Feeding ecology and conservation of Esmeraldas Woodstar *Chaetocercus berlepschi* in the Chongón-Colonche Hills, western Ecuador

Ana E. Ágreda

Durante diez horas de observación en diciembre de 2005 se registraron detalles del comportamiento territorial de forrajeo de la Estrellita de Esmeraldas *Chaetocercus berlepschi* durante la floración de *Razisea* cf. *ericae* (Acanthaceae), en el borde de un bosque montano de *garúa* dentro de la Reserva Comunal Dos Mangas, prov. Guayas, aprox. 500 msnm. Las observaciones a esta altura sugieren movimientos migratorios locales asociados con la disponibilidad de recursos florales. Esta especie de colibrí se encuentra amenazada de extinción debido a la intensa deforestación.

Little is known of the natural history of Esmeraldas Woodstar *Chaetocercus berlepschi,* a monotypic hummingbird endemic to Ecuador. It is a globally threatened species restricted to isolates of evergreen coastal forest in western Ecuador[6,15]. Between the 1950s and late 1980s, intensive agricultural practices and a significant expansion of the road system obliterated most primary forest in western Ecuador, leaving less than 5% of the original vegetation cover[3,8]. Based on these estimates, it has been suggested that *C. berlepschi* is potentially Endangered due to a decline in its range of occupancy and extent of occurrence, and a deterioration in habitat quality and ongoing fragmentation[9,15], though it seems that *Area of Occupancy,* which reflects the probability of occurrence in appropriate habitat, is still poorly known[9].

C. berlepschi was described from eight specimens collected in 1912 deposited at the American Museum of Natural History (AMNH), including three males and three females from the city of Esmeraldas, prov. Esmeraldas (00°59'S 79°42'W; 20 m), two males from Chone, prov. Manabí (00°41'S 80°06'W; 20 m) and at least one specimen of uncertain locality labelled as 'río Napo, eastern Ecuador' (AMNH 37925)[7]. The species was not relocated until 20 January 1991, in the lower río Ayampe drainage, below 200 m, at the southern boundary of Machalilla National Park, prov. Guayas (01°40'S 80°45'W), where a male was collected in secondary semi-deciduous forest and deposited at the Academy of Natural Sciences of Philadelphia (ANSP 183118)[7,12]. The species was reported in subsequent years from the same area in October–March[4,12]. Additionally, a female and male were observed north of Quinindé, prov. Esmeraldas, in January 1993 and September 1995 respectively[12]. *C. berlepschi* has also been recorded in evergreen premontane forest (known as *garúa* forest), above 500 m, at Cerro La Torre (01°49'S 80°36'W) within Communal Reserve Loma Alta

(RECLA), prov. Guayas, in December 1996[1], and different males were repeatedly observed there in December 2000 and 2003 (AEÁ pers. obs.), associated with flowering understorey shrubs of *Psychotria alba* (Rubiaceae) and a recently described species of herb *Razisea* cf. *ericae* Mildbraed ex Wassh. (Acanthaceae). Here I describe the foraging behaviour of a territorial male of *C. berlepschi* in a patch of *Razisea* at Cerro La Culebra, Communal Reserve Dos Mangas, prov. Guayas, in December 2005.

Study site and methods

On 17–21 December 2005 a total of ten hours were spent in mature secondary *garúa* forest at Cerro La Culebra (01°47'S 80°37'W), c.7 km east of Dos Mangas, prov. Guayas, above 500 m. Several understorey plants were flowering simultaneously (*P. alba, R.* cf. *ericae, Gasteranthus* sp., *Kohleria* sp.), some in clumps at the forest border or along trails. The latter was true of *Razisea* cf. *ericae,* which reaches 1.5–2.0 m tall and forms large clumps 2–5 m wide within *garúa* forest. An area of 4 m² held over 149 fresh and 94 recently opened flowers, representing an important feeding territory for hummingbirds. A flowering patch of c.25 m² was used to observe hummingbird feeding behaviour. Although this patch had only 14 individual plants, each covered a substantial area. Plants presented long (1.0–1.5 m), erect branches (4–15), sprouting vertically near the base of the long horizontal stems. Branches were entirely moss-covered with few leaves. Flowers (20–25) with tubular red corollas of 20–30 mm were growing alone or in fascicles of 2–(4) flowers at opposite nodes of the rachis[19]. This herb flowers November to mid January, in the rainy season (AEÁ pers. obs.). Data on nectar quality and quantity were obtained by inserting micro capillary tubes of 75 µl; nectar volume was calculated from the column and sugar concentration in a pocket refractometer that measures the percentage of sucrose on the BRIX

