

## Hummingbirds of Santa Teresa, State of Espírito Santo, Southeastern Brazil

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**ABSTRACT: Hummingbirds of Santa Teresa, State of Espírito Santo, Southeastern Brazil.** Although the avifauna composition of Santa Teresa is well known, its hummingbird's data are based on the studies conducted by Augusto Ruschi between 1930 and 1970. The present work assesses the actual composition of hummingbirds in this locality, based on field research conducted between November 2002 and January 2004. Our study pointed the occurrence of 22 species along an altitudinal gradient of almost 1.000m. From this total, 16 species showed to be locally common, including species of Phaethornithinae and Trochilinae. Twenty one species were recorded in the mountain region (> 500m), whereas 9 species were recorded exclusively there. In contrast, 13 species were recorded in the lowland region (< 500m), where only one species was found to be exclusive. Cluster Analyses demonstrated that the PMBML (7.7 ha), which presents historical resources for hummingbird attraction, was the most dissimilar environment, differing even from the protected forests (Euclidian Distance= 0.60), for which 12 species were recorded. Thirteen species known for Santa Teresa were not recorded during our field survey. The reasons for their absence in our field survey are discussed in the present work.

**Keywords:** hummingbirds, Trochilidae, Santa Teresa, Espírito Santo, Atlantic Forest.

**RESUMO: Beija-flores de Santa Teresa, Estado do Espírito Santo, Sudeste do Brasil.** Embora a composição da avifauna de Santa Teresa seja bem conhecida, a base de dados sobre beija-flores apóia-se principalmente nos estudos realizados por Augusto Ruschi, entre 1930 e 1970. O presente trabalho avalia a composição atual da troquilifauna dessa localidade, a partir de trabalhos de campo conduzidos entre novembro de 2002 e janeiro de 2004. Nosso estudo

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acusou a ocorrência de 22 espécies em um gradiente de quase 1.000m de altitude. Dezesesseis espécies mostraram-se regulares ou localmente comuns, incluindo representantes de Phaethornithinae e Trochilinae. Vinte e uma espécies foram registradas na região serrana (altitude > 500m), onde nove foram dali exclusivas. Em contraste, 13 espécies foram registradas na região de baixada (< 500m), a qual apresentou apenas uma espécie exclusiva. Dos seis tipos de ambientes amostrados no município, a floresta urbana, representada pelo Parque do Museu de Biologia Prof. Mello Leitão (PMBML), apresentou a maior riqueza de espécies (21 spp). A análise de Cluster demonstrou que o PMBML, cuja área (7,7 ha) apresenta fontes históricas de atração de beija-flores, foi o mais dissimilar dos ambientes estudados, distinguindo-se inclusive dos remanescentes de florestas protegidos (Euclidian Distance= 0,60), para os quais apenas 12 espécies foram registradas. Treze espécies de ocorrência conhecida para Santa Teresa (e.g., *Phaethornis margarettae*, *Florisuga mellivora*, *Chrysolampis mosquitos*, *Lophornis chalybeus*, *Discosura langsdorffi*, *Thalurania furcata* e *Heliiothryx aurita*) não foram encontradas em nossa prospecção de campo. As razões para a ausência de tais espécies no atual inventário são discutidas no presente estudo. **Palavras-chave:** beija-flores, Trochilidae, Santa Teresa, Espírito Santo, Mata Atlântica.

## Introduction

Hummingbirds belong to the family Trochilidae (328 species) and are historically divided in two subfamilies: Phaethornithinae (34 species) and Trochilinae (294 species) (Schuchmann, 1999). Their distribution is restricted to the new world, occurring from Alaska to Patagonia (Ruschi, 1986a). Although some species are endemic of specific biomas others are extremely plastic on their distribution (Grantsau, 1988). But it is in the Colombian Andean Cordillera that the family reaches its maximum diversity, with over 140 species (Hilty & Brown, 1986; Salaman & Mazariegos, 1998).

The hummingbirds' composition of the Atlantic Forest is represented by 39 species, corresponding to 45% of the hummingbirds that can be found in Brazil (84 spp.) (Ruschi, 1986a combined with Schuchmann, 1999). The only Atlantic Forest hummingbird that has no record for the State of Espírito Santo, Southeastern Brazil, is *Heliactin bilopha* (Ruschi, 1982; Willis & Oniki, 2002; Ruschi & Simon, 2007; Simon, 2009). Moreover, 34 of these have been recorded in the Municipality of Santa Teresa, which is one of the most studied localities in the State of Espírito Santo (e.g. Ruschi, 1961, 1981, 1982; Parker *et al.*, 1996; Simon 2000, 2006; Willis & Oniki, 2002;

Ruschi & Simon, 2007). However, most of the studies conducted in Santa Teresa date from field research previous to 1977, from the publication series of Augusto Ruschi (*e.g.* Ruschi, 1949, 1953b, 1961, 1965, 1977). Since then, no specific study about the hummingbirds' composition of Santa Teresa has been performed. Instead, the main studies on hummingbirds realized there in the last 10 years have focused their interaction on the polinization of native plants (*e.g.* Varassim & Sazima, 2000; Varassim, 2002; Capucho *et al.* 2007; Koschnitzke *et al.*, 2009).

The purpose of this study was to survey the actual hummingbirds' composition of Santa Teresa, as well as their spacial distribution according to the environment complexity and altitudinal gradient of the region. Possible changes on species composition were verified by comparing our data with extensive literature review and museum specimens. The degree of rarity, calculated for all the species recorded in field, allowed the verification of the specie's affinity to native forests and other environments in Santa Teresa.

