



## NOTES ON DISPLAYS AND POSSIBLE LEK BEHAVIOR OF THE FIERY TOPAZ (*TOPAZA PYRA*) (APODIFORMES: TROCHILIDAE)

Tomaz Nascimento de Melo<sup>1,2</sup> · Fábio Olmos<sup>3</sup> · Rita Cerqueira Ribeiro de Souza<sup>3</sup> · Guy M. Kirwan<sup>4,5</sup>

<sup>1</sup> Programa de Pós-Graduação em Zoologia, Universidade Federal do Amazonas (UFAM), Av. General Rodrigo Otávio, 1200, Coroado I, Manaus -AM, Brazil.

<sup>2</sup> Rainforest Connection, Science Department, San Francisco, California, USA.

<sup>3</sup> Largo do Paissandu, 100, apt 4C, São Paulo-SP, Brazil.

<sup>4</sup> Setor de Ornitologia, Departamento de Vertebrados, Museu Nacional, Universidade Federal do Rio de Janeiro, Quinta da Boa Vista, s/n, 20940–040 Rio de Janeiro, RJ, Brazil. E-mail: gmkirwan@aol.com

<sup>5</sup> Research Associate, Field Museum of Natural History, 1400 South Lakeshore Drive, Chicago, IL 60605, USA.

E-mail: Tomaz Nascimento de Melo · tomazramphotrignon@gmail.com

**Abstract** · The genus *Topaza* comprises two species of large hummingbirds with allopatric distributions in Amazonia. Lek behavior has already been described in almost 30 species of hummingbirds, including the Crimson Topaz (*Topaza pella*), but not for the Fiery Topaz (*T. pyra*). We describe male displays by *T. pyra* and how these might possibly be correlated to lek behavior, based on observations at different locations in Ecuador, Colombia, and Brazil. These behaviors are compared to the previously described behavior of *T. pella* and other hummingbirds, but we also describe an extremely unusual upside-down hanging behavior during male-to-male interactions. Furthermore, some of our observations evidence an apparent tendency for more than one male to converge on a specific perch, perhaps to compete for dominance within a group of otherwise more dispersed, probably linear song territories.

### Resumo · Comportamento de lek do topázio-de-fogo *Topaza pyra* (Apodiformes: Trochilidae)

O gênero *Topaza* inclui duas espécies de beija-flores de grande porte com distribuições alopatricas na Amazônia. O comportamento de lek já foi descrito em diversas espécies de beija-flores, incluindo *Topaza pella* e até então não era descrito em *T. pyra*. Descrevemos displays de machos de *T. pyra* e como estes são possivelmente correlacionados ao comportamento de lek, baseado em observações feitas no Equador, Colômbia e Brasil. Os comportamentos observados são comparados aos comportamentos previamente descritos para *T. pella* e outras espécies de beija-flores. Também descrevemos um comportamento de pendurar de cabeça para baixo extremamente incomum durante as interações entre machos. Além disso, algumas de nossas observações evidenciam uma tendência aparente de mais de um macho convergir para um poleiro específico, talvez para competir pelo domínio dentro de um grupo de territórios de canto possivelmente mais dispersos e provavelmente distribuídos linearmente.

**Key words:** Amazonian hummingbirds · Breeding · Lekking · Sexual behavior

## INTRODUCTION

The Fiery Topaz (*Topaza pyra*, Gould, 1846) is one of two species of markedly sexually dimorphic hummingbirds in the genus *Topaza*, with its most striking feature being the two elongated central rectrices of the mostly red plumage in the males (del Hoyo et al. 2020). *T. pyra* was previously considered a subspecies of the Crimson Topaz (*T. pella*, Linnaeus, 1758) due to its morphology and allopatric distribution (Schuchmann 1982). Despite some controversy regarding the taxonomy (Schmitz-Ornés & Schuchmann 2011), the distinctiveness of the two species is accepted by virtually all modern authorities (Hu et al. 2000, Dickinson & Remsen 2013, Piacentini et al. 2015, Gill et al. 2020, del Hoyo et al. 2020, Remsen et al. 2020).