scale[10]. Compared to other ornithophilous plants[16], nectar production is moderate (volume = 11.3 µl, *n*=25), concentrated (sucrose = 24.2% BRIX, *n*=25) and, like others, scentless. To register hummingbird foraging behaviour, two observers stood within the patch to record feeding bouts and intra- or interspecific interactions. The distance of the nectar reservoir at the base of the corolla (14.7 mm, *n*=13) from the receptive stigma and pollen of the anthers (corolla + exposed androceum = 31.2 mm, *n*=13) is sufficient to secure pollination by legitimate small- and medium-sized hummingbird visitors (Table 1). Morphometrics, taken from museum specimens (see Table 1), were: wing-chord, bill-length to feathers (culmen 1) and to distal part of the nostril (culmen 3), and tail-length.

Results

A total 3,673 avian feeding bouts were recorded, of which 3,393 were *Razisea* and 280 at a single *Psychotria alba* (3.5 m tall) at the border of the patch. The most territorial species was a male *C. berlepschi*. The presence of one or more adult females of Little Woodstar *C. bombus* was noted. Considerable care was taken to separate individuals of the two woodstar species. Speckled Hummingbird *Adelomyia melanogenys*, Violet-bellied Hummingbird *Damophila julie*, Green-crowned Woodnymph *Thalurania fannyi* and Bananaquit *Coereba flaveola* also visited the patch (Table 1). The male *C. berlepschi* made 41 foraging visits and perched in the patch during 47% of observations over intervals of five seconds to c.12

minutes. *C. bombus* made 16 foraging visits and was chased by *C. berlepschi* on several occasions. Encounters were very brief, just a few seconds, though once *C. berlepschi* chased its congener until the latter left the patch. No vocalisations were registered, just mechanical sounds produced by the wings. *C. bombus* was also chased by *Adelomyia* twice and once by a female *Damophila*. Preferred perches of *C. berlepschi* were two treelets, of 3.5 and 4 m, a *Cecropia* sp. (Moraceae) tree, 4 m tall, in the centre of the patch, and short lianas, 6 and 10 m above ground, at the border of the patch. The bird preened on the distal part of the leaves or branches; in contrast, female *C. bombus* perched at the border of the patch in the afternoon when the male *C. berlepschi* was absent, or presumably elsewhere.

C. berlepschi foraged at different heights over the entire patch. Occasionally, it visited the white flowers of *P. alba,* then moved to the centre of the patch and approached the red flowers of *Razisea*. At this patch, only Bananaquit robbed nectar from these flowers (Table 1). *C. berlepschi* exhibited simple foraging behaviour. It followed the flowers along the branch, hovered before the corollas, shortly inserted the bill into one of them, brushing its forehead and bill against the pollen of the anthers, before moving down to the next flower. Flight was very characteristic, slow and almost motionless, compared to the fast movements of *Adelomyia.* After checking several branches in an area, it performed a short fast flight to another section of the patch. The bird foraged mostly 2–3 m above ground and was not observed to avoid flowers

Table 1. Mean number of feeding bouts and foraging time recorded at the flowering patch and morphometrics of adult specimens of species observed at the patch.