## Methods

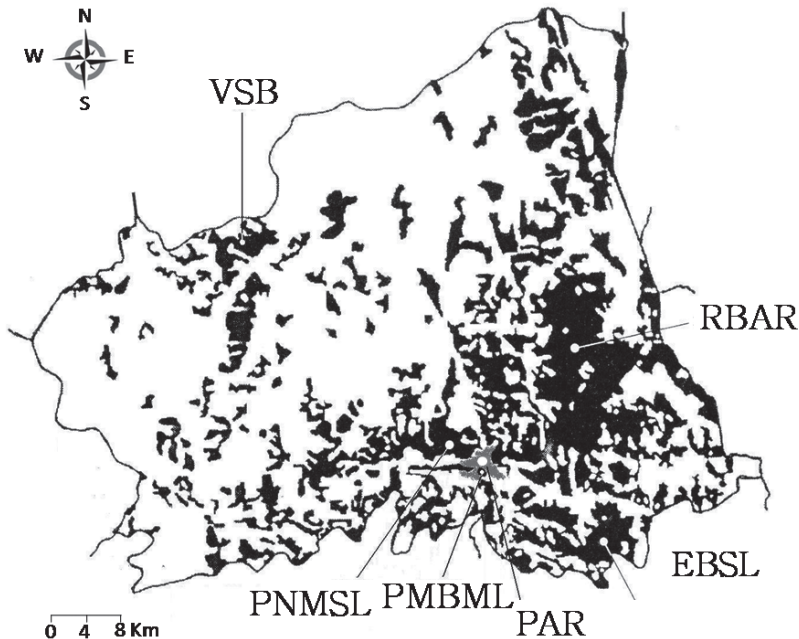
**Study Area, field effort and systematic.** The municipality of Santa Teresa (19° 55' S e 40° 36' W) is located in the state of Espírito Santo, in Southeastern Brazil. Considering the historical massive deforestation in the Atlantic Forest, Santa Teresa outstands on the conservationist scenario, with 40% (about 284 km<sup>2</sup>) of its territory covered by native forest (Mendes & Padovan, 2000), being considered an important area for birds conservation within the Atlantic Forest Bioma (Bencke & Maurício, 2006). Despite its impressive native forest cover, only 15.8% (45 km<sup>2</sup>) of its territory is legally protected, while the rest is characterized by different sized fragments distributed throughout the municipality in private areas. This situation occurs due to the historical random process of deforestation and its replacement by different crops that led to fragmentation of the native forest (Fig. 1). The fragmentation is more attenuated in the mountain region of the municipality, as the deforestation process in the lowland was much more severe than it was in the mountain region (Willis & Oniki, 2002).

Six areas were surveyed in this study: Reserva Biológica Augusto Ruschi (RBAR: 19° 56' S e 40° 33' W), Estação Biológica de Santa Lúcia (EBSL: 19° 57' S e 40° 32' W), Parque Natural Municipal de São Lourenço (PNMSL: 19° 55' S e 40° 36' W), Vale do São Brás (VSB: 19° 47' S e 40° 41' W), the park area of the Museu de Biologia Prof. Mello Leitão (PMBML: 19° 56' S e 40° 35' W) and the urban area of the city (19° 56' S e 40° 36' W) (Fig. 1).

Field work was conducted by 6-day field expedition a month from November 2002 to November 2003 (excepting January 2003), totalizing 12 expeditions (72 field samples, 350h of observation). All the six environments were sampled every month (see Studied Environments below). The observations occurred between dawn and 10 am, period pointed as the bird's peak activity time (Antunes, 2008).

Species were recorded through visual contact by the use of 7x35 Olympus binoculars, audio contacts and eventual captures with mist nets and butterfly nets. For the observations in the field we used existing trails and blossomed spots (e.g. Bromeliaceae, Mimosaceae, Bombacaceae and Bignoniaceae), as well as feeders when present.

Cryptic species identification was based on specialized literature (Ruschi, 1986a; 1986b; Grantsau, 1988; Vielliard, 1994; Sick, 1997; Schuchmann 1999) and consults to ornithological collections (Museu de Biologia Mello



**Figure 1.** Localities sampled by the present study in the municipality of Santa Teresa, State of Espírito Santo, Southeastern Brazil (adapted from Mendes & Padovan, 2000). RBAR – Reserva Biológica Augusto Ruschi; EBSL – Estação Biológica de Santa Lúcia; PAR – Praça Augusto Ruschi (city center); PNMSL – Parque Natural Municipal de São Lourenço; PMBML – Parque do Museu de Biologia Prof. Mello Leitão; VSB – Vale do São Brás.

Leitão and Museu Nacional do Rio de Janeiro). Atlantic Forest endemic hummingbirds were mentioned according to Parker *et al.* (1996).

The systematic adopted follows Schuchmann (1999), except for the treatment as full species of *Phaethornis margarettae* Ruschi, 1972 (Vielliard, 1994) and *Agyrtria breviostris* (Lesson, 1829) (Ruschi, 1986b). Concerning *Agyrtria breviostris*, recent work on its taxonomy (Ruschi & Raposo, in. prep.) have elucidated its diagnosis, making much of the data about this species gathered by us at that time useless. For this reason, the only information we present about this species is the presence of it in the studied environments, not considering any further information based on the number of times it was recorded.

**Studied environments.** Our survey was conducted in six different environments, which were chosen due to the high complexity degree of the vegetation and wide altitudinal variation of the region: 145 to 1.100 m (Mendes & Padovan, 2000; Brown & Freitas, 2000).

