually between 13.39 and 15.75 mm, ranging from 9.79 to 18.63 mm (Appendix C)–Subadult Female *Calypte costae.*

Crown greenish or greenish/brown, no metallic purple/violet feathers; throat contains no purple, greenish, or purple/brown feathers, brown streaks rarely present (<5%); dark rachis of outer three rectrices does not enter white tips (Fig. 2E); rectrix 2 generally (95%) tipped with white; maximum width of rectrix 5 usually between 4.07 and 4.21 mm, ranging from 3.70 to 4.30 mm (Appendix C).

14b. Outer rectrices may or may not resemble adult female; if not those of an adult male (i.e., lacking white tips), then "area" of white at tip of rectrix 3 usually between 2.34 and 4.02 mm, ranging from 0.00 to 9.25 mm (Appendix C)–Subadult Male *Calypte costae.*

Crown may lack metallic purple/violet feathers, in which case coloration is greenish or greenish/brown, but if metallic feathers are present, coverage is generally incomplete; throat generally contains numerous metallic purple/violet feathers, coverage is usually incomplete, although occasionally complete; dark rachis of outer three rectrices frequently (86%) extends into white tips (Fig. 2E); the few birds in which the extension of the dark rachis into the white tips of at least one of the outer rectrices is not clearly visible are still separable from females of the same age or younger by the reduced amount of white at the tip of rectrix 3 (Appendix C); rectrix 2 not tipped with white; maximum width of rectrix 5 usually between 3.43 and 3.57 mm, ranging from 2.90 to 4.00 mm (Appendix C).

15a. Outer rectrices resemble those of adult female (i.e., tipped with white); "area" of white at tip of rectrix 3 usually between 6.85 and 9.95 mm, ranging from 1.53 to 22.61 mm (Appendix D); dark rachis of outer three rectrices does not enter white tips (Fig. 2F)–Subadult Female *Calypte anna.*

Crown greenish or greenish/brown, no metallic reddish/magenta feathers; throat generally contains at least a few metallic reddish/magenta feathers, or if not, then at least a few rather broad greenish/brown feathers are present (86%); only rarely does throat lack metallic or greenish/brown feathers; extent of white at tip of rectrix 3 reduced, especially in some birds, but still more extensive than in the limited number of males that share this trait (Appendix D); rectrix 2 generally (83%) not tipped with white.

15b. Outer rectrices may or may not resemble adult female; if not those of an adult male (i.e., lacking white tips), then "area" of white at tip of rectrix 3 usually between 0.02 and 0.08 mm, ranging from 0.00 to 0.62 mm (Appendix D); dark rachis of outer two rectrices extends into white tips (Fig. 2F)–Subadult Male *Calypte anna.*

Crown may lack metallic reddish/magenta feathers, in which case coloration is greenish or greenish/brown, but if metallic feathers are present, coverage is generally incomplete; throat generally contains numerous metallic reddish/magenta feathers, coverage is usually incomplete, although occasionally complete; rectrix 3 generally not tipped with white in subadult males, but if present, white greatly reduced when compared to females of the same age or younger; rectrix 2 not tipped with white.

16a. Outer rectrices resemble those of adult female (i.e., tipped with white); "area" of white at tip of rectrix 3 usually between 12.86 and 15.52 mm, ranging from 8.67 to 20.87 mm (Appendix E); outer web of primary 6 decidedly present (Fig. 2G)–Subadult Female *Archilochus colubris.*

Metallic reddish/gold feathers absent from throat; throat usually not streaked (89%), but when streaked (11%), streaking generally very faint; rectrix 2 generally (81%) tipped with white.

16b. Outer rectrices may or may not resemble adult female; if not those of an adult male (i.e., lacking white tips), then "area" of white at tip of rectrix 3 usually between 3.29 and 4.53 mm, ranging from 0.01 to 9.68 mm (Appendix E); outer web of primary 6 virtually absent (Fig. 2G)–Subadult Male *Archilochus colubris.*

One or two metallic reddish/gold feathers usually present (>95%) on throat, remaining areas moderately to heavily streaked in most birds (91%); rectrix 2 not tipped with white.

