Nestling growth and plumage development of the Black-chinned Hummingbird (*Archilochus alexandri*) in southeastern Arizona

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Abstract
We studied plumage development and growth of nestling Black-chinned Hummingbirds (*Archilochus alexandri*) in southeastern Arizona. Nestlings fledge after 20-22 days and reach a maximum weight of around 4.16 g prior to fledging; approximately 126% of adult weight. Nestlings hatch with 11 pairs of beige neossoptiles, in two dorsal rows. Contour pin feathers begin emerging through the skin around day 6. Wing pin feathers begin emerging from their sheaths around day 12, and contour feathers begin breaking sheaths around day 9. We provide a photographic key to aging nestlings in the field and the first published record of growth rates for this species.
Key words: photographic key, nestling aging, growth curve.

Crecimiento de polluelos y desarrollo del plumaje del colibrí barba negra (*Archilochus alexandri)* en el sureste de Arizona

Resumen
Estudiamos el desarrollo del plumaje y crecimiento de los polluelos del colibrí barba negra (*Archilochus alexandri)* en el sureste de Arizona, EUA. Los polluelos vuelan después de 20-22 días de haber eclosionado y llegan a un peso máximo de 4.16 g antes de comenzar a volar; lo que representa aproximadamente el 126% del peso de los adultos. Los polluelos nacen con 11 pares de *neossoptiles* de color café claro, organizados en dos hileras dorsales. Las plumas del cuerpo comienzan a emerger de la piel a los 6 días de edad. Las plumas de las alas comienzan a emerger alrededor de los 12 días, y las plumas del cuerpo comienzan a emerger alrededor de los 9 días de edad. Aquí presentamos una guía fotográfica que será útil para estimar la edad de los polluelos en campo, con base en el desarrollo de las plumas, así como los primeros registros publicados de las tasas crecimiento de esta especie.
Palabras clave: guía fotográfica, asignación de edad a polluelos, ecuación de crecimiento.

Croissance des oisillons et développement du plumage du colibri à gorge noire (*Archilocus alexandri*) dans le sud-est de l'Arizona

Resumé
Nous avons étudié le développement du plumage et la croissance d'oisillons du colibri à gorge blanche (*Archilocus alexandri*) dans le sud-est de l'Arizona. Les oisillons prennent leur envol après 20-22 jours et, avant de quitter le nid, atteignent une masse maximale d'environ 4.1 g, soit près de 126% la masse d'un adulte. Les oisillons naissent avec 11 paires de plumes de duvet beige, réparties sur deux rangées dorsales. Les pennes naissantes commencent à émerger à travers la peau vers le jour 6 et à briser les fourreaux vers le jour 9. Les rémiges naissantes commencent à émerger de leur fourreau vers le jour 12. Nous fournissons une clé photographique afin de déterminer l'âge des oisillons sur le terrain ; ce travail constitue le premier registre publié des taux de croissance chez cette espèce.
Mots clé: clé photographique, chronométrie des oisillons, courbe de croissance.

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Introduction

The Black-chinned Hummingbird (*Archilochus alexandri*) is one of two species in the genus (Schuchmann 1999). It breeds from southern British Columbia southward, through the western United States to southern California, Arizona and New Mexico, and over-winters in western and south-central Mexico from southern Sonora to northern Guerrero and western Veracruz (Johnsgard 1997, Rappole 1999, Baltosser and Russell 2000). Like many North American birds, there is a fair amount of data published concerning the general biology of this species (see Baltosser and Russell 2000 and references therein), but there are still many gaps in our knowledge. What is known of its breeding biology comes largely from studies in southern California, southwestern New Mexico, and southeastern Arizona (Pitelka 1951, Baltosser 1983, 1986, Brown 1992). Despite the ease with which large numbers of nests can be found (*e.g.*, Baltosser 1983), there is relatively little known of the details of its reproductive biology. For example, little is known about the onset of incubation, events at hatching, early vocalizations, and other aspects of its basic natural history (Baltosser and Russell 2000). While a few studies have addressed various issues of plumage in juveniles and adults, as well as nestling bill development (Baldridge 1983, Baltosser 1987, Elliston and Baltosser 1995), there have been no studies documenting rates of nestling mass gain, a useful tool for comparing the reproductive strategies and evolution of life history traits in birds (Ricklefs 1979, Starck and Ricklefs 1998, Remeš and Martin 2002). In order to help biologists wishing to study the nesting of this, and other small hummingbirds, we carefully documented the plumage development of nestling Black-chinned Hummingbirds and here provide a photographic guide with which field workers can accurately age nestlings. In addition, we provide the first data concerning growth rates for this species.