Four of the environments are situated in the mountain region of the municipality (> 500m): Native Forest Remnant (NFR), Mountain Anthropic Vegetation (MAV), Urban Forest Patch (UFP) and Urban Area (URA). The other two environments are in the lowland region (< 500m): Native Forest Fragment (NFF) and Lowland Anthropic Vegetation (LAV).

The NFR corresponds to three protected forests in the municipality: Estação Biológica de Santa Lúcia (EBSL), Parque Natural Municipal de São Lourenço (PNMSL) e Reserva Biológica Augusto Ruschi (RBAR). The vegetation of these protected areas is predominantly composed of pristine forest, as well explained by Mendes & Padovan (2000) and Simon (2006). For statistical cohesion we divided the field work at the NRF in three periods and dedicated 1/3 (4 field samples) of the total for each of the protected forests: EBSL, PNMSL and RBAR, respectively.

The sampling model of NRF was also used in the MAV, as it corresponds to the surrounding areas of the same protected forests. The MAV is characterized mainly by coffee crops, eucalyptus plantations (in constant expansion), secondary growth forest, capueira and annual crops. This environment is frequently surrounded by forest often continuous to protected forests, what creates a mosaic vegetation complex (Brown & Freitas, 2000).

The UFP corresponds to the park area of the Museu de Biologia Prof. Mello Leitão, located in the city centre. Its 7.7 ha are characterized by the presence of secondary native forest with a remarkable presence of exotic nectarine plants (*e.g. Grevillea banksii*) and hummingbirds feeders since 1939 (Ruschi, 1949). Thus, this study area was considered as a separate environment from NFR despite the presence of native forest.

The URA environment of the municipality was represented by the Praça Augusto Ruschi, a leafy square located in the city center. The NFF is located at Vale do São Bráz (19° 53' S e 40° 41' W), in São João de Petrópolis, municipal district of Santa Teresa. It is composed of Semidecidual Seasonal Forest (*sensu* Veloso *et al.*, 1991) and belongs to the Instituto Federal do Espírito Santo - IFES. The LAV is represented essentially by coffee plantations, pastures and annual crops (corn, bean, etc.) as well as flooding areas during the rainy season. This environment extends from the borders of the NFF to the rest of the lowland region of the municipality. The LAV differs drastically from the MAV due to the severe deforestation in the lowlands of the municipality, where only few fragments remain.

**Statistical analyses.** We calculated species frequency of occurrence (FO) for each searched environment by the equation:

$$F = NE/NT$$

Where F = frequency, NE = number of expeditions that the species was registered and NT = total of expeditions (NT = 12). The same equation was used to calculate specie's frequency of occurrence in the municipality (FOM), in which we used the summit of environments investigated. This frequency allowed us to establish the rarity degree of the species, according to three categories: high, for those species recorded up to four expeditions ( $0.08 \leq FOM \leq 0.33$ ); medium, from five to eight expeditions ( $0.41 \leq FOM \leq 0.66$ ); low, for those recorded in nine or more expeditions ( $0.75 \leq FOM \leq 1.0$ ).

We used the Chi-square ( $X^2$ ) test to verify the affinity of the Atlantic Forest endemic hummingbirds (*Ramphodon naevius*, *Phaethornis idaliae*, *Phaethornis eurynome*, *Florisuga fusca*, *Thalurania glaucopis*, *Leucochloris albicollis* and *Clytolaema rubricauda*) to native forest based on their frequencies of occurrence in the surveyed environments. The  $X^2$  was not calculated for species with less than two records ( $FO \leq 0.17$ ) in the lowland region (*P. eurynome* and *T. glaucopis*). *Agyrtria brevirostris*, which has no data on its frequency in this study, was not included in any comparison of this matter. Yates correction was used for *P. idaliae* which was registered in only two environments (NFF and LAV).

For the fauna similarity among the studied environments we used Cluster Analyses (Euclidian distance, unweighted pair-groups method using arithmetic averages - UPGMA), according to Margurran (1988). The lower values between the areas indicate higher similarities of species composition (0= complete similarity), not existing a fix superior limit for it (Felfili & Rezende, 2003). The dendrogram and the Euclidian Distance Media were elaborated in Fitopac 1.6 (Shepherd, 2006).

## Results

**Hummingbird's composition of the municipality.** We recorded 22 species of hummingbirds in Santa Teresa. Six of them belong to the subfamily Phaethornithinae and the other 16 to the subfamily Trochilinae (Table 1). Among the 22 species we recorded, one (*Ramphodon naevius*) is locally threatened (Simon *et al.*, 2007).

Almost all the species (n= 21) we recorded in the municipality could be found in the mountain region (altitude > 500m), from where 9 were found to be exclusive: *R. naevius*, *G. hirsuta*, *P. squalidus*, *A. nigricollis*, *L. albicollis*, *A. brevirostris*, *P. fimbriata*, *C. rubricauda* and *C. amethystina*. Meanwhile, only one species (*P. idaliae*) among the other 13 recorded for the lowland region was exclusively recorded in this region (Figure 2).

The first three field samplings were enough to inventory almost all the species (20 spp.) we recorded in Santa Teresa. At the end of our field work only two species (*A. fimbriata* and *A. nigricollis*) were added to our hummingbird list (Figure 3).

**Hummingbirds richness per environment.** The richness of hummingbirds in the environments varied from 9 to 21 species. UFP was the richest environment in number of species, where we recorded all the 21 species found in the mountain region. The next three in number of species were also in the mountain region: MAV and URA, both with 13 species; and NFR with 12 species. The lowest number of species was recorded in the LAV (9 spp.). Only 10 species were recorded in the NFF (Table 1).