The Fiery Topaz occurs in southeastern Colombia, eastern Ecuador, northeastern Peru, southern Venezuela, and in northwestern Brazil at the north of the Rio Madeira and west of the Rio Negro (Grantsau 2010, del Hoyo et al. 2020). It is a forest-based species that occurs in formations of white sand soils, especially along the banks of black-water streams and around *Mauritia* palm groves. It is typically found in lower elevations up to 400 m, but locally as high as 750 m in Ecuador (Ridgely & Greenfield 2001) and 450 m in Peru (Harvey et al. 2014).

This a resident species, but presumably makes local seasonal movements in response to food availability (Hu et al. 2000). According to Hu et al. (2000), little has been published about the behavior of *T. pyra* and any observation could contribute to

Submitted 15 September 2020 · First decision 15 March 2021 · Acceptance 9 April 2021 · Online publication 18 June 2021

Communicated by Paulo Pulgarín © Neotropical Ornithological Society

improving our knowledge about its natural history. Although there is more information about the breeding behavior of *T. pella* (Nicholson 1931, França et al. 2020), including its lekking behavior (Davies 1958, Borges et al. 2004), the breeding and lekking behavior (if any) of *T. pyra* remain undescribed.

Lekking behavior is an aggregation of males that display competitively in arenas (known as leks), aiming to attract females. These exhibit a strong mate choice, then incubate the eggs and provide for the young without assistance from the male (Payne 1984). Lekking is known in at least 28 species of hummingbirds (Schuchmann 1999, Pizo 2012). Its repeated evolution among Trochilidae, as it has been recorded in at least three of the six subfamilies (Florisuginae, Phaethornithinae, Trochilinae) (Atwood et al. 1991, Schuchmann 1999, Pizo & Silva 2001, Pizo 2012), suggests that lekking behavior lacks a strong phylogenetic component, but is a common result of sexual selection among species in which males are divorced from the responsibilities of parental care (Bleiweiss 1998). The distance and contact between neighboring males in lekking species vary from individuals that are dispersed across an area and are only in auditory contact ('exploded leks'), to those that are in close proximity and constant visual contact ('classical leks'). Due to hummingbirds' dependence on nectar, a resource with highly diverse temporal and spatial distribution, there is much variation in their social organization, including their mating systems, making it difficult to define an overall spatial pattern (Payne 1984). Males in some species maintain a short distance between their perches at the lek site, e.g. 2–5 m for the Wedge-tailed Sabrewing (*Campylopterus curvipennis*) (González & Ornelas 2009). Others remain more distant, maintaining only vocal contact between the closest males, such as the Swallow-tailed Hummingbird (*Eupetomena macroura*) (Pizo & Silva 2001). Several species of the genus *Phaethornis* routinely sing from more than one perch without visual contact between neighboring males and actively chase males that enter their territorial space within the larger lek area (Stiles & Wolf 1979, Harger & Lyon 1980, Sick 1997).

To understand the role of historical and ecological processes in the evolution of lek behavior in hummingbirds, it is essential to increase our knowledge on this behavior among different clades within the hummingbird phylogeny (Pizo 2012). Here, we describe some displays and a possible lek of *T. pyra*, based on observations made in Ecuador, Colombia, and Brazil, as a contribution to the cumulative knowledge of the species' natural history.

## METHODS

Our observations were made at four different localities: Shiripuno Lodge, located along the Río Shiripuno within the Yasuní Biosphere Reserve in the Pastaza province, eastern Ecuador (01°06'28"S, 76°43'89"W); Anavilhanas Jungle Lodge, on the right bank of Rio Negro, in the municipality of Novo Airão, Amazonas state, Brazil (02°38'20"S, 60°56'27"W); Pousada Cirandeira Bela (03°11'52.30"S, 60°40'52.69"W), in the municipality of Manacapuru, state of Amazonas, Brazil; and in the municipality of Mitú, departamento Vaupés, southeastern Colombia (01°13'14.1"N, 70°14'18.3"W). All the observations were made incidentally during non-targeted fieldwork and are presented in a chronological sequence. In some observations, the behavior was docu-

mented using sound recordings, photographs and videos lodged in the Xeno-canto ([www.xeno-canto.org](http://www.xeno-canto.org)) or Macaulay Library online collections ([www.macaulaylibrary.org](http://www.macaulaylibrary.org)), in the latter case via the eBird platform ([www.ebird.org](http://www.ebird.org)).