17a. Outer rectrices resemble those of adult female except that rectrix 5 (outermost) not pointed or emarginated at tip as in most adult females and young males (Fig. 2M); "area" of white at tip of rectrix 3 usually between 17.60 and 20.06 mm, ranging from 10.01 to 28.07 mm (Appendix F)–Subadult Female *Archilochus alexandri.*

Black and/or metallic purple feathers absent from throat; throat usually (81%) at least very faintly streaked, only occasionally (19%) are streaks of moderate to heavy intensity present; trailing edge of inner primaries generally lacks minute notch that is present in at least some of the inner six primaries of adult females and young males (Fig. 2L); rectrix 2 generally (87%) tipped with white.

17b. Outer rectrices may or may not resemble adult female; if not those of an adult male (i.e., lacking white tips), then the tip of rectrix 5 (outermost) generally pointed and/or emarginated (Fig. 2M); "area" of white at tip of rectrix 3 usually between 4.63 and

6.15 mm, ranging from 1.84 to 9.45 mm (Appendix F)–Subadult Male *Archilochus alexandri.*

One or two black and/or metallic purple feathers usually present (80%) on throat, remaining areas moderately to heavily streaked in most birds (87%); trailing edge of inner primaries usually minutely notched (Fig. 2L); rectrix 2 very rarely (3%) tipped with white.

JUVENILE BIRDS

18a. Maximum width of rectrix 5 generally less than 4.17 mm (Appendices G, H, I, and J); inner primaries approximately equal to or greater in width than outer primaries (Fig. 2H); "arc" formed at tip of inner primaries relatively short and rounded with no angular notches (Fig. 2N)–Juvenile *Calypte costae* **21**

18b. Maximum width of rectrix 5 always greater than 4.45 mm (Appendices G, H, I, and J); inner primaries may or may not be equal to or greater in width than outer primaries (Figs. 2H and 2I); "arc" formed at tip of inner primaries variable, angular notches may or may not be present (Figs. 2K, 2L, and 2N)... **19**

19a. Wing length generally less than 48.00 mm, ranging from 37.25 to 48.50 mm (Appendices I and J); inner six primaries much narrower than outer four (Fig. 2I) **20**

19b. Wing length generally greater than 48.00 mm, ranging from 47.10 to 52.25 mm (Appendix H); inner primaries approximately equal to or greater in width than outer primaries (Fig. 2H)–Juvenile *Calypte anna* **22**

20a. Maximum width of inner web of primary 10 within 5 mm of tip generally less than 2.50 mm (see Figs. 1G and 2J)–Juvenile *Archilochus colubris* **23**

"Arc" formed at tip of inner primaries relatively long and gradual, producing tip that is relatively narrow and pointed (Fig. 2K); at least many of the inner six primaries in both males and females are deeply notched in the majority of birds (Fig. 2K), or if not, then long-gradual "arc" at tip nonetheless present (Fig. 2K).

20b. Maximum width of inner web of primary 10 within 5 mm of tip generally greater than 2.50 mm (see Figs. 1G and 2J)–Juvenile *Archilochus alexandri* **24**

"Arc" formed at tip of inner primaries relatively short and angular, producing tip that is relatively broad and blunt (Fig. 2L); shape of inner six primaries (i.e., notches) not as above.

21a. "Area" of white at tip of rectrix 3 usually between 11.29 and 16.15 mm, ranging from 6.30 to 22.92 mm (Appendix G)–Juvenile Female *Calypte costae.*

Throat contains no purple, greenish, or purple/brown feathers, brown streaks rarely present (<5%); dark rachis of outer three rectrices does not enter white tips (Fig. 2E); rectrix 2 generally (92%) tipped with white; maximum width of rectrix 5 usually between 3.85 and 4.17 mm, ranging from 3.50 to 4.45 mm (Appendix G).

21b. "Area" of white at tip of rectrix 3 usually between 3.53 and 5.61 mm, ranging from 0.15 to 9.95 mm (Appendix G)–Juvenile Male *Calypte costae*.

Throat almost always (>95%) contains at least a few metallic purple/violet feathers; dark rachis of outer three rectrices usually (>95%) extends into white tips (Fig. 2E); the few individuals in which the extension of the dark rachis into the white tips of at least one of the outer rectrices is not clearly visible are still separable from females of the same age or older by the reduced amount of white at the tip of rectrix 3 (Appendix G); rectrix 2 generally (88%) not tipped with white; maximum width of rectrix 5 usually between 3.07 and 3.37 mm, ranging from 2.40 to 3.95 mm (Appendix G).

