

SHORT COMMUNICATION

Evidence of altitudinal moult-migration in a Central American hummingbird, *Amazilia cyanura*

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(Accepted 2 July 2010)

Key Words: altitudinal migration, diet, intratropical migration, Neotropical birds, Nicaragua, resource tracking, seasonality

For birds, moulting is an energetically costly endeavour (Murphy & King 1991), the timing and location of which may be flexible and governed by local ecological factors (Pyle *et al.* 2009, Rohwer *et al.* 2005). Some species or individuals may pause during long-distance migration, or migrate specifically to moult (Greenberg *et al.* 1974, Pyle *et al.* 2009, Rohwer *et al.* 2005, 2008). This strategy may be most common when food abundance reaches a nadir at the end of the breeding period, promoting movement to areas where food is more plentiful and the energetic and nutritive demands of moult may be met more suitably (Rohwer *et al.* 2005). This pattern is exemplified by insectivorous songbirds breeding in temperate, western North America that pause on southward migration to moult amidst the food flush that occurs following heavy rains in the Mexican monsoon region (Pyle *et al.* 2009, Rohwer *et al.* 2005, 2009), or more rarely, migrate upslope after breeding to moult in more moist, productive areas at higher elevation (Butler *et al.* 2002, Greenberg *et al.* 1974, Rohwer *et al.* 2008, Steele & McCormick 1995). Such altitudinal migration may be much more common in the Neotropics where many species engage in seasonal shifts in elevation. Hypotheses proposed to explain this behaviour, however, have focused on links made between migration and a principally frugivorous or nectarivorous diet (Levey & Stiles 1992, Stiles 1985, 1988) and not

on moult requirements or phenology. Fruit and nectar availability may vary seasonally over an elevational gradient, and birds may migrate in order to track peak abundances (Levey & Stiles 1992, Loiselle & Blake 1991). Hummingbirds may also track arthropod (particularly spider) abundance, but this possibility remains little explored (Cotton 2007, Stiles 1980).

From 2005 to 2010, we observed a common but little studied Central American endemic hummingbird (*Amazilia cyanura*, Gould 1859, blue-tailed hummingbird, 4.5 g) at our Nicaraguan study site (El Jaguar; 1350 m asl; 13° 10' N, 86° 02' W) during the wet season, but at no other time of year. An individual captured during mist-net monitoring at the site in 2005 was in flight-feather and body moult, but no indicators of local breeding were observed. Considering that El Jaguar sits atop the highest peaks in the region, and that most observations of *Amazilia cyanura* are on the Pacific coast near sea level (L. Chavarría pers. obs., M. Torrez pers. comm., Stiles & Skutch 1989), we presumed that individuals arriving at the study area were derived from lowland populations. We hypothesized that *Amazilia cyanura* may be a moult-migrant that moves from lower elevation to the study site to complete moult, but not to breed. The closely related, and better-studied *A. saucerrottei* (De Lattre & Bourcier 1846; steely-vented hummingbird), breeds from December to April in Costa Rica (Stiles & Skutch 1989). If we presume similar timing of breeding for *Amazilia cyanura*, then arrival at El Jaguar is consistent with migration following breeding. From 2007 to 2010 we expanded mist-netting efforts to determine