Cluster analysis (UPGMA) revealed high dissimilarity (Euclidian Distance: 0.56) between the environments of the lowland region (NFF and LAV), which differ widely (0.76) from those of the mountain region in fauna composition (Figure 4). The UFP was the most dissimilar (0.60) environment of the mountain region, while the MAV was more similar (0.30) to the NRF than it was to the URA.

**Species frequency of occurrence in the sites.** Some species, especially those of the subfamily Phaethornithinae, had differentiated frequency of occurrence values through the studied sites, what suggests affinity to specific habitats. Besides, although no Phaethornithinae species was exclusive of the native forest, *P. squalidus*, *P. idaliae* and *R. naevius* had their higher frequency of occurrence values in these environments (respectively, NRF, NFF and NRF), indicating a strong association to the native forest of the region (Table 1). For example, *R. naevius*, which was only recorded in the mountain region, had FO= 0.58 in

**Table 1.** Hummingbirds composition according to surveyed environments in two altitudinal zones and rarity degree of the species in the municipality of Santa Teresa, State of Espírito Santo, Southeastern Brazil.

a.- The systematic follows Schuchmann (1999), except for the treatment as full species of *Phaethornis margaritae* (according to Vielliard, 1994) and *Agyrtria brevirostris* (according to Ruschi, 1986).

b.- Identification method: a- audio; v- visual; c- capture.

c.- Frequency of occurrence (FO): Mountain region - native forest remnant (NFR); mountain anthropic vegetation (MAV); urban forest patch (UFP); urban area (URA). Lowland region - native forest fragment (NFF); lowland anthropic vegetation (LAV).

d.- Frequency of occurrence in the municipality (FOM).

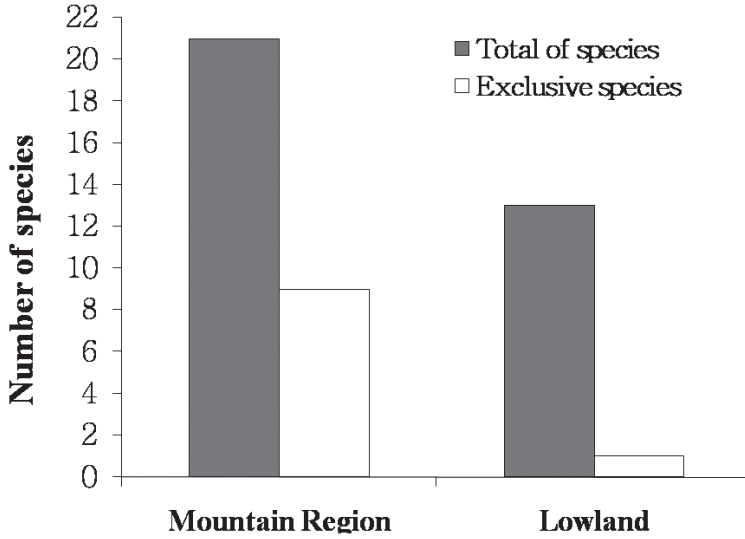
e.- Rarity degree of the species in the municipality, calculated according to FOM values: high ( $0.08 \leq FOM \leq 0.33$ ); medium ( $0.41 \leq FOM \leq 0.66$ ); low ( $0.75 \leq FOM \leq 1.0$ ).

f.- Additional records for the municipality of Santa Teresa: 1-Vielliard (1994); 2- P. A. Ruschi (pers. obs.); 3-Ruschi (1961); 4-Ruschi (1965); 5-Ruschi (1953a); 6-Ruschi (1953b); 7- Ruschi (1969); 8- Ruschi (1977); 9-Parker & Goerck (1997); 10-Willis & Oniki (2002); 11-Simon (2000); 12-Simon (2006); 13-P. A. Ruschi (pers. obs. in 2001); 14-P. A. Ruschi (pers. obs. in 2002).

