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Lucas Vilela de Carvalho Rodrigues

THE VOCAL REPERTOIRE OF MONKEY LEAF FROGS OF THE GENUS *PITHECOPUS* COPE, 1866 (ANURA: HYLIDAE: PHYLLOMEDUSINAE) AND ITS SIGNIFICANCE FOR THE TAXONOMY OF THE GENUS

Belo Horizonte

2025

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LUCAS VILELA DE CARVALHO RODRIGUES

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Davi Lee Bang

Membro - USP

Felipe Camurugi Almeida Guimarães

Membro - UFPB

Thiago Ribeiro de Carvalho

Orientador - UFMG

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When the ebbing tide retreats along the rocky shoreline
It leaves a trail of tide pools in a short-lived galaxy
Each microcosmic planet, a complete society
A simple kind of mirror to reflect upon our own
All the busy little creatures chasing out their destinies
Living in their pools, they soon forget about the sea

Natural Science

Permanent Waves (1980)

Rush

ABSTRACT

Acoustic signaling is the main form of communication in anuran amphibians. To date, 13 call types are known to occur among anurans, which are divided into three categories: reproductive, aggressive, and defensive calls, each related to a specific emission context. Anuran taxonomy has changed in recent decades, and part of this can be attributed to the use of new character systems. One of them, bioacoustics, has proved to be an informative character system for recognizing and formally describing new species, particularly the reproductive acoustic signals, defined as advertisement calls. In this context, the charismatic leaf frog genus *Pithecopus* has a problematic taxonomic history, including synonyms, redescriptions, and new species descriptions. Many of the taxonomic difficulties in the genus stem from the classic morphological diagnoses, which are based primarily on characters with a broad intraspecific overlap. In addition, the presence of cryptic species in the genus highlights the need for using additional sources of information in the taxonomy of the genus. Currently, five types of vocalizations are known in the genus, but call descriptions differ in analytical procedures and terminology, which hamper intrageneric comparisons. This study sought to carry out a detailed review of the vocal repertoire of *Pithecopus* species with the aim of (1) redescribing and standardizing vocalizations for the genus, (2) describing new vocalizations for the genus, and (3) studying intra- and interspecific variation in advertisement calls, searching for possible acoustic diagnoses. To describe the vocalizations of the genus, we compiled and analyzed recordings from acoustic repositories. We analyzed a total of 6450 advertisement calls, 300 aggressive calls, 8 fight calls, 156 male release calls, and 45 female release calls. We then calculated the intra- and interspecific coefficient of variation. We applied a Principal Components Analysis and also an interspecific pairwise distance analysis considering individual variation using the Phylogenetic Bray-Curtis method to assess the relationships between acoustic variation and phylogenetic relationships. We did not find any acoustic variable in the advertisement calls that could be used as a diagnostic character to discriminate species. Advertisement calls generally vary more at the interspecific level than at the intraspecific level. The Principal Component Analysis reinforced the lack of acoustic diagnoses in the genus by clustering all species, except *P. rohdei* and *P. megacephalus*, which have different vocal production mechanisms. The pattern of acoustic variation is similar to the pattern of variation in other phenotypic characters for the genus, such as the patterns of variation in the coloration of flanks and thighs. The description of female release calls was novel for the genus and corresponds to the fifth record for Neotropical anurans and the fourth within Phyllomedusinae. The prevalence of this type of call in this clade of Neotropical treefrogs showcases an opportunity for future research on the evolution of acoustic signaling in female anurans.

Keywords: advertisement call; acoustic diagnosis; coefficient of variation; cryptic diversity; phenotypic variation.

RESUMO

A sinalização acústica é a principal forma de comunicação nos anfíbios Anuros. Atualmente são conhecidos 13 tipos de cantos que são divididos em três categorias: cantos reprodutivos, agressivos e defensivos, cada um relacionado a um contexto específico de emissão. A taxonomia de anuros tem passado por mudanças nas últimas décadas, e parte disso pode ser atribuído a utilização de novos sistemas de caracteres. Um deles, a bioacústica tem se mostrado como um eficiente sistema de caracteres para o reconhecimento e descrição formal de novas espécies, particularmente sinais acústicos reprodutivos, conhecidos como cantos de anúncio. Nesse contexto, o gênero das carismáticas pererecas de folhagem *Pithecopus* possui um conturbado histórico taxonômico, incluindo sinonimizações, redescrições e novas descrições. Muito das dificuldades taxonômicas no gênero vem das diagnoses morfológicas clássicas, que são baseadas em caracteres de ampla sobreposição intraespecífica. Além disso, a presença de espécies crípticas no gênero evidencia a necessidade de usar caracteres alternativos na taxonomia do gênero. Atualmente, para o gênero conhecem-se cinco tipos de vocalizações, no entanto a descrição dessas vocalizações difere em relação aos procedimentos metodológicos e terminologia associada aos cantos, o que dificulta comparações intragenéricas. O objetivo deste trabalho foi de realizar uma revisão sistematizada do repertório vocal das espécies de *Pithecopus* com a proposta de (1) redescrever e padronizar vocalizações para o gênero, (2) descrever novas vocalizações para o gênero e (3) estudar a variação intra e interespecífica nos cantos de anúncio, buscando possíveis diagnoses acústicas. Para descrever as vocalizações do gênero, compilamos e analisamos gravações provenientes de repositórios acústicos. Posteriormente calculamos o coeficiente de variação intra e interespecífico. Aplicamos uma análise de Componentes Principais realizamos uma análise de distância par-a-par interespecífica considerando a variação individual através do método de Bray-Curtis. Ao todo nós analisamos 6450 cantos de anúncio, 300 cantos agressivos, 8 cantos de luta, 156 cantos de soltura de macho e 45 cantos de soltura de fêmea. Não encontramos nenhuma variável acústica nos cantos de anúncio que possa ser utilizada como um caractere diagnóstico para separar as espécies. Cantos de anúncio geralmente variam mais inter do que intraespecificamente. A análise de Componentes Principais reforçou a falta de diagnoses no grupo com o agrupamento das espécies, com exceção de *P. rohdei* e *P. megacephalus* que possuem mecanismos de produção vocal diferentes. Os padrões de variação acústica são semelhantes aos padrões de caracteres fenotípicos que também possuem ampla variação no gênero. A descrição de cantos de soltura de fêmea foi inédita para o gênero e corresponde ao quinto registro para anuros neotropicais, a prevalência desse tipo de canto em Phyllomedusinae levanta a possibilidade de estudos evolutivos.

Palavras-chave: canto de anúncio; diagnoses acústicas; coeficiente de variação; diversidade críptica; variação fenotípica.

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1. INTRODUCTION

Acoustic communication is a conspicuous and diversified behavior in the life history of anurans (Wells, 2007). To date, there are 13 types of calls divided into three main categories: reproductive, aggressive, and defensive calls, each one related to a specific social context of emission (Toledo *et al.*, 2015). Reproductive calls mediate intraspecific interactions, generally linked to the attraction of conspecific mates (Wells, 2007). The principal type of reproductive call is the advertisement call, emitted mostly by males, although females of some anuran species are known to produce advertisement calls (Bush; Dyson; Halliday, 1997). The advertisement call informs the presence, location, and attributes of a calling male, and plays a role in the attraction of conspecific females for mating (Littlejohn, 1977; Wells & Schwartz, 2007). Accessory functions involve the maintenance of inter-male spacing in chorus aggregations (Wilczynski & Brenowitz, 1988). Another type of reproductive call, the release call (Toledo *et al.*, 2015) is emitted by males and females when they are not receptive to the amplexus (Aronson, 1944; Bogert, 1960). When emitted by males, it conveys information to the clasping male that he is not amplexed on a mate, i.e., a female, which prevents mating success, involves loss of energy, and raises the risks of predation (Bowcock, 2009). When emitted by females, it informs that the amplectant female is not ready to mate, because there are no significant egg masses in her reproductive tract (Bogert, 1960; McClelland & Wilczynski, 1989). Other reproductive calls are the courtship, amplectant, post-oviposition male release, and rain calls (Toledo *et al.*, 2015).

Aggressive calls mediate intraspecific interactions, generally linked to agonistic encounters between males (Wells, 2007). Among these, the territorial call is a long-range aggressive signal emitted by males exclusively of territorial species. This type of call signals aggression from a resident male towards an invader (Littlejohn, 1977; Wells, 1977a). Some species with elaborated vocal repertoire can display both short and long-range acoustic aggressive signals (Wells, 2007; Costa & Toledo, 2013; Hutter *et al.,* 2013). Aggressive signaling may sometimes comprise two or more types of calls, as observed in males of the Neotropical treefrog *Boana punctata*, which emit long-range aggressive calls when bothered by an intruder male and a short-range call (fighting call) when in physical disputes (Brunetti; Taboada & Faivovich, 2015). In other species, aggressive signaling strategies can encompass two ends of a continuum, with subtle changes related to specific temporal acoustic parameters. One example is the Neotropical treefrog *Dendropsophus ebraccatus*. Males of this species increase the duration of the introductory aggressive “buzz-like” note when responding to different playback intensities (Wells & Schwartz, 1984). This latter case is known as a graded aggressive signaling, characterized by changes in acoustic parameters of their calls in response to an escalated aggressive behavior (Wells & Schwartz, 1989). Finally, defensive calls are emitted in interspecific interactions and are generally used to warn or ward off predators (Hödl & Gollman, 1986). Defensive calls sound like loud and high-pitched screams that are emitted with the mouth open, giving them a rich harmonic structure (Gridi-Papp, 2008; Toledo *et al.*, 2009). These include the alarm, distress, and warning calls (Toledo *et al.*, 2015).

Over the past few decades, anuran taxonomy has witnessed the description and formal acknowledgment of more than 700 new species (Streicher; Sadler; Loader, 2020; Womack *et al.*, 2022). This could be partially credited to the usage of different lines of evidence, in an approach known as integrative taxonomy (Dayrat, 2005). Bioacoustical characters are considered a reliable tool in taxonomic studies, particularly among anurans, constituting a diagnostic character of several anuran species (Köhler *et al.*, 2017) and have been widely included in taxonomic studies in the past few decades (Streicher; Sadler; Loader, 2020). In general, reproductive calls, especially advertisement calls, are used to describe new species, as they serve a role in the speciation and delimitation of anuran species, presumably acting as a premating isolation mechanism (Ryan & Guerra, 2014). Although uncommon, the male release call between two closely related species of *Odontophrynus* was shown to be a diagnostic character as well (Grenat & Martino, 2013).

One of the parameters extracted from advertisement calls that are informative in taxonomic studies is the coefficient of variation proposed by Gerhardt (1991). He studied the acoustic variation in male advertisement calls of three North American treefrog species: *Dryophytes versicolor*, *Dryophytes cinereus*, and *Pseudacris crucifer*, and found that the inter-male variation in acoustic properties could be divided into two categories: (1) static, represented by the dominant frequency and pulse rate, and (2) dynamic, represented by the call rate and other temporal variables (Gerhardt, 1991; Gerhardt & Bee, 2007). He also discussed that static parameters are under stabilizing selection because they are used for individual and intraspecific recognition, whereas the dynamic parameters, which are under directional selection and can be influenced by female preferences (Gerhardt, 1991).

Identifying homology of acoustic characteristics is crucial for their application as bioacoustical characters in the anuran taxonomy and systematics (Köhler *et al.*, 2017; Hepp & Pombal Jr., 2019). The anuran calling behavior is stereotyped (Wells, 2007) and the structures involved in the biomechanics of vocal sound production (larynx and associated muscles, trunk muscles) can produce similar or divergent acoustic units (McLister; Stevens; Bogart, 1995). One possible approach is to define correspondence between vocal outputs following mechanistic criteria, where units produced during one exhalation cycle could be considered homologous (McLister; Stevens; Bogart, 1995; Robillard *et al.,* 2006). This approach copes with the mismatch between similar vocal outputs that can be produced by different mechanisms, which also has implications for macroevolutionary studies on the evolution of acoustic signals (Robillard *et al.,* 2006).

The genus *Pithecopus* Cope, 1886 comprises 12 species of Neotropical leaf frogs with a wide distribution in South America (Andrade *et al*., 2020; Frost, 2024). The species in the genus occur in the east of the Andes from the southern Venezuela and Guiana Shield to north Argentina (Duellman; Marion; Hedges, 2016). *Pithecopus* species are classified into two major clades (Faivovich *et al*. 2010; Duellman; Marion; Hedges, 2016, Haga *et al*., 2017a; Andrade *et al*. 2020). One of them is composed of species from “campo rupestre” and Atlantic Forest ecosystems, that includes the species with a reticulated pattern on the flank and thigh: *P. ayeaye* Lutz, 1966, *P. centralis* (Bokermann, 1965), *P. megacephalus* Miranda-Ribeiro, 1926), *P. oreades* (Brandão, 2002), *P. rohdei* (Mertens, 1926), and *P. rusticus* (Bruschi, Lucas, Garcia, and Recco-Pimentel, 2014). The other clade is formed by lowland species that are distributed throughout Amazonia, Caatinga, Cerrado, and Lllanos, whose species have other colour patterns on the flank and thigh: *P. araguaius* Haga, Andrade, Bruschi, Recco-Pimentel, and Giaretta, 2017, *P. azureus* (Cope, 1862), *P. gonzagai* Andrade, Haga, Ferreira, Recco-Pimentel, Toledo, and Bruschi, 2020, *P. hypochondrialis* (Daudin, 1800), *P. nordestinus* (Caramaschi, 2006), and *P. palliatus* (Peters, 1873) (Faivovich *et al*., 2010; Duellman; Marion; Hedges, 2016; Andrade *et al*., 2020). The genus has been through a shifting taxonomy history, with synonyms (Baêta *et al.,* 2009; Brandão & Álvares, 2009), revalidations (Caramaschi, 2006), and recent new species descriptions (Bruschi *e al.,* 2014; Haga *et al.,* 2017a; Andrade *et al.,* 2020; Frost, 2024). These taxonomic changes result from a turn in the classical point of view that would define and diagnose species based solely on morphological characteristics (e.g., color patterns with broad interspecific overlap; Bruschi *et al*., 2013) to a more integrated approach, also including bioacoustical, ecological, and DNA sequence data (Magalhães *et al.,* 2018; Ramos *et al.,* 2019). Furthermore, the presence of morphologically and acoustically cryptic lineages makes it difficult to resolve taxonomic problems and delimit species within the genus (Ramos *et al.,* 2019; Andrade *et al*., 2020).

The vocal repertoire of the genus *Pithecopus* comprises five types of calls. In the category of reproductive calls, the advertisement call is described for all species: *P. araguaius* (Haga *et al.*, 2017a); *P. azureus* (Haga *et al.,* 2017b); *P. ayeaye* (Nali; Borges; Prado, 2015); *P. centralis* (Brandão *et al.*, 2009); *P. gonzagai* (Andrade *et al.*, 2020); *P. hypochondrialis* (Pyburn & Glidewell, 1971); *P. megacephalus* (Giaretta; Oliveira Filho; Kokubum, 2007); *P. nordestinus* (Vilaça; Silva; Solé, 2011); *P. oreades* (Brandão & Álvares, 2009); *P. palliatus* (Duellman, 1978); *P. rohdei* (Wogel; Abrunhosa; Pombal, 2004); *P. rusticus* (Boschetti *et al.* 2019). The male release call is described for *P. ayeaye*, *P. gonzagai*, *P. nordestinus*, and *P. rohdei* (Vilaça; Silva; Solé, 2011; Mângia *et al.*, 2019; Nali; Borges; Prado, 2015). In the category of aggressive calls, the territorial call is described for *P. ayeaye*, *P. azureus*, *P. centralis*, *P. hypochondrialis*, *P. nordestinus*, *P. rohdei*, and *P. rusticus* (Guimarães *et al.,* 2001; Wogel; Abrunhosa & Pombal Jr., 2004; Brandão *et al.*, 2009; Vilaça; Silva; Solé, 2011; Nali; Borges; Prado, 2015; Haga *et al.*, 2017a; Boschetti *et al.*, 2019). The encounter call is described only for *P. rohdei* (Wogel; Abrunhosa; Pombal Jr., 2004). The fighting call is described for *P. ayeaye* and *P. gonzagai* (Brasileiro; Cascon; Passos, 2021; Silva *et al.,* in press). The category of defensive calls has the distress call described only for *P. nordestinus* (Toledo *et al.*, 2015).

There have been several publications that provided call descriptions of *Pithecopus* in the past two decades, but terminology and analytical procedures differ greatly among publications or are not clear enough to be reproducible. This has made direct comparisons among species difficult. Since the advertisement call is considered an important tool in anuran taxonomy, in addition to the historical taxonomic problems within this clade of charismatic leaf frogs, an in-depth review of the vocal repertoire of the genus *Pithecopus* is needed. Based on that scenario, we propose a review of the vocal repertoire of the 12 species of *Pithecopus*, with the following objectives: (1) characterize reproductive, aggressive, and defensive calls following standardized terminology and methodology; (2) associate call types with a behavioral context and corresponding mechanistic approach of vocal sound production; and (3) review acoustic diagnoses originally proposed and search for possible diagnostic characters in the reproductive calls of *Pithecopus*.

2. MATERIAL AND METHODS

2.1 Sound analyses

We obtained calls from acoustic repositories: Fonoteca Jacques Vielliard (FNJV, Unicamp), Coleção Bioacústica da UFMG (CBUFMG), Coleção Audiovisual do Semiárido (CASA, UFERSA), Macaulay Library (Cornell Lab, USA), Fonoteca de Madrid (FonoZoo, Spain), AAG-UFU acoustic collection (UFU), Arquivos Sonoros da UFRN (ASUFRN) (see Appendix I for summary on archive name, filter applied, air and water temperature, time and date of the recording, and municipality). Before the analysis, we screened all archives, applied up to a 500-Hz high-pass filter in Audacity v.3.3.3 (Audacity Team, 2023), and standardized the sound recordings at a sampling rate of 44.1 kHz. We analyzed the calls using Raven Pro v.1.6.5 (Bioacoustics Research Program, 2024), employing the following spectrogram parameters: window type = Hann, window size = 512 samples, bandwidth 3dB filter = 124 Hz, overlap = 90%, DFT size = 1024 samples, grid spacing = 43.1 Hz. We quantified temporal and spectral variables of the calls from oscillograms and spectrograms, respectively. From each call, we measured: note duration (s; delta time in Raven Pro), note rise time (%; peak time relative in Raven Pro), pulses per note, pulse repetition rate (pulses/s), note repetition rate (notes/s), call rate (calls/min), dominant frequency (Hz; peak frequency in Raven Pro), minimum frequency (Hz; Frequency 5% in Raven Pro), and maximum frequency (Hz; Frequency 95% in Raven Pro). We adapted the pulse and note rate variable from Cocroft & Ryan (1995) as follows: we measured those by dividing the delta time until the start of the last pulse with the number of pulses minus one. (see Figure 1). We followed Köhler *et al.*, (2017) for acoustic definitions and terminology. We based our descriptions on a note-centered approach, where calls are the coherent unit of sound and these calls can be subdivided into notes that can be subdivided into pulses (Köhler *et al.,* 2017). We identified two types of sound production in *Pithecopus*. Species that produce one note in each exhalation cycle, i.e., single-note calls (*P. araguaius*, *P. ayeaye, P. azureus*, *P. centralis*, *P. gonzagai*, *P. hypochondrialis*, *P. nordestinus*, *P. oreades*, *P. palliatus*, *P. rusticus*) and species that produce more than one note in each exhalation cycle, i.e., multi-note calls (*P. megacephalus*, *P. rohdei*) (Figure 2). We made field observations of multi-note call production in *P. megacephalus* and extrapolated to *P. rohdei*, given the similarities in their calls and their close phylogenetic relationships (Faivovich *et al.,* 2010; Duellman *et al.,* 2016). Nevertheless, confirmation on the call production mechanism in *P. rohdei* is still needed. We classified the calls as reproductive, aggressive, defensive and subsequent categories (advertisement, release, etc…) by the presence of descriptive context in the recordings or by comparing the acoustic variables and/or temporal envelope with previously available descriptions. We produced sound figures using the packages *seewave* v.2.2.1 (Sueur; Aubin; Simons, 2008) and *tuneR* v.1.4.5 (Ligges *et al*., 2017) in the R v.4.4.2 platform (R Core Team, 2024), with the following settings: Hann window, FFT size = 512 samples, FFT overlap = 90%.

2.2 Coefficient of Variation

We calculated the coefficient of variation (CV), which consists of a standardized measure, applying the following equation: CV = (standard deviation × 100)/mean, for each analyzed acoustic parameter. We calculated the CV at the intraspecific level through the individual means from different populations. And, we calculated the CV at the interspecific level through species mean. After that, we classified the parameters as static, when the values from CV were less than 5%. Intermediate, when the values from the CV were between 5 and 12 %. And dynamic when the values were higher than 12%. We calculated the CV at the intra and inter specific level because this is the level utilized to make intrageneric comparisons. For *P. azureus* and *P. rusticus* the CV was calculated based on one population each.

2.3 Principal Component Analysis

We performed Principal Component Analysis (PCA) to explore the statistical groupings of species' acoustic variables. Before running the analysis, we applied a logarithmic transformation to the data to meet the normality of residuals assumption. We conducted the analysis using the packages *readr* v.2.1.5 and *dplyr* v.1.1.4 in the R v.4.4.2 platform (R Core Team, 2024). We generated graphics using the *ggplot2* v.3.5.1 package. We applied the PCA in two distinctive acoustic data, because we could not quantify pulse number and pulse rate for *P. palliatus*: (1) A data matrix with all species included, excluding the pulse number and pulse rate variable. (2) A data matrix excluding *P. palliatus*. We did this because we noticed in exploratory analyses that calls with non-available data interfere with the analysis result.

2.4 Correlation between acoustic variation and phylogeny

To assess the relationship between acoustic variation and the phylogeny of the genus *Pithecopus*, we generated a pairwise distance matrix for the species' calls and a pairwise phylogenetic distance matrix, then tested the correlation between them. To construct the acoustic distance matrix, we computed pairwise distances between individuals using the Bray-Curtis method, implemented in the *proxy* package in the R platform v.4.4.2 (R Core Team, 2024). From this pairwise matrix, we calculated interspecific pairwise distances while accounting for individual variability, applying the Phylogenetic Bray-Curtis (PBC) method (Göker & Grimm, 2008) as implemented in POFAD v.1.7 (Joly *et al.,* 2015) under default parameters. We extracted the phylogenetic distance matrix from the most inclusive phylogeny of the genus *Pithecopus* (Almeida-Silva *et al.,* 2024), applying logarithmic transformation to the distance values, using the *ape* v.5.8-1 and *phytools* 2.4-4 packages in R v.4.2.2 (R Core Team, 2024). Finally, we tested the correlation between these matrices using a Mantel test with 10,000 replicates, implemented in the *ader* v.1.7-22 package in R. Additionally, we performed a hierarchical cluster analysis using the Unweighted Pair Group Method with Arithmetic Mean (UPGMA) to facilitate graphical representation and visual comparison with phylogeny. A UPGMA dendrogram was generated from the acoustic distance matrix using the *ape* v.5.8-1 package in R platform v.4.4.2 (R Team Core, 2024). Considering the uncertain phylogenetic relationships among the cryptic lineages of *P. rohdei* and other *Pithecopus* species, we excluded the acoustic variables from these lineages from the PBC analysis.

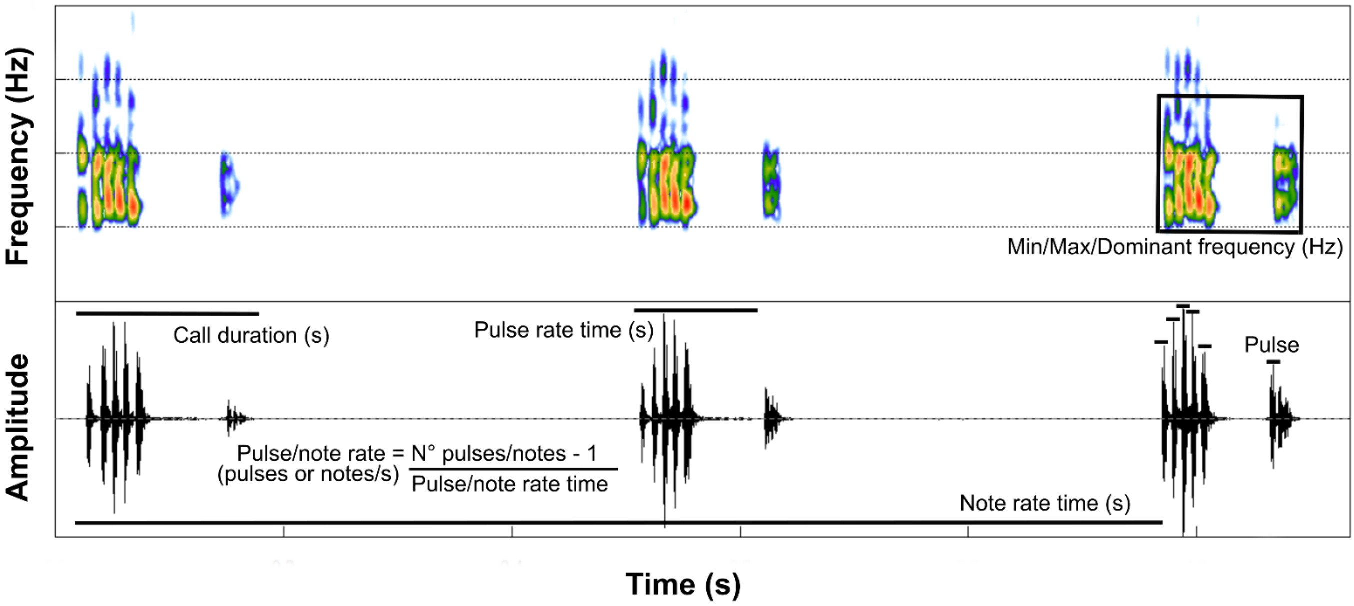

Figure 1 - Acoustic variables measured for *Pithecopus*

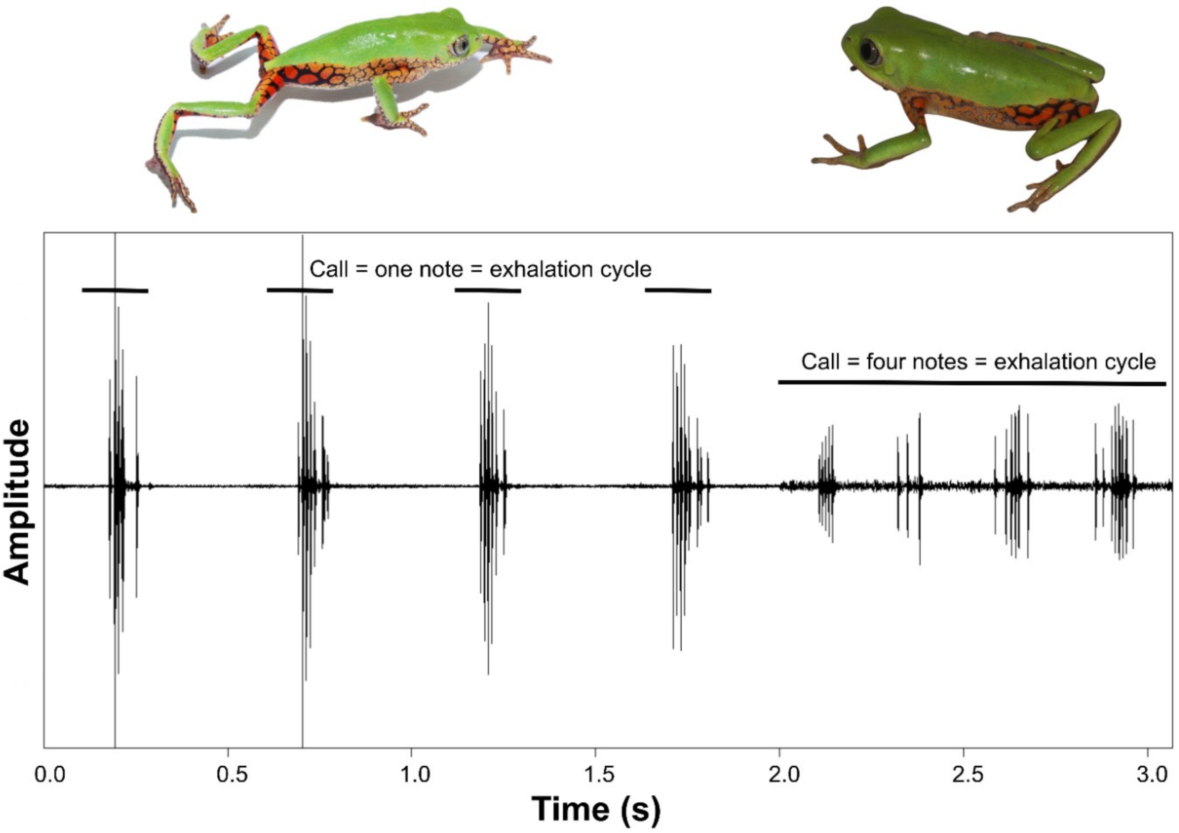

Figure 2. Differences of vocal production in *Pithecopus*. On the left, the advertisement call of *P. ayeaye* each note is produced by one exhalation cycle (call = note). On the right, the advertisement call of *P. megacephalus* the call is composed of one or more notes that are produced in one exhalation cycle each (call = note series).

3. RESULTS

We quantified five types of calls: advertisement, aggressive, fighting (see Appendix II for a detailed description of the fighting call in *P. ayeaye*, and reinterpretation of the aggressive calls category), and male/female release. The next sections describe each type of call followed by description of parameter values for each species of the genus.

3.1 Advertisement calls in *Pithecopus*

In total, we quantified temporal and spectral parameters from 6450 advertisement calls of 12 species and two lineages, representing 80 populations (see text below and Table 1 for a summary of the sample size for each species, and Figure 3 for the geographic distribution of sampled populations). The advertisement calls of *Pithecopus* species share a conserved pattern: a single type of pulsed note, without frequency modulation or rich harmonic structure. Generally, notes have regularly spaced pulses but sometimes can be accompanied by one or more isolated pulses at the beginning or at the end of the call. Notes can be emitted isolated, in pairs, or series (Figure 4 and 5).