Methods

We made all observations in the vicinity of the Southwestern Research Station (31°53’ N, 109°12’ W, 1600 m.a.s.l.), just west of Portal in the Chiricahua Mountains, Cochise County, in southeastern Arizona. We searched for and monitored nests from mid-April to mid-July 2007. Nests of this species vary greatly in height above the ground, and thus accessibility (*e.g.*, Pitelka 1951, Baltosser 1983), and we were able to closely monitor nestling growth at only the lower nests (generally those below 3 m). For those nests we could reach without fear of damaging them, we weighed nestlings to the nearest 0.01 g. The data presented below are only for nests where we observed hatching, and are thus certain of nestling age. As hatching was asynchronous (HFG pers. observ.), based on weight (mean ± SD) we were able to monitor individual nestlings. We fitted our data to a logistic growth equation, relating body mass to age using a least squares method, as proposed by Ricklefs (1967, 1976):

$$\text{mass(age)} = A/[1+e(-K(\text{age}-t))]$$

where A is the asymptotic weight reached, K is the growth constant, t is the age of the nestling at the inflection of the curve (0.5 asymptotic weight), and e is the base of the natural logarithm. We calculated the inverse measure of growth rate, that is, the time required to grow from 10% to 90% of the asymptote, using the formula $4.4/K$ (Ricklefs 1976). As our sample size included only 11 nestlings for which we obtained solid data, we plotted individual nestling weights, despite possible problems with pseudo-replication within nests.

Results

Nestling growth

The asymptotic body mass (A), attained by nestlings close to fledging, was 4.16 g. When compared with the body mass of Black-chinned Hummingbirds weighed during monitoring sessions conducted in 2007 at the research station (SW unpubl.), the fledglings weighed 130% of the mean body mass of adult (3.2 ± 0.8 g, n = 95) or juvenile females (3.2 ± 0.2 g, n = 9), 149% of adult males (2.8 ± 0.6 g, n = 114), and 134% of juvenile males (3.1 ± 0.3 g, n = 11). Growth rate expressed by the K parameter of the logistic equation equaled 0.365. The curve inflected at age 6.7 days and nestlings needed 12.1 days to grow from 10% to 90% of the asymptote (Figure 1).

Nestling feather development

On the day of hatching (0.39 ± 0.02 g; Figure 2), nestlings are dark skinned dorsally and pink below. The bill is yellow with a small white egg-tooth. Dorsally, nestlings bear two rows of 11 pale beige or blond neossoptiles. Two days later (0.74 ± 0.12 g; Figure 2), their appearance has changed little, but dorsal skin color has darkened to black and the base of the upper mandible has become dusky. At 4 days old (1.07 ± 0.30 g; Figure 2), nestlings still have no visible contour feather development but their bills are dusky dorsally to the tip and they have lost their egg-tooth. By six days of age (1.91 ± 0.15 g; Figure 3), nestling coloration has changed little, but the upper mandible is noticeably darker. All feather tracts are just beginning to emerge from the skin. Contour pin feathers on the dorsal tracts are the first to begin emerging from their sheaths, usually around nine

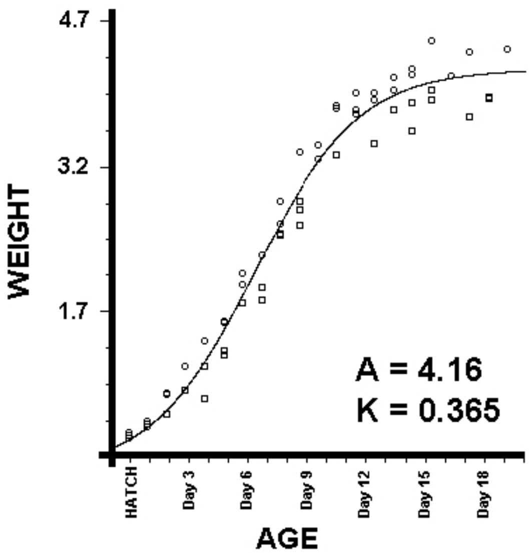

Figure 1. Nestling growth of Black-chinned Hummingbird (*Archilochus alexandri*) at the Southwest Research Station, Portal, Arizona, USA. The equation of the growth curve was: mass (age) = 4.16/[1+e(-0.365(age-6.7))]. Circles indicate points above the curve and squares indicate points which fall below the curve. Both *A* (asymptote) and *K* (growth constant) are given.

