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Phoretic mites identified on andean hummingbirds (Trochilidae) of Caldas, Colombia

Ácaros foréticos em beija-flores dos Andes (Trochilidae) de Caldas, Colômbia

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Abstract

Within the bird-plant-mite system, the relationship between hummingbirds, flowers, and mites remains poorly understood. In this study, we evaluated the degree of association between nasal mites and eight species of Andean hummingbirds in Colombia (*Amazilia saucerrottei, A. tzacatl, Chalybura buffonii, Chlorostilbon mellisugus, Florisuga mellivora, Glaucis hirsutus, Phaethornis guy* and *P. striigularis*). Over a five-month period (trapping effort 360 hours/month), a total of 178 birds were captured, from which 81 mite specimens were collected and identified as belonging to three genera (*Proctolaelaps, Rhinoseius* and *Tropicoseius*) spanning eleven species. This is the first report of its kind from Colombia on the identification of the mite species *P. rabulatus, R. luteyni, R. rafinskii, T. berryi, T. colwelli, T. erro* and *T. uniformis* and the first record of *P. guy* as phoretic host for *Proctolaelaps rabulatus*. Morphological characteristics (length of the dorsal plate, width of the dorsal plate and setae z5 length) alone failed to distinguish between mite species. The ecologic impact of this relationship on flowers with respect to nectar and pollen availability and the effect of mites on pollination by hummingbirds needs to be determined.

Keywords: Hummingbirds, *Tropicoseius*, nasal mites, flower mites, phoresia.

Resumo

Pouco conhecido, o termo "ácaros de flores de beija-flor" define as relações entre o sistema ave-planta-ácaro. Nesta pesquisa foi avaliado o grau de associação entre ácaros foréticos nasais e oito espécies de beija-flores dos Andes colombianos (*Amazilia saucerrottei, A. tzacatl, Chalybura buffonii, Chlorostilbon mellisugus, Florisuga mellivora, Glaucis hirsutus, Phaethornis guy, P. striigularis*). Um total de 178 beija-flores foram capturados durante cinco meses (esforço de captura 360 horas/mês) no qual 81 espécimes de ácaros foram coletados e identificados em três gêneros (*Proctolaelaps, Rhinoseius* e *Tropicoseius*) e onze espécies. Este é o primeiro registro para Colômbia das espécies *P. rabulatus, R. luteyni, R. rafinskii, T. berryi, T. colwelli, T. erro* e *T. uniformis*, e o primeiro registro de *P. guy* como hospedeiro forético para *Proctolaelaps rabulatus*. Adicionalmente, foram avaliados os caracteres morfológicos (comprimento da placa dorsal, largura da placa dorsal e comprimento da seta z5) que não foram suficientes, para distinguir entre as espécies de ácaros. O impacto ecológico desta relação nas flores, em termos de néctar e pólen, e o efeito na polinização pelos beija-flores necessita ser esclarecida.

Palavras-chave: Beija-flor, *Tropicoseius*, ácaros nasais, ácaros de flores, forésia.

Introduction

Mites of the family Ascidae (Order: Mesostigmata) are commonly found on birds, with over 22 genera and 60 species having been identified (NASKRECKI; COLWELL, 1998). This group includes four genera of nasal mites: *Lasioseius* Berlese 1916, *Proctolaelaps* Berlese 1923, *Rhinoseius* Baker and Yunker 1964 and *Tropicoseius* Bayer and Yunker 1964 (O'CONNOR et al., 1991; PROCTOR; OWENS, 2000; DUSBÄBEK et al., 2007).

Nasal mites are dispersed via a mechanism known as phoresis (Greek *phore* = to take) (PROCTOR; OWENS, 2000), whereby the temporal association between a mite phoronte and a bird appears to suggest a functional relationship (BAKER; YUNKER, 1964; HOFFMANN, 1996). According to MacChioni (2007), there are at least four types of phoreses classified by relation to the surface of the host, state of quiescence, recognition of signals

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to depart an individual host and, in some cases, synchronization with the life cycle of the host. In this relationship, plants act as a transitory habitat, while birds act as a means of transportation and dispersion but not as hosts for their reproduction (HUNTER, 1972; GUERRA et al., 2010).