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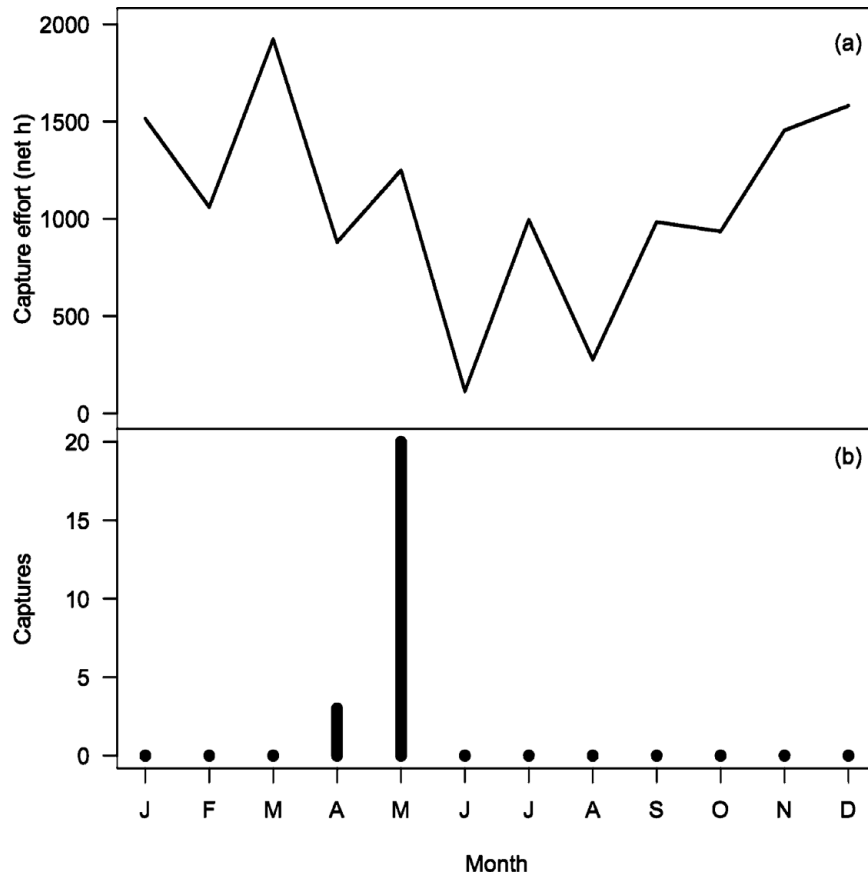


Figure 1. Netting effort (a) and captures (b) of *Amazilia cyanura* between October 2007 and May 2010 at 1350 m in north-western Nicaragua. Most captured individuals (22/23) were in active moult (91% in body moult, 74% in flight feather moult). No breeding activity has been observed at the capture site from 2004–2010.

more specifically the period of tenure and activity of *Amazilia cyanura* at the study site.

El Jaguar can be classified as lower-montane moist forest (Holdridge 1967) and consists of mostly primary forest and second-growth (~80% of the site) as well as active coffee (*Coffea* spp.) plantation (~20%), shaded by banana, *Musa acuminata*. Capture effort was divided between the coffee plantation and adjacent forest. Birds were captured using 2–27 mistnets (12 × 2.5 m, 36-mm mesh). From October 2007 to May 2010, mistnetting took place for 2–6 d each month, except in April 2008, June 2009 and February 2010. All data collected from individuals in the field followed protocols outlined by Monitoreo de Sobrevivencia Invernal (De Sante *et al.* 2009). Body moult was scored on a four-point scale (0 = none to 4 = heavy). Flight feather moult was recorded as absent or present (which included adventitious, symmetric or juvenile growth); which specific feathers were moulting was recorded for some captures. Fat was scored visually on a scale of 0 (none) to 7 (excess) based on estimates of amount of fat in the furcular region of each individual. Breeding indicators were assessed visually and

recorded on a number scale (brood patch: 0 = none to 5 = new feathers growing in; cloacal protuberance: 0 = none to 3 = large). We were not able to distinguish older from younger adults as no published accounts of visual age indicators exist for *Amazilia cyanura* or a closely related species, but plumage characters would allow the identification of juveniles (Howell & Webb 1995).

We logged 12 968 cumulative net hours between October 2007 and May 2010 (Figure 1a). We captured 12 *Amazilia cyanura* between 22–23 May 2008, 8 between 12–13 May 2009, and three on 19 April 2010 (Figure 1b). We did not capture, or observe any *Amazilia cyanura* during the mist-netting bouts in any other months (June–March). In our pilot work for this project, we captured one *Amazilia cyanura* in July (2005) but from 2007 to 2010 we captured birds only in April and May. All individuals were caught in mist nets placed in the coffee plantation and no *Amazilia cyanura* was captured, or observed, in the adjacent forest. Although we captured many individuals of several hummingbird species smaller than 5 g, the mesh-size of the mist nets we used was large for birds of this size (36 mm). If this reduced our capture rate, our

main results should not be affected, but it may preclude the use of our data for density estimates.