Pithecopus araguaius — We analyzed 257 notes from 13 males belonging to two populations. The advertisement call consists of a single type of pulsed note (Figure 6A) that can be emitted isolated (sporadically) or in series (Figure 4A and 5A). Although we did not observe a fixed pattern of rhythm emission in *P. araguaius*, the population from Chapada dos Guimarães (type locality) tends to emit note series, whereas the population from Pontal do Araguaia tends to emit isolated notes. When in series, the number of notes varies from 3 to 11 (4.9 ± 2.1), emitted at a rate of 1 to 2 (1.6 ± 0.2) per second. Note duration varies from 14 to 126 (55.9 ± 14.2) ms, with rise time ranging from 10 to 80 (48.0 ± 10.9) %. Pulse number varies from 3 to 19 (8.3 ± 2.1), emitted at a rate of 71 to 250 (148.1 ± 17.1) per second. The note minimum frequency varies from 1421 to 2110 (1803.3 ± 129.0) Hz and the maximum frequency varies from 2024 to 2799 (2416.8 ± 199.0) Hz, with a dominant frequency varying from 1637 to 2670 (2172.7 ± 169.8) Hz.

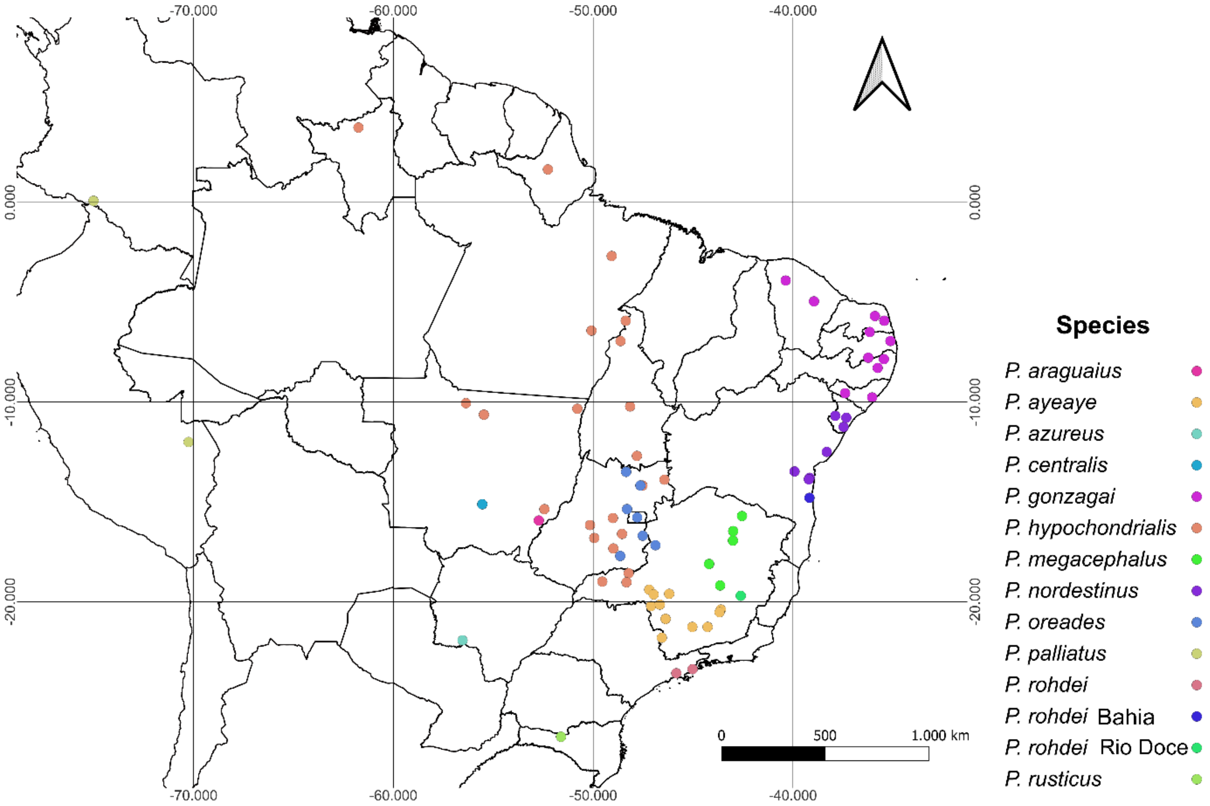

Figure 3. Geographic sampling of *Pithecopus* advertisement calls.

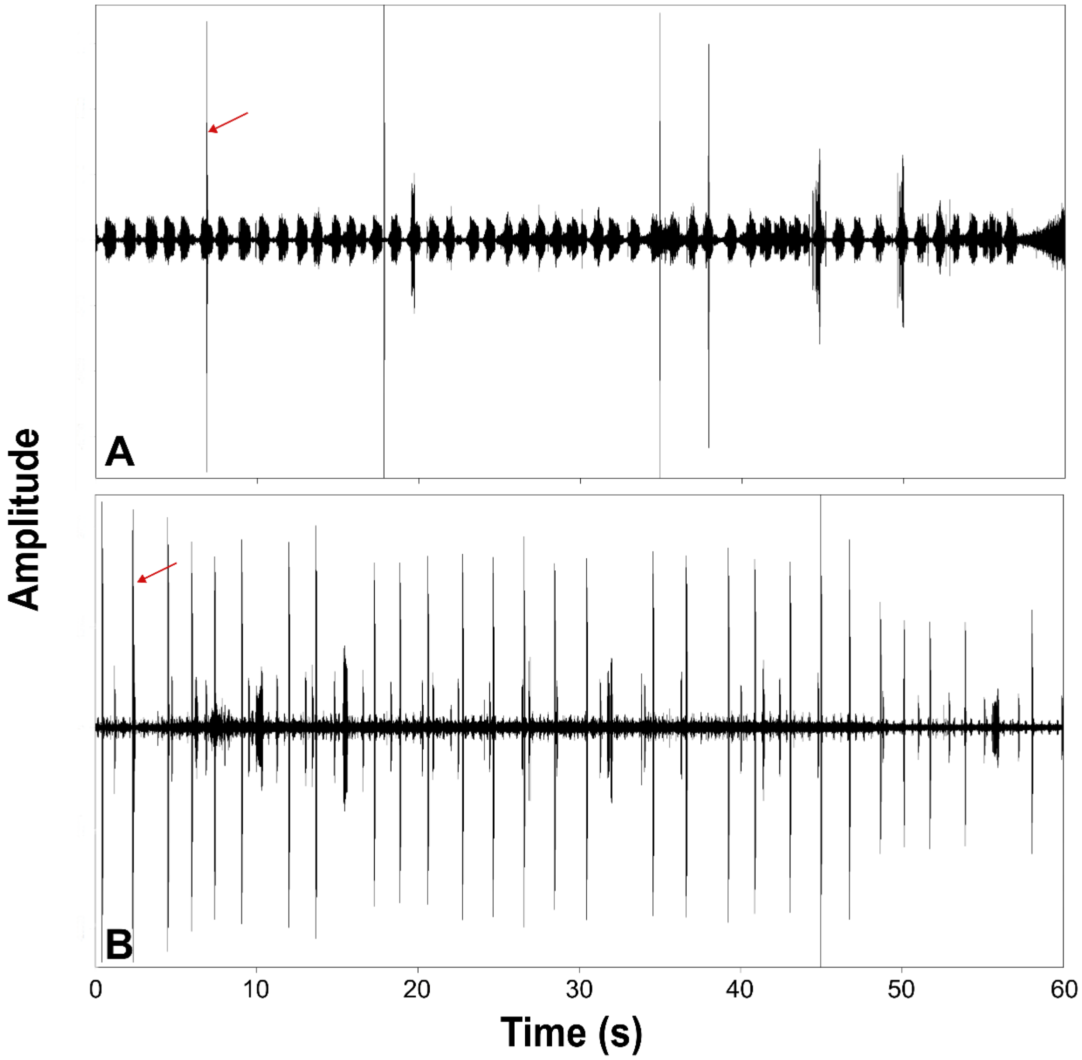

Figure 4. Calling emission patterns in *Pithecopus*. (A) Irregularly emitted isolated notes, (B) frequently emitted isolated notes.

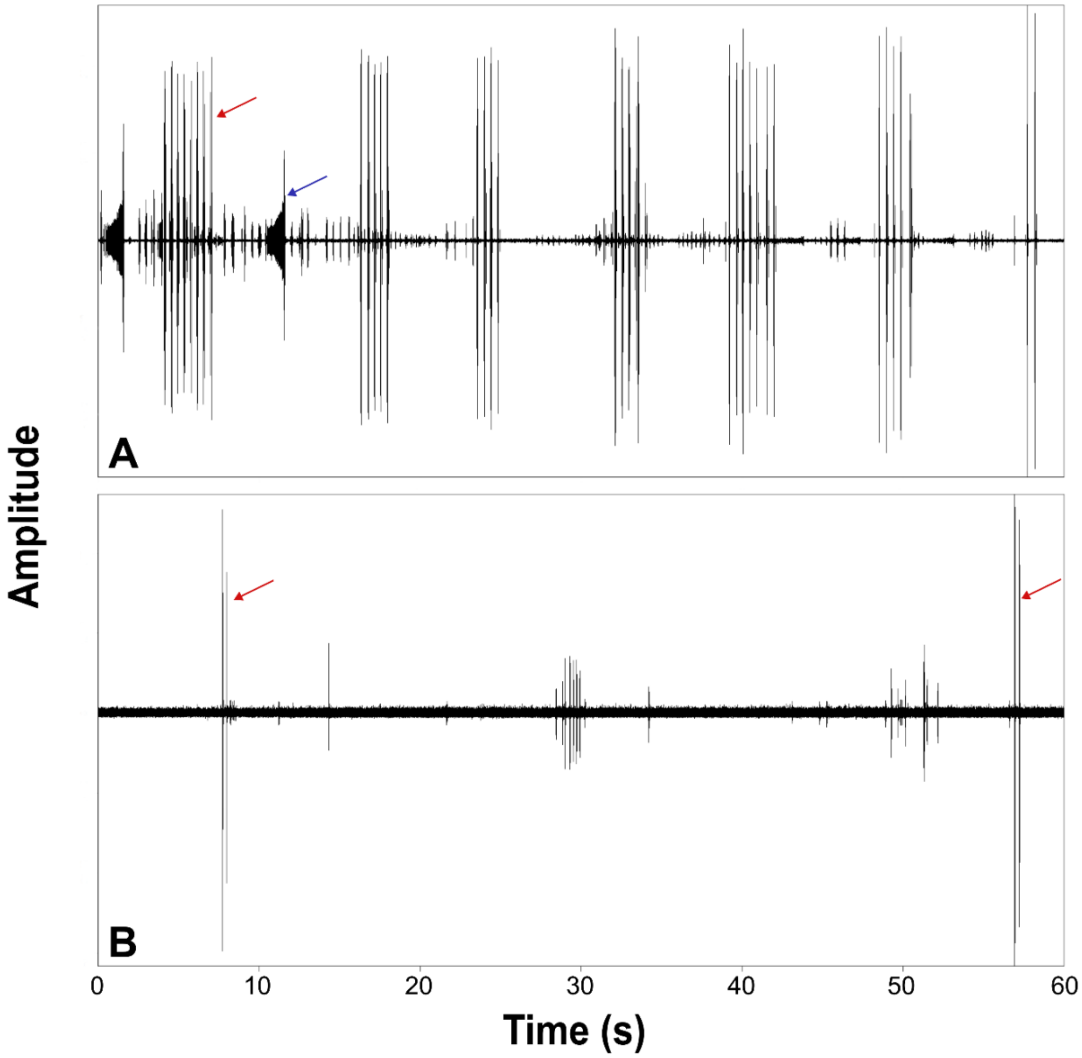

Figure 5. Calling emission patterns in *Pithecopus*. (A) note series (advertisement call) indicated by the red arrow; blue arrow indicates an aggressive note. (B) two-note calls (paired notes) indicated by red arrows.

Pithecopus azureus — We analyzed 74 calls from four males, belonging to one population. The advertisement call consists of a single type of pulsed note (Figure 6B) emitted sporadically and isolated (Figure 4A). Note duration varies from 19 to 54 (48.6 ± 5.7) ms with rise time ranging from 3 to 36 (22.2 ± 4.5) %. Pulse number varies from 3 to 4 (4.2 ± 0.3) emitted at a rate of 45 to 113 (88.4 ± 6.8) per second. The note minimum frequency varies from 1335 to 1637 (1589.6 ± 74.8) Hz and the maximum frequency varies from 1981 to 2067 (2092 ± 46.6) Hz with a peak of dominant frequency varying from 1593 to 1938 (1920.3 ± 52.6) Hz.

Table 1. Advertisement call variables for all analyzed *Pithecopus*. Data is presented as mean ± SD (min – max). Sample sizes are presented in parentheses (recorded males / analyzed calls).

Species	**N° pulses**	**N° notes**	**Peak time relative (%)**	**Call duration (ms)**	**Pulse rate (pulses/s)**	**Note rate (notes/s)**	**Min Freq (Hz)**	**Max Freq (Hz)**	**Peak Freq (Hz)**
P. araguaius (257/13)	8.3 ± 2.1 (3 – 19)	4.9 ± 2.1 (3 – 11)	48.0 ± 10.9 (10 – 80)	55.9 ± 14.2 (14 – 126)	148.1 ± 17.1 (71 – 250)	1.6 ± 0.2 (1 – 2)	1803.3 ± 129.0 (1421 – 2110)	2416.8 ± 199.0 (2024 – 2799)	2172.7 ± 169.8 (1637 – 2670)
P. ayeaye (1626/42)	5.5 ± 1.4 (1 – 13)	5.7 ± 2.7 (2 – 25)	33.7 ± 13.0 (2 – 97)	62.1 ± 23.5 (6 – 280)	91.4 ± 20.9 (29 – 175)	2.4 ± 0.4 (1 – 4)	1295.0 ± 150.2 (947 – 1809)	2013.0 ± 193.2 (1550 – 2799)	1732.9 ± 215.7 (1077 – 2369)
P. azureus (74/4)	4.2 ± 0.3 (3 – 4)	–	22.2 ± 4.5 (3 – 36)	48.6 ± 5.7 (19 – 54)	88.4 ± 6.8 (45 – 113)	–	1589.6 ± 74.8 (1335 – 1637)	2092.5 ± 46.6 (1981 – 2067)	1920.3 ± 52.6 (1593 – 1938)
P. centralis (123/5)	5.2 ± 2.4 (2 – 12)	3.6 ± 2.1 (2 – 11)	23.0 ± 5.8 (1 – 84)	42.9 ± 17.3 (15 – 104)	122.2 ± 24.0 (47 – 169)	2.7 ± 1.1 (1 – 4)	1035.1 ± 400.0 (732 – 1766)	1782.0 ± 371.2 (1206 – 2455)	1443.0 ± 425.5 (818 – 2326)
P. gonzagai (1247/76)	3.4 ± 0.7 (2 – 6)	–	17.5 ± 11.0 (1 – 86)	34.1 ± 13.6 (10 – 89)	109.0 ± 27.7 (46 – 235)	–	1809.8 ± 142.0 (1335 – 2239)	2399.2 ± 155.7 (2024 – 2885)	2194.2 ± 171.5 (1637 – 2713)
P. hypochondrialis (630/93)	4.3 ± 1.1 (3 – 13)	–	33.7 ± 16.5 (2 – 89)	37.6 ± 13.8 (19 – 137)	122.5 ± 23.4 (50 – 199)	–	1693.3 ± 143.4 (1292 – 2369)	2280.3 ± 177.1 (1895 – 3101)	2079.4 ± 170.6 (1550 – 2713)
P. megacephalus (52/12)	7.1 ± 1.3 (2 – 23)	5.1 ± 2.6 (2 – 13)	60.5 ± 12.9 (1 – 98)	958.8 ± 602.8 (253 – 2214)	76.4 ± 14.5 (12 – 508)	4.5 ± 0.4 (3 – 6)	1345.7 ± 114.9 (1077 – 1766)	1923.6 ± 174.3 (1464 – 2713)	1676.9 ± 142.6 (1163 – 2369)
P. nordestinus (576/34)	3.7 ± 0.8 (2 – 7)	–	14.6 ± 9.7 (1 – 84)	42.7 ± 14.8 (12 – 90)	90.9 ± 21.8 (22 – 161)	–	1626.1 ± 96.3 (1378 – 1981)	2189.2 ± 143.6 (1852 – 2627)	1994.7 ± 141.0 (1593 – 2369)
P. oreades (1331/35)	4.3 ± 0.7 (3 – 11)	4.6 ± 1.9 (2 – 10)	22.8 ± 9.7 (1 – 94)	39.2 ± 18.3 (17 – 200)	122,7 ± 27.9 (30 – 197)	3.2 ± 0.9 (1 – 5)	1199.8 ± 126.1 (861 – 1593)	1910.8 ± 186.5 (1550 – 2196)	1623.8 ± 193.2 (1120 – 2196,39)
P. palliatus (50/8)	–	2.2 ± 0.2 (2 – 3)	10.1 ± 7.3 (2 – 31)	38.5 ± 6.0 (25 – 50)	–	1.9 ± 0.2 (2 – 2)	1307.0 ± 145.5 (1163 – 1680)	1948.0 ± 177.3 (1593 – 2196)	1672.4 ± 259.3 (1292 – 2067)
P. rohdei (17/4)	2.6 ± 0.6 (2 – 5)	2.5 ± 0.6 (2 – 4)	52.5 ± 9.5 (4 – 98)	309.3 ± 54.7 (204 – 488)	71.6 ± 26.0 (34 – 122)	6.2 ± 0.9 (4 – 9)	1506.4 ± 74.2 (1335 – 1680)	2053.7 ± 55.2 (1852 – 2196)	1799.6 ± 142.1 (1464 – 2067)

P. rusticus (437/14)	2,1 ± 0.2 (2 – 3)	–	20.4 ± 9.8 (3 – 85)	25.2 ± 4.6 (15 – 126)	69.7 ± 9.9 (17 – 121)	–	1575.1 ± 129.6 (1249 – 1809)	1988.8 ± 130.7 (1723 – 2326)	1814.9 ± 127.1 (1550 – 2067)
Lineages									
P. rohdei Bahia (23/6)	6.4 ± 2.9 (3 – 12)	–	67.7 ± 12.6 (29 – 94)	222.8 ± 102.6 (83 – 488)	25.1 ± 4.8 (16 – 42)	–	1409.0 ± 81.3 (1206 – 1637)	2063.6 ± 161.4 (1809 – 2498)	1692.5 ± 210.3 (1292 – 2067)
P. rohdei Rio Doce (7/1)	2.0 ± 0.2 (2 – 3)	3.0 ± 0.0 (3 – 3)	42.3 ± 35.1 (5 – 85)	286.4 ± 9.5 (272 – 300)	286.4 ± 9.5 (272 – 300)	68.3 ± 3.7 (61 – 75)	1501.2 ± 29.7 (1464 – 1550)	2147.2 ± 57.9 (2067 – 2196)	1950.3 ± 41.0 (1895 – 2024)

Pithecopus gonzagai — We analyzed 1247 calls from 76 males, belonging to 12 populations. The advertisement call consists of a single type of pulsed note (Figure 6C) emitted sporadically and isolated (Figure 4A). The emission of isolated notes can be sustained for a long period of time (Figure 4B). Note duration varies from 10 to 89 (34.1 ± 13.6) ms with rise time ranging from 1 to 86 (17.5 ± 11.0) %. Pulse number varies from 2 to 6 (3.4 ± 0.7) emitted at a rate of 46 to 235 (109.0 ± 27.7) per second. The note minimum frequency varies from 1135 to 2239 (1809.8 ± 142.0) Hz and the maximum frequency varies from 2024 to 2885 (2399.2 ±155.7) Hz with a peak of dominant frequency varying from 1637 to 2713 (2194.2 ± 171.5) Hz.

Pithecopus hypochondrialis — We analyzed 630 calls from 93 males, belonging to 28 populations. The advertisement call consists of a single type of pulsed note (Figure 7A) emitted sporadically and isolated (Figure 4A). Note duration varies from 19 to 137 (37.2 ± 13.8) ms with rise time ranging from 2 to 89 (33.7 ± 16.5) %. Pulse number varies from 3 to 13 (4.3 ± 1.1) emitted at a rate of 50 to 199 (122.5 ± 23.4) per second. The note minimum frequency varies from 1292 to 2369 (1693.3 ± 143.4) Hz and the maximum frequency varies from 1895 to 3101 (2280.3 ± 177.1) Hz with a peak of dominant frequency varying from 1550 to 2713 (2079.4 ± 170.6) Hz.

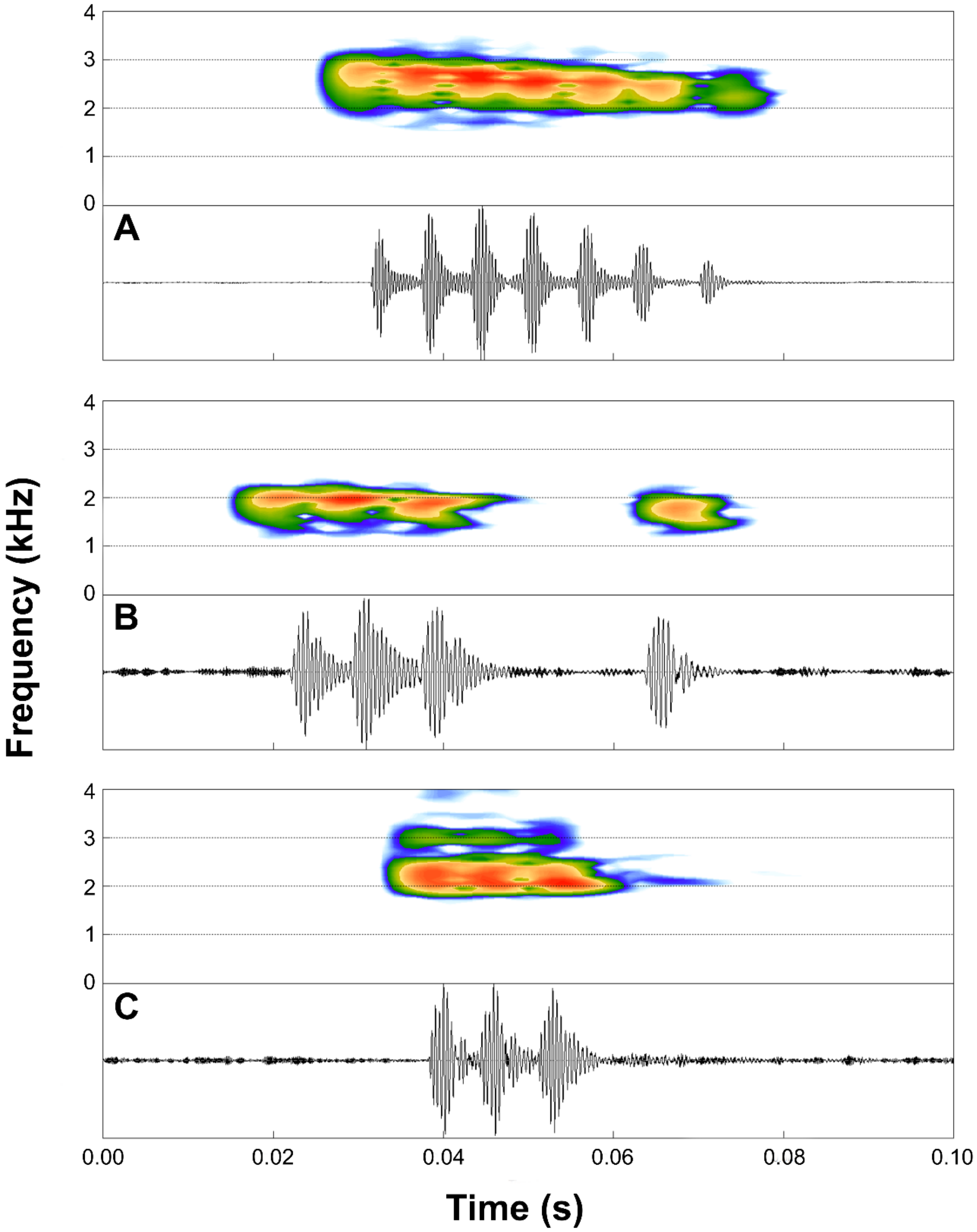

Figure 6. Advertisement calls of the lowland clade of *Pithecopus*. (A) *P. araguaius* (archive: Pithecopus_araguaiusPontalAraguMT1bAAGmt), (B) *P. azureus* (archive: Pithecopus_azureusBelaVistaMS1bTRC_AAGmt), (C) *P. gonzagai* (archive: FNJV 12231).

Pithecopus nordestinus — We analyzed 576 calls from 34 males, belonging to seven populations. The advertisement call consists of a single type of pulsed note (Figure 7B) emitted isolated (Figure 4A). Sometimes these sporadic isolated notes can be emitted for long periods (Figure 4B). Note duration varies from 12 to 90 (42.7 ± 14.8) ms with rise time ranging from 1 to 84 (14.6 ± 9.7) %. Pulse number varies from 2 to 7 (3.7 ± 0.8) emitted at a rate of 22 to 161 (90.9 ± 21.8) per second. The note minimum frequency varies from 1378 to 1981 (1626.1 ± 96.3) Hz and the maximum frequency varies from 1852 to 2627 (2189.2 ± 143.6) Hz with a peak of dominant frequency varying from 1593 to 2369 (1994.7 ± 141.0) Hz.

Pithecopus palliatus — We analyzed 50 calls from eight males, from two populations. The advertisement call consists of a single type of pulsed note (Figure 7C) emitted isolated or in series (Figure 4A and 5A), but pulse number and rate could not be quantified because of low sound input and background noise When in series, the number of notes varies from 2 to 3 (2.2 ± 0.2) emitted at a rate of 1 to 2 (1.9 ± 0.2) per second. Note duration varies from 25 to 50 (38.5 ± 6.0) ms with rise time ranging from 2 to 31 (10.1 ± 7.3) %. The note minimum frequency varies from 1163 to 1680 (1307.0 ± 145.5) Hz and the maximum frequency varies from 1593 to 2196 (1948.0 ± 177.3) Hz with a peak of dominant frequency varying from 1292 to 2067 (1672.4 ± 259.3) Hz.

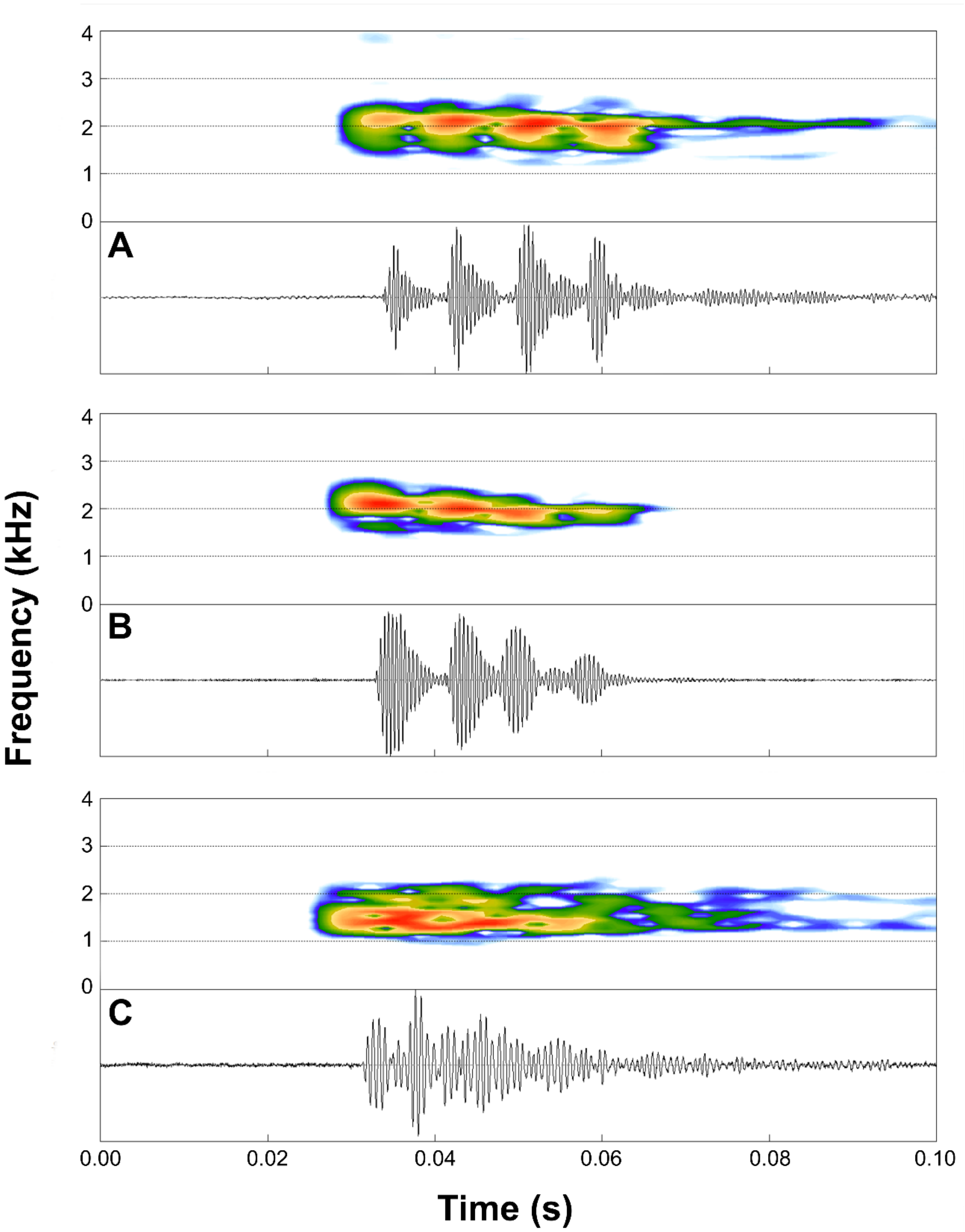

Figure 7. Advertisement calls of the lowland clade of *Pithecopus*. (A) *P. hypochondrialis* (archive: Pithecopus_hypochondrialisUberlandiaMG13aAAGm671), (B) *P. nordestinus* (archive: ASUFRN401), (C) *P. palliatus* (archive: FZ 7293).