Mites of the Ascidae family feed on pollen during the nymphal stage and on nectar during the adult stage (HUNTER, 1972). This food preference is considered to be relatively high, impinging on the food supply of nectarivorous birds and the duration of bird overflights and negatively impacting ornithophilous plant propagation (HEYNEMAN et al., 1991; LARA; ORNELAS, 2001; VELÁSQUEZ; ORNELAS, 2010). As a result, the co-specialization of the mite - hummingbird system is a negative interaction in terms of energy for birds (COLWELL, 1995).

The colonization of hummingbirds by nasal mite species has been reported in several Latin American countries (BAKER; YUNKER, 1964; DUSBÄBEK; ČERNÝ, 1970; HUNTER, 1972; FAIN et al., 1977; HYLAND, 1978; COLWELL; NAEEM, 1979; FAIN; HYLAND, 1980; MICHERDZINSKI; LUKOSCHUS, 1980; O'CONNOR et al., 1991; OHMER, 1991; NASKRECKI; COLWELL, 1998; DUSBÄBEK et al., 2007); however, few studies have considered the hummingbird species as a carrier. In this study, we describe the frequency of presentation of nasal mites on hummingbirds in the Andean region of Colombia and evaluate the degree of association between mite and hummingbird species.

Materials and Methods

This research was performed in a forest plantation located in Chinchiná, Caldas, Colombia, with an extension of 43 hectares along the Central Cordillera of the Colombian Andes (05° 03' 32" N and 75°44' 07.6" O) that is forested with native species (*Cupania americana, Cedrela odorata, Aegiphila grandis* and *Cordia alliodora*) at an altitude of 825-1025 m.a.s.l and has an average temperature of 22.5 °C and an annual rainfall of 2245 mm.

Five samplings were carried out in April, May, July, August, and September of 2006, with June omitted due to logistical problems. The hummingbirds were captured using mist nets (12 × 2.5 × 0.036 m) located 100 meters from the edge of the plantation (capture effort 360 hours/month) that divided the study area into 40 plots. The birds were identified by a unique combination of color bands and classified according to the system developed by Remsen et al. (2013). Before the birds were released, the following capture variables were registered: date; plot; species; age (immature, adult and unknown), sex (male, female, unknown); reproductive variables, including brood patches (absent, loss of feathers, vascularized, wrinkled, moult, unknown) and protuberance (none, small, medium, large, unknown); and morphometric variables, including exposed culmen, total culmen, beak length, beak width and weight as described by the manual for monitoring birds proposed by Ralph et al. (1996).

Nasal mites were collected directly from the nostrils of birds with the aid of a fine brush (000) and were deposited into 70% ethanol in glass flasks. Mites were maintained in Entellan® following diaphanization via treatment with 10% KOH and drying at 30 °C for 24 hours (HENDERSON, 2001). Morphological characteristics related to gnathosoma, idiosoma and chaetotaxy were examined via optical microscopy at various magnifications (10X, 40X, 100X) and were used for identification according to the keys proposed by O'Connor et al. (1991) and Naskrecki and Colwell (1998). Each specimen was analyzed for 25 chaetotaxic characters. Morphometric changes in dorsal plate length (DPL), dorsal plate width (DPW) and setae z5 length (z5) were obtained and expressed as mean values (mm) and standard deviation (DS) (SILVA et al., 2009). The material deposited for reference in the laboratory of Veterinary Parasitology at the University of Caldas.

The data were processed in Excel, and the results were subsequently analyzed using the SPSS 19 package for contingency tables and the Pearson correlation test (p 0.05 and 0.001). For the morphometric variables, major components analysis was performed.

Results

Over the course of five months, 124 captures and 54 recaptures were performed for 178 hummingbirds spanning eight species (*Amazilia saucerrottei, A. tzacatl, Chalybura buffonii, Chlorostilbon mellisugus, Florisuga mellivora, Glaucis hirsutus, Phaethornis guy* and *P. striigularis*). Nasal mites were observed in 25.8% of the captured birds (46/178), as illustrated in Table 1.

The highest proportion of nasal mites (74%) was observed in July, coinciding with the frequent capture of *A. saucerrottei* (41.2%), *P. guy* (17.7%) and *C. buffonii* (14.7%) hummingbirds (Table 1). This relationship between mite and hummingbird species establishes a generalist dispersion pattern for *Rhinoseius rafinskii* and *Tropicoseius uniformis* mites, while specificity for host transporter was observed among *Proctolaelaps rabulatus*, *R. luteyni*, *R. richardsoni* and *R. tiptoni* (Table 2).