22a. Dark rachis of outer three rectrices does not enter white tips (Fig. 2F); "area" of white at tip of rectrix 3 usually between 5.53 and 10.43 mm, ranging from 1.44 to 13.20 mm (extent of white at tip of rectrix 3 reduced in some birds, but still more extensive than in subadult and juvenile males–Appendix H)–Juvenile Female *Calypte anna*.

Throat may or may not contain metallic reddish/magenta feathers or rather broad greenish/brown feathers, but if present, then limited in number; rectrix 2 may (44%) or may not (56%) be tipped with white.

22b. Dark rachis of outer two rectrices extends into white tips (Fig. 2F); "area" of white at tip of rectrix 3 presumably resembles that of subadult males (i.e., usually between 0.02 and 0.08 mm, ranging from 0.00 to 0.62 mm–see Appendices D and H)–Juvenile Male *Calypte anna*.

Throat may or may not contain metallic reddish/magenta feathers or rather broad greenish/brown feathers, but if present, then limited in number; rectrix 2 occasionally (25%) contains a trace of white at the tip, but this undoubtedly wears off almost immediately after fledging.

23a. "Area" of white at tip of rectrix 3 usually between 14.12 and 15.54 mm, ranging from 10.62 to 17.97 mm (Appendix I); outer web of primary 6 decidedly present (Fig. 2G)–Juvenile Female *Archilochus colubris*.

Throat contains no metallic reddish/gold feathers and only rarely (6%) are streaks present, the latter of which are usually very faint; rectrix 2 generally (81%) tipped with white.

23b. "Area" of white at tip of rectrix 3 usually between 4.14 and 5.50 mm, ranging from 1.15 to 7.40 mm (Appendix I); outer web of primary 6 virtually absent (Fig. 2G)–Juvenile Male *Archilochus colubris*.

Throat generally (84%) contains no metallic reddish/gold feathers, but occasionally (16%) there are one or two such feathers emerging; throat moderately to heavily streaked in most (76%) birds; rectrix 2 generally (>95%) not tipped with white.

24a. "Area" of white at tip of rectrix 3 usually between 17.67 and 21.17 mm, ranging from 12.73 to 24.00 mm (Appendix J); rectrix 5 (outermost) not pointed or emarginated at tip as in most adult females and young males (Fig. 2M)–Juvenile Female *Archilochus alexandri*.

Black and/or metallic purple feathers absent from throat; throat usually (89%) at least very faintly streaked, only occasionally (11%) are streaks of moderate to heavy intensity present; trailing edge of inner primaries lacks minute notch that is present in at least some of the inner six primaries of adult females and young males (Fig. 2L); rectrix 2 tipped with white.

24b. "Area" of white at tip of rectrix 3 usually between 6.17 and 8.55 mm, ranging from 3.40 to 12.00 mm (Appendix J); rectrix 5 (outermost) generally pointed and/or emarginated at tip (Fig. 2M)–Juvenile Male *Archilochus alexandri.*

Black and/or metallic purple feathers frequently absent (61%) from throat, but occasionally (39%) one or two such feathers emerging; throat moderately to heavily streaked in most individuals (83%); minute notch at tip of trailing edge of most inner primaries generally visible (Fig. 2L); rectrix 2 occasionally (39%) has trace of white at tip, but this undoubtedly wears off very soon after fledging.

Note

* The diminutive race of *A. alexandri* is at least occasionally sympatric with *A. colubris* during winter and migration. Excluding adult males that are easily distinguished, the diminutive race of *A. alexandri* is separable from *A. colubris* on the basis of (1) the width and subsequent shape of the inner web of primary 10 (outermost), (2) the shape of the inner primaries, and (3) on the basis of forehead and crown coloration.

1. In the diminutive race (as well as in the large race) of *A. alexandri*, the maximum width of the inner web of primary 10 within 5 mm of the tip is greater than 2.50 mm (small race $\bar{x}$ = 3.07, s.d. = 0.19, range 2.65 to 3.40; large race $\bar{x}$ = 3.22, s.d. = 0.18, range 2.95 to 3.55) and thus more asymmetrically "club-shaped" than *A. colubris* (see Figs. 1G and 2J). In contrast, the maximum width of the inner web of primary 10 within 5 mm of the tip in *A. colubris* is less than 2.50 mm ($\bar{x}$ = 2.13, s.d. = 0.17, range 1.60 to 2.50), which produces a more slender "knife-shaped" tip (see Figs. 1G and 2J).