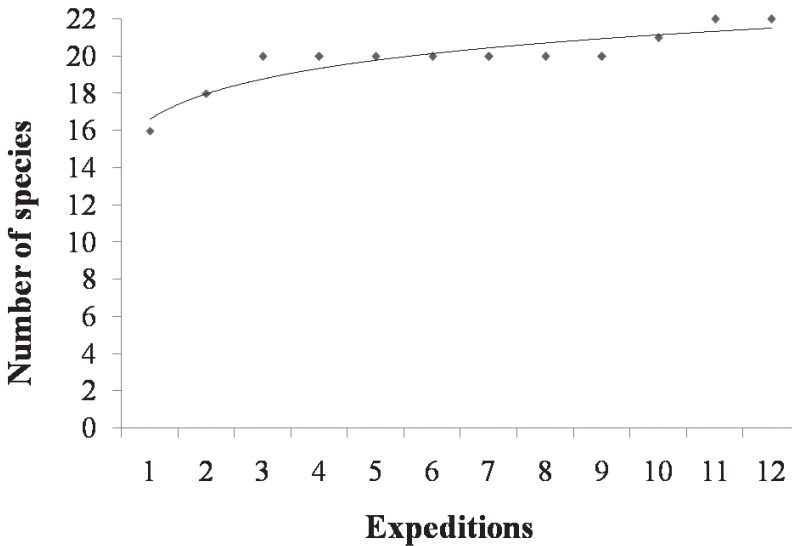
Species/Subfamily <sup>a</sup>	Identification Method <sup>b</sup>	Frequency of occurrence <sup>c</sup>						FOM <sup>d</sup>	Rarity Degree <sup>e</sup>	Additional Record <sup>f</sup>
		Mountain Region			Lowland					
		NFR	MAV	UFP	UA	NFF	LAV			
<b>Phaethornithinae</b>										
<i>Ramphodon naevius</i> (Dumont, 1818)	a v c	0.58	0.08	0.08	0.00	0.00	0.00	0.58	-	-
<i>Glaucois hirsuta</i> (Gmelin, 1788)	a v c	0.08	0.17	1.00	0.67	0.00	0.00	1.00	low	1, 2, 3, 4, 5, 7, 8, 10, 11
<i>Phaethornis margaritae</i> Ruschi, 1972	-	-	-	-	-	-	-	-	-	10
<i>Phaethornis eurynome</i> (Lesson, 1832)	a v c	0.75	0.17	1.00	0.17	0.17	0.00	1.00	low	1, 2, 4, 7, 8, 9, 10, 11, 12
<i>Phaethornis pretrei</i> (Lesson & Delattre, 1839)	a v c	0.08	0.17	1.00	0.58	0.33	0.00	1.00	low	1, 2, 4, 7, 8, 9, 10, 11, 12
<i>Phaethornis squialidus</i> (Temminck, 1822)	a v c	0.42	0.08	0.08	0.08	0.00	0.00	0.50	moderate	1, 2, 3, 4, 7, 10, 11, 12
<i>Phaethornis idaliae</i> (Bourcier & Mulsant, 1856)	a v	0.00	0.00	0.00	0.00	1.00	0.08	1.00	low	1, 2, 3, 4, 7
<i>Phaethornis ruber</i> (Linnaeus, 1758)	-	-	-	-	-	-	-	-	-	4, 7, 8
<b>Trochilinae</b>										
<i>Campylopterus currochloris</i> (Viellot, 1818)	a v c	0.17	0.92	1.00	1.00	0.08	0.08	1.00	low	1, 2, 3, 4, 5, 7, 8, 10, 11, 12
<i>Campylopterus macrourus</i> (Gmelin, 1788)	a v c	0.00	0.42	1.00	1.00	0.00	0.25	1.00	low	1, 2, 3, 4, 5, 7, 8, 10, 11, 12







**Figure 2.** Total and exclusive number of species recorded per altitudinal region in the municipality of Santa Teresa by the present study.

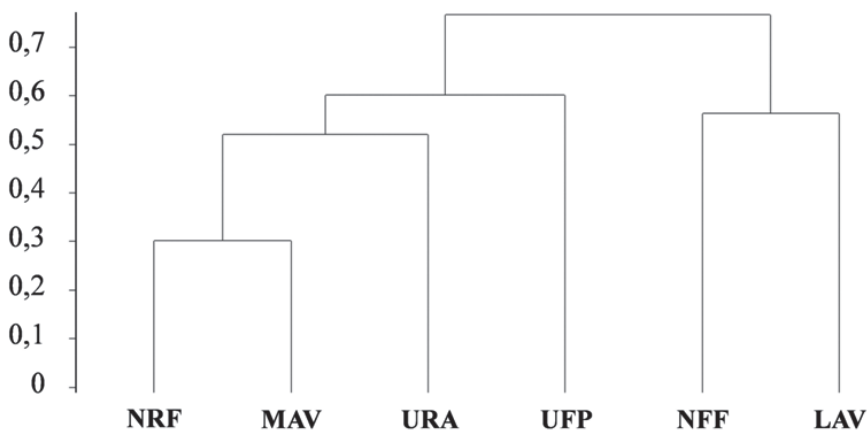


**Figure 3.** Cumulative curve of the number of species recorded in Santa Teresa by the present study.

the NFR. Hence, it was uncommon in the UFP, with FO= 0.08 (Table 1). In the same way, *P. idaliae*, only recorded in the lowland region, was common in the NFF (FO= 1.0) and uncommon in the LAV (FO= 0.08) (Table 1). Furthermore, despite *P. eurynome* had its highest value of FO recorded in the UFP (FO= 1.0) its value for the NRF was also high (FO= 0.75), mainly when compared to the NFF (FO= 0.17), indicating that *P. eurynome* is also strongly associated to the native forests of the region. In contrast to Phaethornithinae, many species of the subfamily Trochilinae, such as *C. macrourus*, *L. albicollis* and *C. cirrochloris*, had high FO values (> 0.6) in more than one environment.

**Rarity Degree and Atlantic Forest endemism.** Most of the species (n= 16 or 72%) had a low degree of rarity in the municipality, including species of both subfamilies (e.g. *P. eurynome*, *P. idaliae*, *L. magnificus* and *C. rubricauda*). Four species had medium degree of rarity (*R. naevius*, *P. squalidus*, *H. cyanus* and *P. lactea*), whereas *A. nigricollis* and *P. fimbriata* had high degree of rarity (Table 1).

Five of the seven Atlantic Forest endemic species tested by chi-square had significant occupation (p-value > 0.05) in the studied environments: *R. naevius*, *P. idaliae* and *C. rubricauda* had their highest values of FO in the native forest of the municipality (NFR, UFP and NFF); *P. eurynome* and *L.*



**Figure 4.** Fauna Similarity (Euclidian distance - UPGMA) of the environments sampled by the present study: NRF- native forest remnant; MAV- mountain anthropic vegetation; UFP - urban forest patch; URA- urban area; NFF- native forest fragment; LAV- lowland anthropic vegetation.