The eighty-one nasal mite specimens identified were classified as belonging to three genera: *Tropicoseius* (55.6%), *Rhinoseius* (43.2%) and *Proctolaelaps* (1.2%). *R. rafinskii* was the most abundant species (27/81), followed by *T. uniformis* (20/81) and *T. berryi* (14/81) (Table 2.). This study is the first report on the colonization of hummingbirds in Columbia by seven different species of nasal mites: *P. rabulatus, R. luteyni, R. rafinskii, T. berryi, T. colwelli, T. erro* and *T. uniformis*. Additionally, this report presents five cases of hyperphoresy by an unidentified mite that was transported by *P. rabulatus*, *R. rafinskii* and *T. uniformis* nasal mites.

Statistical analyses of the variables using the Pearson correlation test demonstrated associations between the presence of mites, plot (p= 0.05) and date of collection (p = 0.000) (Table 3). Mites were most frequently observed during the month of July (34/81). Although the condition of the feathers of the pectoral muscle "brood patches" (a variable of reproductive type) showed a positive association with the presence of mites (p = 0.016), birds lacking brood patches (absent) were more frequently transporters of mites (26/46) than individuals of the same sex and age.

There was no statistical association between bird and mites species, although it was clear that both hummingbirds and nasal mites showed significant differences in their distributions between the plots studied (p = 0.026 and 0.050). In the case of birds, *A. saucerottei, C. buffoni, P. guy* and *P. striigularis* were present in most plots, while *A. tzacatl, C. mellisugus, F. mellivora* and

Table 1. Number of hummingbirds captured each month during april - september 2006 in Colombia. The number of hummingbirds with nasal phoretic mites is in brackets.

Species of hummingbird	April	May	July	August	September	Subtotal
Amazilia saucerrottei	0 (0)	9 (0)	35 (14)	0 (0)	0 (0)	44 (14)
Amazilia tzacatl	1 (0)	2 (0)	1 (1)	0 (0)	0 (0)	4 (1)
Chalybura buffonii	18 (1)	9 (0)	17 (5)	2 (0)	7 (2)	53 (8)
Chlorostilbon mellisugus	1 (0)	2 (0)	10 (3)	2 (0)	0 (0)	15 (3)
Florisuga mellivora	1 (0)	3 (0)	3 (1)	0 (0)	0 (0)	7 (1)
Glaucis hirsutus	0 (0)	1 (0)	2 (2)	0 (0)	0 (0)	3 (2)
Phaethornis guy	3 (0)	7 (0)	7 (6)	3 (2)	2 (2)	22 (10)
Phaethornis striigularis	8 (0)	2 (0)	13 (2)	3 (2)	4 (3)	30 (7)
Total	32 (1)	35 (0)	88 (34)	10 (4)	13 (7)	178 (46)

Table 2. Frequency of nasal phoretic mites and mite-hummingbird species relationship collected in an Andean forest from Colombia.

Phoretic nasal mite				Mite species per hummingbird species							
Genera	Species	Femalee	Male	*As*	*At*	*Cb*	*Cm*	*Fm*	*Gh*	*Pg*	*Ps*
Proctolaelaps	*rabulatus*	0	1							1	
Rhinoseius	*caucaensis*	3	2		1	2	1		1		
	luteyni	1	0			1					
	rafinskii	25	2	8		4	3		2	8	2
	richardsoni	0	1				1				
	tiptoni	0	1	1							
Tropicoseius	*berryi*	9	5	5	1	2				2	4
	chazdonae	3	0	1		1				1	
	colwelli	0	2	1							1
	erro	6	0	1		1	1			1	2
	uniformis	18	2	5		2	3	1	1	4	4
Total		65	16	22	2	13	9	1	4	17	13

Amazilia saucerrottei (As), *Amazilia tzacatl* (At), *Chalybura buffonii* (Cb), *Chlorostilbon mellisugus* (Cm), *Florisuga mellivora* (Fm), *Glaucis hirsutus* (Gh), *Phaethornis guy* (Pg), *Phaethornis striigularis* (Ps).

G. hirsutus were restricted to a subset of plots (Figure 1). Although the *R. rafinskii*, *T. berryi* and *T. uniformis* mite species were found in the majority of the plots, other mite species exhibited localized distribution (Figure 2). Sexual dimorphism among nasal mites was evident, and the females were more widely distributed across the plots than were males (Figure 2).