## RESULTS

On 1 November 2007, between 08:30 h and 09:00 h, GMK briefly observed at least two male *T. pyra* hovering and chasing each other along a narrow black-water stream at Shiripuno Lodge, eastern Ecuador. This behavior occurred at the forest edge, ~10 m above ground, and involved sustained vocalizations by multiple individuals. However, it was difficult to determine precisely how many birds were involved or to observe the behavior in more detail as the observer was stationed inside the dense understory and watching from at least 20 m away without a clear, unobstructed view of the gap where the birds were present.

On 10 December 2007 around 17:00 h, along a rather broad (c. 20 m wide) black-water stream at Anavilhanas Jungle Lodge, GMK observed two males hovering separately for short periods (never longer than c. 30 seconds) at the forest edge, c. 1.5 m above the creek's water (rather than the ground), with their legs splayed at near right angles to the body (i.e. forward) facing the direction of the trees. The birds were not observed to be feeding during this behavior, and indeed the position of the legs and feet would have potentially made this very difficult (as the individuals would have been unbalanced). In one case, a female Fiery Topaz was observed perched low just inside the forest, close to one of the males, apparently watching the latter intently; however, any subsequent interaction between them could not be seen.

In late September and early October 2014, GMK observed *T. pyra* lek displays in a low height and comparatively open white sand forest (*campina*) at a site just south of Mitú, Vaupés, in southeastern Colombia. Up to three males were seen displaying to or at each other near an unidentified flowering tree at the edge of a clearing. These individuals were typically up to 8 m above ground chasing each other but especially hovering while facing each other in a roughly triangular formation (each bird no more than 50 cm from its neighbor). The males were calling nearly continuously. A sound recording was deposited in Xeno-Canto (XC 321617). This behavior was seen several times on two mornings, always before 09:00 h, but starting after the sun had fully risen and the day had started to warm up. None of the males were observed to feed from the tree, despite regular visits to the same clearing at several different times of each day on three separate dates. However, the possibility that the behavior GMK observed was related to establishing a foraging dominance hierarchy cannot be discarded at this stage.

On 17 July 2020 at 06:15 h, TMN, FO, and RCRS heard the typical song of *T. pyra* (see <https://www.xeno-canto.org/species/Topaza-pyra> for examples) at Pousada Cirandeira Bela, in a mosaic of open areas and sparse patches of *campinarana* (a type of arboreal, relatively low forest vegetation that grows on nutrient-poor white sand soils in Amazonia). At the observation site, a small black-water stream (*igarapé*) runs through the *campinarana* vegetation and nearby open areas. A male was observed vocalizing frequently and with seemingly agitated behavior, moving along the vegetation bordering the *igarapé*.



**Figure 1.** Three *Topaza pyra* males performing displays and singing a few centimeters apart (photo by Fábio Olmos).

After a few minutes, the observers noticed the presence of two additional males that landed nearby and were vocalizing frequently. The birds sang from the narrow bare branches of the same tree, approximately 2 m above the water (Figure 1). Occasionally, one or two males would leave, but they would return after a few moments.

When perched, the males maintained a distance of 5–15 cm between them. The birds vocalized often, moving their heads to clearly display the metallic colors in their throats and bellies while throwing their wings back and fanning their tails. The calling birds would tilt their heads forward, without ceasing to vocalize, alternating between simple calls and quick sequences of the song, occasionally with the tongue protruding from the bill. Video recordings of this behavior have been deposited in the Macaulay Library (ML 251149111, ML 251151411).

Sometimes the males were observed chasing each other and performing maneuvers in flight close to the perch used for displaying. The exchange of positions between the males on the branches was confirmed, as one of them was molting one of the elongated tail feathers. This individual was watched constantly changing positions among the branches the trio used.

Another display was made by two males perched facing each other and separated by about 5 cm. Both vocalized, and opened and closed their wings quickly, flying and changing positions afterwards (ML 250823031).

A third display was made by a male perched in front of another that hung suspended at a 180° angle, belly up and the bill pointing upwards, while the other hovered and vocalized close to the branch where the first was perched (Figure 2). Occasionally, all the males left the tree, but whenever one