Pithecopus ayeaye — We analyzed 1626 calls from 42 males, belonging to nine populations. The advertisement call consists of a single type of pulsed note (Figure 8A) emitted sporadically isolated or in series (Figure 4A and 5A). Males of *P. ayeaye* have no fixed pattern of note emission, but it seems that the most common pattern is that of note series. When in series, the number of notes varies from 2 to 25 (5.7 ± 2.7) emitted at a rate of 1 to 4 (2.4 ± 0.4) per second. Note duration varies from 21 to 280 (60.8 ± 25.4) ms with rise time ranging from 2 to 97 (33.6 ± 13.0) %. Pulse number varies from 2 to 13 (5.5 ± 1.4) emitted at a rate of 29 to 175 (91.4 ± 20.9) per second. The note minimum frequency varies from 947 to 1809 (1295.0 ± 150.2) Hz and the maximum frequency varies from 1550 to 2799 (2012.9 ± 193.1) Hz with a peak of dominant frequency varying from 1077 to 2369 (1732.9 ± 215.7) Hz.

Pithecopus centralis — We analyzed 123 calls from five males, belonging to two populations. The advertisement call consists of a single type of pulsed note (Figure 8B) that can be emitted isolated (Figure 4A) (more frequent in the Chapada dos Guimarães population), or in note series (Figure 5A) (more frequent in the Barra do Garças population). When in series, the number of notes varies from 2 to 11 (3.6 ± 2.1) emitted at a rate of 1 to 4 (2.7 ± 1.1) per second. Note duration varies from 15 to 104 (42.9 ± 17.3) ms with rise time ranging from 1 to 84 (23.0 ± 5.8) %. Pulse number varies from 2 to 12 (5.2 ± 2.4) emitted at a rate of 47 to 169 (122.2 ± 24.0) per second. The note minimum frequency varies from 732 to 1766 (1035.1 ± 400.0) Hz and the maximum frequency varies from 1206 to 2455 (1782 ± 371.2) Hz with a peak of dominant frequency varying from 818 to 2326 (1443 ± 425.5) Hz.

Pithecopus megacephalus — We analyzed 52 calls and 295 notes from 12 males, belonging to five populations. The advertisement call consists of two to 13 (5.1 ± 2.6) pulsed notes (Figure 8C and 9A) emitted at a rate of 3 to 6 (4.5 ± 0.4) per second. One individual (recording CBUFMG 452) emitted one isolated note. Call duration varies from 253 to 2214 (958.8 ± 602.8) ms. Note duration varies from 13 to 324 (91.1 ± 20.2) ms with rise time ranging from 1 to 98 (60.5 ± 12.9) %. Pulse number varies from 2 to 23 (7.1 ± 1.3) emitted at a rate of 12 to 508 (76.4 ± 14.5) per second. The note minimum frequency varies from 1077 to 1766 (1345.7 ± 114.9) Hz and the maximum frequency varies from 1464 to 2713 (1923.6 ± 174.3) Hz with a peak of dominant frequency varying from 1163 to 2369 (1676 ± 142.6) Hz.

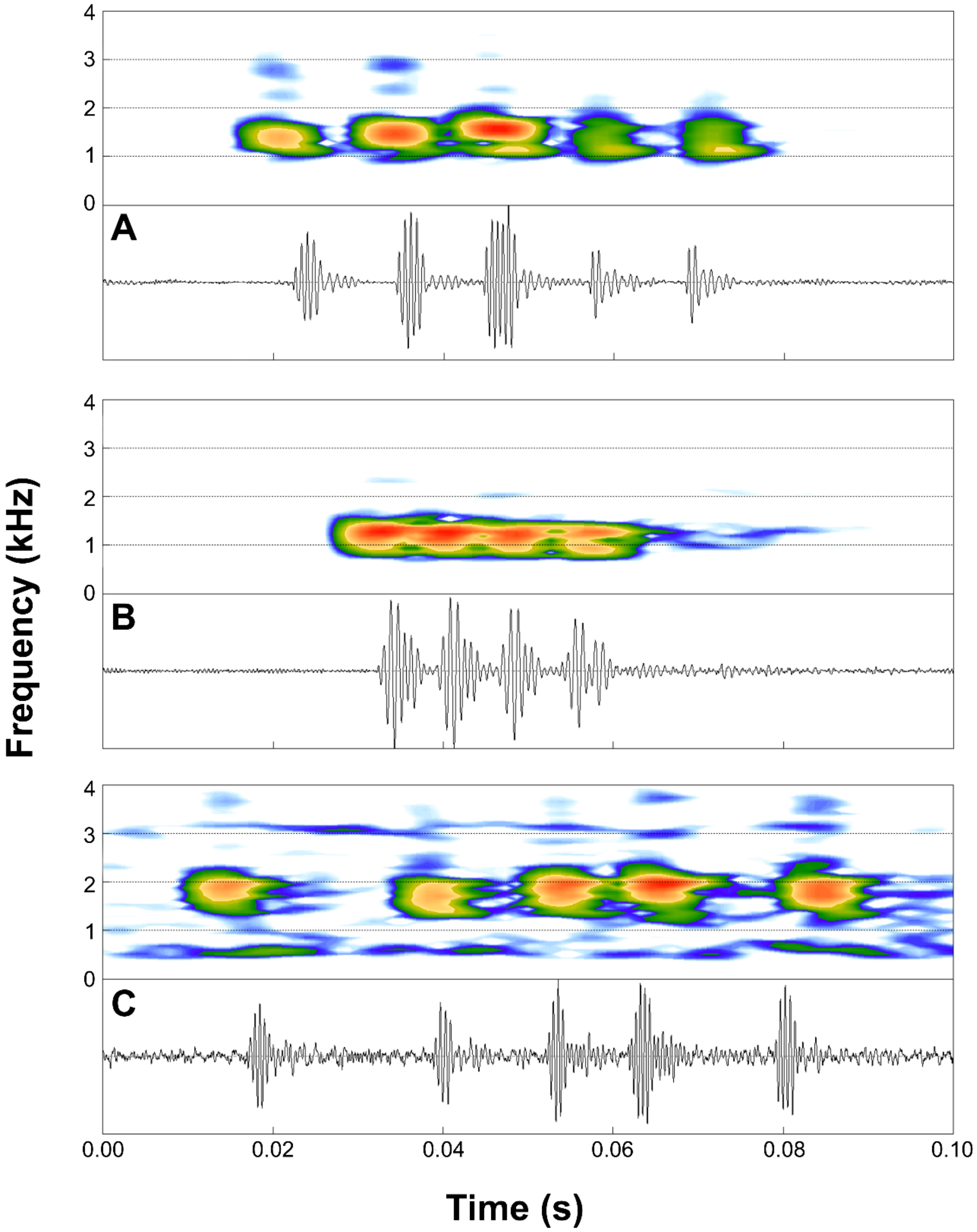

Figure 8. Advertisement calls of the highland clade of *Pithecopus*. (A) *P. ayeaye* (archive: Pithecopus_ayeayePocosCaldasMG6dAAGm671), (B) *P. centralis* (archive: Pithecopus_centralBarraGarcasMT1iAAGm671). (C) A single-note call for *P. megacephalus* (archive: Pithecopus_megacepCipoMG2aAAGb).

Pithecopus oreades — We analyzed 1331 calls from 35 males, belonging to seven populations. The advertisement call consists of a single type of pulsed note (Figure 10A) emitted isolated or in series (Figure 4A and 5A). When in series, the number of notes varies from 2 to 10 (4.6 ± 1.9) emitted at a rate of 1 to 5 (3.2 ± 0.9) per second. Note duration varies from 17 to 200 (39.2 ± 18.3) ms with rise time ranging from 1 to 94 (22.8 ± 9.7) %. Pulse number varies from 3 to 11 (4.3 ± 0.7) emitted at a rate of 30 to 197 (122.7 ± 27.9) per second. The note minimum frequency varies from 861 to 1593 (1199.8 ± 126.1) Hz and the maximum frequency varies from 1550 to 2541 (1910.8 ± 186.5) Hz with a peak of dominant frequency varying from 1120 to 2196 (1623.8 ± 193.2) Hz.

Pithecopus rohdei — We analyzed 17 calls and 47 notes from four males, belonging to two populations. The advertisement call consists of two to four (2.5 ± 0.6) pulsed notes (Figure 9B and 10B) emitted at a rate of 4 to 9 (6.2 ± 0.9) per second. We did not observe single notes in the sound files analyzed. Call duration varies from 204 to 488 (309.3 ± 54.7). Note duration varies from 15 to 119 (39.3 ± 22.4) ms with rise time ranging from 4 to 98 (52.5 ± 9.5) %. Pulse number varies from 2 to 5 (2.6 ± 0.6) emitted at a rate of 34 to 122 (71.6 ± 26.0) per second. The note minimum frequency varies from 1335 to 1680 (1506.4 ± 74.2) Hz and the maximum frequency varies from 1852 to 2196 (2053.7 ± 55.2) Hz, with the dominant frequency varying from 1464 to 2067 (1799.6 ± 142.1) Hz.

Additionally, we analyzed 23 calls from six males, belonging to another population. These calls were analyzed separately, given their different temporal envelope and acoustic variables. The advertisement call of *P. rohdei* from the Bahia lineage is composed of a single type of pulsed note (Figure 9C) emitted isolated (Figure 4A), pulses have different sound amplitudes throughout the note. Note duration varies from 83 to 488 (222.8 ± 102.6), with rise time ranging from 29 to 94 (67.7 ± 12.6) %. Pulse number varies from 3 to 12 (6.4 ± 2.9) emitted at a rate of 16 to 42 (25.1 ± 4.8) per second. The note minimum frequency varies from 1206 to 1637 (1409.0 ± 81.3) Hz and the maximum frequency varies from 1809 to 2498 (2063.6 ± 161.4) Hz, with the dominant frequency varying from 1292 to 2067 (1692.5 ± 210.3) Hz.

We also analyzed 7 calls and 21 notes, from one male from the Rio Doce lineage, and they were analyzed separately, because this is a divergent lineage relative to the nominal lineage, as well as distinct from the Bahia lineage (Ramos *et al.,* 2019). The advertisement call consists of a multi-note call emitted at a rate of 7 to 8 (7.6 ± 0.4) per second. This call is very similar in temporal envelope to populations assigned to the nominal lineage (Figure 10B). Call duration varies from 272 to 300 (286.4 ± 9.5). Note duration varies from 20 to 40 (23.4 ±

4.2), with rise time ranging from 5 to 85 (42.3 ± 35.1) %. Pulse number varies from 2 to 3 (2.0 ± 0.2) emitted at a rate of 61 to 75 (68.3 ± 3.7) per second. The note minimum frequency varies from 1464 to 1550 (1501.2 ± 29.7) Hz and the maximum frequency varies from 2067 to 2196 (2147.2 ± 57.9) Hz, with the dominant frequency varying from 1895 to 2024 (1950.3 ± 41.0) Hz.

Pithecopus rusticus — We analyzed 437 calls from 14 males, belonging to one population. The advertisement call of *P. rusticus* consists of a single type of pulsed note (Figure 10C) emitted isolated (Figure 4A). Note duration varies from 15 to 126 (25.2 ± 4.6) ms with rise time ranging from 3 to 85 (20.4 ± 9.8) %. Pulse number varies from 2 to 3 (2.1 ± 0.2) emitted at a rate of 17 to 121 (69.7 ± 9.9) per second. The note minimum frequency varies from 1249 to 1809 (1575.1 ± 129.6) Hz and the maximum frequency varies from 1723 to 2326 (1988.8 ± 130.7) Hz with a peak of dominant frequency varying from 1550 to 2067 (1814.9 ± 127.1) Hz.

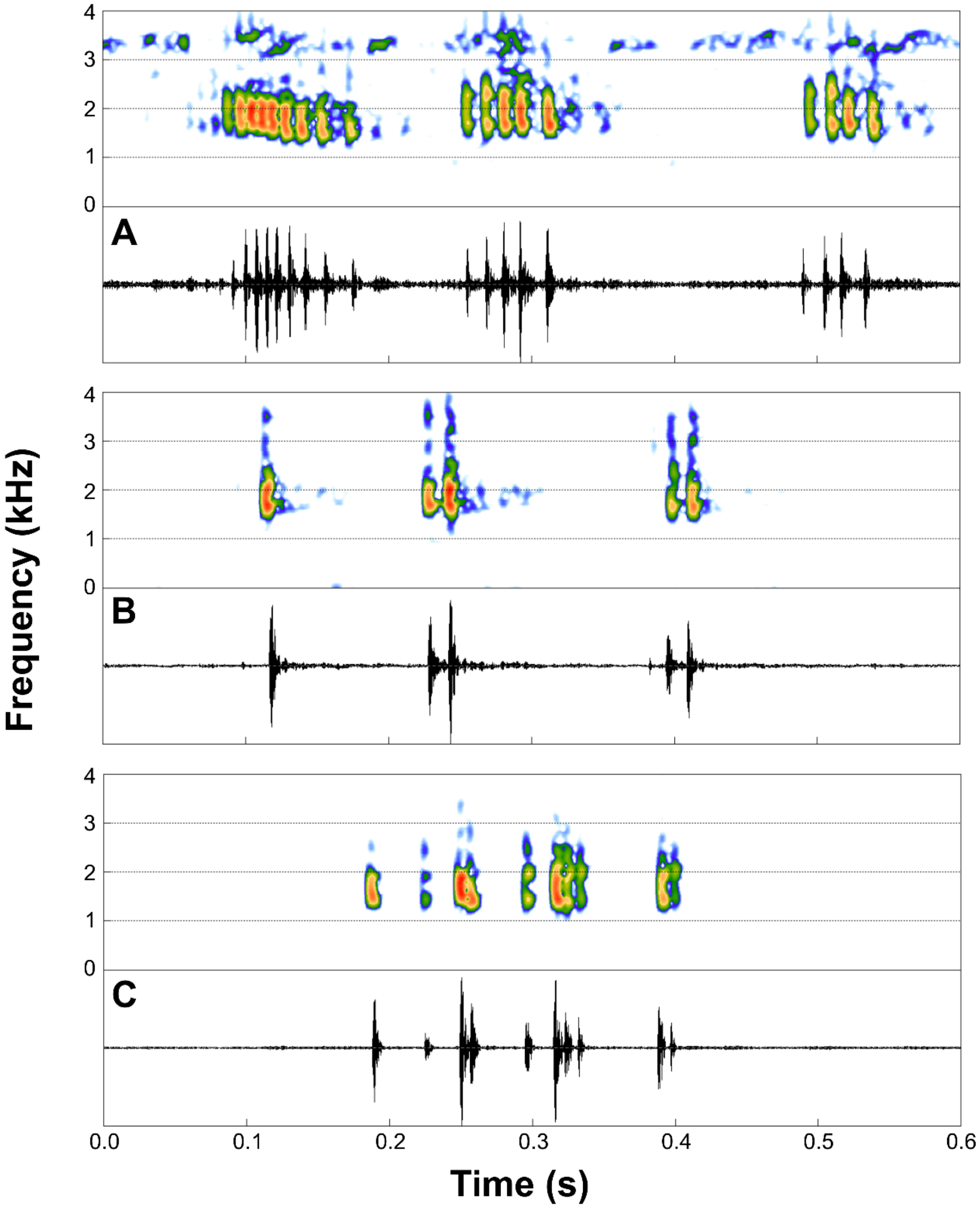

Figure 9. Multinote advertisement calls of (A) *P. megecephalus* (CBUFMG 1100) and (B) *P. rohdei* (archive: Pithecopus_rhodeiSalesopolisSP1b). (C) Single note advertisement call in *P. rohdei* from Ilhéus, BA (archive: ASUFRN 449).

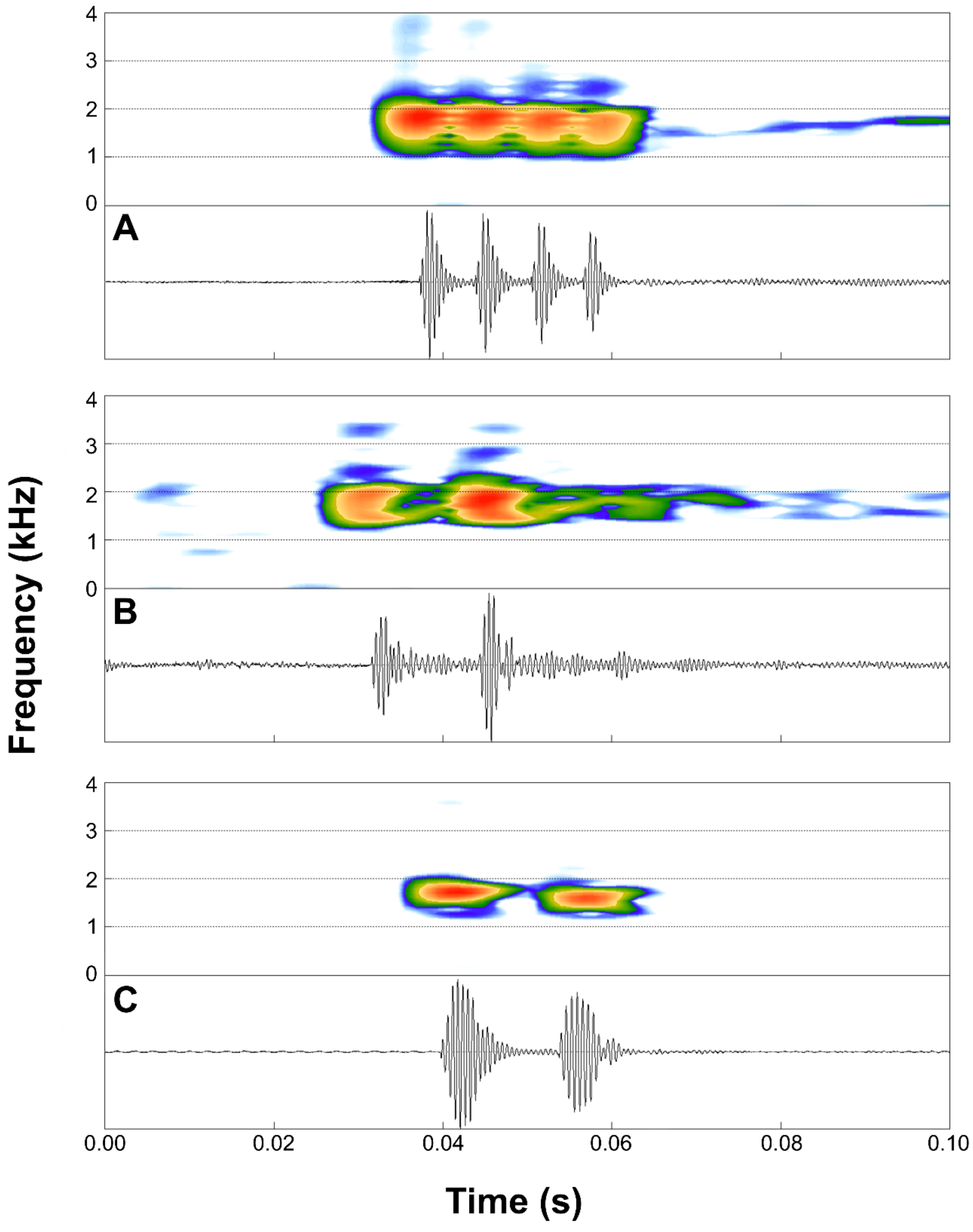

Figure 10. Advertisement calls of the highland clade of *Pithecopus*. (A) *P. oreades* (archive: Pithecopus_oreadesMinacuGO4aAAGm671), (C) *P. rusticus* (archive: 1004). (B) A single note from *P. rohdei* (archive: FNJV 34247).

3.2 Aggressive calls in *Pithecopus*

The aggressive call of *Pithecopus* is conserved among species of the genus. This type of call is composed of a single type of multipulsed note with a slight amplitude modulation that reaches its peak around 90% of the call. The final portion of the call can have regular-spaced pulses or incomplete pulses (i.e. silent intervals absent). We identified and categorized variation related to the organization of the pulses into two main patterns, as follows: (1) occurrence of pulse groups at the beginning of the call (Figure 11A), and (2) occurrence of pulses with regular interpulse intervals throughout the call (Figure 11D). The note has no frequency modulation nor evident harmonic structure (see Table 2 for a summary of acoustic variables).

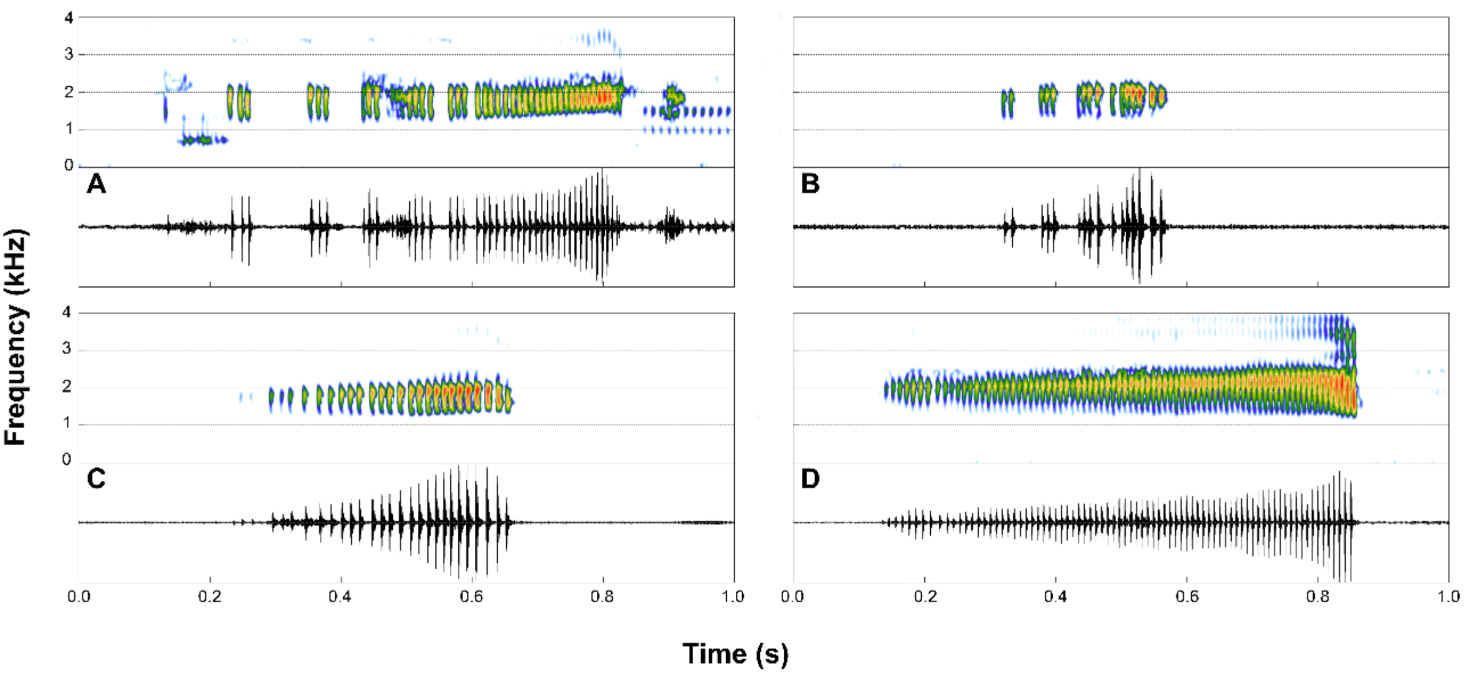

Figure 11. Aggressive calls of *Pithecopus*. (A) *P. araguaius* (CBUFMG 230), (B) *P. azureus* (Pithecopus_azureusBelaVistaMS4aTRC_AAGmt), (C) *P. gonzagai* (ASUFRN 348), (D) *P. hypochondrialis* (Pithecopus_hypochondrialisAraguariMG7bTRC_LMmt).

Table 2. Aggressive and fighting call variables for all analyzed *Pithecopus*. Data is presented as mean ± SD (min – max). Sample sizes are presented in parentheses (recorded males / analyzed calls). *Data presented in appendix II.

Species	**Pulse number**	**Peak time relative (%)**	**Call duration (ms)**	**Pulse rate (pulses/s)**	**Min Freq (Hz)**	**Max Freq (Hz)**	**Peak Freq (Hz)**
P. araguaius (4/2)	37.8 ± 13.1 (28 – 50)	93.3 ± 1.8 (91 – 95)	483.3 ± 253.3 (255 – 733)	82.3 ± 15.7 (59 – 107)	1539.6 ± 137.0 (1421 – 1680)	2174.9 ± 152.3 (2067 – 2283)	1873.4 ± 91.4 (1809 – 2153)
P. ayeaye (64/17)	56.4 ± 26.9 (14 – 128)	95.8 ± 3.1 (55 – 99)	1213.1 ± 367.2 (339 – 2431)	45.1 ± 13.9 (23 – 88)	1228.7 ± 152.8 (947 – 1593)	2145.3 ± 208.7 (1766 – 2627)	1813.8 ± 189.2 (1077 – 2283)
P. azureus (20/2)	30.8 ± 9.4 (14 – 43)	87.6 ± 3.3 (76 – 96)	405.3 ± 93.3 (236 – 544)	73.4 ± 6.9 (56 – 86)	1501.9 ± 38.1 (1421 – 1637)	2002.6 ± 60.9 (1938 – 2110)	1819.6 ± 121.8 (1593 – 1938)
P. centralis (5/2)	24.3 ± 3.2 (16 – 33)	92.1 ± 2.1 (88 – 95)	533.4 ± 9.3 (413 – 616)	45.7 ± 2.7 (37 – 58)	875.7 ± 101.5 (775 – 947)	1607.8 ± 40.6 (1550 – 1637)	1421.2 ± 60.9 (1378 – 1464)
P. gonzagai (38/9)	35.8 ± 9.1 (18 – 70)	86.7 ± 3.7 (78 – 94)	410.4 ± 131.5 (228 – 933)	88.3 ± 20.0 (39 – 112)	1712.8 ± 179.2 (1378 – 1981)	2345.2 ± 211.1 (1981 – 2627)	2024.1 ± 248.5 (1766 – 2455)
P. hypochondrialis (94/17)	42.4 ± 14.1 (13 – 82)	90.0 ± 7.8 (63 – 100)	405.3 ± 93.5 (206 – 743)	101.3 ± 21.0 (51 – 135)	1564.0 ± 144.0 (1292 – 1981)	2163.4 ± 154.5 (1895 – 2498)	1893.0 ± 204.7 (1507 – 2283)
P. megacephalus (5/2)	107.9 ± 14.0 (98 – 142)	75.7 ± 7.3 (70 – 98)	2143.2 ± 1020.1 (1584 – 2870)	58.1 ± 34.3 (34 – 141)	1343.7 ± 316.7 (1120 – 1637)	2256.7 ± 389.8 (1981 – 2498)	1912.1 ± 511.6 (1550 – 2326)
P. nordestinus (18/3)	52.1 ± 43.8 (20 – 114)	83.9 ± 4.2 (63 – 95)	583.1 ± 259.8 (364 – 982)	78.5 ± 32.5 (47 – 125)	1566.3 ± 63.7 (1464 – 1723)	2105.8 ± 84.3 (1981 – 2239)	1884.2 ± 58.6 (1723 – 1981)
P. oreades (50/9)	43.8 ± 8.6 (17 – 61)	96.2 ± 1.6 (81 – 98)	1011.4 ± 268.9 (355 – 1669)	45.2 ± 10.2 (31 – 72)	1188.5 ± 122.7 (1034 – 1464)	2011.0 ± 146.2 (1766 – 2326)	1682.1 ± 175.5 (1163 – 2024)
P. rusticus (2/2)	61.0 ± 7.8 (53 – 80)	91.1 ± 7.4 (85 – 97)	1049 ± 52.6 (813 – 1361)	57.7 ± 5.2 (54 – 65)	1399.7 ± 30.5 (1292 – 1464)	1959.5 ± 91.4 (1895 – 2110)	1711.9 ± 76.1 (1637 – 1809)

Fighting call							
*P. ayeaye** (25/2)	139.3 ± 19.4 (100 – 173)	96.1 ± 3.7 (80 – 98)	1487.9 ± 187.0 (1123 – 1908)	96.3 ± 4.5 (86 – 102)	1228.3 ± 54.4 (1120 – 1292)	2067.2 ± 136.8 (1809 – 2283)	1748.5 ± 163.5 (1421 – 2067)
P. gonzagai (8/4)	112.6 ± 37.8 (37 – 181)	88.4 ± 19.2 (60 – 100)	1043.8 ± 376.6 (401 – 1702)	112.6 ± 37.8 (37 – 181)	1702.9 ± 75.4 (1550 – 1809)	2422.5 ± 239.5 (2110 – 2756)	2009.8 ± 178.4 (1766 – 2239)

Pithecopus araguaius — We analyzed four calls from two males, belonging to two populations. The aggressive call of *P. araguaius* consists of a single type of multipulsed note (Figure 11A). Notes are generally associated with pattern 1. Of the four notes analyzed, only one (25% of the analyzed notes) was classified into pattern 2. Note duration varies from 255 to 732 (483.3 ± 253.3) ms and has a slight increment in amplitude along the note, which reaches its peak from 91 to 95 (93.3 ± 1.8) %. Pulse number varies from 28 to 50 (37.8 ± 13.1), emitted at a rate of 59 to 107 (82.3 ± 15.7) per second. The note minimum frequency varies from 1421 to 1680 (1539.6 ± 137.0) Hz and the maximum frequency varies from 2067 to 2283 (2174.9 ± 152.3) Hz, with the dominant frequency varying from 1809 to 2153 (1873.4 ± 91.4) Hz.