In total, 65 female and 16 male nasal mites were analyzed for at least nine and at most 25 chaetotaxic characteristics, resulting in their classification into three genera and eleven species. In addition, measurements were obtained for DPL, DPW and z5, the median values of which are presented in Table 4. These morphometric characteristics were not sufficient for differentiation between species, as indicated in Figure 3. The set of morphological characters related to gnatosoma, idiosoma and chaetotaxic characteristics were fundamental to the identification of nasal mites, but the morphometric variables (DPL, DPW and z5) did not facilitate differentiation.

Discussion

Few studies provide information about the mite – hummingbird relationship. In southern Colombia, studies by Fain and Hyland (1980) and Ohmer et al. (1991) registered a total of 16 species of phoretic mites present in the nostrils of twenty species of hummingbirds. Our results for the Andean region of this country show the presence of seven mite species (*P. rabulatus, R. luteyni, R. rafinskii, T. berryi, T. colwelli, T. erro* and *T. uniformis*). These new records are of great value, as they strengthen the understanding of these mites and their relationships with birds.

Observations made by O'Connor et al. (1991, 1997) of *P. guy* and by Colwell (1979) of *G. hirsutus* indicate that a single bird may carry different nasal phoretic mite species. This observation was also made in the present work for *R. rafinskii* and *T. uniformis*, confirming that phoresis is a determining factor in the dispersion of mites.

Other studies developed by O'Connor et al. (1991) and Guerra et al. (2010) describe *P. rabulatus* species as exclusive flower mites of the Apocynaceae and Bromeliaceae families. Baker and Yunker (1964) previously documented *T. braziliensis, T. peregrinator* and *T. erro* mites in bromelia flowers from Brazil and Mexico and *T. venezuelensis* and *T. heliconiae* in *Heliconia* bracts (Venezuela and Panama) and *Heliconia* cuttings (Colombia). In Brazil, *T. braziliensis* mites were rediscovered and redescribed as *Rhinoseius braziliensis* based on their presence in bromeliads (FLECHTMANN; JOHNSTON, 1978). The authors of these works suggest that birds such as hummingbirds do not act as

Table 3. Capture, reproductive and morphometric variables related to the presence of nasal phoretic mites of hummingbirds in Colombia.

Bird Variables	Number	Presence of nasal mites *N* (%)
Capture variables		
Plot*	178	46 (25.8)
Date**		
April	32	1 (3.1)
May	35	0 (0.0)
July	88	34 (38.6)
August	10	4 (40.0)
September	13	7 (53.9)
Capture		
First capture	124	35 (28.2)
Recapture	54	11 (20.4)
Age		
Immature	8	3 (37.5)
Adult	32	10 (31.3)
Unknown	138	33 (23.9)
Sex		
Female	60	14 (23.3)
Male	63	13 (20.6)
Unknown	55	19 (34.6)
Reproductive variables		
Brood patches *		
Absent	110	26 (23.6)
Loss of feathers	15	9 (60.0)
Vascularized	9	3 (33.3)
Wrinkled	10	4 (40.0)
Moult	1	0 (0.0)
Unknown	33	4 (12.1)
Protuberance		
None	100	28 (28.0)
Small	12	2 (16.7)
Medium	20	8 (40.0)
Large	13	4 (30.8)
Unknown	33	4 (12.1)
Morphometric variables		
Exposed culmen	147	43 (29.3)
Total culmen	137	42 (30.7)
Beak length	147	43 (29.3)
Beak width	147	43 (29.3)
Weight	79	15 (19.0)

Pearson correlation * $p < 0.05$; ** $p < 0.001$.

carriers for mites. However, our identification of *P. rabulatus* as phoretic nasal mites of *P. guy* hummingbirds is of great value, as it contradicts the hypotheses formulated in previous studies; however, further observations to establish the true role of hummingbirds as *P. rabulatus* phorontes are needed.

Although no statistical associations were observed between variables related to morphometric aspects of the birds and the presence of mites, this study did find an association between phoresis and the reproductive variable "brood patches". The impact of phoretic mites on the reproductive development of their host birds remains unknown.