2. There is only a minute notch, and this is not always clearly visible in birds with worn plumage, at the tip of the trailing edge of many of the inner six primaries of males of all ages and adult female *A. alexandri* (both races–see Fig. 2L). The "arc" formed at the tip of the inner six primaries in the diminutive race, as well as the large race, of *A. alexandri* is relatively short and angular, which produces a tip that is relatively broad and blunt (Fig. 2L). In *A. colubris*, there is generally a deeply incised notch at the tip of the trailing edge of most of the inner six primaries (Fig. 2K). The few *A. colubris* lacking the deeply incised notch at the trailing edge of the inner primaries are still separable from the small, as well as the large, race of *A. alexandri* of all ages and sex on the basis of the longer "arc" at the tip of the inner primaries, which produces a relatively narrow and pointed tip (Fig. 2K), rather than the relatively broad and blunt tip found in both races of *A. alexandri* (Fig. 2L).

3. In *A. alexandri* (both races) the forehead and crown in adult females is generally brownish/gray, whereas in *A. colubris* it is usually more greenish.

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(Appendices on following pages)

APPENDIX A. Measurements (mm) of adult female Costa's, Anna's, Ruby-throated, and Black-chinned hummingbirds. Significant differences between species depicted by letter groupings (i.e., B ACR indicates that Black-chins (B) differ significantly from Costa's (C), Anna's (A), and Ruby-throats (R); the latter three of which do not differ significantly from each other).

Character	Statistics	Costa's	Anna's	Ruby-throated	Black-chinned	Significance
Bill	$\bar{X}$	17.59	17.63	17.36	20.39	Sig. P<0.01
(exp. culmen)	S.D.	0.55	0.73	0.79	0.69	
	N	63	78	83	82	(F = 336.68)
	RANGE	16.40-18.65	16.20-19.50	15.05-19.30	19.00-22.05	
	95% C.I.	17.45-17.73	17.46-17.80	17.19-17.53	20.24-20.54	B ACR
Wing	$\bar{X}$	44.64	49.62	44.46	46.14	Sig. P<0.01
(chord)	S.D.	1.05	1.00	1.07	1.10	
	N	63	77	81	82	(F = 388.67)
	RANGE	42.30-46.60	47.05-51.85	41.90-47.40	43.60-48.30	
	95% C.I.	44.38-44.90	49.39-49.85	44.21-44.69	45.90-46.38	A B CR
Tail	$\bar{X}$	23.26	26.52	25.41	26.10	Sig. P<0.01
(length)	S.d.	0.96	1.04	0.83	0.87	
	N	65	79	82	81	(F = 169.57)
	RANGE	21.00-25.00	24.00-29.00	23.00-27.00	24.00-29.00	
	95% C.I.	23.02-24.50	26.29-26.75	25.23-25.59	25.91-26.29	A B R C
Maximum width	$\bar{X}$	3.66	5.63	5.34	5.10	Sig. P<0.01
5th rectrix	S.D.	0.34	0.39	0.29	0.28	
	N	64	77	73	79	(F = 479.79)
	RANGE	2.90-4.25	4.90-6.75	4.60-6.20	4.25-5.85	
	95% C.I.	3.57-3.75	5.54-5.72	5.27-5.41	5.04-5.16	A R B C
Length of white	$\bar{X}$	5.69	5.84	6.86	6.42	Sig. P<0.01
5th rectrix	S.D.	0.77	0.66	0.89	0.69	
	N	64	77	72	78	(F = 36.02)
	RANGE	3.65-7.10	4.15-7.15	4.55-8.90	4.80-8.55	
	95% C.I.	5.50-5.88	5.69-5.99	6.65-7.07	6.26-6.58	R B AC

APPENDIX B. Measurements (mm) of adult female Black-chinned Hummingbirds showing significant differences between the large and small races of this species.