Pithecopus azureus — We analyzed 20 calls from two males, belonging to one population. The aggressive call of *P. azureus* consists of a single type of multi-pulsed note (Figure 11B). All analyzed notes were associated with pattern 1. Note duration varies from 236 to 544 (405.3 ± 93.3) ms and has a slight increment in amplitude along the note, which reaches its peak from 76 to 96 (87.6 ± 3.3) %. Pulse number varies from 14 to 43 (30.8 ± 9.4) emitted at a rate of 56 to 86 (73.4 ± 6.9) per second. The note minimum frequency varies from 1421 to 1637 (1501.9 ± 38.1) Hz and the maximum frequency varies from 1938 to 2110 (2002.6 ± 60.9) Hz with a peak of dominant frequency varying from 1593 to 1938 (1819.6 ± 121.8) Hz.

Pithecopus gonzagai — We analyzed 38 calls from nine males, belonging to five populations. The aggressive call of *P. gonzagai* consists of a single type of multi-pulsed note (Figure 11C). Notes are generally associated with pattern 2 (61% of analyzed notes) followed by pattern 1 (39% of the analyzed notes). Note duration varies from 228 to 933 (410.4 ± 131.5) ms and has a slight increment in amplitude along the note, which reaches its peak from 78 to 94 (86.7 ± 3.7) %. Pulse number varies from 18 to 70 (35.8 ± 9.1) emitted at a rate of 39 to 112 (88.3 ± 20.0) per second. The note minimum frequency varies from 1378 to 1981 (1712.8 ± 179.2) Hz and the maximum frequency varies from 1981 to 2627 (2345.2 ± 211.1) Hz with a peak of dominant frequency varying from 1766 to 2455 (2024.1 ± 248.5) Hz.

Pithecopus hypochondrialis — We analyzed 94 calls from 17 males, belonging to nine populations. The aggressive call of *P. hypochondrialis* consists of a single type of multi-pulsed note (Figure 11D). Notes are generally associated with pattern 2 (78% of the analyzed notes) followed by pattern 1 (22% of the analyzed notes). Note duration varies from 206 to 743 (405.3 ± 93.5) ms and has a slight increment in amplitude along the note, which reaches its peak from 63 to 100 (90.0 ± 7.8) %. Pulse number varies from 13 to 82 (42.4 ± 14.1) emitted at a rate of 51 to 135 (101.3 ± 21.0) per second. The note minimum frequency varies from 1292 to 1981 (1564.0 ± 144.0) Hz and the maximum frequency varies from 1895 to 2498 (2163.4 ± 154.5) Hz with a peak of dominant frequency varying from 1507 to 2283 (1893.0 ± 204.7) Hz.

Pithecopus nordestinus — We analyzed 18 calls from 3 males, belonging to two populations. The aggressive call of *P. nordestinus* consists of a single type of multi-pulsed note (Figure 12A). Notes are generally associated with pattern 1 (72% of the analyzed notes) followed by pattern 2 (28% of the analyzed notes). Note duration varies from 364 to 982 (583.1 ± 259.8) ms and has a slight increment in amplitude along the note, which reaches its peak from 63 to 95 (83.9 ± 4.2) %. Pulse number varies from 20 to 114 (52.1 ± 43.8) emitted at a rate of 47 to 125 (78.5 ± 32.5) per second. The note minimum frequency varies from 1464 to 1723 (1566.3 ± 63.7) Hz and the maximum frequency varies from 1981 to 2239 (2105.8 ± 84.3) Hz with a peak of dominant frequency varying from 1723 to 1981 (1884.2 ± 58.6) Hz.

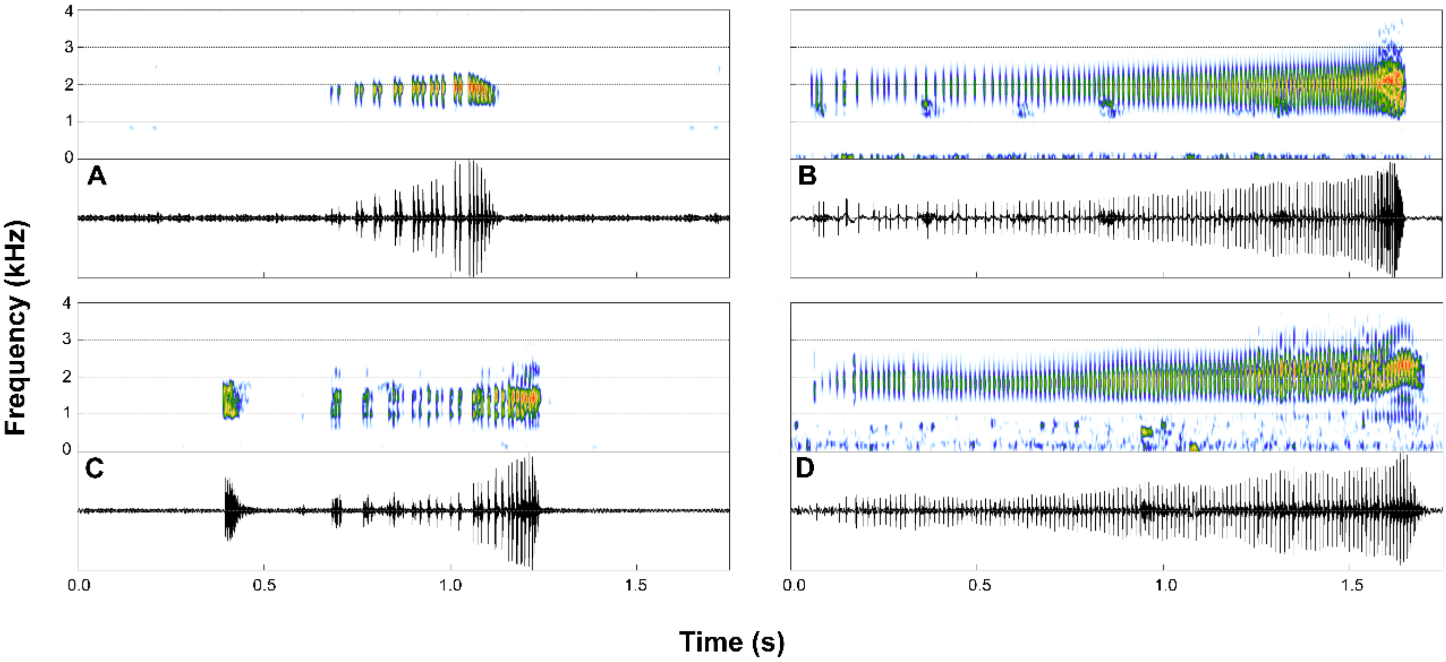

Figure 12. Aggressive calls of *Pithecopus*. (A) *P. nordestinus* (ASUFRN 402), (B) *P. ayeaye* (CBUFMG1019), (C) *P. centralis* (CBUFMG 236), and (D) *P. megacephalus* (FNJV 32069).

Pithecopus ayeaye — We analyzed 64 calls from 17 males, belonging to seven populations. The aggressive call of *P. ayeaye* consists of a single type of multi-pulsed note (Figure 12B).

Notes are generally associated with pattern 1 (64% of the analyzed notes) followed by pattern 2 (36% of the analyzed notes). Note duration varies from 339 to 2431 (1213.1 ± 367.2) ms and has a slight increment in amplitude along the note, which reaches its peak from 55 to 99 (95.8 ± 3.1) %. Pulse number varies from 14 to 128 (56.4 ± 26.9) emitted at a rate of 23 to 88 (45.1 ± 13.9) per second. The note minimum frequency varies from 947 to 1593 (1228.7 ± 152.8) Hz and the maximum frequency varies from 1766 to 2627 (2145.3 ± 208.7) Hz with a peak of dominant frequency varying from 1077 to 2283 (1813 ± 189.2) Hz.

Pithecopus centralis — We analyzed five calls from two males, belonging to one population. The aggressive call of *P. centralis* consists of a single type of multi-pulsed note (Figure 12C). All analyzed notes were associated with pattern 1. Note duration varies from 413 to 616 (533.4 ± 9.3) ms and has a slight increment in amplitude along the note, which reaches its peak from 88 to 95 (92.1 ± 2.1) %. Pulse number varies from 16 to 33 (24.3 ± 3.2) emitted at a rate of 37 to 58 (45.7 ± 2.7) per second. The note minimum frequency varies from 775 to 947 (875.7 ± 101.5) Hz and the maximum frequency varies from 1550 to 1637 (1607.8 ± 40.6) Hz with a peak of dominant frequency varying from 1378 to 1464 (1421.2 ± 60.9) Hz.

Pithecopus megacephalus — We analyzed five calls from two males, belonging to two populations. The aggressive call of *P. megacephalus* consists of a single type of multi-pulsed note (Figure 12D). Notes are generally associated with pattern 2 (80% of the analyzed notes). Only one note was classified into pattern 1 (20% of the analyzed notes). Note duration varies from 1584 to 2870 (2143.2 ± 1020.1) ms and has a slight increment in amplitude along the note, which reaches its peak from 70 to 98 (75.7 ± 7.3) %. Pulse number varies from 98 to 142 (107.9 ± 14.0) emitted at a rate of 34 to 141 (58.1 ± 34.3) per second. The note minimum frequency varies from 1120 to 1637 (1343.7 ± 316.7) Hz and the maximum frequency varies from 1981 to 2498 (2256.7 ± 389.8) Hz with a peak of dominant frequency varying from 1550 to 2326 (1912.1 ± 511.6) Hz.

Pithecopus oreades — We analyzed 50 calls from nine males, belonging to five populations. The aggressive call of *P. oreades* consists of a single type of multi-pulsed note (Figure 13A). All analyzed notes were associated with pattern 1. Note duration varies from 355 to 1669 (1011.4 ± 268.9) ms and has a slight increment in amplitude along the note, which reaches its peak from 81 to 98 (96.2 ± 1.6) %. Pulse number varies from 17 to 61 (43.8 ± 8.6) emitted at a rate of 31 to 72 (45.2 ±10.5) per second. The note minimum frequency varies from 1034 to 1464 (1188.5 ± 122.7) Hz and the maximum frequency varies from 1766 to 2326 (2011.0 ±

146.2) Hz with a peak of dominant frequency varying from 1163 to 2024 (1682.1 ± 175.5) Hz.

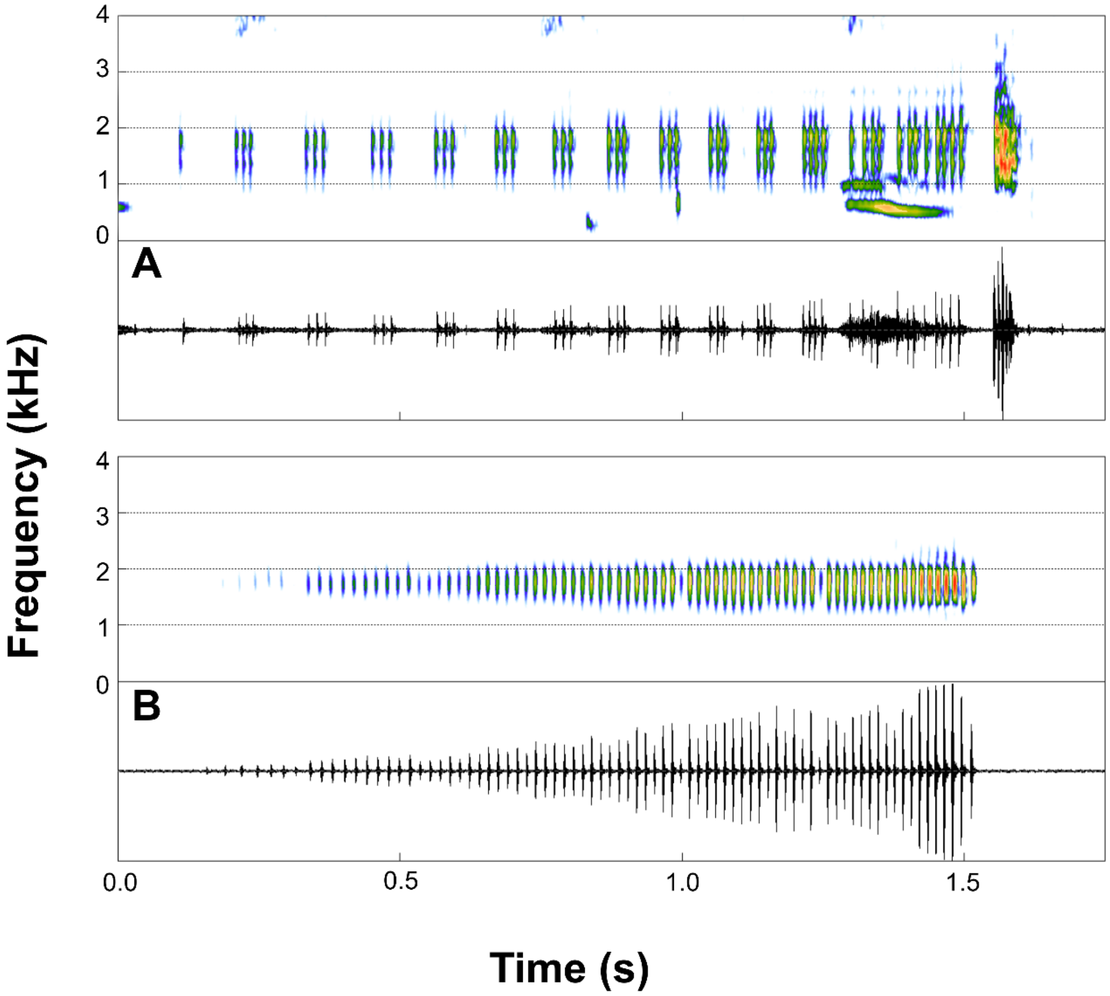

Figure 13. Aggressive calls of *Pithecopus*. (A) *P. oreades* (Pithecopus_araguariBrasiliaDF4aCSB_AAGm671), (B) *P. rusticus* (FNJV 33567).

Pithecopus rusticus — We analyzed two calls from two males. The aggressive call of *P. rusticus* consists of a single type of multi-pulsed note (Figure 13B). The two analyzed notes were associated pattern 2. Note duration varies from 813 to 1361 (1049.9 ± 52.6) ms and has a slight increment in amplitude along the note, which reaches its peak from 85 to 97 (91.1 ± 7.4) %. Pulse number varies from 53 to 80 (61.0 ± 7.8) emitted at a rate of 54 to 65 (57.7 ± 5.2) per second. The note minimum frequency varies from 1292 to 1464 (1399.7 ± 30.5) Hz and the maximum frequency varies from 1895 to 2110 (1959.5 ± 91.4) Hz with a peak of dominant frequency varying from 1637 to 1809 (1711.9 ± 76.1) Hz.

3.3 Fighting calls in ***Pithecopus***

The fighting call of *Pithecopus* is emitted during physical combat and has the same temporal envelope of the typical aggressive call (emitted out of a fight context). We analyzed fighting calls of two species: *P. ayeaye* and *P. gonzagai*. Here we provide a detailed description of the fighting call of *P. gonzagai*. The fighting call of *P. ayeaye* is described in the paper provided in Appendix I (see Table 2 for a summary on acoustic variables).

P. gonzagai — We analyzed eight calls from four males, belonging to one population. The fighting call consists of a single type of multipulsed note. Note duration varies from 401 to 1702 (1043.8 ± 376.6) ms and has a slight increment in amplitude along the note, which reaches its peak from 60 to 100 (88.4 ± 19.2) %. Pulse number varies from 37 to 181 (112.6 ± 37.8), emitted at a rate of 90 to 118 (107.7 ± 8.9) per second. The note minimum frequency varies from 1550 to 1809 (1702.9 ± 75.4) Hz and the maximum frequency varies from 2110 to 2756 (2422.5 ± 239.5) Hz, with the dominant frequency varying from 1766 to 2239 (2009.8 ± 178.4) Hz.

3.4 Male release call in ***Pithecopus***

The male release call of *Pithecopus* is relatively conserved among species of the genus. This type of call can be composed of a single type of nonpulsed or a single type of pulsed note. In some cases, the notes can only have recognizable pulses in some portions of the call (see Table 3 for a summary on acoustic variables analyzed). Data associated (Appendix I) with the recordings indicate when the calls were elicited while the individual was manipulated by the researcher.

Pithecopus hypochondrialis — We analyzed eight calls from one male. The male release call consists of a single type of pulsed note (Figure 14A). Note duration varies from 30 to 65 (54.6 ± 11.3) ms, with a rise time ranging from 30 to 71 (54.4 ± 14.6) %. Pulse number varies from 4 to 8 (6.9 ± 1.4), emitted at a rate of 113 to 123 (117.2 ± 3.1) per second. The note minimum frequency varies from 1034 to 1120 (1065.9 ± 30.5) Hz and the maximum frequency varies from 2110 to 2627 (2401 ± 154.0) Hz, with the dominant frequency varying from 1206 to 2196 (1819.6 ± 376.7) Hz. There is no prominent frequency modulation nor evident harmonic structure.

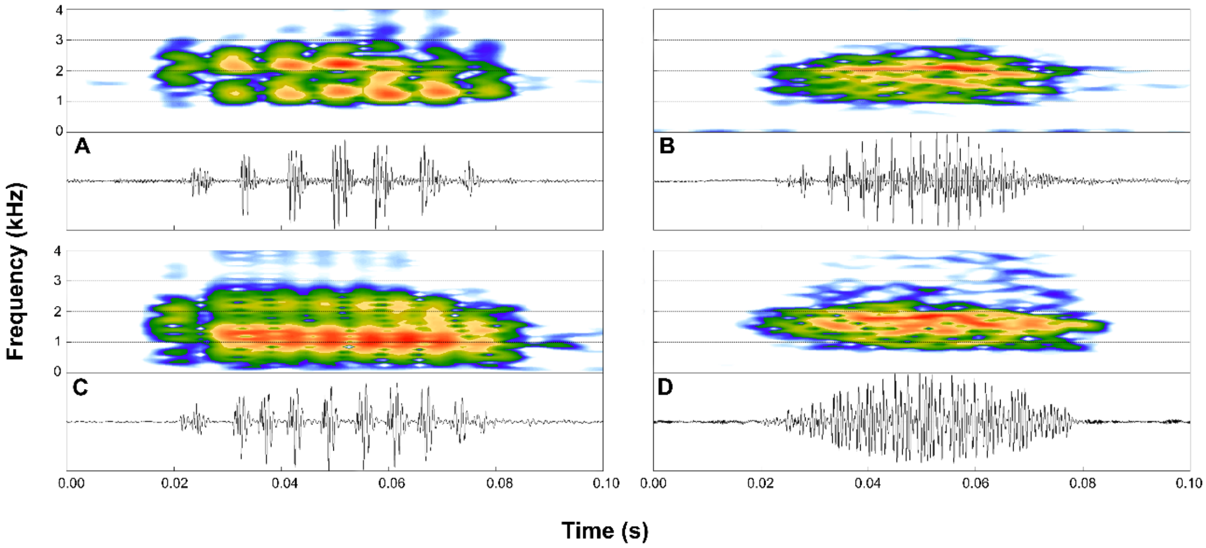

Figure 14. Male release calls of *Pithecopus.* (A) *P. hypochondrialis* (Pithecopus_hypochondrialisUberlandiaMG6aLM_AAGmt_male), (B) *P. ayeaye* (CBUFMG 1086), (C) *P. centralis* (CBUFMG 238), (D*) P. megacephalus* (CBUFMG 1102).

Table 3. Male release call variables for all analyzed *Pithecopus*. Data is presented as mean ± SD (min – max). Sample sizes are presented in parentheses (recorded males / analyzed calls).

Species	**Pulse number**	**Peak time relative (%)**	**Call duration (ms)**	**Pulse rate (pulses/s)**	**Min Freq (Hz)**	**Max Freq (Hz)**	**Peak Freq (Hz)**
P. ayeaye (60/2)	6.8 ± 1.3 (6 – 8)	54.6 ± 2.4 (53 – 56)	41.7 ± 4.0 (39 – 45)	149.7 ± 57.6 (109 –190)	991.3 ± 29.5 (970 – 1012)	2081.6 ± 105.6 (2007 – 2156)	1561.9 ± 20.3 (1548 – 1576)
P. centralis (30/1)	24.3 ± 3.2 (16 – 33)	92.1 ± 2.1 (88 – 95)	533.4 ± 9.3 (413 – 616)	45.7 ± 2.7 (37 – 58)	875.7 ± 101.5 (775 – 947)	1607.8 ± 40.6 (1550 – 1637)	1421.2 ± 60.9 (1378 – 1464)
P. hypochondrialis (8/1)	6.9 ± 1.4 (4 – 8)	54.4 ± 14.6 (30 – 71)	54.6 ± 11.3 (30 – 65)	117.2 ± 3.1 (113 – 123)	1065.9 ± 30.5 (1034 – 1120)	2401.0 ± 154.0 (2110 – 2627)	1819 ± 376.7 (1206 – 2196)
P. megacephalus (58/1)	10.7 ± 0.6 (10 – 11)	52.5 ± 13.7 (32 – 90)	58.4 ± 12.5 (19 – 89)	175 ± 9.4 (167 – 185)	1002.4 ± 126.5 (775 – 1206)	1872.6 ± 90.6 (1723 – 2110)	1600.1 ± 99.1 (1292 – 1852)

Pithecopus ayeaye — We analyzed 60 release calls from two males, belonging to one population. The male release call consists of a single type of note with a non-fixed pattern of pulse organization (Figure 14B). Note duration varies from 39 to 45 (41.7 ± 4.0) ms with a rise time ranging from 53 to 56 (54.6 ± 2.4) %. When present the pulse number varies from 6 to 8 (6.8 ± 1.3) emitted at a rate of 109 to 190 (149.7 ± 21.0) per second. The note minimum frequency varies from 970 to 1012 (991.3 ± 29.5) Hz and the maximum frequency varies from 2007 to 2156 (2081.6 ± 105.6) Hz with a peak of dominant frequency varying from 1548 to 1576 (1561.9 ± 20.3) Hz.

Pithecopus centralis — We analyzed 30 calls from one male. The male release call consists of a single type of note with a non-fixed pattern of pulse organization (Figure 14C). Notes can have distinctive pulses with complete amplitude modulation (70% of all analyzed notes). The remaining notes had distinctive pulses at the beginning/medium/end portion, with the other portion of the note being pulsatile with incomplete pulses (30%). Note duration varies from 37 to 69 (53.3 ± 7.8) ms with a rise time ranging from 35 to 82 (52.7 ± 10.1) %. When present the pulse number varies from 3 to 10 (7.3 ± 2.2) emitted at a rate of 38 to 182 (139.1 ± 39.0) per second. The note minimum frequency varies from 560 to 904 (746.5 ± 98.8) Hz and the maximum frequency varies from 1637 to 2627 (2057.1 ± 280.9) Hz with a peak of dominant frequency varying from 947 to 1464 (1168.5 ± 161.0) Hz. Several of the analyzed notes have a second/third non-harmonic band.

Pithecopus megacephalus — We analyzed 58 calls from one male. The male release call consists of a single type of note with a non-fixed pattern of pulse organization (Figure 14D). Most of the notes analyzed didn't have distinctive pulses (78%). Only three notes analyzed have distinctive pulses throughout the entire note (5%). The remaining notes have distinctive pulses at the beginning/medium/end portion, with the other portion of the note being pulsatile (17%). Note duration varies from 19 to 89 (58.4 ± 12.5) ms with rise time ranging from 32 to 90 (52.5 ± 13.7) %. When present, the pulse number varies from 10 to 11 (10.7 ± 0.6) emitted at a rate of 167 to 185 (175 ± 9.4) per second. The note minimum frequency varies from 775 to 1206 (1002.4 ± 126.5) Hz, and the maximum frequency varies from 1723 to 2110 (1872.6 ± 90.6) Hz, with a peak of dominant frequency ranging from 1292 to 1852 (1600.1 ± 99.1) Hz. The notes have no visible harmonics except in three cases (5% of the analyzed notes), where two to three visible harmonics with upward frequency modulation were observed. In all three notes, the dominant frequency coincides with the second harmonic. Excluding these three notes, there is no prominent frequency modulation nor evident harmonic structure.

3.5 Female release call in *Pithecopus*

The female release call of *Pithecopus* is also similar among species. All analyzed notes consisted of a single type of nonpulsed note with evident harmonic structure (see Table 4 for a summary of the acoustic variables analyzed). Similarly to male release calls, metadata (Appendix I) on the recordings indicated that the calls were elicited while the individual was handled by the researcher.

Pithecopus centralis — We quantified 26 calls from one female. The female release call consists of a single type of nonpulsed note (Figure 15A). Note duration varies from 12 to 36 (23.8 ± 6.4) ms, with a rise time ranging from 9 to 53 (31.2 ± 12.7) % of the note duration. The note minimum frequency varies from 560 to 689 (626.1 ± 32.8) Hz, and the maximum frequency varies from 904 to 2110 (1745.8 ± 344.8) Hz. The dominant frequency ranges from 646 to 1464 (874.6 ± 303.0) Hz and can coincide with the first (77% of the analyzed notes) or the second harmonic (23% of the analyzed notes). The note has the first 2 to 5 (3.3 ± 0.7) harmonics with emphasized sound energy.

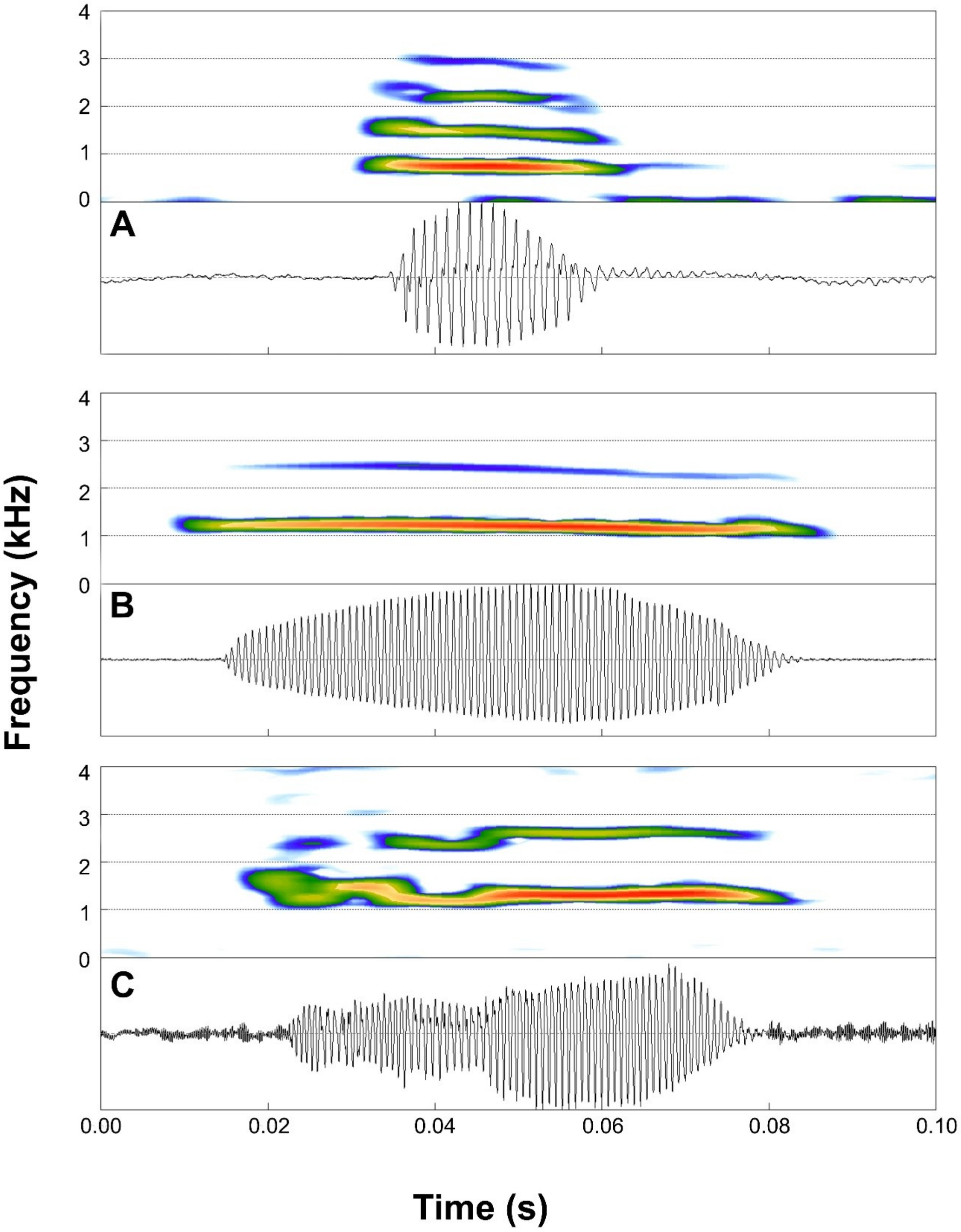

Figure 15. Female release calls of *Pithecopus*. (A) *P. centralis* (CBUFMG 239), (B) *P. megacephalus* (CBUFMG 1031), (C) *P. rusticus* (1024).

Table 4. Female release calls variables for all analyzed *Pithecopus*. Data is presented as mean ± SD (min – max). Sample sizes are presented in parentheses (recorded females / analyzed calls).