days of age (2.84 ± 0.33 g). By day 12 (3.79 ± 0.12 g; Figure 4) both primary and secondary pin feathers are breaking their sheaths. Contour feathers on the ventral track have also begun to emerge from their sheaths, while pins on the capital and submalar tracts remain unbroken. By day 14 (3.92 ± 0.17 g; Figure 4) submalar pin feathers have broken their sheaths and capital feather tracks are just breaking. Only two days later, at 16 days old (4.08 ± 0.32 g; Figure 4), nestlings begin to appear fully feathered, with the last of the capital pin feathers near the base of the bill just breaking. The belly and breast feathers are bright white, with the sternal apterium still largely visible. The dorsum is generally green, with distinct buffy scaling on the crown. Primaries are dark, with greener secondaries, and the white outer retricies are now obvious. By age 19-20 (Figure 5), it is usually possible to sex nestlings by plumage. Females have an immaculate white throat (Figure 5d), while males begin to have visible scaling on the throat (Figure 5e).

General observations on nestling plumage, behavior, and coloration

Like many hummingbird species (Greeney pers. observ.), nestling Black-chinned Hummingbirds show very little differentiation in coloration of the rictal flanges (gape) from the rest of the bill. In general, they were slightly brighter yellow, but by mid-way through development they were barely noticeable (Figures 5b, 5c). Also similar to other hummingbirds (Greeney pers. observ.), after a meal nestlings would show great enlargement of the crop, often distending enough to prevent nestlings from further begging for food (Figure 5a). As the nestlings aged, this filling of the crop was less apparent (Figure 5b), but was an easy way to determine how recently they had been fed. Due to the confining nature of their small nests, nestlings really only had two options in terms of positioning themselves relative to each other. They could either face in opposite directions (Figure 6), or in the same direction (Figure 7). While we did not identify a potential pattern until later in the nesting season (and thus have fairly small sample sizes, Figure 8), at each visit to the nest we recorded the position of the nestlings relative to each other (opposite or same). The results showed that young nestlings were most often found facing in opposite directions and, as nestlings aged, they preferred to face in the same direction (Figure 8).

Discussion

While there are scant data with which to compare, the growth parameter (*K*) of Black-chinned Hummingbirds was similar to that of Rufous Hummingbird (*Selasphorus rufus*; *K* = 0.38; Constanz 1980), a species which also breeds in the United States. There are a few other comparisons available from tropical species, however, including Reddish Hermit (*Phaethornis ruber*; *K* = 0.47; Schuchmann 1986), Blue-tailed Emerald (*Chlorostilbon mellisugus*; *K* = 0.28; Thomas 1994), Rufous-tailed Hummingbird (*Amazilia tzacatl*; *K* = 0.36; Skutch 1931), Glittering-throated Emerald (*A. fimbricata*; *K* = 0.26; Haverschmidt 1952), Copper-rumped Hummingbird (*A. tobaci*; *K* = 0.33; Muir 1925), and Violet-chested Hummingbird (*Sternoclyta cyanopectus*; *K* = 0.28; Fierro-Calderón and Martin 2007). Our results demonstrate that Black-chinned hummingbird growth parameters are very similar to other temperate-breeding species, and slightly higher than most tropical species.

There are so few detailed descriptions of pterylosis and feather development in hummingbirds (but see Schuchmann 1999, Thomas 1994), that a comparative discussion is not warranted at this time. We feel, however, that the illustrations provided here will be a useful tool for studies of other hummingbirds, both for comparative studies as well as for practical use in the field. We encourage others to present similar details of nestling development in order to present future discussions in a more comparative light.

While the reasons for the strikingly robust pattern of nestling positioning in the nest are unclear, we suggest that changes in females' feeding behaviors or inter-sibling competition may drive this shift in behavior. For example, while nestlings are very young and unable to beg vigorously, it may be easier for females to provision each nestling equally if their heads are on opposite sides of the nest. This would prevent any detrimental food deprivation of one nestling, ensuring they both survive to an age where sibling competition will be more important in determining fitness. It would be informative for future studies to report this behavior in other hummingbird species.

Figure 2. Nestlings of Black-chinned Hummingbird (*Archilochus alexandri*) 0-4 days old, at the Southwest Research Station, Portal, Arizona, USA, showing feather development. Note that exposures vary so that true color may not be properly represented (photos by H.F. Greeney).

Figure 3. Nestlings of Black-chinned Hummingbird (*Archilochus alexandri*) 6-10 days old, at the Southwest Research Station, Portal, Arizona, USA, showing feather development. Note that exposures vary so that true color may not be properly represented (photos by H.F. Greeney).