*albicollis* had their highest values of FO in the UFP; On the other hand, *F. fusca* and *T. glaucopsis* showed no preference to any kind of environment surveyed (Table 2).

## Discussion

**Hummingbirds of Santa Teresa.** We recorded 22 of the 35 species known for the municipality of Santa Teresa (Ruschi, 1961, 1965, 1969, 1982; Vielliard, 1994; Simon, 2000, 2006; Willis & Oniki, 2002). The 13 remaining species not recorded by us are: *Phaethornis margarettae*, *Phaethornis ruber*, *Florisuga mellivora*, *Chrysolampis mosquitus*, *Lophornis chalybeus*, *Discosura langsdorffi*, *Discosura longicauda*, *Chlorostilbon notatus*, *Thalurania furcata*, *Hylocharis sapphirina*, *Polytmus guainumbi*, *Heliostyris aurita* and *Heliomaster squamosus*. Nine of these species present testifying skins from Santa Teresa, which are housed in the Museu de Biologia Prof. Mello Leitão - MBML and the Museu Nacional do Rio de Janeiro - MNRJ (Annex 1). Although the other four species have no skins from Santa Teresa in scientific collections, there are consistent records of their presence in the municipality: *P. margarethe* and *T. furcata* were captured with mist nets by Willis and Oniki (2000); *L. chalybea* was well visualized by E. Forrester (*in litt. in Willis & Oniki, 2000*) and P. A. Ruschi (pers. obs. 2002); *P. ruber* is listed for the municipality by Ruschi (1965, 1969, 1977) and was well visualized by J. E. Simon (pers. obs. 2005).

**Table 2.** Results of the chi-square test ( $X^2$ ) for the affinity of the Atlantic Forest endemic hummingbirds (according to Parker *et al.*, 1996) to the native forest of the municipality of Santa Teresa. F- native forest (represented by NFR and NFF); AV- anthropic vegetation (represented by MAV and LAV); UFP- urban forest patch; ARU- urban area.

Species	Environment groups				Statistical test			Significance
	NF	AV	UFP	UA	$X^2$	df	P-value	
<i>Ramphodon naevius</i>	7	1	1	0	13.660	3	0.003	significant
<i>Phaethornis idaliae</i>	12	1	0	0	3.940	1	0.047	significant
<i>Phaethornis eurynome</i>	9	2	12	2	12.280	3	0.006	significant
<i>Florisuga fusca</i>	3	10	12	11	5.556	3	0.135	insignificant
<i>Thalurania glaucopsis</i>	11	5	12	7	3.743	3	0.291	insignificant
<i>Leucochloris albicollis</i>	1	7	12	9	8.931	3	0.030	significant
<i>Clytolaema rubricauda</i>	8	3	7	0	9.111	3	0.028	significant

The lack of records for potentially expected species in surveyed localities may be related to local extinction events (Ribon *et al.* 2003), sporadic occurrence (Budiansky, 1994), natural rarity (Goerck, 1997), altitudinal migration (Schuchman, 1999), etc. Here we present the 13 species mentioned above split into three different groups in an attempt of explaining their absence during this study field work.

Group 1: *Florisuga mellivora* and *Thalurania furcata* have distinctive records for the State of Espírito Santo. *Florisuga mellivora* is a typical Amazonian species. Its occurrence in Santa Teresa is based on a male specimen collected in the Park of the Museu de Biologia Prof. Mello Leitão, in 1994 (MBML N. 6650; Willis & Oniki, 2002). Although there were realized many well succeed studies on hummingbirds' breeding in captive (Ruschi, 1961) at the capture site, It's unlikely that the specimen had such origin, especially when considering the average longevity of hummingbirds in nature - five to eight years (Ruschi, 1982). More parsimonious explanations of this case include possible releasing or nomadic movement from Amazon through Cerrado (Willis & Oniki, 2002), though none of these hypothesis can be confirmed. *Thalurania furcata* is a lowland species, occurring in the country side of Southeastern Brazil, toward the Cerrado (Grantsau, 1988). The only records of it in the State of Espírito Santo are the capture of a vagrant specimen in the lowland region of Santa Teresa, in 1995, which was released after banded (Oniki, 1996; Willis & Oniki, 2002), and the visualization of a male specimen in the Estação Biológica de Santa Lúcia (mountain region of the municipality) in 1994 by Oniki and Willis (1998).

Group 2: *Discosura langsdorffi*, *Discosura longicauda*, *Heliophrys aurita*, *Heliomaster squamosus* and *Lophornis chalybeus* are typical from mountain regions in the State of Espírito Santo (Ruschi, 1982, 1986b), despite the scarcity of records in literature. *D. langsdorffi* and *D. longicauda* are difficult to be detected in field because they frequent the medium and high layers of vegetation (Ruschi, 1986b; Schuchmann, 1999). This might be the reason for their absence in our records, what indicates that they might be naturally rare in Santa Teresa. *D. longicauda* has only two records for the mountain region of Santa Teresa (Ruschi, 1969, 1977). It was first seen in this municipality between 1968 and 1969, about 15 years after its first record in the State of Espírito Santo (Ruschi, 1953a). Similarly, *H. squamosus*, first recorded in the State of Espírito Santo in 1953 (Ruschi, 1953a), was found in the mountain region of Santa Teresa in 1958 (Ruschi, 1961). However, its records in the literature extended up to the decade of 90 (Willis & Oniki, 2002). In a different way, the records for *D. langsdorffi* are scarce and date from the decades of 30 to 90 in the mountain region of the municipality (Ruschi, 1961, 1965, 1969, 1977; Parker *et al.*,

1996). The records of *H. aurita* in the mountain region of the municipality also extend from 1930 to 1990 (Ruschi, 1951, 1965, 1969, 1977; Willis & Oniki, 2002). *Lophornis chalybeus* has only three somewhat recent records for the municipality (Ruschi, 1982; Parker et al. 1996; P. A. Ruschi, pers. obs., 2001). Although this species is a short migratory one (Ruschi, 1981), its presence in Santa Teresa might be related to some unknown movement (Schuchmman, 1999) rather than to a rout of migration.