Species	**Peak time relative (%)**	**Call duration (ms)**	**Min Freq (Hz)**	**Max Freq (Hz)**	**Peak Freq (Hz)**	**N° Harmonics**
P. centralis (26/1)	31.2 ± 12.7 (9 – 53)	23.8 ± 6.4 (12 – 36)	626.1 ± 32.8 (560 – 689)	1745.8 ± 344.8 (904 – 2110)	874.6 ± 303.0 (646 – 1464)	3.3 ± 0.7 (2 – 5)
P. megacephalus (58/1)	39.5 ± 14.1 (23 – 77)	49.2 ± 15.6 (25 – 79)	1007.1 ± 73.6 (861 – 1077)	1613.3 ± 527.9 (1077 – 2412)	1123 ± 66.9 (991 – 1206)	5.2 ± 1.9 (3 – 9)
P. rusticus (6/1)	55.3 ± 25.6 (24 – 90)	45.7 ± 15.5 (23 – 63)	1184.3 ± 160.6 (1077 – 1507)	2345.3 ± 282.6 (1895 – 2670)	1701.1 ± 554.7 (1163 – 2455)	1.8 ± 0.4 (1 – 2)

Pithecopus megacephalus — We quantified 13 calls from one female individual of *P. megacephalus*. The female release call of *P. megacephalus* consists of a single type of non-pulsed note (Figure 15B). Note duration varies from 25 to 79 (49.2 ± 15.6) ms with a rise time ranging from 23 to 77 (39.5 ± 14.1) %. The note minimum frequency varies from 861 to 1077 (1007.1 ± 73.6) Hz and the maximum frequency varies from 1077 to 2412 (1613.3 ± 527.9) Hz. The dominant frequency ranges from 991 to 1206 (1123.0 ± 66.9) Hz and is always located in the first harmonic. The note has 3 to 9 (5.2 ± 1.9) visible harmonics.

Pithecopus rusticus — We analyzed six calls from one female. The female release call consists of a single type of non-pulsed note (Figure 15C). Note duration varies from 23 to 63 (45.7 ± 15.5) ms with a rise time ranging from 24 to 90 (55.3 ± 25.6) %. The note minimum frequency varies from 1077 to 1507 (1184.3 ± 160.6) Hz and the maximum frequency varies from 1895 to 2670 (2354.3 ± 282.6) Hz. The dominant frequency ranges from 1163 to 2455 (1701.1 ± 554.7) Hz and can coincide with the first (67% of the analyzed notes) or the second harmonic (33% of the analyzed notes). Generally, the note has 2 visible harmonics (83% of the analyzed notes) but on one occasion the note did not have an evident harmonic structure (17% of the analyzed notes).

3.6 Coefficient of Variation

We found different levels of variation in the call variables analyzed, generally the interspecific level had higher values of CV than the intraspecific level (see Table 5 for a summary in CV values and classification of each acoustic variable). Regarding the intraspecific level, many temporal variables were classified as dynamic (CV > 15%), with exceptions for pulse number in *P. azureus* (7.7%, intermediate) and *P. rusticus* (7.1%, intermediate), note number in *P. palliatus* (7.2%, intermediate), and pulse rate in *P. araguaius* (11.8%, intermediate) and *P. azureus* (7.6%, intermediate). We found note rate as an intermediate parameter (CV between 5% and 11%) in four species: *P. centralis* (7.3%), *P. megacephalus* (8.3%), *P. palliatus* (11.1%), and *P. rohdei* (7.7%). Conversely, we found most of the spectral parameters classified as intermediate, but dominant frequency was classified as dynamic in *P. ayeaye* (12.4%) and *P. palliatus* (15.5%), and maximum frequency as dynamic in *P. centralis* (12.8%). Spectral variables were classified as static (CV < 5%) only in *P. azureus* (all spectral variables) and *P. rohdei* (3.3%, maximum frequency). We found that all interspecific level CVs were classified as dynamic, except minimum frequency, which was classified as intermediate (CV = 10.8%). The interspecific level showed higher variation in almost all variables analyzed, with exception of the note number, that showed higher intraspecific variation for *P. araguaius* (30.6%, interspecific < 43.0%, intraspecific), *P. ayeaye* (30.6%, interspecific < 48.2%, intraspecific), *P. centralis* (30.6%, interspecific < 56.6%, intraspecific), *P. oreades* (30.6%, interspecific < 40.2%, intraspecific). Peak time relative also varied more intraspecifically in *P. gonzagai* (55.6%, interspecific < 62.7%, intraspecific), *P. nordestinus* (55.6%, interspecific < 66.4%, intraspecific), and *P. palliatus* (55.6%, interspecific < 72.3%, intraspecific). Finally, maximum frequency intraspecific variation was higher only in *P. centralis* (10.8%, interspecific < 12.8%, intraspecific).

Table 5. Summary on the classification of acoustic parameters in *Pithecopus* species. The first lines are from the intraspecific CV for each species. The last line is the interspecific CV.

Species	Pulse number	Note number	Peak time relative (%)	Call duration (ms)	Pulse rate (pulses/s)	Note rate (notes/s)	Min Freq (Hz)	Max Freq (Hz)	Peak Freq (Hz)
P. araguaius	25.1 (Dynamic)	43.0 (Dynamic)	22.8 (Dynamic)	25.3 (Dynamic)	11.6 (Intermediate)	12.4 (Dynamic)	7.2 (Intermediate)	8.2 (Intermediate)	7.8 (Intermediate)
P. ayeaye	26.0 (Dynamic)	48.2 (Dynamic)	38.8 (Dynamic)	41.7 (Dynamic)	22.8 (Dynamic)	18.2 (Dynamic)	11.6 (Intermediate)	9.6 (Intermediate)	12.4 (Dynamic)
P. azureus	7.7 (Intermediate)	–	20.4 (Dynamic)	11.7 (Intermediate)	7.6 (Intermediate)	–	4.7 (Static)	2.2 (Static)	2.7 (Static)
P. centralis	21.9 (Dynamic)	56.6 (Dynamic)	15.7 (Dynamic)	33.8 (Dynamic)	21.3 (Dynamic)	7.3 (Intermediate)	10.4 (Intermediate)	12.8 (Dynamic)	11.9 (Intermediate)
P. gonzagai	19.0 (Dynamic)	–	62.7 (Dynamic)	39.7 (Dynamic)	25.4 (Dynamic)	–	7.8 (Intermediate)	6.5 (Intermediate)	7.8 (Intermediate)
P. hypochondrialis	24.3 (Dynamic)	–	48.9 (Dynamic)	36.8 (Dynamic)	19.1 (Dynamic)	–	8.5 (Intermediate)	7.8 (Intermediate)	8.2 (Intermediate)
P. megacephalus	17.8 (Dynamic)	52.1 (Dynamic)	21.3 (Dynamic)	62.9 (Dynamic)	18.9 (Dynamic)	8.3 (Intermediate)	8.5 (Intermediate)	9.1 (Intermediate)	8.5 (Intermediate)
P. nordestinus	21.4 (Dynamic)	–	66.4 (Dynamic)	34.6 (Dynamic)	24.0 (Dynamic)	–	5.9 (Intermediate)	6.6 (Intermediate)	7.1 (Intermediate)

P. oreades	17.2 (Dynamic)	40.2 (Dynamic)	42.5 (Dynamic)	46.6 (Dynamic)	22.8 (Dynamic)	28.8 (Dynamic)	10.5 (Intermediate)	9.8 (Intermediate)	11.9 (Intermediate)
P. palliatus	–	7.2 (Intermediate)	72.3 (Dynamic)	15.5 (Dynamic)	–	11.1 (Intermediate)	11.1 (Intermediate)	9.1 (Intermediate)	15.5 (Dynamic)
P. rohdei	21.8 (Dynamic)	23.2 (Dynamic)	8.5 (Static)	17.7 (Dynamic)	17.6 (Dynamic)	7.7 (Intermediate)	5.0 (Intermediate)	3.3 (Static)	8.7 (Intermediate)
P. rusticus	7.1 (Intermediate)	–	47.9 (Dynamic)	18.2 (Dynamic)	14.2 (Dynamic)	–	8.2 (Intermediate)	6.6 (Intermediate)	7.0 (Intermediate)
Interspecific CV	39.8 (Dynamic)	30.6 (Dynamic)	55.6 (Dynamic)	191.1 (Dynamic)	26.8 (Dynamic)	51.8 (Dynamic)	18.9 (Dynamic)	10.8 (Intermediate)	14.5 (Dynamic)

3.7 Principal Component Analysis

The first two axes explained more than 85% of the variation in the acoustic dataset including all species (Figure 16 and Figure 17). When looking at the analysis without *P. palliatus* (PCA1), all species formed a single cluster, except *P. megacephalus* and *P. rohdei* (and respective lineages), which differed mostly by their longer calls (Figure 16A). The same is observed for the analysis with five acoustic variables, including *P. palliatus* (PCA2) (Figure 16B). Despite the highly clustered nature of the results in both PCA analysis (Figure 16 and 17), it is possible to identify a slight separation between *P. araguaius* and its congeners, mostly by the call duration (Figure 16A and 17B). Looking at the highland clade we can identify a slight separation between the closely related *P. ayeaye* and *P. oreades*, and more clearly the separation between *P. megacephalus* and *P. rohdei* (Figure 17B).

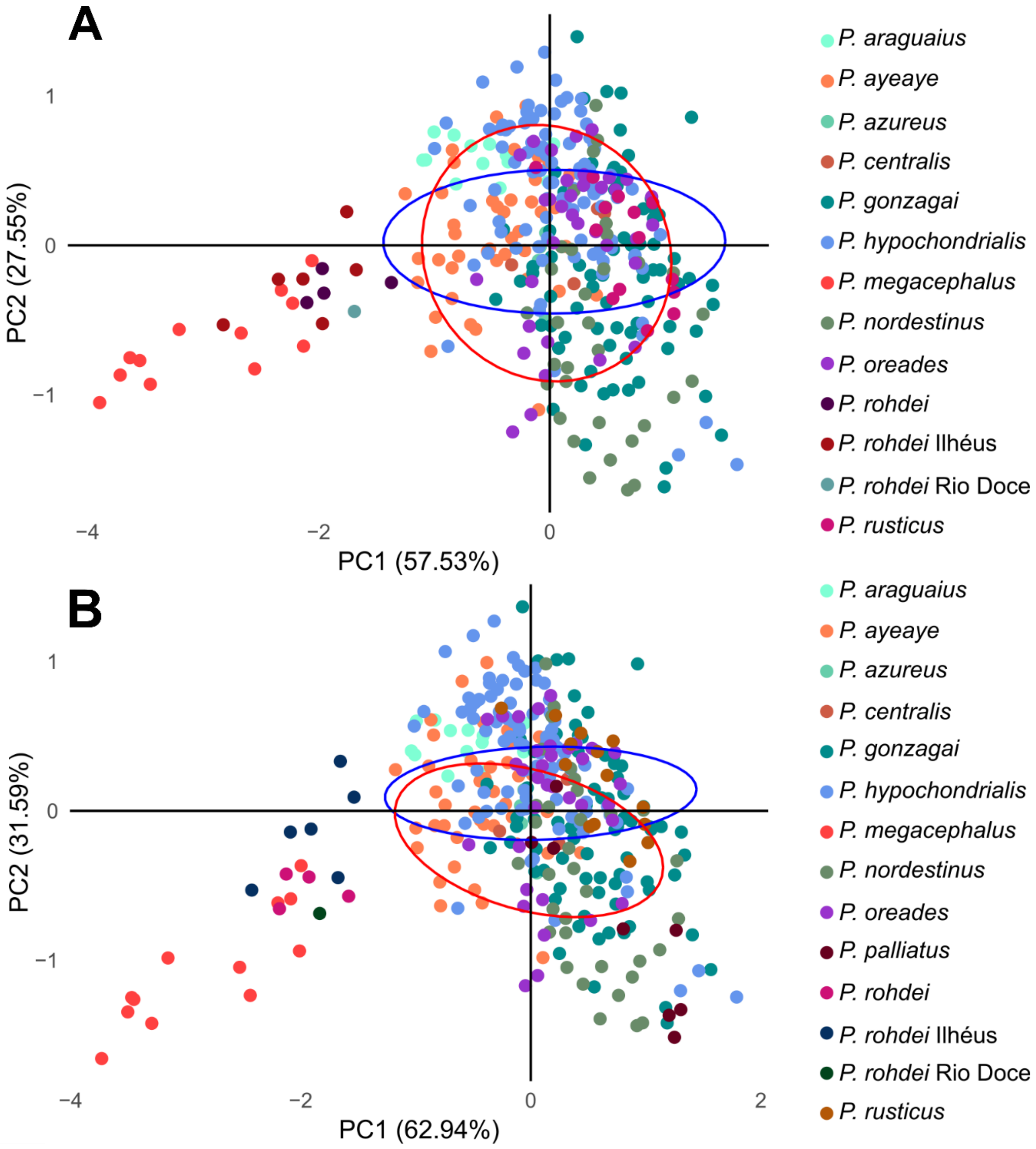

Figure 16. Principal component analysis (PCA) of *Pithecopus* based on advertisement call variables. (A) Seven acoustic variables, excluding one species with unavailable data (*P. palliatus*). (B) Five acoustic variables, including *P. palliatus*.

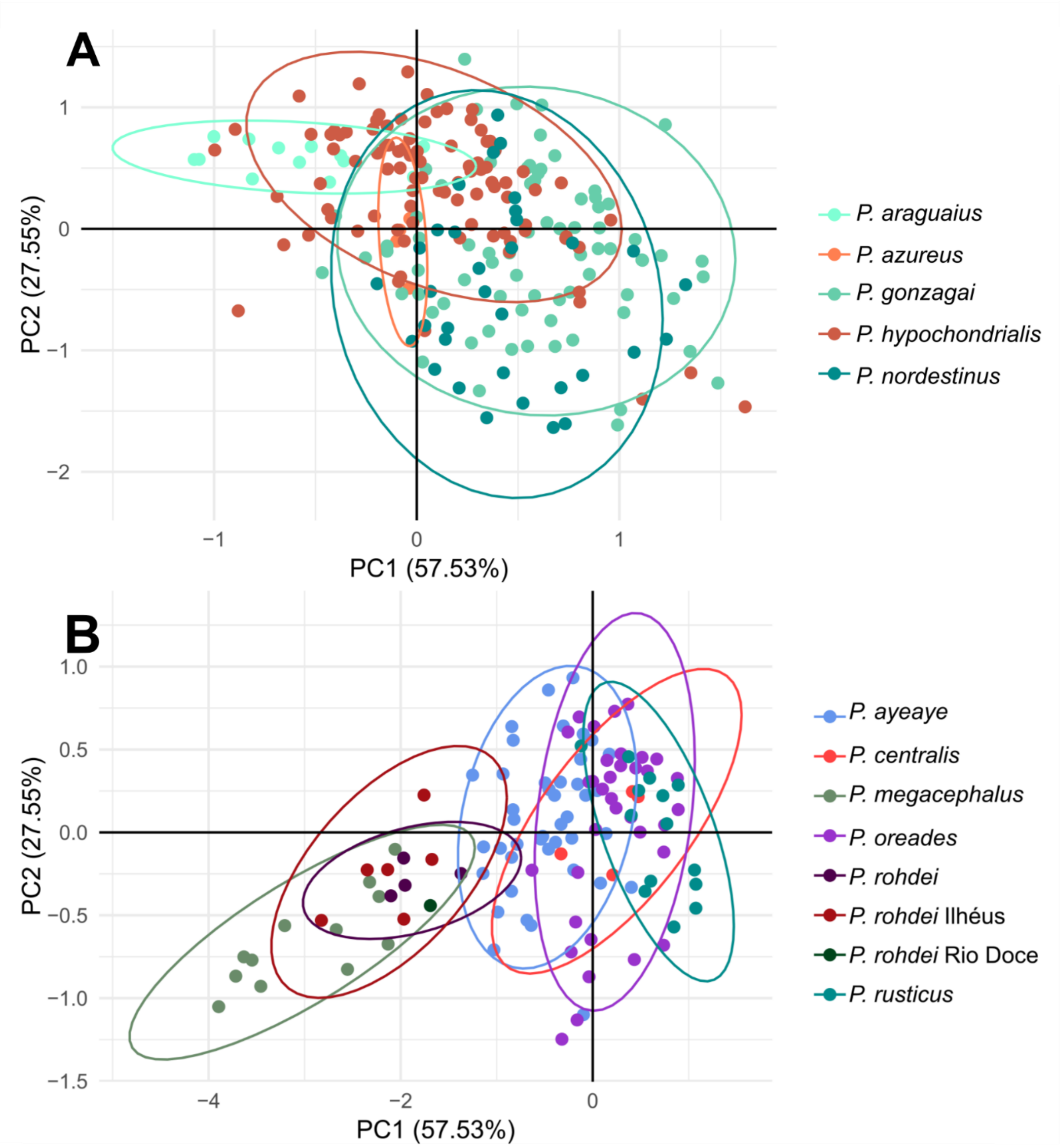

Figure 17. Principal component analysis (PCA) from acoustic variables of *Pithecopus*. (A) PCA from seven acoustic variables including only species from the lowland clade, excluding *P. palliatus*. (B) PCA from seven acoustic variables including only species from the highland clade.

3.8 Correlation between acoustic variation and phylogeny

The interspecific acoustic pairwise distance matrix recovered the smallest distance between *P. hypochondrialis* and *P. gonzagai* (0.012428) and the largest distance between *P. gonzagai* and *P. centralis* (0.265305). There is no correlation between interespecific acoustic distances and phylogeny (r = 0.0058, p = 0.58). The UPGMA dendrogram based on acoustic pairwise distance matrix remarkably diverges from the phylogenetic relationships within *Pithecopus* (Figure 18). The UPGMA dendrogram recovered 3 major clusters, which are: (1) *P. rusticus* and *P. azureus*; (2) *P. hypochondrialis*, *P. gonzagai*, *P. nordestinus*, and *P. araguaius*; (3) *P. oreades*, *P. ayeaye*, and *P. palliatus*. Three species were recovered outside these clusters: *P. rohdei*, *P. megacephalus*, and *P. centralis*. Despite the mismatch between acoustic variation (UPGMA dendogram) and phylogenetic relationships (phylogenetic tree), some clusters coincide with clades. One of them is the grouping of four species of the lowland clade (cluster 2). The cluster 3 grouped *P. oreades* with *P. ayeaye*, two species of the highland clade, together with the Amazonian *P. palliatus*. *Pithecopus rohdei* and *P. megacephalus* shared a similar relative position between the acoustic-based dendrogram and their phylogenetic positions. *Pithecopus centralis* was recovered as the most distinct species in the UPGMA dendogram (Figure 18).

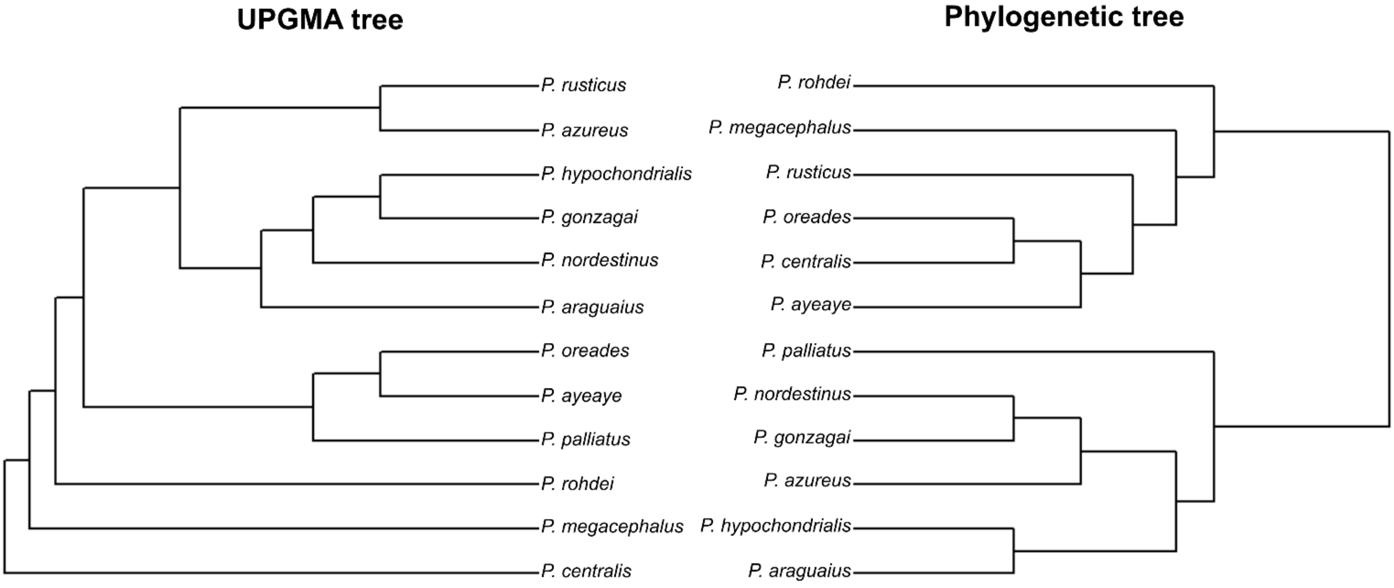

Figure 18. Mirrored UPGMA dendrogram and most recent phylogenetic relationships in *Pithecopus*. The UPGMA dendrogram is based on an interspecific acoustic pairwise distance matrix. The phylogenetic tree was extracted from the most inclusive phylogeny of the genus from Almeida-Silva *et al*., (2024).

4. DISCUSSION

To the current knowledge, the vocal repertoire of *Pithecopus* contains five types of calls. The advertisement call is described for all species in the genus (Duellman, 1978; Köhler & Lotters, 1999; Wogel, Abrunhosa; Pombal 2004; Giaretta; Oliveira Filho; Kokubum, 2007, Brandão *et al*., 2009, Brandão & Álvares 2009; Vilaça; Silva; Solé, 2011; Nali *et al*. 2015; Haga *et al*., 2017a; Haga *et al*. 2017b; Boschetti *et al*. 2019; Andrade *et al*. 2020). The male release call was previously known for four species (Vilaça; Silva; Solé, 2011; Mângia *et al*., 2019; Nali; Borges; Prado, 2015), now it is described for seven species. We described an unknown call for *Pithecopus*, the female release call, which now is described for three species. The aggressive calls were previously known for seven species (Guimarães *et al.,* 2001; Wogel; Abrunhosa & Pombal Jr., 2004; Brandão *et al.,* 2009; Vilaça; Silva; Solé, 2011; Nali; Borges; Prado, 2015; Haga *et al.,* 2017b; Boschetti *et al.,* 2019), now it is described for 10 species. The fighting call was previously known for one species (Brasileiro; Cascon; Passos, 2021), now it is described for two species. The encounter and distress calls remain described for one species each (Wogel; Abrunhosa; Pombal Jr., 2004; Toledo *et al*., 2015). In total, we provided the description of a new type of call for the genus *Pithecopus* (female release call), in addition to the description of nine new vocalizations for multiple species of *Pithecopus*, thus increasing the acoustic knowledge of the genus. The next section is dedicated to revisit the vocal repertoire of *Pithecopus* and propose a unified terminology for describing calls in the genus.

4.1 Revisiting the acoustic terminology in the genus *Pithecopus*

The advertisement call of *P. araguaius* was characterized in the original description of the species (Haga *et al*., 2017a). To make intragenic comparisons, equivalent among species, those authors proposed to compare call traits between species using only the core portion of the call, defined as a main stronger pulse group (Haga *et al*., 2017a), thus not considering the weaker initial/final pulse in the intrageneric comparisons. We reinterpret this terminology and understand that the presence of isolated pulses at the beginning or end of the call is widespread among *Pithecopus*. For this reason, acoustic comparisons should include all pulses and correlated variables, such as call duration, and pulse rate.

The vocal repertoire of *P. azureus* was described first by Barrio (1976). Additional descriptions include those of De la Riva; Márquez & Bosch (1995), and Haga *et al*., (2017b).

Barrio (1976) described three phases of calls which, as discussed by Haga *et al.,* (2017b), are similar to the aggressive calls of the species. Specifically, the first phase resembles the pattern 2 of pulse organization defined here, and the second phase resembles the pattern 1 pulse organization reported by us in aggressive calls of *Pithecopus*. Thus, these two phases are variants of aggressive signals, although we did not observe the presence of the second variant in our analysis. The third phase, as discussed by Haga *et al.,* (2017b), resembles the advertisement call of the species. Similarly, the calls described by De la Riva; Márquez & Bosch (1995) consist of aggressive notes, as mentioned by Haga *et al.,* (2017b). Finally, the redescription of advertisement and aggressive calls by Haga *et al.,* (2017b) matches our description of both call types.

The vocal repertoire of *P. gonzagai* is composed of advertisement (Andrade *et al*., 2020), male release (Mângia *et al*., 2019), and aggressive and fighting calls (Brasileiro *et al*., 2021). The advertisement call was characterized in the original description of the species, and similarly, those authors suggested that intrageneric comparisons should be made by using only the core portion of the call (Andrade *et al*., 2020), which here we interpret differently (as discussed previously for *P. araguaius*). We did not have access to male release calls of *P. gonzagai*, but it is structurally similar to the descriptions of male release calls of other *Pithecopus* species (discussed in further detail in section 4.2). We reanalyzed the same recordings from fighting and aggressive calls from Brasileiro *et al*., (2021). The original description did not provide detailed descriptive acoustic variables, but in Figure 2 from their work it is possible to see that acoustic variable such as number of pulses and call duration apparently presents no overlap. In addition, the authors found statistical significance contrasting calls emitted in both contexts (non-fighting and fighting). We reanalyzed the same archives from Brasileiro *et al.,* (2021), and provided a more descriptive analysis of the acoustic parameters from fighting calls for *P. gonzagai* (see Table 2).

The vocal repertoire of *P. hypochondrialis* was first described by Budgett (1899), who described the advertisement call of the species as “the sound of a dozen men breaking stones” (Budgett 1899, p. 314), but the author did not provide a quantitative characterization of the call. The author also mentioned the presence of a female call, which was not observed by Pyburn & Glidewell (1971), who studied a population of *P. hypochondrialis* in central Colombia. Those authors reported the advertisement call of *P. hypochondrialis* as a “short, raspy sound” (Pyburn & Glidewell, 1971, p. 49) and provided the first sonogram for an advertisement call of *P. hypochondrialis*. Later, Duellman & Pyles (1983) described the advertisement call of *P. hypochondrialis* for a population from eastern Amazonia (Bélem, Pará). Subsequently, Guimarães *et al.,* (2001) described the advertisement and territorial calls of a population from the Cerrado of Central Brazil. Our description matches that of Duellman & Pyles (1983), who considered the advertisement call of *P. hypochondrialis* composed of one type of pulsed note, but diverges from that of Guimarães *et al.,* (2001), who considered the advertisement call of the species composed of one or two notes. The aggressive call described by Guimarães *et al.,* (2001) matches our description of a single type of pulsed note. In addition to the advertisement and territorial calls of *P. hypochodrialis*, we extended the species' vocal repertoire by describing male release calls.

The vocal repertoire of *P. nordestinus* was described by Vilaça; Silva; Solé (2011). Those authors described the advertisement call and two territorial calls (territorial call I, and territorial call II). Our description diverges from that of Vilaça; Silva; Solé (2011)., who considered the advertisement call as composed of one or two multipulsed notes (Vilaça; Silva; Solé 2011, p. 1825). We reinterpret and understand that the advertisement call of *P. nordestinus* is composed of a single type of isolated note that can be emitted continuously. The territorial call I emitted by males of *P. nordestinus* we reinterpret as an aggressive call based on the similarities in context of emission and temporal envelope (Vilaça; Silva; Solé, 2011, Figure 4). The territorial call II, as discussed by Mângia *et al.* (2019)*,* can be reinterpreted as a male release call. Those authors pointed out the total overlap in the acoustic parameters between the territorial call II and the male release call described by them. They also pointed out that territorial calls II were emitted during handling by the researchers, the context in which release calls are emitted (Vilaça; Silva; Solé, 2011; Mângia *et al.,* 2019).

The vocal repertoire of *P. palliatus* was first described by Duellman (1978). He described the call as a soft "click" emitted irregularly, and quantified note duration, pulse rate, fundamental and dominant frequency (Duellman 1978, p. 177). Later, Duellman & Pyles (1983) described the advertisement call based on one call and one male from Santa Cecilia, Ecuador, the same locality from where the call had been originally described in 1978. Köhler & Lötters (1999) described the advertisement call from a population in Bolivia as "single notes and were emitted isolated or in call groups containing two calls (Köhler & Lötters, 1999, p. 268)". We reinterpret and understand that the call groups correspond to notes emitted in series, as observed by us in the calling pattern of the species. Also, the authors reported that the notes are "indistinctly pulsed", and provided a sound figure of the advertisement call (Köhler & Lötters, 1999, p. 268, p. 267, fig. 7). Although Duellman (1978) and Duellman &

Pyles (1983) did not mention the presence or absence of pulses in the advertisement call of *P. palliatus*, they provided the pulse rate of the call analyzed (Duellman, 1978, p. 177; Duellman & Pyles, 1983, Table 2). We analyzed calls of *P. palliatus* from Ecuador and Peru (see Appendix I) and could not quantify pulses in the notes included in our analysis, even though there is an indication of the typical pulsing present in *Pithecopus* calls. We reinforce the importance of collecting new acoustic data of *P. palliatus* to a better evaluation of the microtemporal structure of its advertisement call and intraspecific variation across its geographic range in Amazonia.

The vocal repertoire of *P. ayeaye* was described by Nali; Borges & Prado (2015). They described three types of calls for *P. ayeaye*: (1) a "simple" advertisement call, composed of short-pulsed notes; (2) a "composite" advertisement call, composed of a sequence of short pulsed notes (attributed to attraction of conspecific females), followed by a long-pulsed note (attributed to aggression towards conspecific males); and, (3) a male release call, composed of short pulsed notes. Our description diverges partially from that of Nali; Borges & Prado (2015). We reinterpret and suggest that *P. ayeaye* possesses only one type of advertisement call that can be emitted isolated or in series. The composite advertisement calls (see Appendix I for a more detailed discussion) are, in fact, a combination of an advertisement call (short pulsed note) and an aggressive call (long pulsed note). Based on our data, we understand that these notes are not mutually exclusive, i.e. one note can be emitted independently to the other. Finally, Nali; Borges & Prado (2015) described the male release call of *P. ayeaye* as consisting of short pulsed notes, which diverges from what we observed in our analysis. Although we observed the presence of clearly pulsed notes, a high percentage of our data is composed of non-pulsed notes. So, we suggest that the male release call of *P. ayeaye* consists of a single type of note with variation in amplitude modulation patterns, forming pulsed and nonpulsed notes during the emission of release notes. We extend the vocal repertoire of the species by describing its female release call.