Colwell (1973, 1986) suggests that, under favorable weather conditions, nasal mite populations in a plantation are determined by two main factors: rapid reproduction within flowers and the ease of movement of female mites between inflorescences. In this study, the phenomenon of dispersion was evident during

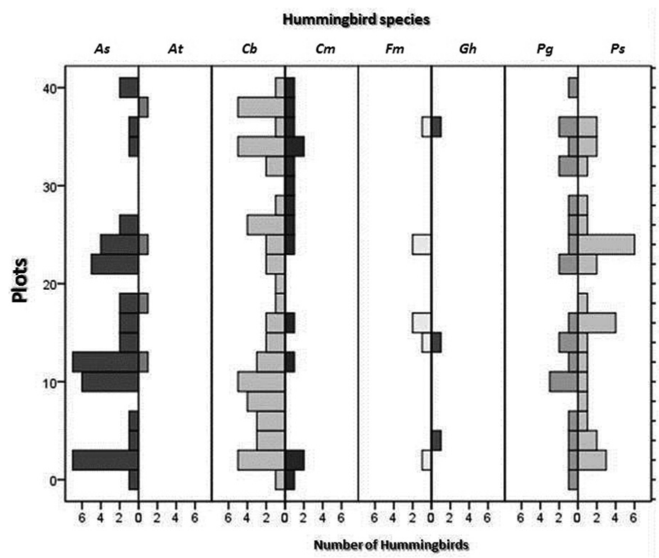

Figure 1. Spatial distribution of hummingbirds collected in a forest plantation in Colombia. *Amazilia saucerrottei* (As), *Amazilia tzacatl* (At), *Chalybura buffonii* (Cb), *Chlorostilbon mellisugus* (Cm), *Florisuga mellivora* (Fm), *Glaucis hirsutus* (Gh), *Phaethornis guy* (Pg), *Phaethornis striigularis* (Ps).

Table 4. Mean values and standard deviation of dorsal plate length (DPL), dorsal plate width (DPW) and setae z5 long (z5) for nasal mites recovered from hummingbirds in Colombia.

Species of nasal mite	Male						Female					
	DPL		DPW		z5		DPL		DPW		z5	
	Mean (μm)	SD	Mean (μm)	SD	Mean (μm)	SD	Mean (μm)	SD	Mean (μm)	SD	Mean (μm)	SD
Proctolaelaps rabulatus	349.4		232.2									
Rhinoseius caucaensis	372.6	9.55	202.8	0.00	71.2	11.10	434.5	18.46	294.6	37.98	59.3	7.85
Rhinoseius luteyni							415.0		192.6		67.7	
Rhinoseius rafinskii	434.6		322.9		80.4		437.7	45.51	275.8	55.10	72.1	17.54
Rhinoseius richardsoni	371.3		202.0		61.4							
Rhinoseius tiptoni	376.4		194.7		87.8							
Tropicoseius berryi	387.7	51.07	262.5	45.51	57.8	24.30	455.4	61.47	315.7	63.64	62.3	30.31
Tropicoseius chazdonae							425.8	63.33	268.8	28.57	49.9	38.61
Tropicoseius colwelli	437.0	18.24	269.0	29.27								
Tropicoseius erro							548.2	157.32	289.7	42.51	68.1	30.19
Tropicoseius uniformis	399.9	4.88	212.1	44.05	54.2		421.7	33.99	256.8	52.02	60.1	20.03