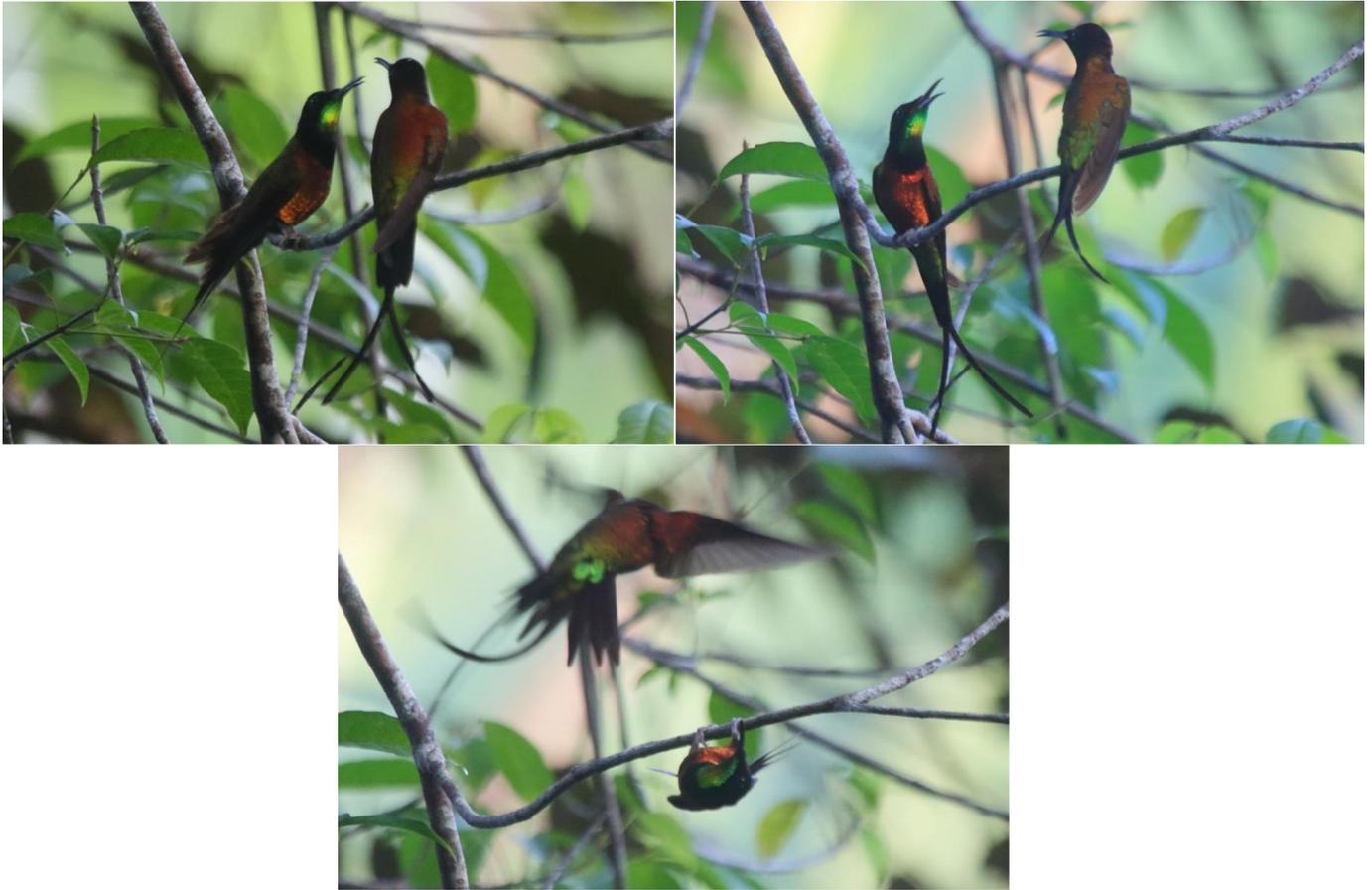
returned to the display perch the others quickly followed. Sometimes the males were observed chasing each other and performing maneuvers in flight close to the display perch.

A female was observed visiting the site briefly once. Due to her discreet behavior, we were unable to confirm if she stayed longer, perhaps on a less obvious perch, watching the males perform. The birds remained until about 07:00 h. No individuals were detected again at the site after that time.

## DISCUSSION

Our observations show elements of similarity with the behavior described for *T. pella*, which forms leks close to streams (Davies 1958, Borges et al. 2004, Restall et al. 2006). The settings in which we observed the display behavior at Mitú (Colombia) and Pousada Cirandeira Bela (Brazil) were most similar to those made by Borges et al. (2004), who found *T. pella* leks in more open areas in north-central Brazil. Davies (1958), on the contrary, described a lek in Guyana within a dense forest where males perched on higher branches, although GMK's observations in eastern Ecuador were made at a natural edge in a dense transition forest. Borges et al. (2004) commented that leks located in more open areas enable males of *Topaza* to better exhibit their colorful plumage, a feature quite evident during the observations we made in Colombia (which were unusual as they were away from running, but not standing water) and Pousada Cirandeira Bela, where the birds benefited both from the exposed sites and the angle of the early morning sun.