Scientific name	Mean feeding bouts (range) ± SD	Time (sec) (range) ± SD	Wing-chord ± SD (mm)	Culmen 1 (mm)± SD	Culmen 3 (mm) ± SD	Tail ± SD (mm)	Weight ± SD (g)
[1]*Chaetocercus berlepschi*	47 (2–138) ± 39.74	178.3 (20–345) ± 95.2	♂ 26.5 ± 2.08 (*n*=6) ♀ 27.4 ± 0.8 (*n*=3)	♂ 12.2 ± 0.8 (*n*=5) ♀ 12.4 ± 0.45 (*n*=3)	♂ 9.7 ± 1 (*n*=3) ♀ 9.4 ± 0.25 (*n*=3)	♂ 14.8 ± 2.3 (*n*=5) ♀ 15.6 ± 5.25 (*n*=3)	
[1]*C. bombus*	90 (5–258) ± 85.5	268 (90–590) ± 170.54	♂ 25.44 ± 0.7 (*n*=5) ♀ 30 ± 0.5 (*n*=5)	♂ 15.6 ± 0.8 (*n*=5) ♀ 16.34 ± 0.4 (*n*=3)		♂ 22.54 ± 0.7 (*n*=5) ♀ 14.08 ± 1.4 (*n*=5)	
[2]*Adelomyia melanogenys*	26 (3–76) ± 21.6	98 (45–180) ± 53.5	50.62 ± 2 (*n*=17)		14.87 ± 0.7 (*n*=17)	33.5 ± 2.1 (*n*=17)	4.35 ± 0.8 (*n*=17)
[2]*Damophila julie*	54 ± 0		♂ 44.06 ± 2 (*n*=8) ♀ 42.8 ± 2.3 (*n*=5)		♂ 13.5 ± 0.8 (*n*=8) ♀ 13.78 ± 0.6 (*n*=5)	♂ 31.5 ± 1.2 (*n*=8) ♀ 26.25 ± 1.3 (*n*=5)	♂ 3.3 ± 0.5 (*n*=8) ♀ 3.36 ± 0.4 (*n*=5)
[2]*Thalurania fannyi*	30 ± 0		♂ 54.4 ± 2.1 (*n*=11) ♀ 50.2 ± 3.2 (*n*=6)		♂ 17.7 ± 1.7 (*n*=11) ♀ 17.5 ± 2.2 (*n*=6)	♂ 34.6 ± 4 (*n*=11) ♀ 28 ± 2.2 (*n*=6)	♂ 4.9 ± 0.6 (*n*=11) ♀ 4.4 ± 0.7 (*n*=6)
[2]*Coereba flaveola*	*20.7 (4–42) ± 19.43	238 (120–480) ± 169.3	51 ± 1.4 (*n*=4)		9.6 ± 0.8 (*n*=4)	29 ± 1.4 (*n*=4)	9.13 ± 0.63 (*n*=4)

[1] Morphometrics from specimens held at AMNH, ANSP and NHM.
[2] Morphometrics from birds captured in mist-nets in *garúa* forest at RECLA in 1999 and 2000.
* Illegitimate feeding bouts.

with holes or damage. Female *C. bombus* is similar in foraging behaviour to *C. berlepschi,* though they kept to the border of the patch 82% of the time and foraged 1.5–2 m above ground. Similarly, *Adelomyia* was observed foraging at the border, 0.8–1.0 m above ground for short periods. In contrast to the woodstars, *Adelomyia* hovered or perched on the plant stem whilst taking nectar. Little interaction occurred between *Adelomyia* and *C. berlepschi.* Almost always the latter ignored the former's presence, but once *C. berlepschi* chased *Adelomyia* from the patch. All recorded chases of other species by *C. berlepschi* were in the morning. No variation was observed in hummingbirds visits during the day (Kruskall-Wallis Test H=3.013, P >0.05) though foraging activity increased in the afternoon.