The vocal repertoire of *P. centralis* was described by Brandão *et al*., (2009). The authors identified and described three call types: (1) type A call, named as "single call", (2) type B call, named as "compound call", (3) and type C call, named as "response call". Our description partially matches that of Brandão *et al*., (2009). We suggest that the single call corresponds to the advertisement call by the similarity of the acoustic variables (Brandão *et al*., 2009, Table 2) and the temporal envelope (Figure 2.1. Brandão *et al*., 2009). We also reinterpret and consider the compound call as corresponding to two advertisement calls emitted in series (see Figure 5B for paired notes in *Pithecopus*). Finally, we suggest that the "response call" corresponds to the aggressive call because of the emission context (Brandão *et al*., 2009) and the temporal envelope. We extend the vocal repertoire of the species by describing its male and female release calls.

The vocal repertoire of *P. megacephalus* comprised only the advertisement call, which was described by Giaretta; Oliveira Filho; and Kokubum, (2007). Our description matches that of Giaretta; Oliveira Filho; and Kokubum, (2007), who considered the advertisement call of *P. megacephalus* as consisting of 6 to 7 notes. This agrees with our proposition of homology, in which the multiple notes in the call of *P. megacephalus* are produced by one exhalation cycle. In addition, we increased the vocal repertoire of the species by describing an aggressive call, as well as male and female release calls.

The vocal repertoire of *P. rohdei* was described by Wogel; Abrunhosa; Pombal Jr. (2004). The authors reported a total of six different types of calls: one advertisement call, two territorial calls, two encounter calls, and one release call. In fact, during a field trip, the vocal repertoire of *P. rohdei* seemed more complex than those of its congeners (Vilela *et al.,* pers. obs.). Audibly we heard four different types of vocalizations. Nevertheless, future studies should address the context of vocal emissions and their behavioral context. Our description matches that of Wogel; Abrunhosa; Pombal Jr. (2004), who considered the advertisement call composed of one to seven multipulsed notes, which is similar to that of *P. megacephalus* and agrees with our proposition of homology of vocal production in these two species (i.e., multiple notes produced by one exhalation cycle). The two territorial calls, as pointed out by the authors, could indicate an escalated aggressive calling behavior because the territorial call type II was emitted sequentially after the territorial call type I (Wogel; Abrunhosa; Pombal Jr., 2004). Furthermore, looking at the acoustic variables, the territorial call type II has a greater number of pulses than the territorial call type I (44 – 116 vs. 4 – 10), which might indicate an escalated aggressive calling behavior in *P. rohdei*, as found in *P. gonzagai* (Brasileiro; Cascon & Passos, 2021) and *P. ayeaye* (see Appendix I). The authors reported two types of encounter calls, emitted at the end of territorial calls, but they did not provide acoustic variables or sound graphics. Finally, the authors described the male release call, but did not provide acoustic variables or sound graphics either. However, they stated that the male release call is similar to the territorial call type I. Mângia *et al.,* (2019) described a male release call from one individual, which matches the previous description by Wogel; Abrunhosa; Pombal. Jr (2004) when we compare the acoustic traits of the male release call

(Mângia *et al.*, 2019) with the acoustic traits of the territorial call type I (Wogel; Abrunhosa; Pombal Jr., 2004).

The vocal repertoire of *P. oreades* was described by Brandão & Álvares (2009) and consists only of an advertisement call. Our description matches the previous description by Brandão & Álvares (2009), who considered the advertisement call of *P. oreades* a single type of pulsed note. We increased the vocal repertoire of the species by describing its aggressive call.

The vocal repertoire of *P. rusticus* was described by Boschetti *et al*., (2019) and Forti *et al*., (2019). Our description matches partially the previous description by Boschetti *et al*., (2019), but diverges from that of Forti *et al*., (2019), who considered the advertisement call of *P. rusticus* composed of two acoustic units: (1) a short-pulsed note, and (2) a long-pulsed note. We reinterpret the description by Forti *et al*., (2019) and understand that the advertisement call of *P. rusticus* consists of only one acoustic unit, a single type of pulsed note. We also reinterpret the second acoustic unit reported by Forti *et al*., (2019) as corresponding to an aggressive call. Boschetti *et al*., (2019) described along with the advertisement call, two territorial calls: (1) territorial call I, consisting of two notes, one having two pulses, and the other a single pulse, and (2) territorial call II. We reinterpret the territorial call I as being an advertisement call with an isolated pulse (see Boschetti *et al.,* 2019, Figure 3), such variation of advertisement calls with isolated pulses was observed in our analysis for the species. Although the context of emission of territorial call I is related to male-male interactions, male interactions, advertisement calls can serve a dual role and can mediate male-male aggressive interactions as well (Wells, 1997). The territorial call II we reinterpret as an aggressive call. We extend the vocal repertoire of the species by describing its female release call.

4.2 Taxonomic considerations

After a thorough review of the advertisement calls in *Pithecopus*, we did not find any potential diagnostic acoustic characters among the species of the genus. All variables analyzed, classified as dynamic, intermediate, or static parameters, overlap among species of the genus. Röhr *et al.,* (2020) on a multiple-level framework, studied the variability by looking at the CV of advertisement call traits in 15 Phyllomedusinae species (including eight

Pithecopus species) and found that the coefficient of variation of acoustic variables vary continuously between lower (intraindividual) and higher levels of analysis (interspecific), thus indicating the possibility of using advertisement calls as a reliable taxonomic tool in the subfamily Phyllomedusinae. Our intraspecific and interspecific CV analysis of all 12 *Pithecopus* species had relatively similar results at the two levels. The analyzed parameters varied more at the interspecific level than at the intraspecific level, with some exceptions (see Results section). Nevertheless, the high intraspecific variation and lack of diagnosis (i.e., lack of non-overlapping traits or discontinuous variation) in the acoustic parameters of *Pithecopus* prevent one from using advertisement calls as a reliable source of information in the taxonomy of *Pithecopus*. The variation in acoustic variables observed for *Pithecopus* agrees with other phenotypic character systems, which exhibit high levels of intraspecific variation. High variation was previously observed in morphometric characters (Andrade *et al.,* 2020), reticulation patterns in the highland clade (Baêta *et al.,* 2009), and morphological patterns (Bruschi *et al.,* 2013; Magalhães *et al.,* 2024).

The presence of cryptic species is evident in the genus. Andrade *et al.,* (2020) pointed out in the description of *P. gonzagai* that they did not find any qualitative or quantitative diagnostic acoustic characters to separate *P. gonzagai* from its sister species *P. nordestinus*. Our analysis recovered the same results and was based on a much larger sample size (N = 1247 calls from 78 males). This might indicate one of the cases of cryptic speciation in the genus or, alternatively, *P. gonzagai* and *P. nordestinus* could represent a single taxonomic entity. Another example of the lack of diagnostic characters between species in the lowland clade of *Pithecopus* is the sister *P. araguaius* and *P. hypochondrialis* (Haga *et al.,* 2017a). These authors considered the significant differences in the pulse number between these species as a diagnostic character. When taking into account only the pulse number in the core portion of the call, there is nonoverlap among *P. araguaius*, and *P. hypochondrialis*, and *P. nordestinus* (Haga *et al.,* 2017a, Table 2). On the other hand, if we take into consideration the total pulse number in the calls, there is considerable overlap among all three species (Haga *et al.,* 2017a, Table 2). Our analysis yielded similar results, with total overlap in all analyzed call traits between *P. araguaius* and *P. hypochondrialis*. However, *P. araguaius* is distinguished from other lowland species in the PBC distances (Figure 18).

The lack of acoustic diagnostic characters among species of the highland clade is also evident. Even though our PCA showed a slight separation between *P. ayeaye* and *P. oreades,* they share much of the same statistical space, further confirmed by the low PBC distances between these two species. However, this “only partially overlap” grouping (Figure 17B) could reflect a variation gradient, and this should be better investigated. Closely related to *P. ayeaye* and *P. oreades* is *P. centralis*, which was recovered as the most divergent species in the PBC, but less evident in our PCA analysis. Differences in the dominant frequency and note duration of *P. centralis* were reported in two previous studies (Brandão *et al.,* 2009; Magalhães *et al.,* 2018). The advertisement call of *P. centralis* generally has a lower dominant frequency, but there is overlap with the dominant frequency of the closely related *P. ayeaye* and *P. oreades* (Table 1).

With our reinterpretation of all advertisement calls in *Pithecopus*, the multi-note calls of *P. megacephalus* and *P. rohdei* were considered the most divergent (Figure 17B). These differences are mostly explained by longer call durations of these species (Table 1). Excluding the one-note calls from the analysis, we found that call duration is a diagnostic character between these species and the other *Pithecopus*. However, the rare occurrence of one-note calls (1.92% of analyzed calls [1 out of 52 calls] in *P. megacephalus*, and absent in *P. rohdei*), in both species puts into question the validation of this diagnostic character. There is uncertainty about the phylogenetic position of *P. megacephalus* and *P. rohdei* (Faivovich *et al.,* 2010; Duellman; Marion & Hedges, 2016; Bandeira *et al.,* 2021). Our PBC distances show similar results regarding these hypotheses (Figure 18), with the two species being more divergent than the others of the genus.

When analyzing populations assigned to distinct lineages of *P. rohdei* (see Faivovich et al., 2010; Ramos *et al.,* 2019), we found acoustic divergence related to the Bahia population but not in the Rio Doce population. The advertisement call of *P. rohdei* Rio Doce shares the same temporal envelope and emission pattern (multi-note calls) of populations assigned to the nominal species. Conversely, *P. rohdei* Bahia has a different temporal envelope and emission pattern (one-note call). The differences seem to result mainly from the mechanistic perspective of vocal production (i.e., one-note vs. multi-note calls). Despite this, the single-note (Bahia population) and multi-note (nominal *P. rohdei*) calls overlap in all analyzed traits. Thus, the acoustic disparity found between lineages has evolutionary implications but might not be informative for taxonomic-decision making. The increase in sample size will certainly improve our evaluation of call traits as informative characters in the phenotypic recognition of *P. rohdei* lineages.

With respect to the mechanistic approach of characterizing acoustic signals, we should aim to understand first the role of the advertisement calls in mate attraction for *Pithecopus*.

Female preference could exert selective pressure on certain acoustic parameters of male advertisement calls (Gerhardt, 1991). Using North American treefrogs and toads as model organisms, Gerhardt (1994) found that females generally prefer higher call rates and longer calls (Gerhardt, 1994). Multi-note calls are longer and exhibit an increment in complexity that is multiple notes in the call, which also could exert a differential selective pressure in the advertisement calls of these species. Extrapolating those observations to *Pithecopus*, we could raise the hypothesis that females of *P. megacephalus* and *P. rohdei* are more attracted to multi-note calls than one-note calls. This hypothesis can be reinforced by the fact that we rarely (see proportions mentioned in paragraphs above) observed single-note calls in both two species. Nevertheless, an experimental framework to study female preferences in conjunction with natural history observations is needed for understanding the vocal behavior and communication strategies in this species, which would serve as a baseline to macroevolutionary studies of call evolution in Phyllomedusinae treefrogs.

The adequate proposition of homology between acoustic units can influence systematic and evolutionary studies (Robillard *et al.,* 2006). The presence of multi-note calls in *P. megacephalus* and *P. rohdei* could represent a putative acoustic synapomorphy that would support molecular-based phylogenetic relationships of these two species within *Pithecopus*. Bezerra; Carvalho-e-Silva; Gonzaga (2021) tested if the evolution of the advertisement calls in 24 Phyllomedusinae species was influenced by morphological or environmental constraints, or by phylogenetic inertia. They found that no correlations could be assigned to phylogenetic inertia. Conversely, Röhr *et al.,* (2020) found a significant phylogenetic signal for all acoustic variables analyzed in their study. These differences could stem from differences in the interpretation of acoustic signals and homology criteria. While Bezerra; Carvalho-e-Silva; Gonzaga (2021) interpreted the advertisement calls of six *Pithecopus* species as multi-note calls (Bezerra; Carvalho-e-Silva; Gonzaga 2021, see Table S3), Röhr *et al.,* (2020) interpreted the advertisement calls of eight *Pithecopus* species according to the homology criteria proposed by us (Röhr *et al.,* 2020, see Table 2). In conclusion, different interpretations of acoustic units and homology rationale can have an impact on evolutionary studies.

There is evidence that the male release call in anurans could be applied to taxonomy as well (Köhler *et al.,* 2017). Grenat & Martino (2013), found that the pulse rate in the male release call of *Odontophrynus americanus* and *O. cordobae* could be used as a diagnostic character. Seven of 12 species of *Pithecopus* have their male release calls described. Although we identified some variation, such as the occurrence of pulsed notes in the male release call of *P. hypochondrialis* (this study), *P. gonzagai* and *P. rohdei* (Mângia *et al.,* 2019), there is variation when analyzing the male release calls of *P. ayeaye*, *P. centralis*, and *P. megacephalus*. For example, although the male release call of *P. centralis* is generally composed of pulsed notes, 30% of the analyzed notes did not have well-defined pulses. In contrast, most notes did not have distinctive pulses (78%) in *P. megacephalus*. In addition, the overlap in all acoustic variables among species prevents us from using male release calls for species discrimination in *Pithecopus.*

The use of advertisement call traits in anuran taxonomy has increased over the past decades, based on the understanding that acoustic mating signals are more labile than morphology among closely related taxa and also play an important role in species recognition (Streicher; Sadler; Loader, 2020). Using Neotropical anurans as example, there are several clades containing morphologically cryptic species but easily distinguished from each other by their calls. Morphological crypsis is prevalent in foam-nesting frogs (Leptodactylidae) and taxonomic identification of several species are biased toward acoustic and DNA-sequence data (e.g., Carvalho *et al.,* 2020; Silva *et al.,* 2020). Among hylids, there are similar cases to that of leptodactylids (e.g., Marinho *et al.,* 2024), but also examples of consistent morphological diagnoses unaccompanied by acoustic disparity (e.g., Teixeira & Giaretta, 2015). A third case involves phenotypically cryptic clades, whose species have highly conserved morphology and calls (and any other independent non-molecular character system), but there is DNA-based evidence indicating independently evolving lineages, i.e., cryptic speciation (e.g., Fouquet *et al.,* 2021). Based on the continuous variation in reproductive acoustic signals among species of *Pithecopus*, we suggest that cryptic diversification predominates in this treefrog genus.

4.3 Evolution of the female release call

As a general rule, female anurans do not vocalize in intraspecific interactions. However, vocal females have been reported in some anuran families, with calls described for at least 50 species (Boistel & Sueur, 2002; Preininger *et al*., 2016). The female release call may be emitted when non-gravid females are clasped by males and such acoustic signals are linked to a negative response to conspecific or non-conspecific male amplexus (Bogert, 1960). This type of call is reported for at least 18 species belonging to six families (see Table 6 for a summary of anuran families and species). Of these, only two are Neotropical anurans:

Rhinella icterica (Pederassi; Caramaschi; Pineschi, 2022) and *Phyllomedusa venusta* (Barros-Granados *et al.*, 2023). We described for the first time the female release calls for three *Pithecopus* species: *P. centralis*, *P. megacephalus*, and *P. rusticus*. Our descriptions add up to five the number of female species of Neotropical anurans that are known to produce release calls. Interestingly, four of them are Phyllomedusinae species, which raises questions about the prevalence and evolution of this type of call in this tree frog clade.

When we compare the female release calls described in our study with the other two previously described for Neotropical anurans, all five calls are composed of a single type of non-pulsed note with evident harmonic structure (Pederassi; Caramaschi; Pineschi, 2022; Barros-Granados *et al.*, 2023). Pederassi; Caramaschi; Pineschi (2022) reported that the dominant frequency is always coincident with the fundamental harmonic. On the other hand, Barros-Granados *et al.*, (2023) did not report any information about the evident harmonic structure in the female release call of *Phyllomedusa venusta*. Nevertheless, looking at their Figure 4, it is possible to identify the presence of harmonic structure and that the fundamental harmonic contains most of the sound energy.

Table 6. Female release calls reported in anurans.

Family/Species	References
Bombinatoridae	
Bombina bombina	Gollman; Benkö; Hödl (2009)
Bombina variegata	Savage (1932)
Bufonidae	
Rhinella icterica	Pederassi; Caramaschi; Pineschi (2022)
Hylidae	
Phyllomedusa venusta	Barros-Granados *et al.,* (2023)
Pelobatidae	
Pelobates fuscus	Stănescu *et al.,* (2018)
Pelobates syriacus	Stănescu *et al.,* (2018)
Pipidae	
Xenopus petersii	Tobias; Korsh; Kelley (2014)
Xenopus laevis	Tobias; Korsh; Kelley (2014)
Xenopus victorianus	Tobias; Korsh; Kelley (2014)
Xenopus borealis	Tobias; Korsh; Kelley (2014)
Xenopus muelleri	Tobias; Korsh; Kelley (2014)
Xenopus sp.	Tobias; Korsh; Kelley (2014)
Xenopus clivii	Tobias; Korsh; Kelley (2014)
Ranidae	
Aquarana catesbeiana	Boyd (1992)
Rana temporaria	Dittrich & Rödel (2019)
Lithobates pipiens	McClelland & Wilczynski (1989)
Pelophylax ridibundus	Sinsch; Werding; Kaya (2023)
Amerana aurora	Licht (1969)

It is known that body size predicts the dominant frequency of the advertisement calls in male frogs (Tonini *et al.,* 2020; Escalona *et al*., 2024). The relationship between body size and fundamental frequency is the area density of the vocal cords producing the call (Martin, 1971). When comparing the dominant frequency of the female release calls of Neotropical anurans, we observed that all calls have emphasized low frequencies and are similar among species, despite varying remarkably in body size (e.g., *Rhinella icterica* SVL = 12.3 cm, Pederassi; Caramaschi; Pineschi, 2022; *P. centralis* SVL = 5.0 cm, measurement taken from the voucher specimen UFMG-AMP 15111). The dominant frequency of the female release call of *P. centralis* is more similar to that of *R. icterica* (560–660 Hz vs. *P. centralis*: 646–732 Hz) than to its congeners. The remaining species have calls with slightly higher frequencies than *R. icterica* and *P. centralis*, but nonetheless all species present with overlapping values of fundamental frequency (*Pi. megacephalus* 991–1206 Hz; *Pi. rusticus* 1163–1335 Hz; *Ph.*

venusta 700–1210 Hz). Furthermore, the temporal envelope is very similar among Neotropical species, but differs from other anurans with described female release calls (see next paragraphs).

Despite the fact that larger body sizes predict lower call frequencies, this tendency is not observed for females. From an ontogenetic perspective, the vocal apparatus of female anurans does not pass through a strong positive allometric growth during development as observed in the male larynx (Guerra; Ryan; Cannatela, 2014). When we compare the male and female release calls of *Pithecopus* described by us, we observe that they have differences in note structure, for instance the presence of pulsed notes and lack of rich harmonic structure, but have similar values of dominant frequency (see Table 3 and Table 4 in Results section), even though females of *Pithecopus* have been reported to be larger and heavier than males (Caramaschi, 2006; Oliveira; Nogueira; Eterovick, 2012; Cândido; Del-Prette; Brandão, 2022). A similar pattern was found by Preininger *et al.*, (2016) for the females of the ranid species *Staurois guttatus*, which produce advertisement calls with similar values of the dominant frequency of male calls of the species. In this species, females are larger, heavier, and have stronger laryngeal muscles than males. In females of the water frog *Pelophylax ridibundus*, this pattern was different (Sinsch; Werding; Kaya, 2023). The authors found that the dominant frequency of release calls decreased as the SVL increases in both sexes. In this case, females were larger and showed release calls with much lower frequencies than their male counterparts.

Future studies should benefit from a more comprehensive sample size of female release calls. It is important to take into consideration that release calls are produced in concert with flank vibrations that could influence the response of amplectant males (Bogert, 1960). Other release strategies are used as well, for example: nonreceptive females from toads of *Anaxyrus americanus* do not emit release calls and depend solely on the flank vibrations and body movements to be released by conspecific males (Aronson, 1944). In other cases, the female of *Amerana aurora* depends more on body movements to be released than the release call itself, which is often ignored by males (Licht, 1969).

When we broaden our comparisons, there is relevant variation in female release calls among anurans. For example, the presence of pulsed notes in the water frog *Pelophylax ridibundus* (Sinsch; Werding; Kaya, 2023) and *Lithobates pipiens* (McClelland & Wilczynski, 1989). The calls of the harlequin toad *Atelopus laetissimus* have two distinct nonpulsed notes with evident harmonic structure and different durations (Rueda-Solano *et al.*, 2020). Two distinct nonpulsed notes were also found in the European Common Frog *Rana temporaria* by Dittrich & Rödel (2019). These calls diverged in their frequency distribution and one call type was referred to as a "grunting sound", which had a lower dominant frequency, and the other call type as a "squeaking sound", which had a higher dominant frequency (Dittrich & Rödel, 2019).

Among the female release calls described across anurans, the call of the fire-bellied toad *Bombina bombina* showed a similar structure with those of Neotropical species, i.e., a nonpulsed note with evident harmonic structure (Gollmann; Benkö; Hödl, 2009). The evolution of female release calls was extensively studied by Tobias; Kosh; Kelley (2014) for the African clawed frogs of the genus *Xenopus*. Those authors found differences in the prevalence of male and female release calls in the molecular phylogeny of the genus. The male release call was recorded for all three clades of *Xenopus*, whereas female release calls were restricted to two clades within the genus. Nevertheless, *Xenopus* is not the best representative taxon for anurans, since this group is represented entirely by aquatic species that produce underwater calls through a non-homologous vocal production mechanism (Yager, 1992). To understand the evolution of this type of call, we emphasize the need for studying female anurans with airborne vocal sound production. Given the prevalence of this call type in Phyllomedusinae treefrogs, we understand that this treefrog clade seems to be a potential model taxon for future research.

Another aspect that is worth of note is the co-occurrence of female release calls and the scramble competition mating system across different anuran clades, for instance, aquatic mating aggregations (e.g., Bufonidae and Ranidae; Wells, 2007) and arboreal frogs (e.g., Phyllomedusinae; Wells, 2007), which have been reported to produce female release calls. This might indicate that the scramble competition is supposedly a selective pressure towards female release signaling. However, the co-occurrence seems not to be universal, given that fire-bellied toads (*Bombina* spp.) maintain and defend small territories as opposed to dense mating aggregations in a scramble competition mating system (Wells, 2007).

5. CONCLUSIONS

Our study on vocalizations of *Pithecopus* treefrogs revealed that the vocal repertoire of *Pithecopus* species are rich and showcase their potential for evolutionary studies of rare call types, such as the female release call. Despite the fact that we described new vocalizations for five species, many call types remain unknown for most species, which highlights the need for collecting additional acoustic data and linking to behavioral context. The thorough acoustic analysis and review of the acoustic terminology in the literature of *Pithecopus* revealed the need for a revised and unified terminology, which should help future research on the bioacoustics of *Pithecopus*. Additionally, by revisiting the acoustic terminology, we found evidence of graded aggressive signaling in one species of the genus, which could be expanded through experimental studies about the aggressive signaling system of *Pithecopus*.

The evaluation of the potential use of reproductive acoustic signals in the taxonomy of the genus showed that no acoustic trait alone can be used consistently to discriminate species. However, in the case of *P. rohdei* the genetic structure among populations seems to be accompanied by acoustic disparity to a certain extent, as demonstrated by the acoustic comparisons between nominal *P. rohdei* and the Bahia lineage as a candidate new species. Similarly to the advertisement calls, the female and male release calls cannot be used consistently to separate species. The patterns of acoustic variation in *Pithecopus* species are similar to those of the *Boana albopunctata* species group, where there is the prevalence of cryptic diversification. Our study on the female release call in anurans revealed that this is a rare type of call, and to date it has been registered in only a few species. The prevalence of this type of call in some anuran families could be linked to the presence of the scramble competition mating system, although this matter should be further investigated. Finally, we also provided a reinterpretation of homology based on a mechanistic approach that will change direct comparisons between acoustic units and their impacts on the understanding of call evolution in this treefrog genus.

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APPENDIX I – List of analyzed sound archives, filter applied, air and water temperatures, time and date of the recording, and municipality (Brazilian state).

Species	Archive name	Filter high-pass (dB)	Air temperature (°C)	Water temperature (°C)	Time (hh:mm)	Date dd/mm/yyyy	Municipality
P. araguaius	Pithecopus_araguaiusPontalAraguMT1b	100	24	26	22:25	15/02/2010	Pontal do Araguaia (MT)
P. araguaius	Pithecopus_araguaiusPontalAraguMT1c	100	24	26	22:30	15/02/2010	Pontal do Araguaia (MT)
P. araguaius	Pithecopus_araguaiusPontalAraguMT2a	100	24	26	22:55	15/02/2010	Pontal do Araguaia (MT)
P. araguaius	Pithecopus_araguaiusPontalAraguMT2b	100	24	26	22:57	15/02/2010	Pontal do Araguaia (MT)
P. araguaius	Pithecopus_araguaiusPontalAraguMT2c	100	24	26	23:00	15/02/2010	Pontal do Araguaia (MT)
P. araguaius	Pithecopus_araguaiusPontalAraguMT2d	100	24	26	23:05	15/02/2010	Pontal do Araguaia (MT)
P. araguaius	Pithecopus_araguaiusPontalAraguMT3a	100	26	30	20:41	06/01/2014	Pontal do Araguaia (MT)
P. araguaius	Pithecopus_araguaiusPontalAraguMT3b	100	26	30	20:43	06/01/2014	Pontal do Araguaia (MT)
P. araguaius	Pithecopus_araguaiusPontalAraguMT3c	100	26	30	20:45	06/01/2014	Pontal do Araguaia (MT)
P. araguaius	Pithecopus_araguaiusPontalAraguMT4a	100	25	31	00:05	08/01/2013	Pontal do Araguaia (MT)
P. araguaius	Pithecopus_araguaiusPontalAraguMT4b	100	25	31	00:08	08/01/2013	Pontal do Araguaia (MT)
P. araguaius	Pithecopus_araguaiusPontalAraguMT4c	100	25	31	-	08/01/2013	Pontal do Araguaia (MT)
P. araguaius	Pithecopus_araguaiusPontalAraguMT5a	100	25	31	23:46	07/01/2014	Pontal do Araguaia (MT)

P. araguaius	Pithecopus_araguaiusPontalAraguMT5b	100	25	31	23:56	07/01/2014	Pontal do Araguaia (MT)
P. araguaius	Pithecopus_araguaiusPontalAraguMT5c	100	25	31	00:09	07/01/2014	Pontal do Araguaia (MT)
P. araguaius	Pithecopus_araguaiusPontalAraguMT5d	100	25	31	00:09	07/01/2014	Pontal do Araguaia (MT)
P. araguaius	Pithecopus_araguaiusPontalAraguMT5e	100	25	31	00:11	07/01/2014	Pontal do Araguaia (MT)
P. araguaius	Pithecopus_araguaiusPontalAraguMT6a	100	25	31	-	07/01/2014	Pontal do Araguaia (MT)
P. araguaius	Pithecopus_araguaiusPontalAraguMT7a	100	26	-	21:05	01/12/2014	Pontal do Araguaia (MT)
P. araguaius	Pithecopus_araguaiusPontalAraguMT8a	100	26	27	02:20	03/12/2014	Pontal do Araguaia (MT)
P. araguaius	Pithecopus_araguaiusPontalAraguMT9a	100	26	27	02:34	03/12/2014	Pontal do Araguaia (MT)
P. araguaius	Pithecopus_araguaiusPontalAraguMT10a	100	26	27	02:53	03/12/2014	Pontal do Araguaia (MT)
P. araguaius	CBUFMG 230	100	24	-	-	14/12/2013	Chapada dos Guimarães (MT)
P. araguaius	CBUFMG 231	100	24	-	-	15/12/2013	Chapada dos Guimarães (MT)
P. araguaius	CBUFMG 232	100	24	-	-	14/12/2013	Chapada dos Guimarães (MT)
P.ayeaye	CBUFMG 445	-	22	-	-	05/12/2012	Ouro Preto (MG)
P.ayeaye	CBUFMG 446	-	22	-	-	05/12/2012	Ouro Preto (MG)
P.ayeaye	CBUFMG 461	100	-	-	-	02/12/2007	Lavras (MG)
P.ayeaye	CBUFMG 463	100	-	-	-	02/12/2007	Lavras (MG)
P. ayeaye	CBUFMG 464	100	-	-	-	02/12/2007	Lavras (MG)