Character Race	$\bar{X}$	S.D.	N	Range	95% Confidence Interval	Significance (large vs small)
Bill (exposed culmen)						
Large race	20.39	0.69	82	19.00-22.05	20.24-20.54	Sig. P<0.01
Small race	18.74	0.53	36	17.80-19.40	18.56-18.92	(F = 163.94)
Wing (chord)						
Large race	46.14	1.10	82	43.60-48.30	45.90-46.38	Sig. P<0.01
Small race	44.72	1.20	36	41.95-46.90	44.31-45.13	(F = 39.92)
Tail (length)						
Large race	26.10	0.87	81	24.00-29.00	25.91-26.29	Sig. P<0.01
Small race	25.36	0.96	36	24.00-28.00	25.03-25.69	(F = 16.67)
Maximum width 5th rectrix						
Large race	5.10	0.28	79	4.25-5.85	5.04-5.16	NS
Small race	5.03	0.16	32	4.65-5.45	4.97-5.09	(F = 1.54)
Length of white 5th rectrix						
Large race	6.42	0.69	78	4.80-8.55	6.26-6.58	NS
Small race	6.21	0.70	32	5.25-7.85	5.96-6.46	(F = 2.01)

APPENDIX C. Measurements (mm) of subadult Costa's Hummingbirds showing significant differences between sexes.

Character Sex	$\bar{X}$	S.D.	N	Range	95% Confidence interval	Significance (female vs male)
Bill (exposed culmen)						
Female	17.11	0.61	24	16.05-18.30	16.85-17.37	Sig. P<0.01
Male	16.47	0.59	50	15.25-17.80	16.31-16.65	(F = 17.97)
Wing (chord)						
Female	44.41	1.01	24	41.90-46.20	43.98-44.84	NS
Male	44.16	0.95	50	42.30-46.75	43.89-44.43	(F = 0.99)
Tail (length)						
Female	23.13	0.90	24	21.00-25.00	22.75-23.51	Sig. P<0.01
Male	22.58	0.73	51	21.00-24.00	22.34-22.76	(F = 8.73)
Maximum width 5th rectrix						
Female	4.14	0.17	24	3.70-4.30	4.07-4.21	Sig. P<0.01
Male	3.50	0.24	46	2.90-4.00	3.43-3.57	(F = 134.92)
Length of white 5th rectrix						
Female	5.19	0.68	24	4.10-6.60	4.90-5.48	Sig. P<0.01
Male	3.78	0.70	46	2.30-5.60	3.57-3.99	(F = 65.59)
Area of white 3rd rectrix						
Female	14.57	2.79	24	9.79-18.63	13.39-15.75	Sig. P<0.01
Male	3.18	2.75	44	0.00-9.25	2.34-4.02	(F = 263.16)

APPENDIX D. Measurements (mm) of subadult Anna's Hummingbirds showing significant differences between sexes.

Character Sex	$\bar{X}$	S.D.	N	Range	95% Confidence interval	Significance (female vs male)
Bill (exposed culmen)						
Female	17.71	0.70	36	15.90-18.75	17.47-17.95	NS
Male	17.59	0.73	63	16.00-19.00	17.41-17.77	(F = 0.72)
Wing (chord)						
Female	49.77	1.17	34	48.00-52.65	49.36-50.18	NS
Male	49.74	0.93	62	47.45-51.90	49.50-49.98	(F = 0.06)
Tail (length)						
Female	27.06	0.79	36	26.00-29.00	26.79-27.33	NS
Male	26.96	0.88	50	25.00-29.00	26.71-27.21	(F = 0.26)
Maximum width 5th rectrix						
Female	5.98	0.36	35	5.30-6.95	5.86-6.10	NS
Male	5.87	0.31	49	5.20-6.50	5.78-5.96	(F = 1.98)
Length of white 5th rectrix						
Female	5.59	0.73	35	4.15-6.85	5.34-5.84	Sig. P<0.01
Male	3.48	0.70	48	1.60-5.25	3.28-3.68	(F = 176.86)
Area of white 3rd rectrix						
Female	8.40	4.68	36	1.53-22.61	6.85-9.95	Sig. P<0.01
Male	0.05	0.12	50	0.00-0.62	0.02-0.08	(F = 166.63)

APPENDIX E. Measurements (mm) of subadult Ruby-throated Hummingbirds showing significant differences between sexes.