Group 3: *Phaethornis ruber*, *Polytmus guainumbi*, *Chlorostilbon notatus*, *Chrysolampis mosquitos*, *Hylocharis sapphirina* and *Phaethornis margarettae* are typical of lowlands in the State of Espírito Santo (Ruschi, 1986a, 1986b; Schuchmman, 1999; J. E. Simon, pers. obs.). Their records in the mountain region of Santa Teresa occurred probably due to sporadic altitudinal movements. The only record of *P. margarettae* in the municipality is based on the capture of a vagrant specimen at the UFP (mountain region) feeders in 1990 (Willis & Oniki, 2002). *Phaethornis ruber* and *P. guainumbi* were recorded in the mountain region between 1930 and 1970 (Ruschi, 1965, 1977). These records of *P. ruber* are probably due to altitudinal movements in function of the proximity to its habitat; in this case to Pre-montane Semidecidial Seasonal Forest, which reaches from 0 up to 300m (Rushi, 1986a). This phenomenon is also known for populations of *P. ruber* in Bolivia, Peru and Venezuela (Schuchmann, 1999). Likewise, the records of *P. guainumbi* result from more discreet altitudinal movements, as this species is normally found from 0 up to 600m (Shuchmann, 1999). As well as the previous species, *C. notatus* was recorded in the mountain region between 1930 and 1970 due to altitudinal movements. However, this species was also recorded in the municipality between 1998 and 1999 (Simon, 2000), what indicates continuity of movements (Ruschi, 1986a). In the same way, *H. sapphyrina*, migratory in Southeastern Brazil, has records for both the mountain and the lowland regions of the municipality (Ruschi, 1951, 1965, 1969, 1977; Willis & Oniki, 2002), in spite of the lowland record being based on a specimen captured in 1937 and housed in 1941 in the MBML ornithological collection, n° 727 (Ruschi, 1961; Vielliard, 1994). Likewise, *C. mosquitos*, which is migratory (Ruschi, 1986b; Schuchmann, 1999), was first found in the Espírito Santo State in Santa Teresa in 1953 (Ruschi, 1953a; 1961) and keeps in records until nowadays (Ruschi, 1961, 1969, 1977; Willis & Oniki, 2002; P. A. Ruschi pers. obs., 2008). Its natural rarity in the municipality, as well as in mountain regions, is because it is migratory (Ruschi, 1886; Schuchmann, 1999; Willis & Oniki, 2002). In addition, its presence in the State of Espírito Santo is more remarkable in the countryside (Willis & Oniki, 2002).

At the lowland region (< 500m) we did not record two species formerly

known for this region: *G. hirsuta*, last recorded there by Willis and Oniki (2002) and *L. albicollis*, last recorded there in 1938 (Ruschi, 1961). Other three species known for Santa Teresa (*P. squalidus*, *P. fimbriata* and *C. rubricauda*) that also include lowland regions in their altitudinal limits (Schuchmann, 1999) have no records in this region of the municipality.

We recorded *P. eurynome* for the first time at the lowland region of the municipality. This is based on two audio/visual contacts at the NFF (Vale do São Brás). Although the record of this species, which is sedentary, was within the altitudinal limits of its distribution (Schuchmann, 1999), it might be related to altitudinal movements from mountain region population's specimens in function of vegetation continuity rather than to the existence of a residual population in the lowland, which's forests are poorly represented nowadays (Willis & Oniki, 2002).

Progress on hummingbird's studies, such as behavior and intra-specific competition studies, which influence bird migration (Cox *apud* Pough *et al.*, 2003), as well as nomadic and altitudinal movements, still poorly understood (Schuchmann, 1999), may shed some light on their distribution and seasonality locally.

Concerning the total of species known for Santa Teresa, one should note that the records of those species we did not find in our field investigation are based on a long termed period of study, which begun in the decade of 30 until the final 70's, by A. Ruschi (1961, 1965, 1977), and was extended from the seventies to the nineties by Willis and Oniki (2002). In fact, our study's collector curve points to the probable occurrence of more species in the municipality, as two more species were recorded at the final expeditions (Total= 12 months, 350h).

Still, it is worth mentioning that from all the 38 hummingbird species known for the State of Espírito Santo (Simon, 2009), only three have never been recorded in Santa Teresa: *Glaucis dohrnii*, *Stephanoxis lalandi* and *Agyrtria leucogaster*. *Glaucis dohrnii* is known only for the lowland forests of extreme North Espírito Santo and extreme South Bahia (Ruschi, 1986a). *Agyrtria leucogaster* is a recent invador in this state (Ruschi & Simon, 2007). *Stephanoxis lalandii* is restricted to the highlands in the Espírito Santo (Ruschi, 1986b).

**Richness of species per environment.** Although the present study does not increase the number of species recorded in Santa Teresa, it improves the knowledge about the family Trochilidae, as it surveyed the hummingbird's distribution on different altitudinal zones and different environments.