Of the 23 individuals captured, 17 (74%) were in active flight feather moult and 21 (91%) were in active body moult. When time at the ringing station allowed, specific feather tracts in moult were noted; four birds were growing primary feathers and one was growing retrices. Of those in body moult, 17 (81%) were scored as 'medium' or 'heavy' moult. All birds captured had adult plumage (Howell & Webb 1995, Stiles & Skutch 1989). Most birds (68%) had fat scores of 1 ($n = 9$) or 2 ($n = 4$). We did not observe any indications of breeding such as nests, breeding displays or the capture of juveniles or recently fledged young. No captured birds had brood patches or cloacal protuberances, although these may not be reliable indicators of breeding activity in hummingbirds (Diamond 1974). We did not ring individuals so have no data on inter-year recaptures. Missing tail feathers (due to sampling for a related project) would have identified intra-year recaptures but we did not observe any.

Our data suggest that *Amazilia cyanura* moves upslope to high-elevation cloud forest in Nicaragua to moult, but not to breed. This is the first observation of a moult-migration strategy in a hummingbird. Our captures from 2007 to 2010, along with an earlier observation, suggest that *Amazilia cyanura* tenure at El Jaguar is from late April to mid-July. Despite 9730 h of trapping effort between August and March, we caught no *Amazilia cyanura*. It is unlikely that this species breeds while at El Jaguar, as we found no signs of breeding activity (capture of fledged young, nests or displays, brood patch or cloacal protuberance). No nests or breeding activity have been observed during fieldwork at this site since 2004 (L. Chavarría, unpubl. data). Future research may show whether *Amazilia cyanura* captured at El Jaguar originate, and possibly breed, in lowland areas along the Pacific coast where they are more commonly observed. Little is known about breeding activity in *Amazilia cyanura* and the nest of this species is undescribed (Howell & Webb 1995).

Most (68%) *Amazilia cyanura* individuals were carrying relatively large amounts of fat and yielded scores of one or two. For comparison, two other hummingbird species that spend the year in the El Jaguar study area carried less fat; in *Campylopterus hemileucurus* (Deppe 1830; violet sabrewing) 34% of captures had fat scores of 1 or 2; in *Phaethornis longirostris* (Delattre, 1843; long-billed hermit), 23% of captures had a score of 1 and 0% had a score of 2 (K. Fraser & L. Chavarría unpubl. data). Higher fat scores in *Amazilia cyanura*, as compared to known sedentary species, are consistent with patterns of fat deposition to support migration, but also patterns reported for hummingbirds in active moult (Stiles 1980).

Determining which factors favour upslope migration and moult in *Amazilia cyanura* is an interesting area

for future research. Unproductive late-summer breeding areas seem to favour moult migration in some North American insectivorous passerines, which delay moult until arrival in Mexican monsoon region or at higher elevation within the USA where more moist conditions support a higher abundance of arthropods (Pyle *et al.* 2009, Rohwer *et al.* 2005, 2009). Tenure of *Amazilia cyanura* at El Jaguar coincides with the early rainy season, which generally corresponds to peak arthropod abundance and bird breeding activity in tropical forests (Poulin *et al.* 1992). Hummingbirds, including *Amazilia* species, commonly moult in the mid-rainy season (Stiles 1980) perhaps owing to the increased availability of arthropods. *Amazilia cyanura* and five other hummingbird species captured at the study site derive their feather protein principally from arthropods. Two of these species (*Campylopterus hemileucurus* and *Phaethornis longirostris*) consumed prey with higher protein concentration in the breeding and moulting period than in the non-breeding period (Fraser *et al.* unpubl. data) which emphasizes the seasonal importance of arthropods. An exploration of seasonal arthropod availability over an elevational gradient may yield insight into factors driving a moult-migration strategy in *Amazilia cyanura*.

Species that migrate seasonally over an elevational gradient may pose a particular challenge to conservationists, in that altitudinal migrants often make use of multiple habitat types over a broader geographical range than more sedentary species (Powell & Bjork 1995, Winker *et al.* 1997). *Amazilia cyanura*, a Central American endemic, may require both suitable lowland habitat for breeding, as well as upland habitat for moulting. Further investigation may yield other altitudinal moult-migrants in this region.

ACKNOWLEDGEMENTS

Georges Duriaux, Moisés Siles, Oscar and Johnny Rodríguez, provided field assistance and we thank Wayne Arendt of the U.S. Forest Service and Cuentas Criticas Project for field support. We thank Meredith Clayden and Trina Du for sample preparation and Anne McGeachy and Christine Paton for their work at the SINLAB. Funding was provided by a NSERC post-graduate scholarship to KCF. We thank Emily McKinnon and four anonymous reviewers for their helpful comments on earlier drafts of this manuscript.

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