P. ayeaye	CBUFMG 465	100	-	-	-	02/12/2007	Lavras (MG)
P. ayeaye	CBUFMG 1019	100	-	-	-	15/01/2020	São João del-Rei (MG)
P. ayeaye	CBUFMG 1020	100	-	-	-	15/01/2020	São João del-Rei (MG)
P. ayeaye	CBUFMG 1021	100	-	-	-	15/01/2020	São João del-Rei (MG)
P. ayeaye	1) 10-10-2010_short and long notes	100	18.5	-	-	10/10/2010	Sacramento (MG)
P. ayeaye	2A) 7-11-10_short and long notes	100	22.2	-	-	17/11/2010	Sacramento (MG)
P. ayeaye	2B) 07-11-10_short and long notes	100	22.2	-	-	17/11/2010	Sacramento (MG)
P. ayeaye	3) 07-11-10_short notes	100	22.2	-	-	17/11/2010	Sacramento (MG)
P. ayeaye	4) 07-11-10_short notes	100	22.2	-	-	17/11/2010	Sacramento (MG)
P. ayeaye	15-12-10_RCN016_some short notes	100	21.4	-	-	15/12/2010	Sacramento (MG)
P. ayeaye	Pithecopus_ayeayeOuroBrancoMG1b	500	20	-	20:47	04/01/2017	Ouro Branco (MG)
P. ayeaye	Pithecopus_ayeayeOuroBrancoMG1c	500	20	-	20:48	04/01/2017	Ouro Branco (MG)
P. ayeaye	Pithecopus_ayeayeOuroBrancoMG1d	500	20	-	21:04	04/01/2017	Ouro Branco (MG)
P. ayeaye	Pithecopus_ayeayeOuroBrancoMG4a	500	19	21	22:09	05/01/2017	Ouro Branco (MG)
P. ayeaye	Pithecopus_ayeayeOuroBrancoMG4b	500	19	21	22:09	05/01/2017	Ouro Branco (MG)
P. ayeaye	Pithecopus_ayeayePocosCaldasMG2e	500	17.3	18,6	01:00	01/11/2009	Poços de Caldas (MG)
P. ayeaye	Pithecopus_ayeayePocosCaldasMG2f	500	17.3	18,6	01:02	01/11/2009	Poços de Caldas (MG)

P. ayeaye	Pithecopus_ayeayePocosCaldasMG3a	100	18	18	23:53	28/12/2012	Poços de Caldas (MG)
P. ayeaye	Pithecopus_ayeayePocosCaldasMG4a	100	18	19	21:16	29/12/2012	Poços de Caldas (MG)
P. ayeaye	Pithecopus_ayeayePocosCaldasMG5a	300	18	19	21:59	29/12/2012	Poços de Caldas (MG)
P. ayeaye	Pithecopus_ayeayePocosCaldasMG5b	100	18	19	22:00	29/12/2012	Poços de Caldas (MG)
P. ayeaye	Pithecopus_ayeayePocosCaldasMG5c	100	18	19	22:09	29/12/2012	Poços de Caldas (MG)
P. ayeaye	Pithecopus_ayeayePocosCaldasMG5d	100	18	19	22:30	29/12/2012	Poços de Caldas (MG)
P. ayeaye	Pithecopus_ayeayePocosCaldasMG5e	100	18	19	22:31	29/12/2012	Poços de Caldas (MG)
P. ayeaye	Pithecopus_ayeayePocosCaldasMG5f	100	18	19	23:26	29/12/2012	Poços de Caldas (MG)
P. ayeaye	Pithecopus_ayeayePocosCaldasMG5g	100	18	19	23:30	29/12/2012	Poços de Caldas (MG)
P. ayeaye	Pithecopus_ayeayePocosCaldasMG6a	500	18	19	00:16	30/12/2012	Poços de Caldas (MG)
P. ayeaye	Pithecopus_ayeayePocosCaldasMG6b	100	18	19	00:18	30/12/2012	Poços de Caldas (MG)
P. ayeaye	Pithecopus_ayeayePocosCaldasMG6c	500	18	19	00:19	30/12/2012	Poços de Caldas (MG)
P. ayeaye	Pithecopus_ayeayePocosCaldasMG6d	100	18	19	00:20	30/12/2012	Poços de Caldas (MG)
P. ayeaye	Pithecopus_ayeayePocosCaldasMG6e	300	18	19	00:21	30/12/2012	Poços de Caldas (MG)
P. ayeaye	Pithecopus_ayeayePocosCaldasMG6f	100	18	19	00:23	30/12/2012	Poços de Caldas (MG)
P. ayeaye	Pithecopus_ayeayePocosCaldasMG8a	100	18.5	23	21:40	19/12/2013	Poços de Caldas (MG)
P. ayeaye	Pithecopus_ayeayePocosCaldasMG8b	100	18.5	23	21:45	19/12/2013	Poços de Caldas (MG)

P. ayeaye	Pithecopus_ayeayePocosCaldasMG8c	100	18.5	23	21:46	19/12/2013	Poços de Caldas (MG)
P. ayeaye	Pithecopus_ayeayePocosCaldasMG8d	100	18.5	23	21:49	19/12/2013	Poços de Caldas (MG)
P. ayeaye	Pithecopus_ayeayePocosCaldasMG8e	100	18.5	23	21:51	19/12/2013	Poços de Caldas (MG)
P. ayeaye	Pithecopus_ayeayePocosCaldasMG9a	300	18	19	22:08	29/12/2012	Poços de Caldas (MG)
P. ayeaye	Pithecopus_ayeayePocosCaldasMG10a	500	18	19	22:10	29/12/2012	Poços de Caldas (MG)
P. ayeaye	Pithecopus_ayeayePocosCaldasMG11a	500	18	19	22:22	29/12/2012	Poços de Caldas (MG)
P. ayeaye	Pithecopus_ayeyaePocosCaldasMG12a	300	22	25	21:38	01/01/2015	Poços de Caldas (MG)
P. ayeaye	Pithecopus_ayeyaePocosCaldasMG12b	300	22	25	21:44	01/01/2015	Poços de Caldas (MG)
P. ayeaye	Pithecopus_ayeyaePocosCaldasMG12c	300	22	25	21:46	01/01/2015	Poços de Caldas (MG)
P. ayeaye	Pithecopus_ayeyaePocosCaldasMG12d	500	22	25	21:48	01/01/2015	Poços de Caldas (MG)
P. ayeaye	Pithecopus_ayeyaePocosCaldasMG13a	500	22	25	22:20	01/01/2015	Poços de Caldas (MG)
P. ayeaye	Pithecopus_ayeyaePocosCaldasMG13b	500	22	25	22:22	01/01/2015	Poços de Caldas (MG)
P. ayeaye	Pithecopus_araguariAlpinopMG1a	500	21	25	22:20	19/12/2009	Alpinópolis (MG)
P. ayeaye	Pithecopus_araguariAlpinopMG1c	500	21	25	22:35	19/12/2009	Alpinópolis (MG)
P. ayeaye	Pithecopus_araguariAlpinopMG1d	500	21	25	22:45	19/12/2009	Alpinópolis (MG)
P. ayeaye	Pithecopus_araguariAlpinopMG1e	500	21	25	22:45	19/12/2009	Alpinópolis (MG)
P. ayeaye	Pithecopus_araguariAlpinopMG1f	500	21	25	-	19/12/2009	Alpinópolis (MG)

P. ayeaye	Pithecopus_araguariAlpinopMG3a	500	19	23	22:34	26/12/2011	Alpinópolis (MG)
P. ayeaye	Pithecopus_araguariAlpinopMG3b	300	19	23	-	26/12/2011	Alpinópolis (MG)
P. ayeaye	Pithecopus_araguariAlpinopMG3c	300	19	23	-	26/12/2011	Alpinópolis (MG)
P. ayeaye	Pithecopus_araguariAlpinopMG3d	300	19	23	-	26/12/2011	Alpinópolis (MG)
P. ayeaye	Pithecopus_araguariAlpinopMG3e	300	19	23	-	26/12/2011	Alpinópolis (MG)
P. ayeaye	Pithecopus_araguariAlpinopMG4a	-	19	23	-	26/12/2011	Alpinópolis (MG)
P. ayeaye	Pithecopus_araguariAlpinopMG4b	100	19	23	-	26/12/2011	Alpinópolis (MG)
P. ayeaye	Pithecopus_araguariCanastraMG1a	100	19	17	-	17/12/2009	Vargem Bonita (MG)
P. ayeaye	Pithecopus_araguariCanastraMG1b	100	19	17	-	17/12/2009	Vargem Bonita (MG)
P. ayeaye	Pithecopus_araguariCanastraMG1c	100	19	17	-	17/12/2009	Vargem Bonita (MG)
P. ayeaye	Pithecopus_araguariCanastraMG1d	100	19	17	-	17/12/2009	Vargem Bonita (MG)
P. ayeaye	Pithecopus_araguariCanastraMG1e	100	19	17	-	17/12/2009	Vargem Bonita (MG)
P. ayeaye	Pithecopus_araguariCanastraMG1f	100	19	17	-	17/12/2009	Vargem Bonita (MG)
P. ayeaye	Pithecopus_araguariCanastraMG2c	500	18.8	21,4	20:39	17/12/2009	Vargem Bonita (MG)
P. ayeaye	Pithecopus_araguariCanastraMG2d	500	18.8	21,4	20:58	17/12/2009	Vargem Bonita (MG)
P. ayeaye	Pithecopus_araguariCanastraMG2e	500	18.8	21,4	21:06	17/12/2009	Vargem Bonita (MG)
P. ayeaye	Pithecopus_araguariCanastraMG4b	500	22	20	21:00	28/11/2010	São Roque de Minas (MG)

P. ayeaye	Pithecopus_araguariCanastraMG5a	500	22	20	21:02	28/11/2010	São Roque de Minas (MG)
P. ayeaye	Pithecopus_araguariCanastraMG5b	500	22	20	21:02	28/11/2010	São Roque de Minas (MG)
P. ayeaye	Pithecopus_araguariCanastraMG6a	500	22	20	21:22	28/11/2010	São Roque de Minas (MG)
P. ayeaye	Pithecopus_araguariCanastraMG7a	500	22	20	22:31	28/11/2010	São Roque de Minas (MG)
P. ayeaye	Pithecopus_araguariCanastraMG8a	100	18	-	21:15	29/10/2013	São Roque de Minas (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG1a	100	23	-	21:00	05/12/2003	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG2a	500	21	21,7	20:40	15/10/2009	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG3a	500	21	21,7	21:15	15/10/2009	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG4a	500	21	21,7	21:20	15/10/2009	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG4b	500	21	21,7	21:20	15/10/2009	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG5a	500	23.3	-	19:40	15/10/2009	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG6a	500	-	-	19:57	-	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG7a	100	21	21	-	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG7b	100	21	21	-	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG7c	100	21	21	-	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG8a	100	21	21	21:38	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG8b	100	21	21	22:09	06/12/2012	Perdizes (MG)

P. ayeaye	Pithecopus_araguariPerdizes (MG)MG8c	100	21	21	22:22	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG8d	100	21	21	22:26	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG8e	100	21	21	22:25	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG8f	100	21	21	22:30	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG8g	100	21	21	22:35	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG9a	100	21	21	20:56	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG9b	100	21	21	21:04	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG9c	100	21	21	21:06	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG9d	100	21	21	22:12	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG9e	100	21	21	21:21	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG9f	100	21	21	21:32	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG9g	100	21	21	21:36	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG9h	100	21	21	21:44	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG9i	100	21	21	21:48	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG9j	100	21	21	21:52	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG9k	100	21	21	21:55	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG9l	100	21	21	22:03	06/12/2012	Perdizes (MG)

P. ayeaye	Pithecopus_araguariPerdizes (MG)MG9m	100	21	21	22:10	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG9n	100	21	21	22:18	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG9o	100	21	21	22:22	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG9p	100	21	21	22:24	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG9q	100	21	21	22:31	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG10a	100	21	21	20:17	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG10b	500	21	21	20:23	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG10d	500	21	21	20:32	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG10e	500	21	21	20:33	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG10f	500	21	21	20:37	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG10g	500	21	21	20:53	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG10h	500	21	21	20:54	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG10i	500	21	21	21:05	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG10j	500	21	21	21:21	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG10k	500	21	21	21:22	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG10l	500	21	21	21:25	06/12/2012	Perdizes (MG)
P. ayeaye	Pithecopus_araguariPerdizes (MG)MG10m	500	21	21	21:35	06/12/2012	Perdizes (MG)

P. azureus	P.azureaBelaVistaMS1a	100	26	32	20:40	18/12/2010	Bela Vista (MS)
P. azureus	P.azureaBelaVistaMS1b	100	26	32	20:43	18/12/2010	Bela Vista (MS)
P. azureus	P.azureaBelaVistaMS1c	100	26	32	20:44	18/12/2010	Bela Vista (MS)
P. azureus	P.azureaBelaVistaMS2a	100	26	32	20:52	18/12/2010	Bela Vista (MS)
P. azureus	P.azureaBelaVistaMS2c	100	26	32	20:52	18/12/2010	Bela Vista (MS)
P. azureus	P.azureaBelaVistaMS2d	100	26	32	21:02	18/12/2010	Bela Vista (MS)
P. azureus	P.azureaBelaVistaMS3a	100	26	32	21:06	18/12/2010	Bela Vista (MS)
P. azureus	P.azureaBelaVistaMS4a	100	26	31	23:14	18/12/2010	Bela Vista (MS)
P. centralis	CBUFMG 234	100	24	-	-	20/03/2013	Chapada dos Guimarães (MT)
P. centralis	CBUFMG 235	100	24	-	-	20/03/2013	Chapada dos Guimarães (MT)
P. centralis	CBUFMG 236	100	24	-	-	20/03/2013	Chapada dos Guimarães (MT)
P. centralis	FNJV 31142	100	19.5	23	18:30	14/10/1982	Chapada dos Guimarães (MT)
P. centralis	Pithecopus_centralBarraGarcasMT1d	100	25	27	21:00	02/12/2014	Barra do Garças (MT)
P. centralis	Pithecopus_centralBarraGarcasMT1e	100	25	27	21:13	02/12/2014	Barra do Garças (MT)
P. centralis	Pithecopus_centralBarraGarcasMT1g	100	25	27	21:44	02/12/2014	Barra do Garças (MT)
P. centralis	Pithecopus_centralBarraGarcasMT1h	100	25	27	21:57	02/12/2014	Barra do Garças (MT)
P. centralis	Pithecopus_centralBarraGarcasMT1i	100	25	27	21:59	02/12/2014	Barra do Garças (MT)

P. centralis	Pithecopus_centralBarraGarcasMT2a	100	25	27	00:30	03/12/2014	Barra do Garças (MT)
P. centralis	Pithecopus_centralBarraGarcasMT2b	100	25	27	00:38	03/12/2014	Barra do Garças (MT)
P. gonzagai	ASUFRN 123	100	24.5	-	22:02	22/03/2012	Macaíba (RN)
P. gonzagai	ASUFRN 124	100	24.5	-	22:02	22/03/2012	Macaíba (RN)
P. gonzagai	ASUFRN 125	100	24.5	-	22:02	22/03/2012	Macaíba (RN)
P. gonzagai	ASUFRN 128	100	26	-	19:40	13/04/2009	Macaíba (RN)
P. gonzagai	ASUFRN 338	100	24.5	-	-	29/06/2013	João Câmara (RN)
P. gonzagai	ASUFRN 339	100	24.6	-	-	29/06/2013	João Câmara (RN)
P. gonzagai	ASUFRN 340	100	24.3	-	-	29/06/2013	João Câmara (RN)
P. gonzagai	ASUFRN 341	100	24.4	-	-	29/06/2013	João Câmara (RN)
P. gonzagai	ASUFRN 342	100	24	-	-	29/06/2013	João Câmara (RN)
P. gonzagai	ASUFRN 343	100	24	-	-	29/06/2013	João Câmara (RN)
P. gonzagai	ASUFRN 344	100	23.1	-	-	29/06/2013	João Câmara (RN)
P. gonzagai	ASUFRN 345	100	23.1	-	-	29/06/2013	João Câmara (RN)
P. gonzagai	ASUFRN 346	300	21	-	20:40	01/07/2013	Cuité (PB)
P. gonzagai	ASUFRN 347	100	21.4	-	21:08	01/07/2013	Cuité (PB)
P. gonzagai	ASUFRN 348	100	-	-	-	01/07/2013	Cuité (PB)

P. gonzagai	ASUFRN 349	100	-	-	-	01/07/2013	Cuité (PB)
P. gonzagai	ASUFRN 351	100	-	-	22:51	01/07/2013	Cuité (PB)
P. gonzagai	ASUFRN 352	100	20.5	-	23:20	01/07/2013	Cuité (PB)
P. gonzagai	ASUFRN 353	100	22.3	-	-	01/07/2013	Cuité (PB)
P. gonzagai	ASUFRN 355	100	20.3		21:15	02/07/2013	Cuité (PB)
P. gonzagai	ASUFRN 358	100	-	-	-	02/07/2013	Cuité (PB)
P. gonzagai	ASUFRN 359	100	-	-	-	04/07/2013	Taquaritinga do Norte (PE)
P. gonzagai	ASUFRN 360	100	-	-	-	04/07/2013	Taquaritinga do Norte (PE)
P. gonzagai	ASUFRN 361	100	-	-	-	05/07/2013	Taquaritinga do Norte (PE)
P. gonzagai	ASUFRN 362	100	-	-	-	05/07/2013	Taquaritinga do Norte (PE)
P. gonzagai	ASUFRN 363	100	-	-	-	05/07/2013	Taquaritinga do Norte (PE)
P. gonzagai	ASUFRN 364	100	-	-	-	05/07/2013	Taquaritinga do Norte (PE)
P. gonzagai	ASUFRN 365	100	-	-	-	05/07/2013	Taquaritinga do Norte (PE)
P. gonzagai	ASUFRN 366	100	-	-	-	05/07/2013	Taquaritinga do Norte (PE)
P. gonzagai	ASUFRN 368	100	-	-	-	05/07/2013	Taquaritinga do Norte (PE)
P. gonzagai	ASUFRN 369	100	-	-	-	06/07/2013	Taquaritinga do Norte (PE)
P. gonzagai	ASUFRN 370	100	-	-	-	06/07/2013	Taquaritinga do Norte (PE)

P. gonzagai	ASUFRN 371	100	-	-	-	06/07/2013	Taquaritinga do Norte (PE)
P. gonzagai	ASUFRN 373	100	-	-	-	06/07/2013	Taquaritinga do Norte (PE)
P. gonzagai	ASUFRN 374	100	-	-	-	09/07/2013	São Miguel dos Campos (AL)
P. gonzagai	ASUFRN 375	100	-	-	-	09/07/2013	São Miguel dos Campos (AL)
P. gonzagai	ASUFRN 376	100	-	-	-	09/07/2014	São Miguel dos Campos (AL)
P. gonzagai	ASUFRN 377	100	-	-	-	09/07/2015	São Miguel dos Campos (AL)
P. gonzagai	ASUFRN 378	100	-	-	-	09/07/2016	São Miguel dos Campos (AL)
P. gonzagai	ASUFRN 379	100	-	-	-	09/07/2017	São Miguel dos Campos (AL)
P. gonzagai	ASUFRN 380	100	-	-	-	09/07/2018	São Miguel dos Campos (AL)
P. gonzagai	ASUFRN 381	100	-	-	-	09/07/2019	São Miguel dos Campos (AL)
P. gonzagai	ASUFRN 382	100	22.1	-	-	11/07/2013	São José da Tapera (AL)
P. gonzagai	ASUFRN 383	100	22.9	-	-	11/07/2013	São José da Tapera (AL)
P. gonzagai	ASUFRN 384	100	22	-	-	11/07/2013	São José da Tapera (AL)
P. gonzagai	ASUFRN 385	100	-	-	20:45	11/07/2013	São José da Tapera (AL)
P. gonzagai	ASUFRN 386	100	19.5	-	-	11/07/2013	São José da Tapera (AL)
P. gonzagai	ASUFRN 387	100	-	-	-	11/07/2013	São José da Tapera (AL)
P. gonzagai	ASUFRN 388	100	-	-	21:58	11/07/2013	São José da Tapera (AL)

P. gonzagai	ASUFRN 389	100	19.5	-	-	11/07/2013	São José da Tapera (AL)
P. gonzagai	ASUFRN 390	100	19.5	-	-	11/07/2013	São José da Tapera (AL)
P. gonzagai	ASUFRN 391	100	-	-	22:30	11/07/2013	São José da Tapera (AL)
P. gonzagai	ASUFRN 392	100	-	-	-	13/07/2013	São José da Tapera (AL)
P. gonzagai	ASUFRN 433	100	22.5	-	-	27/07/2013	Mamanguape (PB)
P. gonzagai	ASUFRN 434	100	22	-	-	27/07/2013	Mamanguape (PB)
P. gonzagai	ASUFRN 435	100	21	-	22:35	27/07/2013	Mamanguape (PB)
P. gonzagai	ASUFRN 436	100	20	-	-	27/07/2013	Mamanguape (PB)
P. gonzagai	ASUFRN 437	100	21.5	-	-	27/07/2013	Mamanguape (PB)
P. gonzagai	ASUFRN 438	100	-	-	-	27/07/2013	Mamanguape (PB)
P. gonzagai	ASUFRN 439	100	21.1	-	-	27/07/2013	Mamanguape (PB)
P. gonzagai	ASUFRN 452	100	19.7	-	19:56	04/06/2012	Bezerros (PE)
P. gonzagai	ASUFRN 453	100	19.3	-	20:43	04/06/2012	Bezerros (PE)
P. gonzagai	ASUFRN 455	100	19.7	-	18:28	05/06/2012	Bezerros (PE)
P. gonzagai	ASUFRN 456	100	19.1	-	19:14	05/06/2012	Bezerros (PE)
P. gonzagai	ASUFRN 457	100	19.1	-	19:38	05/06/2012	Bezerros (PE)
P. gonzagai	ASUFRN 458	100	21.1	-	-	07/06/2012	Bezerros (PE)

P. gonzagai	ASUFRN 459	500	21.1	-	-	07/06/2012	Bezerros (PE)
P. gonzagai	ASUFRN 460	100	19.5	-	18:18	08/06/2012	Bezerros (PE)
P. gonzagai	ASUFRN 461	100	19.8	-	21:10	08/06/2012	Bezerros (PE)
P. gonzagai	ASUFRN 606	500	-	-	19:30	12/04/2015	Quixadá (CE)
P. gonzagai	ASUFRN 609	500	24.5	-	20:50	13/04/2015	Quixadá (CE)
P. gonzagai	ASUFRN 616	500	24.5	-	-	15/04/2015	Quixadá (CE)
P. gonzagai	FNJV 12233	100	28		20:45	22/05/2011	Araruna (PR)
P. gonzagai	FNJV 12236	100	28	25	20:54	24/05/2011	Macaíba (RN)
P. gonzagai	FNJV 12231	100	29	26	19:35	17/05/2011	Limoeiro (PE)
P. gonzagai	FNJV 40939	100	29	-	20:54	24/05/2011	Macaíba (RN)
P. gonzagai	CASA 114	100	-	-	22:52	05/05/2017	Groaíras (CE)
P. gonzagai	CASA 115	100	-	-	22:56	05/05/2017	Groaíras (CE)
P. gonzagai	CASA 117	100	-	-	22:13	21/04/2017	Groaíras (CE)
P. gonzagai	CASA 118	100	-	-	19:24	17/03/2017	Groaíras (CE)
P. gonzagai	CASA 121	100	-	-	21:58	11/04/2017	Groaíras (CE)
P. gonzagai	CASA 122	100	-	-	21:19	28/04/2017	Groaíras (CE)
P. gonzagai	CASA 124	100	-	-	20:44	21/04/2017	Groaíras (CE)

P. gonzagai	CASA 127	100	-	-	22:32	07/04/2017	Groaíras (CE)
P. gonzagai	CASA 128	100	-	-	20:07	11/04/2017	Groaíras (CE)
P. gonzagai	CASA 129	500	-	-	20:10	11/04/2017	Groaíras (CE)
P. gonzagai	CASA 131	100	-	-	21:05	20/04/2017	Groaíras (CE)
P. gonzagai	CASA 132	100	-	-	21:08	20/04/2018	Groaíras (CE)
P. gonzagai	CASA 133	100	-	-	21:30	20/04/2019	Groaíras (CE)
P. gonzagai	CASA 134	100	-	-	21:00	17/03/2017	Groaíras (CE)
P. hypochondrialis	ASUFRN 071	500	26	-	20:25	-	Moju (PA)
P. hypochondrialis	ASUFRN 072	100	26	-	21:20	17/01/2011	Moju (PA)
P. hypochondrialis	ASUFRN 322	100	23.5	-	20:26	12/02/2012	Porto Grande (AP)
P. hypochondrialis	ASUFRN 323	100	23.5	-	20:26	12/02/2012	Porto Grande (AP)
P. hypochondrialis	ASUFRN 324	100	23.5	-	20:26	12/02/2012	Porto Grande (AP)
P. hypochondrialis	ASUFRN 327	100	22.6	-	20:50	12/02/2012	Porto Grande (AP)
P. hypochondrialis	ASUFRN 329	100	23.5	-	21:10	12/02/2012	Porto Grande (AP)
P. hypochondrialis	ASUFRN 330	100	23.4	-	21:23	12/02/2012	Porto Grande (AP)
P. hypochondrialis	ASUFRN 331	100	22.8	-	20:31	12/02/2012	Porto Grande (AP)
P. hypochondrialis	ASUFRN 332	100	22.5	-	21:41	12/02/2012	Porto Grande (AP)

P. hypochondrialis	ASUFRN 333	100	22.2	-	21:58	12/02/2012	Porto Grande (AP)
P. hypochondrialis	ASUFRN 334	100	22.3	-	22:07	12/02/2012	Porto Grande (AP)
P. hypochondrialis	ASUFRN 336	100	22.3	-	22:36	12/02/2012	Porto Grande (AP)
P. hypochondrialis	ASUFRN 337	100	22.4	-	23:00	12/02/2012	Porto Grande (AP)
P. hypochondrialis	FNJV 31153	100	25	24	21:20	07/08/1984	Carajás (PA)
P. hypochondrialis	FNJV 31154	300	28	27	22:30	24/12/1989	Santa Terezinha (MT)
P. hypochondrialis	FNJV 31724	100	-	-	21:00	18/07/1986	Serra do Tepequém (RR)
P. hypochondrialis	FNJV 31727	100	-	-	19:00	21/07/1986	Serra do Tepequém (RR)
P. hypochondrialis	FNJV 32719	100	20.5	-	00:40	08/01/1996	Silvânia (GO)
P. hypochondrialis	FNJV 32858	100	21	-	22:30	15/01/2000	Piracanjuba (GO)
P. hypochondrialis	FNJV 32866	100	-	-	-	21/01/2000	Mossâmedes (GO)
P. hypochondrialis	FNJV 34164	100	-	-	18:56	02/02/2015	Óbidos (PA)
P. hypochondrialis	Pithecopus_hypochondrialisColiderMT1a	100	-	-	23:52	23/01/2013	Colíder (MT)
P. hypochondrialis	Pithecopus_hypochondrialisColiderMT2b	100	-	-	00:05	23/01/2013	Colíder (MT)
P. hypochondrialis	Pithecopus_hypochondrialisAltaFlorestaMT1a	100	25	-	21:21	20/01/2020	Alta Floresta (MT)
P. hypochondrialis	Pithecopus_hypochondrialisAltaFlorestaMT1bAAG	100	25	-	21:22	20/01/2020	Alta Floresta (MT)
P. hypochondrialis	Pithecopus_hypochondrialisAltaFlorestaMT1bDLB	500	22.6	-	21:31	10/01/2019	Alta Floresta (MT)

P. hypochondrialis	Pithecopus_hypochondrialisAltaFlorestaMT2a	100	25	-	21:33	20/01/2020	Alta Floresta (MT)
P. hypochondrialis	Pithecopus_hypochondrialisAltaFlorestaMT2b	100	25	-		20/01/2020	Alta Floresta (MT)
P. hypochondrialis	Pithecopus_hypochondrialisAltaFlorestaMT3a	100	22.6	-		10/01/2019	Alta Floresta (MT)
P. hypochondrialis	Pithecopus_hypochondrialisAltaFlorestaMT3b	500	22.6	-	21:37	10/01/2019	Alta Floresta (MT)
P. hypochondrialis	Pithecopus_hypochondrialisAragominasTO1a	500	24	28	20:28	07/01/2018	Aragominas (TO)
P. hypochondrialis	Pithecopus_hypochondrialisAraguariMG1a	100	25	27	22:00	14/11/2007	Araguari (MG)
P. hypochondrialis	Pithecopus_hypochondrialisAraguariMG1b	100	25	27	22:00	14/11/2007	Araguari (MG)
P. hypochondrialis	Pithecopus_hypochondrialisAraguariMG1c	100	25	27	22:00	14/11/2007	Araguari (MG)
P. hypochondrialis	Pithecopus_hypochondrialisAraguariMG2a	500	21.2	22.6	21:34	08/12/2009	Araguari (MG)
P. hypochondrialis	Pithecopus_hypochondrialisAraguariMG3a	100	21.2	22.6	21:54	08/12/2009	Araguari (MG)
P. hypochondrialis	Pithecopus_hypochondrialisAraguariMG4a	100	21.2	22.6	22:13	08/12/2009	Araguari (MG)
P. hypochondrialis	Pithecopus_hypochondrialisAraguariMG5a	100	21.2	22.6	22:13	08/12/2009	Araguari (MG)
P. hypochondrialis	Pithecopus_hypochondrialisAraguariMG6a	100	20	22.6	00:30	09/12/2009	Araguari (MG)
P. hypochondrialis	Pithecopus_hypochondrialisAraguariMG6b	100	20	22.6	00:30	09/12/2009	Araguari (MG)
P. hypochondrialis	Pithecopus_hypochondrialisAraguariMG7a	100	20	22.6	00:26	09/12/2009	Araguari (MG)
P. hypochondrialis	Pithecopus_hypochondrialisAraguariMG7b	500	20	22.6	01:07	09/12/2009	Araguari (MG)
P. hypochondrialis	Pithecopus_hypochondrialisAraguariMG10a	100	22.5	22	22:35	06/11/2010	Araguari (MG)