The high number of species we recorded in the mountain region of

Santa Teresa (N=21) agrees with the data on general birds composition in the municipality (Simon, 2000, 2006; Willis & Oniki, 2002). Also the low number of bird's species in the lowland region of the municipality due to low degree of forest conservation has been reported by Willis and Oniki (2002). Only one (*P. idaliae*) of the 13 species recorded in this region was exclusively found there. Other lowland typical species of the Espírito Santo State can also be absent there due to deforestation, including *P. margarete*, *P. ruber*, *C. mosquitus*, *L. chalybeus*, *D. langsdorffi*, *D. longicauda*, *C. notatus*, *H. sapphyrina*, *P. guainumbi*, *H. aurita* and *H. squamosus*. Of those, *P. ruber*, *C. mosquitus*, *L. chalybeus*, *C. notatus*, *P. guainumbi* and *H. squamosus* are associated to open landscapes (cerrado, savanna, restinga, etc.), which are poorly present or absent (e.g. restinga and cerrado) in the lowlands of the municipality (Willis & Oniki, 2002; Simon, 2006).

Although urban forests are known as retaining low diversity of birds (Borges & Guilherme, 2000; Simon *et al.*, 2007), the Park area of the Museu de Biologia Prof. Mello Leitão (UFP: 7,7 ha) was the environment with the highest number of species (N= 21), including both non-forest and forest species. The high richness of hummingbirds in this area is related to the well preserved vegetation (Sick, 1997), as well as the historical introduction of nectarine plants and feeders (Ruschi, 1949). In fact, only four species of hummingbirds (*P. pretrei*, *C. aureoventris*, *T. glaucopsis* and *A. versicolor*) frequented this local before the forest restoration and introduction of plants and feeders (Ruschi, 1949). After the transformation of the UFP (park of the Museu de Biologia Prof. Mello Leitão) into a place of high abundance and richness of hummingbirds, It has received birdwatchers from all over the world, as well as being used for field sampling in research (Ferreira *et al.*, 2000, Ferreira *et al.*, 2006).

We only recorded 12 species in the NFR (forest reserves) of the total 21 recorded in the mountain region. This can be explained by the lower frequency of occurrence of some species in forest environments (see discussion above), and for the occupation of the upper stratum of the vegetation by some species, where their detection becomes harder (Grantsau, 1988).

**Environment's frequency of occurrence and rarity degree in the municipality.** The frequency of occurrence analysis revealed that some species have ecological affinity to particular environments of the municipality, in special the Phaethornithinae to the forest environments. The only exception is *P. pretrei*, as cited in literature (Sick, 1997; Grantsau, 1988).

However, the Trochilidae, as a functional ecological group (Nectarivorous), revealed lower restriction of habitat quality when compared to other groups, for example Formicariidae (undergrowth insectivores), Dendrocolap-



tidae (climber insectivores), Pipridae (small frugivorous of the undergrowth) and Cotingidae (large canopy frugivorous) (Simon, 2006). It happens because hummingbirds usually engage on nomadic movements and migration (Schuchmann, 1999), exploiting different environment conditions as breeding and feeding spots (Willis & Oniki, 2002). In fact, recent data on the avifauna of Santa Teresa revealed that hummingbirds of the mountain region were mildly affected by the process of forest fragmentation, possibly by maintaining a meta-population system favored by the anthropic vegetation (matrix), which does not act as a strong barrier for them (Simon, 2006). A good illustration of this situation is performed by *T. glaucopsis* in Santa Teresa. This species, which is Atlantic Forest endemic, was recorded in different environments, including the URA. Furthermore, many species are able of exploring modified environments, becoming even common if plenty food is available. This is the case of *G. hirsuta* and *C. amethystina* in the UFP.

Thus, the rarity degree may be more related to the species seasonality (nomadic behavior or altitudinal migration) in one region than it is to population decreasing. This is the case of some open landscape typical species, as *A. nigricollis* and *P. fimbriata*, which have a high degree of rarity in the municipality of Santa Teresa, but are far common in some other places of Espírito Santo.

The unexpressive occurrence ( $F < 0.25$ ) of some species in the lowland seems to be related to sporadic altitudinal movements. For example, we recorded *L. magnificus* in the lowland region (Table 1) only in August, visiting exclusively flowers of Sapindaceae, what characterizes movement related to food availability (Schuchmann, 1999).

*Discosura langsdorffi* and *P. margaretae* deserve distinction for their historic records in Santa Teresa, dated from 1942 and 1990 (Vielliard, 1994; Willis & Oniki 2002, respectively) being included in the list of threatened birds of Espírito Santo (Simon *et al.*, 2007). Hence, future works focusing on the rediscovery of residual populations of these species in the municipality are important to their conservation in Espírito Santo.

The Chi-square analyses of the forest and Atlantic Forest endemic species revealed that: *R. naevius* and *P. idaliae* are strongly associated to the forest environment in the municipality; *P. eurynome* and *C. rubricauda* are associated to forest environment, but frequent suitable anthropic environments, such as the UFP; *L. albicollis* uses the different environments of the municipality in different ways. In this case, it outstands the low FO values for the forest environment, what may result from difficult detection on field (see discussion of species richness per environment). Therefore, this species may be as plastic as the followings discussed. The plasticity on environment occupation observed

for *F. fuscus* and *T. glaucopis* seems to be consequent of the meta-population system, as discussed earlier.

Another peculiarity of the hummingbirds in Santa Teresa is that most of the species found by the present study (n=16 or 72%) are locally common or regular, including species of both Phaethornithinae (e.g. *P. eurynome* and *P. idaliae*.) and Trochilinae (e.g. *L. magnificus* and *C. rubricauda*).

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