Character Sex	$\bar{X}$	S.D.	N	Range	95% Confidence interval	Significance (female vs male)
Bill (exposed culmen)						
Female	17.46	0.55	25	16.30-18.65	17.23-17.69	Sig. P<0.01
Male	15.67	0.78	53	13.80-17.90	15.46-15.88	(F = 107.83)
Wing (chord)						
Female	45.14	0.72	26	43.30-46.25	44.85-45.43	Sig. P<0.01
Male	41.70	1.03	55	40.00-45.15	41.42-41.98	(F = 235.52)
Tail (length)						
Female	25.19	0.94	26	23.00-27.00	24.81-25.57	Sig. P<0.01
Male	24.42	0.87	52	23.00-27.00	24.18-24.66	(F = 12.83)
Maximum width 5th rectrix						
Female	5.34	0.33	25	4.80-6.00	5.21-5.47	NS
Male	5.23	0.37	52	4.50-6.25	5.13-5.33	(F = 1.71)
Length of white 5th rectrix						
Female	6.60	0.84	25	5.30-8.95	6.25-6.95	Sig. P<0.01
Male	5.65	0.75	51	4.10-7.35	5.44-5.86	(F = 24.92)
Area of white 3rd rectrix						
Female	14.19	3.30	25	8.67-20.87	12.86-15.52	Sig. P<0.01
Male	3.91	2.21	52	0.01-9.68	3.29-4.53	F = 267.58)

APPENDIX F. Measurements (mm) of subadult Black-chinned Hummingbirds showing significant differences between sexes.

Character Sex	$\bar{X}$	S.D.	N	Range	95% Confidence interval	Significance (female vs male)
Bill (exposed culmen)						
Female	19.24	1.07	48	16.95-21.65	18.93-19.55	Sig. P<0.01
Male	17.63	1.05	36	15.80-20.00	17.28-17.98	(F = 47.10)
Wing (chord)						
Female	46.03	1.06	48	43.85-48.50	45.72-46.34	Sig. P<0.01
Male	43.42	1.33	37	40.05-46.80	42.98-43.86	(F = 101.02)
Tail (length)						
Female	25.71	0.99	48	23.00-28.00	25.42-26.00	Sig. P<0.01
Male	24.27	1.24	37	22.00-26.00	23.86-24.68	(F = 35.43)
Maximum width 5th rectrix						
Female	5.26	0.34	48	4.65-6.25	5.16-5.36	Sig. P<0.01
Male	5.00	0.31	37	4.45-5.95	4.90-5.10	(F = 12.39)
Length of white 5th rectrix						
Female	6.03	0.69	48	4.90-7.60	5.83-6.23	Sig. P<0.01
Male	5.50	0.69	37	4.10-7.05	5.27-5.73	(F = 12.57)
Area of white 3rd rectrix						
Female	18.83	4.18	47	10.01-28.07	17.60-20.06	Sig. P<0.01
Male	5.39	2.29	37	1.84-9.45	4.63-6.15	(F = 308.40)

APPENDIX G. Measurements (mm) of juvenile Costa's Hummingbirds showing significant differences between sexes.

Character Sex	$\bar{X}$	S.D.	N	Range	95% Confidence interval	Significance (female vs male)
Bill (exposed culmen)						
Female	16.42	0.61	14	14.30-17.10	15.95-16.89	Sig. P<0.05
Male	15.71	0.98	26	13.70-17.40	15.32-16.10	(F = 5.38)
Wing (chord)						
Female	44.56	0.73	14	43.05-45.65	44.14-44.98	NS
Male	44.34	1.01	26	42.10-46.05	43.93-44.75	(F = 0.51)
Tail (length)						
Female	23.00	0.78	14	22.00-24.00	22.55-23.45	Sig. P<0.05
Male	22.31	0.93	26	21.00-24.00	21.93-22.69	(F = 5.61)
Maximum width 5th rectrix						
Female	4.01	0.28	14	3.50-4.45	3.85-4.17	Sig. P<0.01
Male	3.22	0.37	26	2.40-3.95	3.07-3.37	(F = 49.71)
Length of white 5th rectrix						
Female	4.92	0.80	14	3.40-6.25	4.46-5.38	Sig. P<0.01
Male	3.55	0.47	26	2.55-4.60	3.36-3.74	(F = 47.52)
Area of white 3rd rectrix						
Female	13.72	4.22	14	6.30-22.92	11.29-16.15	Sig. P<0.01
Male	4.57	2.56	26	0.15-9.95	3.53-5.61	(F = 73.21)

APPENDIX H. Measurements (mm) of juvenile Anna's Hummingbirds showing significant differences between sexes.