The number of attending individuals varies at *T. pella* leks. Davies (1958) estimated the number of males in the lek he observed at more than 20, whereas Borges et al. (2004)



**Figure 2.** *Topaza pyra* males performing displays in the lek site at Pousada Cirandeira Bela, Amazonas state, Brazil (photos by Fábio Olmos).

found between four and eight individuals, with varying percentages of males and females depending on the day. The latter was similar to the number of individuals we observed at Pousada Cirandeira Bela and Colombia, and to the usual number of birds present at the leks of many species of trochilids, which is typically 'two or three, sometimes up to ten' (Schuchmann 1999:495). For the Eastern Long-tailed Hermit (*Phaethornis superciliosus*), leks comprise 4–15 males, and occasionally more than 20 (Stiles & Wolf 1979). The factor that possibly limits the number of males in a hummingbird lek is the availability of nearby nectar, favoring the formation of leks with fewer individuals and thereby preventing the rapid exhaustion of the resource (Stiles & Wolf 1979).

Some of the displays we observed are identical to the descriptions by Davies (1958), especially the opening of the wings behind the body and the opening and closing of the fan-shaped rectrices. Some behaviors were also similar to those described by Borges et al. (2004), such as the display of the tongue and the rapid movements of the head, as well as chases between individuals. Such displays have also been observed in species of the genus *Phaethornis* (Stiles & Wolf 1979, Sick 1997). For *P. superciliosus*, the displays made by the perch owner become more vigorous when an intruder enters its territorial space (Stiles & Wolf 1979).

While describing the display of *T. pella*, Sick (1997) commented that the color change of the throat feathers produces an effect similar to a light being turned on and off, which is akin to the observations we made at Pousada Cirandeira Bela. In *Topaza*, tibial feathers can also play an important role in displays, as reported by Whittaker (2009), who observed a

male *T. pella* displaying the white tibial feathers to the females while hovering, in a maneuver similar to that observed in *T. pyra* by GMK at Novo Airão.

A feature of the display that we observed, which was not described by Davies (1958) and Borges et al. (2004), was the close interaction between the males when perched, sometimes just a few centimeters apart (the males displaying in flight in Colombia also remained close together). This, as well as the different colors of the tibial feathers may be key differences in the displays in both species. The combined display of more than one male on the same perch is possibly the most peculiar characteristic in the behavior of *T. pyra* and has not been described for *T. pella*. Species of Trochilinae and Phaethorninae for which lek behavior is known usually maintain only auditory contact and vigorously defend their display perches (Stiles & Wolf 1979, Harger & Lyon 1980, Atwood et al. 1991, Sick 1997, Pizo & Silva 2001, González & Ornelas 2009).

It was not possible to observe where males went, but sometimes all three males at Pousada Cirandeira Bela disappeared or just one remained on the song perch. This raises the possibility of it being the territory of one of the males, or that each male has a territory at different locations along the stream, but visits these perches to dispute dominance (this could also have been true of the observations made in eastern Ecuador). Visits by male intruders to song perches in the territory of another male occur in some species of hummingbirds, where usually dominant (alpha) males visit the perches of subordinate (beta) males (Stiles & Wolf 1979). In *P. superciliosus*, display in flight by an intruder male is common near the perch where a territorial male sings, as are chases be-

tween males and exchange of perches. Although rarer, two males occasionally land side by side on the same perch (Stiles & Wolf 1979), as we observed for *T. Pyra* at Pousada Cirandeira Bela. Generally, dominance disputes such as these occur several times, but they are more linked to resolving male dominance than to achieving copulations. Although male-male interaction is common, we have not seen reports of more than two males participating in such close and simultaneous displays in other species of Trochilidae.