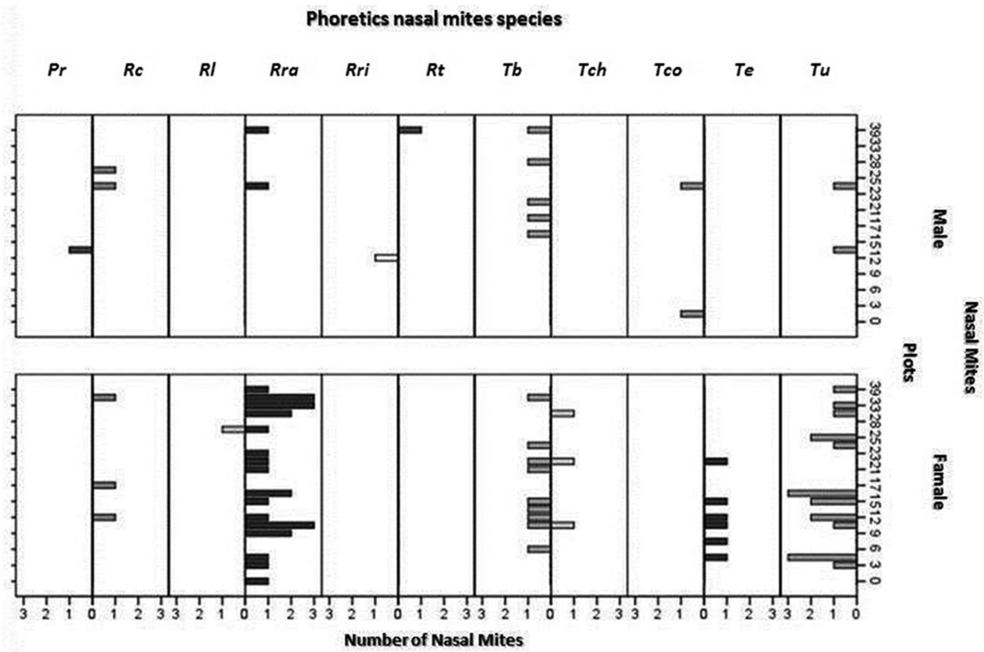

Figure 2. Nasal phoretic mite species collected in a forest plantation in Colombia. *Proctolaelaps rabulatus* (Pr), *Rhinoseius caucaensis* (Rc), *Rhinoseius luteyni* (Rl), *Rhinoseius rafinskii* (Rra), *Rhinoseius richardsoni* (Rri), *Rhinoseius tiptoni* (Rt), *Tropicoseius berryi* (Tb), *Tropicoseius chazdonae* (Tch), *Tropicoseius colwelli* (Tco), *Tropicoseius erro* (Te), *Tropicoseius uniformis* (Tu).

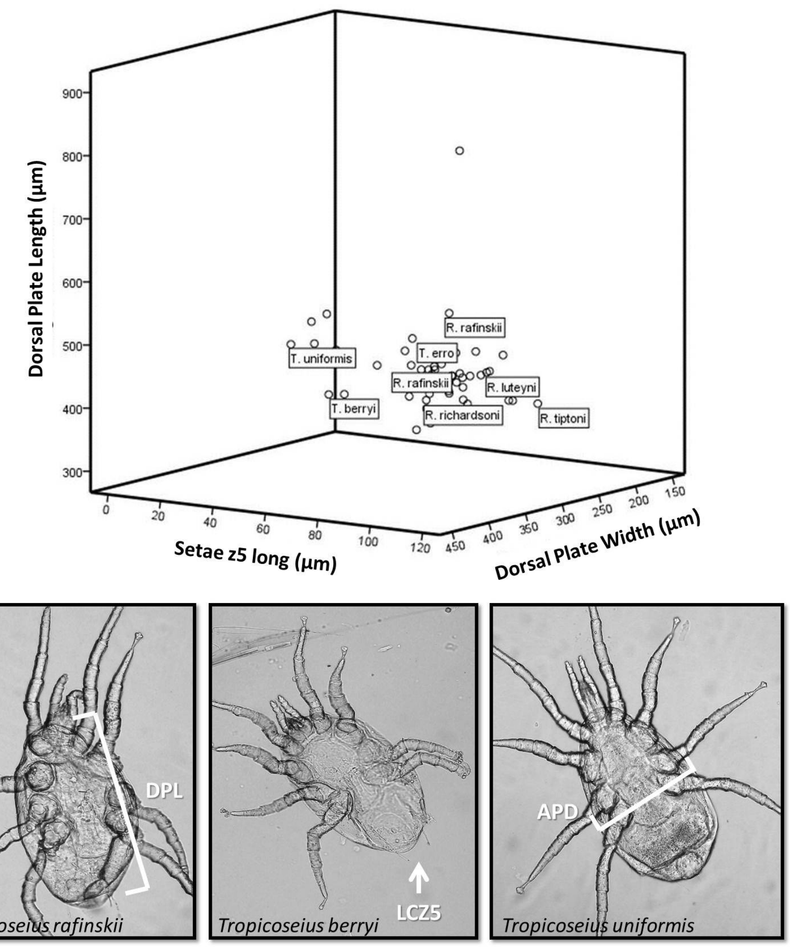

Figure 3. 3-D dispersion graphic for analyses of major components (DPL, DPW and z5) of nasal phoretic mites recovered from hummingbirds in Colombia.

the month of July, when there was an increase in floral supply following an increase in precipitation. These are ideal conditions for an increase nasal mite, which is facilitated by dispersion via at least three of the eight species of hummingbirds (*A. saucerrottei, P. guy* and *C. buffonii*) (CASTAÑO et al., 2008).

Consistent with previous work, we identified several species of mites from a single hummingbird. Moreover, the species of birds (*A. saucerrottei, P. guy* and *C. buffonii*), their observed habitat specificity and their territorial foraging behavior are likely to have facilitated the spread of mites within the area studied. Female nasal mites were collected in the majority of the plots visited, as was demonstrated statistically.

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