Figure 4. Nestlings of Black-chinned Hummingbird (*Archilochus alexandri*) 12-16 days old, at the Southwest Research Station, Portal, Arizona, USA, showing feather development. Note that exposures vary so that true color may not be properly represented (photos by H.F. Greeney).

Figure 5. Nestlings of Black-chinned Hummingbird (*Archilochus alexandri*) 18-20 days old, at the Southwest Research Station, Portal, Arizona, USA, showing feather development. Note that exposures vary so that true color may not be properly represented. Additional photos include A) ventral view of a young nestling showing engorged crop; B) mid-aged nestling showing full crop; C) mid-aged nestling showing yellow gape flanges; D) 20 day old female nestling showing immaculate white throat; E) 20 day old male nestling showing faint scaling on throat (photos by H.F. Greeney).

Figure 6. Young nestlings of Black-chinned Hummingbird (*Archilochus alexandri*), at the Southwest Research Station, Portal, Arizona, USA, showing typical resting position in the nest during the first half of the nestling period (photos by H.F. Greeney).

Figure 7. Older nestlings of Black-chinned Hummingbird (*Archilochus alexandri*), at the Southwest Research Station, Portal, Arizona, USA, showing typical resting position in the nest during the second half of the nestling period (photos by H.F. Greeney).

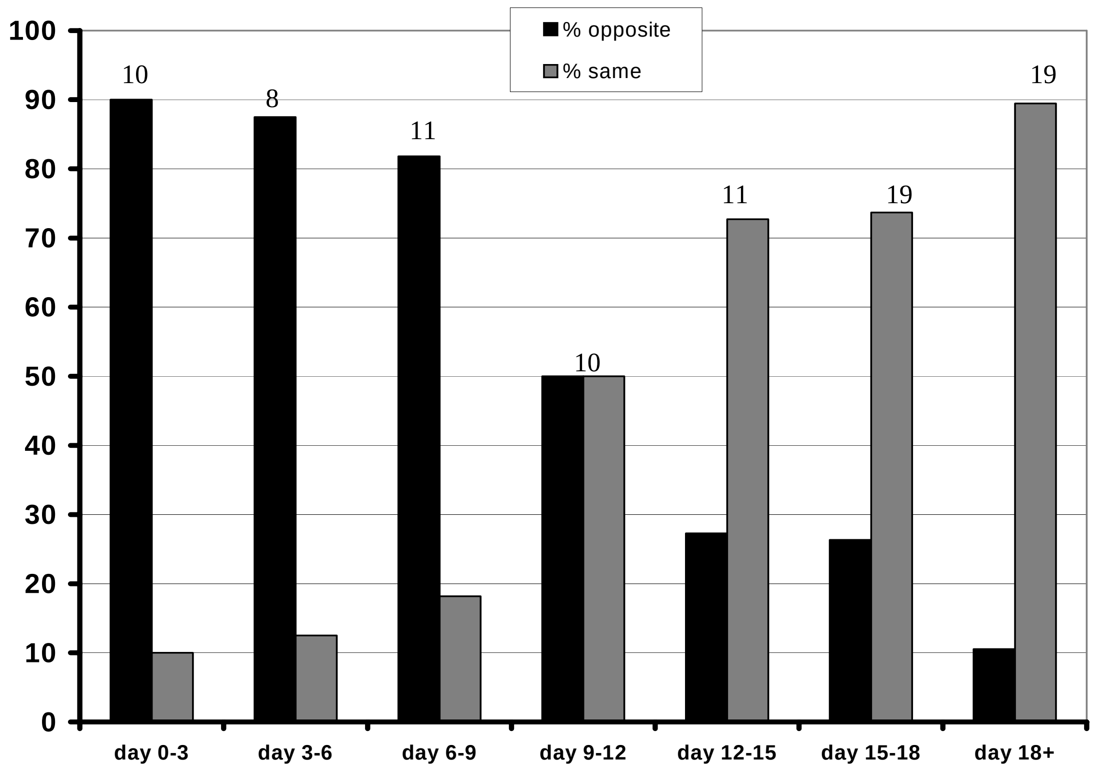

Figure 8. Illustration of the preferred position of nestlings in the nest, in relation to each other. At each nest visit, nestlings noted to be either facing in the same direction (black bars) or in opposite directions (grey bars), and the relative percent of observations where this occurred are given on the left. Nestling age categories are shown along the bottom and sample sizes of nest visits are given above the bars for each category.

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