Another peculiar feature of lek behavior in *Topaza* is the relatively short period dedicated to the activity. Borges et al. (2004) always observed *T. pella* leks in the late afternoon, and we observed apparent male-female display at this time of day (in central Amazonian Brazil). In contrast, Davies (1958) observed greater activity from dawn until 07:30–08:00 h, with reduced activity in the evening, similar to GMK's experience in Guyana at Arrowpoint Nature Resort, Santa Mission (06°57.272"N, 58°37.377"W), in early October 2009. It was not possible to conclude whether *T. pyra* also leks in the evening, but at least at Pousada Cirandeira Bela the species appears to be active only early in the morning (G. A. Leite pers. com.).

As with other characteristics of lekking behavior in hummingbirds, the daily duration of male activity at the lek varies between species. A notable peak of activity concentrated at certain hours of the day contrasts especially with some hummingbirds of the genus *Phaethornis*, which can remain active at leks throughout the day (Harger & Lyon 1980, Sick 1997) or be divided into peaks throughout the day (Stiles & Wolf 1979). Even more concentrated and briefer lek activity has been described through detailed observations of *E. macroura* by Pizo & Silva (2001), who witnessed lek activity in this species for just ten minutes pre-dawn. According to Pizo & Silva (2001), this behavior may reflect the result of a trade-off between expending energy at the lek and defending a foraging territory. In *P. superciliosus*, peaks of vocal activity, chases, and visits by females are directly related to the availability of nectar, and thus of feeding bouts. Intense vocal activity and chases commence at dawn and last about 1 h, followed by a pause that coincides with the opening of *Heliconia* flowers and the need to feed. In the afternoon there is little activity at the lek, which coincides with the exhaustion of nectar in the *Heliconia* flowers, which does not allow for intense activity by the birds (Stiles & Wolf 1979). As *Topaza* hummingbirds are also known to actively defend feeding territories (del Hoyo et al. 2020), the same may be true for species in this genus.

Our observations from Brazil are probably the first to describe the behavior of different males meeting in the same place for display in the genus *Topaza*. Future observations at the same (or other) localities could seek to establish how the territories of different males are distributed, which food resources they exploit, and whether dominance among males is related to lekking activity or to control of food resources, further contributing to our knowledge of this species' natural history.

#### ACKNOWLEDGMENTS

TNM receives financial support from Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES). We thank

Gabriel Leite for additional information and Fernando Pacheco for helping with the bibliography. GMK is grateful to Hadoram Shirihai for entirely funding the field work in Ecuador and Brazil reported herein. Neil Bostock, Mike Coverdale, Pablo Flórez, Andy Marshall, and Pete Shepherd shared the observations made in Colombia. We thank F. Gary Stiles and an anonymous reviewer for their important contributions to the manuscript.