Discussion

The range of *C. berlepschi* has suffered a drastic contraction in recent decades due to the destruction of coastal forests. Currently, this rare endemic is patchily distributed in forest fragments of Esmeraldas, Guayas and Manabí provinces which were formerly connected. Specimens are from secondary deciduous and semi-deciduous forests between see level and 200 m. This study reports *C. berlepschi* in evergreen premontane forest, which is at low elevations (400–800 m) and unlike Andean cloud forest (1,800–3,000 m) obtains moisture directly from oceanic mists and fog in the *garúa* (drizzle) season (May–October)[1]. Mature secondary *garúa* forest presents a high diversity of vascular plants, up to 218 species of trees and epiphytes in 500 ha[5]. The broken canopy at 20–30 m is densely covered with epiphytes of *Tillandsia* (Bromeliaceae), *Philodendron* and *Anthurium* (Araceae), and the understorey is rich in shrubs and herbs of *Psychotria* (Rubiaceae), *Heliconia* (Heliconiaceae), *Razisea* (Acanthaceae), and plants of Gesneriaceae, all of which are hummingbird-pollinated. A phenological study of *garúa* forest in RECLA revealed that peak flowering of trees coincided with the early rainy season (December), though flowers started to open three months prior to this, in the late *garúa* season[5]. Similarly, understorey plants exhibited a peak flowering during the same period in consecutive years at different localities in the Colonche hills (AEÁ pers. obs.). Local migrations of *C. berlepschi* might be dependent on the spatial distribution of floral resources. Like other trochilids, seasonal altitudinal movements are probably associated with flowering understorey and canopy plants. Thus, asynchronous flowering events might promote seasonal local movements between *garúa* and coastal semi-deciduous forests.

Razisea is adapted for hummingbird and insect pollination as it forms dense clumps and inflores-cences comprise several medium-size flowers that can be used by small to medium-size trochilids. Moreover, this herb blooms for short periods, c.5–8 weeks (AEÁ pers. obs.), offering a reasonable nectar source for hummingbirds. Successful pollination depends on the foraging efficiency of specific pollinators, and bill morphology influences the efficiency at which specific resources are exploited[13]. Long-billed hummingbirds and trap-liners rarely visited the *Razisea* patch, though they can access this type of flower. Small and medium-size hummingbirds were common visitors and displayed two foraging strategies: territorial or opportunistic. Small territorial hummingbirds, like *C. berlepschi,* have a low ratio between body mass and wing area, and can be expected to use less energy in hovering compared to trap-liners[15,18,20]. In contrast, medium-size hummingbirds were generalists and foraged opportunistically according to their moderate energy demands[13]. Though size plays an important role in interspecific dominance amongst hummingbirds[16] and small species are more apt to display non-territorial behaviour[11,20], the costs related to such behavior in woodstars might be compensated at *Razisea* patches.

Chaetocercus is a difficult genus to identify to species. Female-type plumages of *C. berlepschi* could be confused with immature *C. bombus*[2,12]. Given that the two species are sympatric, problems of identification might explain why *C. berlepschi* is under-recorded in the field. Fresh studies are needed to characterise juvenile and adult female plumages in order to determine field identification. However, current populations might be relicts, making conservation more difficult. *C. berlepschi* and *C. bombus* were both considered Endangered[7], but more recently only *C. berlepschi* has been categorised thus[15], whilst Ridgely & Greenfield[12] gave *C. bombus* Vulnerable status, despite a decline in recent years. I concur with Ridgely & Greenfield[12] that *berlepschi* merits Critically Endangered status and the latter should be further studied in view of rapid deforestation in Ecuador and that most forested areas in the Colonche Hills are still unprotected[12]. However, *C. bombus* is far commoner and more widespread in humid secondary and dry scrub forests, and might tolerate habitat disturbance. In contrast, all recent records of *C. berlepschi* are from riverine vegetation, humid semi-deciduous and cloud forests. It is unclear if the two share similar ecological niches. In addition, studies are needed to better understand local movements by these hummingbirds and their tolerance of habitat degradation and disturbance. Recent studies[14] suggest that coastal *garúa* forest covers just 54% of its original area (62,136 ha) and only 3,775 ha of such remnants are protected within Machalilla National Park. Conservation of a continuous belt including lowland and submontane

or *garúa* forests is a priority to ensure the survival of *C. berlepschi* and other threatened birds.

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Ana E. Ágreda
PO Box 0904466, Guayaquil, Ecuador. E-mails: agreda@ecua.net.ec, piranga_72@hotmail.com.