Character Sex	$\bar{X}$	S.D.	N	Range	95% Confidence interval	Significance (female vs male)
Bill (exposed culmen)						
Female	15.55	2.52	12	10.55-18.15	13.95-17.15	NS
Male	14.65	1.66	3	12.80-16.00	---	(F = 0.34)
Wing (chord)						
Female	49.96	1.62	10	47.10-52.25	48.80-51.12	NS
Male	50.52	0.78	3	49.90-51.40	---	(F = 0.33)
Tail (length)						
Female	27.50	1.27	10	25.00-29.00	26.59-28.41	NS
Male	28.00	1.73	3	26.00-29.00	---	(F = 0.31)
Maximum width 5th rectrix						
Female	5.84	0.34	11	5.40-6.45	5.61-6.07	NS
Male	6.15	0.39	3	5.90-6.60	---	(F = 1.88)
Length of white 5th rectrix						
Female	5.20	0.90	11	3.30-6.45	4.60-5.80	Sig. P<0.01
Male	3.55	0.40	3	3.15-3.95	---	(F = 9.27)
Area of white 3rd rectrix						
Female	7.98	3.65	11	1.44-13.20	5.53-10.43	Sig. P<0.01
Male	0.04	0.06	3	0.00-0.10	---	(F = 13.38)

APPENDIX I. Measurements (mm) of juvenile Ruby-throated Hummingbirds showing significant differences between sexes.

Character Sex	$\bar{X}$	S.D.	N	Range	95% Confidence interval	Significance (female vs male)
Bill (exposed culmen)						
Female	16.59	0.92	15	14.80-17.85	16.08-17.10	Sig. P<0.01
Male	14.25	1.17	24	10.80-15.80	13.76-14.74	(F = 43.28)
Wing (chord)						
Female	45.64	1.28	16	42.95-47.75	44.96-46.32	Sig. P<0.01
Male	41.60	1.39	25	37.25-43.70	41.03-42.17	(F = 88.12)
Tail (length)						
Female	25.25	0.86	16	24.00-27.00	24.79-25.71	Sig. P<0.05
Male	24.58	0.72	24	23.00-26.00	24.28-24.88	(F = 7.10)
Maximum width 5th rectrix						
Female	5.26	0.22	15	4.90-5.75	5.14-5.38	NS
Male	5.27	0.48	25	4.60-6.50	5.07-5.47	(F = 0.00)
Length of white 5th rectrix						
Female	6.82	0.84	15	5.50-8.75	6.37-7.27	Sig. P<0.01
Male	5.88	0.49	25	4.90-6.65	5.68-6.08	(F = 20.73)
Area of white 3rd rectrix						
Female	14.83	2.18	14	10.62-17.97	14.12-15.54	Sig. P<0.01
Male	4.82	1.66	25	1.15-7.40	4.14-5.50	(F = 260.08)

APPENDIX J. Measurements (mm) of juvenile Black-chinned Hummingbirds showing significant differences between sexes.

Character Sex	$\bar{X}$	S.D.	N	Range	95% Confidence interval	Significance (female vs male)
Bill (exposed culmen)						
Female	18.85	0.88	17	16.90-20.45	18.40-19.30	Sig. P<0.01
Male	17.77	1.10	17	15.80-19.20	17.21-18.33	(F = 10.21)
Wing (chord)						
Female	46.57	1.12	17	44.50-48.50	45.99-47.15	Sig. P<0.01
Male	43.97	1.33	17	40.90-45.95	43.29-44.65	(F = 38.07)
Tail (length)						
Female	26.53	0.94	17	24.00-28.00	26.04-27.02	Sig. P<0.01
Male	25.47	1.07	17	24.00-27.00	24.92-26.02	(F = 9.38)
Maximum width 5th rectrix						
Female	5.23	0.25	17	4.60-5.60	5.10-5.36	NS
Male	5.10	0.30	17	4.60-5.65	4.98-5.26	(F = 1.74)
Length of white 5th rectrix						
Female	6.24	0.91	17	4.60-7.85	5.77-6.71	NS
Male	5.76	0.64	17	4.60-6.95	5.43-6.09	(F = 3.29)
Area of white 3rd rectrix						
Female	19.42	3.28	16	12.73-24.00	17.67-21.17	Sig. P<0.01
Male	7.36	2.31	17	3.40-12.00	6.17-8.55	(F = 150.37)