#### REFERENCES

- Atwood, JL, VL Fitz, & JE Bamesberger (1991) Temporal patterns of singing activity at leks of the White-bellied Emerald. *Wilson Bulletin* 103: 373–386.
- Bleiweiss, R (1998) Phylogeny, body mass, and genetic consequences of lek-mating behavior in hummingbirds. *Molecular Biology and Evolution* 15: 492–498.
- Borges SH, PC Stouffer & AMP Carvalhaes (2004) Comportamento de “lek” em *Topaza pella* (Aves: Trochilidae) na Amazônia Central. in Cintra, R (ed.). *História Natural, Ecologia e Conservação de Algumas Espécies de Plantas e Animais da Amazônia*. Editora INPA, Manaus, Brazil.
- Davies, TAW (1958) The displays and nests of three forest hummingbirds of British Guiana. *Ibis* 100: 31–39.
- del Hoyo, J, N Collar, GM Kirwan & PFD Boesman (2020) Fiery Topaz (*Topaza pyra*), version 1.0. in del Hoyo, J, A Elliott, J Sargatal, DA Christie & E de Juana (eds). *Birds of the World*. Cornell Lab of Ornithology, Ithaca, USA. Available at <https://www.doi.org/10.2171/bow.fietop1.01> [Accessed 24 July 2020]
- Dickinson, EC, & JV Remsen Jr (2013) *The Howard and Moore complete checklist of the world*. Vol. 1. Fourth edn. Aves Press, Eastbourne, UK.
- França, PF, WA Santos, CE Costa-Campos & EV Lopes (2020) Nestling development and data on nests and eggs of *Topaza pella* (Aves, Trochilidae) in Amapá state, northern Brazil. *Acta Amazonica* 50: 138–141.
- Gill, F, D Donsker & P Rasmussen (2020) IOC Bird List (v10.2). Available at <https://www.doi.org/10.14344/IOC.ML.10.2>
- González, C & JF Ornelas (2009) Song variation and persistence of song neighborhoods in a lekking hummingbird. *The Condor* 111: 633–640.
- Grantsau, R (2010) *Guia completo para identificação das aves do Brasil*, v. 1. Editora Vento Verde, São Carlos, Brazil.
- Harger, M & D Lyon (1980) Further observations of lek behaviour of the Green Hermit Humming-bird *Phaethornis guy* at Monte verde, Costa Rica. *Ibis* 122: 525–530.
- Harvey, MG, GF Seeholzer, D Cáceres A, BM Winger, JG Tello, F Hernández Camacho, MAA Justiniano, CD Judy, S Figueroa Ramírez, RS Terrill, CE Brown, LA Alza León, G Bravo, M Combe, O Custodio, AQ Zumaeta, AU Tello, WAG Bravo, AZ Savit, FWP Ruiz, WM Mauck, & O Barden (2014) The avian biogeography of an Amazonian headwater: the Upper Ucayali River, Peru. *Wilson Journal of Ornithology* 126: 179–191.
- Hu, DS, L Joseph & D Agro (2000) Distribution, variation, and taxonomy of *Topaza* hummingbirds (Aves: Trochilidae). *Ornitología Neotropical* 11: 123–142.
- Nicholson, EM (1931) Field-notes on the Guiana King Hummingbird. *Ibis* 73: 534–553.
- Payne, RB (1984) Sexual selection, lek and arena behavior, and sexual size dimorphism in birds. *Ornithological Monographs* 33: 1–52.
- Piacentini, VQ, A Aleixo, CE Agne, GN Maurício, JF Pacheco, GA Bravo, GRR Brito, LN Naka, F Olmos, S Posso, LF Silveira, GS Betini, E Carrano, I Franz, AC Lees, LM Lima, D Pioli, F Schunck, FR Amaral, GA Bencke, M Cohn-Haft, LFA Figueiredo, FC Straube & E Cesari (2015) Annotated checklist of the birds of Brazil by the Brazilian Ornithological Records Com

- mittee. *Revista Brasileira de Ornitologia* 23: 91-298.
- Pizo, MA (2012) Lek behavior of the Plovercrest (*Stephanoxis lalandi*, Trochilidae). *The Wilson Journal of Ornithology* 124: 106–112.
- Pizo, MA & AWR Silva (2001) The dawn lek of the Swallow-tailed Hummingbird. *The Wilson Bulletin* 113: 388–397.
- Remsen, JV, JI Areta, E Bonaccorso, S Claramunt, A Jaramillo, JF Pacheco, MB Robbins, FG Stiles, DF Stotz & KJ Zimmer (2020) *A classification of the bird species of South America*. American Ornithological Society. Available at <https://www.museum.lsu.edu/~Remsen/SACCBaseline.htm>
- Restall, R, C Rodner & M Lentino (2006) *Birds of northern South America: an identification guide. Volume 1: species accounts*. Christopher Helm, London, UK.
- Ridgely, RS & PJ Greenfield (2001) *The Birds of Ecuador. Vols. 1–2*. Cornell University Press, Ithaca, NY.
- Schmitz-Ornés, A & KL Schuchmann (2011) Taxonomic review and phylogeny of the hummingbird genus *Topaza* Gray, 1840 using plumage color spectral information. *Ornitología Neotropical* 22: 25–38.
- Schuchmann, KL (1982) Zur Biologie des Königskolibris (*Topaza pella*). *Trochilus* 3: 56–93.
- Schuchmann, KL (1999) Family Trochilidae (hummingbirds). Pp. 468–680 in del Hoyo, J, A Elliott, & J Sargatal (eds.) *Handbook of the Birds of the World. Vol. 5*. Lynx Edicions, Barcelona, Spain.
- Sick H (1997) *Ornitologia Brasileira*. Editora Nova Fronteira, Rio de Janeiro, Brazil.
- Stiles FG & LL Wolf (1979) Ecology and evolution of lek mating behavior in the Long-tailed Hermit Hummingbird. *Ornithological Monographs* 27: 1–78.
- Whittaker, A (2009) Pousada Rio Roosevelt: a provisional avifaunal inventory in south-western Amazonian Brazil, with information in life history, new distributional data and comments on taxonomy. *Cotinga* 31: 23–46.