P. hypochondrialis	Pithecopus_hypochondrialisBarraGarcasMT2a	100	22	25	23:34	19/02/2012	Barra do Garças (MT)
P. hypochondrialis	Pithecopus_hypochondrialisBarraGarcasMT2b	100	22	25	23:39	19/02/2012	Barra do Garças (MT)
P. hypochondrialis	Pithecopus_hypochondrialisBarraGarcasMT2c	100	22	25	23:42	19/02/2012	Barra do Garças (MT)
P. hypochondrialis	Pithecopus_hypochondrialisBarraGarcasMT3a	100	26	29	22:31	09/01/2014	Barra do Garças (MT)
P. hypochondrialis	Pithecopus_hypochondrialisBarraGarcasMT4a	100	26	29	22:31	09/01/2014	Barra do Garças (MT)
P. hypochondrialis	Pithecopus_hypochondrialisBarraGarcasMT4b	100	26	29	22:35	09/01/2014	Barra do Garças (MT)
P. hypochondrialis	Pithecopus_hypochondrialisBarraGarcasMT6a	500	27.6	-	20:26	08/01/2014	Barra do Garças (MT)
P. hypochondrialis	Pithecopus_hypochondrialisBrasiliaDF1a	100	24	25	22:33	13/01/2015	Brasília (DF)
P. hypochondrialis	Pithecopus_hypochondrialisBrasiliaDF1b	100	24	25	22:33	13/01/2015	Brasília (DF)
P. hypochondrialis	Pithecopus_hypochondrialisBrasiliaDF1c	100	24	25	22:49	13/01/2015	Brasília (DF)
P. hypochondrialis	Pithecopus_hypochondrialisItuiutabaMG1a	100	25	29	-	12/01/2010	Ituiutaba (MG)
P. hypochondrialis	Pithecopus_hypochondrialisMinacuGO1a	100	24	30	21:35	19/11/2014	Minaçu (GO)
P. hypochondrialis	Pithecopus_hypochondrialisMinacuGO2a	100	24	30	20:40	19/11/2014	Minaçu (GO)
P. hypochondrialis	Pithecopus_hypochondrialisPadBernarGO1b	100	24.6	26.5	23:07	10/12/2010	Padre Bernardo (GO)
P. hypochondrialis	Pithecopus_hypochondrialisPalestinaPA1a	100	23	26	20:23	08/01/2018	Palestina (PA)
P. hypochondrialis	Pithecopus_hypochondrialisPalmasTO1a	100	24.5	-	19:55	01/12/2013	Palmas (TO)
P. hypochondrialis	Pithecopus_hypochondrialisPalmasTO2a	100	24.5	-	20:20	01/12/2013	Palmas (TO)

P. hypochondrialis	Pithecopus_hypochondrialisPalmeirasGoiasGO1a	100	26	28	21:27	04/11/2016	Palmeiras de Góias (GO)
P. hypochondrialis	Pithecopus_hypochondrialisPalmeirasGoiasGO2a	100	26	28	21:31	04/11/2016	Palmeiras de Góias (GO)
P. hypochondrialis	Pithecopus_hypochondrialisPalmeirasGoiasGO3a	100	26	28	21:43	04/11/2016	Palmeiras de Góias (GO)
P. hypochondrialis	Pithecopus_hypochondrialisPalmeirasGoiasGO3b	100	26	28	21:49	04/11/2016	Palmeiras de Góias (GO)
P. hypochondrialis	Pithecopus_hypochondrialisPalmeirasGoiasGO4a	100	26	28	21:50	04/11/2016	Palmeiras de Góias (GO)
P. hypochondrialis	Pithecopus_hypochondrialisPalmeirasGoiasGO4b	100	26	28	21:51	04/11/2016	Palmeiras de Góias (GO)
P. hypochondrialis	Pithecopus_hypochondrialisPalmeirasGoiasGO5a	100	26	28	22:13	04/11/2016	Palmeiras de Góias (GO)
P. hypochondrialis	Pithecopus_hypochondrialisPalmeirasGoiasGO5b	100	26	28	22:14	04/11/2016	Palmeiras de Góias (GO)
P. hypochondrialis	Pithecopus_hypochondrialisPalmeirasGoiasGO5c	100	26	28	22:16	04/11/2016	Palmeiras de Góias (GO)
P. hypochondrialis	Pithecopus_hypochondrialisPalmeirasGoiasGO6a	100	24.6	25.6	21:38	07/11/2016	Palmeiras de Góias (GO)
P. hypochondrialis	Pithecopus_hypochondrialisParanaTO2a	100	26.2	-	21:10	04/12/2013	Paranã (TO)
P. hypochondrialis	Pithecopus_hypochondrialisParanaTO2b	100	26.2	-	21:10	04/12/2013	Paranã (TO)
P. hypochondrialis	Pithecopus_hypochondrialisParanaTO2c	100	26.2	-	21:10	04/12/2013	Paranã (TO)
P. hypochondrialis	Pithecopus_hypochondrialisPirenopGO2a	100	24	26	22:00	11/02/2011	Pirenópolis (GO)
P. hypochondrialis	Pithecopus_hypochondrialisPirenopGO3a	100	24	26	22:14	11/02/2011	Pirenópolis (GO)
P. hypochondrialis	Pithecopus_hypochondrialisSNavioAP1a	100	26	-	19:48	27/03/2017	Serra do Navio (AP)
P. hypochondrialis	Pithecopus_hypochondrialisSNavioAP2a	100	26	-	22:11	27/03/2017	Serra do Navio (AP)

P. hypochondrialis	Pithecopus_hypochondrialisSNavioAP2b	100	26	-	22:31	27/03/2017	Serra do Navio (AP)
P. hypochondrialis	Pithecopus_hypochondrialisSNavioAP3a	100	26	-	22:31	27/03/2017	Serra do Navio (AP)
P. hypochondrialis	Pithecopus_hypochondrialisSNavioAP4a	100	26	-	22:57	27/03/2017	Serra do Navio (AP)
P. hypochondrialis	Pithecopus_hypochondrialisSNavioAP5a	300	26	-	19:24	28/03/2017	Serra do Navio (AP)
P. hypochondrialis	Pithecopus_hypochondrialisSNavioAP6a	100	26	-	20:21	28/03/2017	Serra do Navio (AP)
P. hypochondrialis	Pithecopus_hypochondrialisSNavioAP7a	100	26	-	20:34	28/03/2017	Serra do Navio (AP)
P. hypochondrialis	Pithecopus_hypochondrialisSNavioAP7b	100	26	-	20:55	28/03/2017	Serra do Navio (AP)
P. hypochondrialis	Pithecopus_hypochondrialisSNavioAP7c	100	26	-	20:57	28/03/2017	Serra do Navio (AP)
P. hypochondrialis	Pithecopus_hypochondrialisSNavioAP7d	100	26	-	20:58	28/03/2017	Serra do Navio (AP)
P. hypochondrialis	Pithecopus_hypochondrialisSNavioAP7e	100	26	-	20:59	28/03/2017	Serra do Navio (AP)
P. hypochondrialis	Pithecopus_hypochondrialisSNavioAP8a	100	26	-	20:37	29/03/2017	Serra do Navio (AP)
P. hypochondrialis	Pithecopus_hypochondrialisSNavioAP9a	100	26	-	20:39	29/03/2017	Serra do Navio (AP)
P. hypochondrialis	Pithecopus_hypochondrialisSNavioAP9b	100	26	-	20:43	29/03/2017	Serra do Navio (AP)
P. hypochondrialis	Pithecopus_hypochondrialisUberlandiaMG1a	500	18	20	03:00	22/12/2009	Uberlândia (MG)
P. hypochondrialis	Pithecopus_hypochondrialisUberlandiaMG2a	500	19	20	03:10	22/12/2009	Uberlândia (MG)
P. hypochondrialis	Pithecopus_hypochondrialisUberlandiaMG3a	500	19	20	03:43	22/12/2009	Uberlândia (MG)
P. hypochondrialis	Pithecopus_hypochondrialisUberlandiaMG4b	500	19	20	-	22/12/2009	Uberlândia (MG)

P. hypochondrialis	Pithecopus_hypochondrialisUberlandiaMG6a	100	-	-	-	03/11/2010	Uberlândia (MG)
P. hypochondrialis	Pithecopus_hypochondrialisUberlandiaMG7a	100	21	25	20:10	14/10/2011	Uberlândia (MG)
P. hypochondrialis	Pithecopus_hypochondrialisUberlandiaMG8a	100	21	25	19:46	14/10/2011	Uberlândia (MG)
P. hypochondrialis	Pithecopus_hypochondrialisUberlandiaMG8b	100	21	25	20:05	14/10/2011	Uberlândia (MG)
P. hypochondrialis	Pithecopus_hypochondrialisUberlandiaMG9a	100	21	25	-	14/10/2011	Uberlândia (MG)
P. hypochondrialis	Pithecopus_hypochondrialisUberlandiaMG10a	100	21	25	20:23	14/10/2011	Uberlândia (MG)
P. hypochondrialis	Pithecopus_hypochondrialisUberlandiaMG11a	100	24	26	19:40	07/11/2015	Uberlândia (MG)
P. hypochondrialis	Pithecopus_hypochondrialisUberlandiaMG12a	100	24	26	21:59	07/11/2016	Uberlândia (MG)
P. hypochondrialis	Pithecopus_hypochondrialisUberlandiaMG12b	100	24	26	19:41	07/11/2017	Uberlândia (MG)
P. hypochondrialis	Pithecopus_hypochondrialisUberlandiaMG13a	100	24	26	-	07/11/2018	Uberlândia (MG)
P. hypochondrialis	Pithecopus_hypochondrialisUberlandiaMG14a	100	21	21	20:25	29/11/2017	Uberlândia (MG)
P. hypochondrialis	Pithecopus_hypochondrialisUberlandiaMG15a	100	20	24	19:53	08/12/2018	Uberlândia (MG)
P. hypochondrialis	Pithecopus_hypochondrialisUberlandiaMG16a	300	18	23	20:47	08/12/2018	Uberlândia (MG)
P. hypochondrialis	Pithecopus_hypochondrialisUberlandiaMG17a	100	18	23	20:47	08/12/2018	Uberlândia (MG)
P. hypochondrialis	Pithecopus_hypochondrialisVeadeirosGO1a	100	22	24	19:27	13/11/2012	Alto Paraíso de Góias (GO)
P. hypochondrialis	Pithecopus_hypochondrialisVeadeirosGO1b	100	22	24	19:30	13/11/2012	Alto Paraíso de Góias (GO)
P. hypochondrialis	Pithecopus_hypochondrialisVeadeirosGO2a	100	20.4	20.8	22:26	06/02/2019	Alto Paraíso de Góias (GO)

P. hypochondrialis	Pithecopus_hypochondrialisVeadeirosGO2b	100	20.4	20.8	22:07	06/02/2019	Alto Paraíso de Góias (GO)
P. hypochondrialis	Pithecopus_hypochondrialisVeadeirosGO2c	100	20.4	20.8	22:30	06/02/2019	Alto Paraíso de Góias (GO)
P. hypochondrialis	Pithecopus_hypochondrialisVeadeirosGO3a	100	20.4	20.8	21:53	06/02/2019	Alto Paraíso de Góias (GO)
P. hypochondrialis	Pithecopus_hypochondrialisVeadeirosGO3b	100	20.4	20.8	21:58	06/02/2019	Alto Paraíso de Góias (GO)
P. hypochondrialis	Pithecopus_hypochondrialisVeadeirosGO3c	100	20.4	20.8	22:03	06/02/2019	Alto Paraíso de Góias (GO)
P. hypochondrialis	Pithecopus_hypochondrialisVeadeirosGO3d	100	20.4	20.8	22:05	06/02/2019	Alto Paraíso de Góias (GO)
P. hypochondrialis	Pithecopus_hypochondrialisVeadeirosGO4a	100	20.4	20.8	22:13	06/02/2019	Alto Paraíso de Góias (GO)
P. hypochondrialis	Phyllom_azureaMG1	300	22	26	20:39	28/12/2010	Uberlândia (MG)
P. hypochondrialis	Phyllom_azureaMG2a	100	22	26	20:42	28/12/2010	Uberlândia (MG)
P. hypochondrialis	Phyllom_azureaMG2b	100	22	26	20:45	28/12/2010	Uberlândia (MG)
P. hypochondrialis	Phyllom_azureaMG3	100	22	26	21:04	28/12/2010	Uberlândia (MG)
P. hypochondrialis	Phyllom_azureaMG4	100	22	26	21:19	28/12/2010	Uberlândia (MG)
P. hypochondrialis	Phyllom_azureaMG5	100	22	26	21:23	28/12/2010	Uberlândia (MG)
P. hypochondrialis	Phyllom_azureaMG6b	100	22	26	21:51	28/12/2010	Uberlândia (MG)
P. hypochondrialis	Phyllom_azureaMG6c	100	22	26	21:56	28/12/2010	Uberlândia (MG)
P. hypochondrialis	Phyllom_azureaMG7	100	22	26	22:30	28/12/2010	Uberlândia (MG)
P. hypochondrialis	Phyllom_azureaMG8a	100	22	26	22:43	28/12/2010	Uberlândia (MG)

P. hypochondrialis	Phyllom_azureaMG8b	100	22	26	22:54	28/12/2010	Uberlândia (MG)
P. hypochondrialis	Phyllom_azureaMG8c	100	22	26	22:52	28/12/2010	Uberlândia (MG)
P. hypochondrialis	Phyllom_azureaMG8d	100	22	26	22:54	28/12/2010	Uberlândia (MG)
P. hypochondrialis	Phyllom_azureaMG8e	100	22	26	22:55	28/12/2010	Uberlândia (MG)
P. hypochondrialis	Phyllom_azureaMG8f	500	22	26	22:57	28/12/2010	Uberlândia (MG)
P. hypochondrialis	Phyllom_azureaMG8g	100	22	26	22:58	28/12/2010	Uberlândia (MG)
P. hypochondrialis	Phyllom_azureaMG9	100	22	26	23:19	28/12/2010	Uberlândia (MG)
P. megacephalus	CBUFMG 444	500	-	-	-	09/01/2011	Botumirim (MG)
P. megacephalus	CBUFMG 450	100	-	-	-	18/12/2007	Rio Pardo de Minas (MG)
P. megacephalus	CBUFMG 452	300	-	-	-	18/12/2007	Rio Pardo de Minas (MG)
P. megacephalus	CBUFMG 453	500	-	-	-	20/12/2007	Rio Pardo de Minas (MG)
P. megacephalus	CBUFMG 454	500	-	-	-	20/12/2007	Rio Pardo de Minas (MG)
P. megacephalus	CBUFMG 1031	100	-	-	-	27/01/2020	Botumirim (MG)
P. megacephalus	CBUFMG 1100	100	-	-	-	08/01/2020	Augusto de Lima (MG)
P. megacephalus	CBUFMG 1101	500	-	-	-	08/01/2020	Augusto de Lima (MG)
P. megacephalus	CBUFMG 1102	100	-	-	-	08/01/2020	Augusto de Lima (MG)
P. megacephalus	CBUFMG 1105	500	-	-	-	09/01/2020	Itacambira (MG)

P. megacephalus	Pithecopus_megacepCipoMG1a	500	18.8	20.7	-	03/12/2005	Santana do Riacho (MG)
P. megacephalus	Pithecopus_megacepCipoMG2a	500	18.8	20.7	-	03/12/2005	Santana do Riacho (MG)
P. megacephalus	Pithecopus_megacepCipoMG3A	500	17.9	22.9	18:40	04/12/2005	Santana do Riacho (MG)
P. megacephalus	FNJV 31484	100	21	-	00:50	01/12/2005	Grão Mogol (MG)
P. megacephalus	FNJV 32069	100	20	-	20:15	10/12/1973	Serra do Cipó (MG)
P. nordestinus	ASUFRN 393	100	20	-	20:50	13/07/2013	Parapiranga (BA)
P. nordestinus	ASUFRN 394	100	20	-	21:10	13/07/2013	Parapiranga (BA)
P. nordestinus	ASUFRN 397	100	-	-	-	13/07/2013	Parapiranga (BA)
P. nordestinus	ASUFRN 398	100	20	-	22:00	13/07/2013	Parapiranga (BA)
P. nordestinus	ASUFRN 399	100	20.5	-	-	19/07/2013	Jaguaquara (BA)
P. nordestinus	ASUFRN 400	100	19.5	-	19:50	19/07/2013	Jaguaquara (BA)
P. nordestinus	ASUFRN 401	100	-	-	-	19/07/2013	Jaguaquara (BA)
P. nordestinus	ASUFRN 402	100	-	-	21:10	19/07/2013	Jaguaquara (BA)
P. nordestinus	ASUFRN 403	100	18	-	-	19/07/2013	Jaguaquara (BA)
P. nordestinus	ASUFRN 404	100	18	-	-	19/07/2013	Jaguaquara (BA)
P. nordestinus	ASUFRN 405	100	18	-	-	19/07/2013	Jaguaquara (BA)
P. nordestinus	ASUFRN 406	100	25.9	-	-	19/07/2013	Jaguaquara (BA)

P. nordestinus	ASUFRN 407	100	27.3	-	-	20/07/2013	Igrapiúna (BA)
P. nordestinus	ASUFRN 408	100	21.3	-	-	20/07/2013	Igrapiúna (BA)
P. nordestinus	ASUFRN 409	100	19	-	-	20/07/2013	Igrapiúna (BA)
P. nordestinus	ASUFRN 410	100	19	-	-	20/07/2013	Igrapiúna (BA)
P. nordestinus	ASUFRN 412	100	21.3	-	-	21/07/2013	Igrapiúna (BA)
P. nordestinus	ASUFRN 413	100	20.5	-	-	21/07/2013	Igrapiúna (BA)
P. nordestinus	ASUFRN 415	100	-	-	-	21/07/2013	Igrapiúna (BA)
P. nordestinus	ASUFRN 416	100	18.8	-	23:30	21/07/2013	Igrapiúna (BA)
P. nordestinus	ASUFRN 417	100	-	-	-	23/07/2013	Mata de São João (BA)
P. nordestinus	ASUFRN 418	100	-	-	-	23/07/2013	Mata de São João (BA)
P. nordestinus	ASUFRN 421	100	18	-	-	23/07/2013	Mata de São João (BA)
P. nordestinus	ASUFRN 422	100	18	-	21:30	23/07/2013	Mata de São João (BA)
P. nordestinus	ASUFRN 423	100	18	-	21:30	23/07/2013	Mata de São João (BA)
P. nordestinus	ASUFRN 424	100	18	-	-	23/07/2013	Mata de São João (BA)
P. nordestinus	ASUFRN 427	100	16.8	-	-	23/07/2013	Mata de São João (BA)
P. nordestinus	ASUFRN 428	100	16.3	-	-	23/07/2013	Mata de São João (BA)
P. nordestinus	ASUFRN 429	100	22.2	-	-	25/07/2013	Estância (SE)

P. nordestinus	ASUFRN 430	100	23.2	-	-	25/07/2013	Estância (SE)
P. nordestinus	ASUFRN 431	100	22.4	-	21:40	25/07/2013	Estância (SE)
P. nordestinus	FNJV 12243	100	27	-	21:20	05/05/2011	Areia Branca (SE)
P. nordestinus	FNJV 12244	100	27	-	21:25	05/05/2011	Areia Branca (SE)
P. nordestinus	FNJV 12245	100	27	-	21:30	05/05/2011	Areia Branca (SE)
P. nordestinus	FNJV 45456	500	-	-	21:04	20/11/2007	Igrapiúna (BA)
P. nordestinus	FNJV 45468	100	21	-	20:31	20/11/2007	Igrapiúna (BA)
P. oreades	Pithecopus_oreadesMinacuGO1a	500	28	-	19:13	21/11/2014	Minaçu (GO)
P. oreades	Pithecopus_oreadesMinacuGO1b	500	28	-	19:25	21/11/2014	Minaçu (GO)
P. oreades	Pithecopus_oreadesMinacuGO1c	500	28	-	19:35	21/11/2014	Minaçu (GO)
P. oreades	Pithecopus_oreadesMinacuGO2a	300	28	-	19:59	21/11/2014	Minaçu (GO)
P. oreades	Pithecopus_oreadesMinacuGO2b	300	28	-	20:00	21/11/2014	Minaçu (GO)
P. oreades	Pithecopus_oreadesMinacuGO2c	300	28	-	20:01	21/11/2014	Minaçu (GO)
P. oreades	Pithecopus_oreadesMinacuGO2d	300	28	-	20:04	21/11/2014	Minaçu (GO)
P. oreades	Pithecopus_oreadesMinacuGO3a	300	28	-	20:10	21/11/2014	Minaçu (GO)
P. oreades	Pithecopus_oreadesMinacuGO3b	300	28	-	20:10	21/11/2014	Minaçu (GO)
P. oreades	Pithecopus_oreadesMinacuGO3c	300	28	-	20:22	21/11/2014	Minaçu (GO)

P. oreades	Pithecopus_oreadesMinacuGO4a	300	28	-	20:30	21/11/2014	Minaçu (GO)
P. oreades	Pithecopus_oreadesMinacuGO4b	300	28	-	20:31	21/11/2014	Minaçu (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO1a	300	17.8	21.4	-	02/12/2010	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO1b	100	17.8	21.4	23:05	02/12/2010	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO1c	100	17.8	21.4	23:20	02/12/2010	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO1d	100	17.8	21.4	23:23	02/12/2010	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO1e	100	17.8	21.4	23:30	02/12/2010	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO5a	300	20	-	23:00	18/11/2011	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO5b	100	20	-	23:06	18/11/2011	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO5c	100	20	-	23:00	18/11/2011	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO6a	100	20	-	23:32	18/11/2011	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO6b	100	20	-	-	18/11/2011	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO7a	300	20	20	-	11/12/2011	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO7b	300	20	20	-	11/12/2011	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO7c	500	20	20	-	11/12/2011	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO8a	100	22	22	21:02	13/12/2012	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO8b	100	22	22	21:09	13/12/2012	Alto Paraíso de Goías (GO)

P. oreades	Pithecopus_oreadesVeadeirosGO8d	100	22	22	21:17	13/12/2012	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO8e	100	22	22	21:18	13/12/2012	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO8f	500	22	22	21:18	13/12/2012	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO8g	300	22	22	21:19	13/12/2012	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO8h	500	22	22	21:21	13/12/2012	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO9a	300	21	21	21:54	13/12/2012	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO9b	300	21	21	22:01	13/12/2012	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO9c	300	21	21	22:04	13/12/2012	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO9d	300	21	21	22:07	13/12/2012	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO10a	300	21	21	19:19	14/12/2012	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO10b	300	21	21	19:20	14/12/2012	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO11a	300	21	22	21:44	15/12/2012	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO11b	300	21	22	21:53	15/12/2012	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO11c	300	21	22	21:55	15/12/2012	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO12a	300	21	22	22:10	15/12/2012	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO12b	300	21	22	22:11	15/12/2012	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO12c	300	21	22	22:13	15/12/2012	Alto Paraíso de Goías (GO)

P. oreades	Pithecopus_oreadesVeadeirosGO12d	300	21	22	22:16	15/12/2012	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO12e	300	21	22	22:18	15/12/2012	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO12f	500	21	22	22:21	15/12/2012	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO12g	300	21	22	22:22	15/12/2012	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO12h	300	21	22	22:23	15/12/2012	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO12i	300	21	22	22:31	15/12/2012	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO13a	500	23	24.5	21:24	28/11/2013	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO13b	500	23	24.5	21:27	28/11/2013	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO13c	500	23	24.5	21:31	28/11/2013	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO14a	100	23	24.5	22:06	28/11/2013	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO15a	100	23	24.5	22:26	28/11/2013	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO15b	100	23	24.5	22:28	28/11/2013	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO16a	100	23	24.5	22:38	28/11/2013	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO16b	300	23	24.5	22:45	28/11/2013	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO17a	500	23	24.5	23:00	28/11/2013	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO18a	500	21	22.3	22:25	28/11/2013	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO18b	100	21	22.3	22:44	28/11/2013	Alto Paraíso de Goías (GO)

P. oreades	Pithecopus_oreadesVeadeirosGO19a	500	24	25	21:37	14/01/2015	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_oreadesVeadeirosGO21a	500	24	25	22:05	14/01/2015	Alto Paraíso de Goías (GO)
P. oreades	Pithecopus_araguariBrasiliaDF1a	500	21.5	23.3	18:50	12/12/2010	Brasilia (DF)
P. oreades	Pithecopus_araguariBrasiliaDF1b	300	21.5	23.3	19:47	12/12/2010	Brasilia (DF)
P. oreades	Pithecopus_araguariBrasiliaDF2a	300	21.5	23.3	19:17	12/12/2010	Brasilia (DF)
P. oreades	Pithecopus_araguariBrasiliaDF2b	300	21.5	23.3	19:17	12/12/2010	Brasilia (DF)
P. oreades	Pithecopus_araguariBrasiliaDF2c	300	21.5	23.3	19:22	12/12/2010	Brasilia (DF)
P. oreades	Pithecopus_araguariBrasiliaDF2d	300	21.5	23.3	19:34	12/12/2010	Brasilia (DF)
P. oreades	Pithecopus_araguariBrasiliaDF3a	300	19.4	-	22:52	23/11/2013	Brasilia (DF)
P. oreades	Pithecopus_araguariBrasiliaDF4a	300	19.4	-	21:39	23/11/2013	Brasilia (DF)
P. oreades	Pithecopus_araguariBrasiliaDF5a	500	19.4	-	22:38	23/11/2013	Brasilia (DF)
P. oreades	Pithecopus_araguariCaldasNovasGO1a	500	22.7	23.9	20:25	07/11/2010	Caldas Novas (GO)
P. oreades	Pithecopus_araguariCaldasNovasGO1b	500	22.7	23.9	20:26	07/11/2010	Caldas Novas (GO)
P. oreades	Pithecopus_araguariCaldasNovasGO1c	500	22.7	23.9	21:30	07/11/2010	Caldas Novas (GO)
P. oreades	Pithecopus_araguariCaldasNovasGO1d	300	22.7	23.9	21:50	07/11/2010	Caldas Novas (GO)
P. oreades	Pithecopus_araguariCaldasNovasGO1e	300	22.7	23.9	22:05	07/11/2010	Caldas Novas (GO)
P. oreades	Pithecopus_araguariCaldasNovasGO1f	300	22.7	23.9	22:15	07/11/2010	Caldas Novas (GO)

P. oreades	Pithecopus_araguariCaldasNovasGO2a	300	23.7	24.6	20:22	27/11/2010	Caldas Novas (GO)
P. oreades	Pithecopus_araguariCaldasNovasGO2b	300	23.7	24.6	20:29	27/11/2010	Caldas Novas (GO)
P. oreades	Pithecopus_araguariCaldasNovasGO2c	300	23.7	24.6	20:30	27/11/2010	Caldas Novas (GO)
P. oreades	Pithecopus_araguariCaldasNovasGO2d	300	23.7	24.6	20:31	27/11/2010	Caldas Novas (GO)
P. oreades	Pithecopus_araguariCaldasNovasGO2e	300	23.7	24.6	20:33	27/11/2010	Caldas Novas (GO)
P. oreades	Pithecopus_araguariCaldasNovasGO3a	300	21	23	22:05	26/11/2011	Caldas Novas (GO)
P. oreades	Pithecopus_araguariCaldasNovasGO3b	300	21	23	22:05	26/11/2011	Caldas Novas (GO)
P. oreades	Pithecopus_araguariCaldasNovasGO3c	300	21	23	22:05	26/11/2011	Caldas Novas (GO)
P. oreades	Pithecopus_araguariCaldasNovasGO3d	300	21	23	22:10	26/11/2011	Caldas Novas (GO)
P. oreades	Pithecopus_araguariCaldasNovasGO4a	300	25.7	-	20:42	05/12/2013	Caldas Novas (GO)
P. oreades	Pithecopus_araguariCaldasNovasGO4b	300	25.7	-	20:44	05/12/2013	Caldas Novas (GO)
P. oreades	Pithecopus_araguariCaldasNovasGO4c	300	25.7	-	20:47	05/12/2013	Caldas Novas (GO)
P. oreades	Pithecopus_araguariCaldasNovasGO4d	300	25.7	-	21:04	05/12/2013	Caldas Novas (GO)
P. oreades	Pithecopus_araguariCaldasNovasGO4e	300	25.7	-	21:27	05/12/2013	Caldas Novas (GO)
P. oreades	Pithecopus_araguariCaldasNovasGO5a	300	25.7	-	20:42	05/12/2013	Caldas Novas (GO)
P. oreades	Pithecopus_araguariCaldasNovasGO5b	300	25.7	-	20:44	05/12/2013	Caldas Novas (GO)
P. oreades	Pithecopus_araguariCaldasNovasGO5c	100	25.7	-	20:47	05/12/2013	Caldas Novas (GO)

P. oreades	Pithecopus_araguariCaldasNovasGO5d	100	25.7	-	21:04	05/12/2013	Caldas Novas (GO)
P. oreades	Pithecopus_araguariCaldasNovasGO5e	100	25.7	-	21:27	05/12/2013	Caldas Novas (GO)
P. oreades	Pithecopus_araguariCristalGO1a	500	24	24.1	21:05	04/12/2010	Cristalina (GO)
P. oreades	Pithecopus_araguariCristalGO1b	500	24	24.1	21:19	04/12/2010	Cristalina (GO)
P. oreades	Pithecopus_araguariCristalGO1c	500	24	24.1	21:21	04/12/2010	Cristalina (GO)
P. oreades	Pithecopus_araguariCristalGO1d	500	24	24.1	21:25	04/12/2010	Cristalina (GO)
P. oreades	Pithecopus_araguariCristalGO1e	500	24	24.1	21:13	04/12/2010	Cristalina (GO)
P. oreades	Pithecopus_araguariCristalGO1f	500	24	24.1	21:30	04/12/2010	Cristalina (GO)
P. oreades	Pithecopus_araguariCristalGO2a	500	19	22	21:27	20/11/2011	Cristalina (GO)
P. oreades	Pithecopus_araguariCristalGO2b	100	19	22	21:27	20/11/2011	Cristalina (GO)
P. oreades	Pithecopus_araguariCristalGO2c	100	19	22	21:27	20/11/2011	Cristalina (GO)
P. oreades	Pithecopus_araguariCristalGO2d	100	19	22	21:27	20/11/2011	Cristalina (GO)
P. oreades	Pithecopus_araguariCristalGO2e	100	19	22	21:27	20/11/2011	Cristalina (GO)
P. oreades	Pithecopus_araguariCristalGO2f	100	19	22	21:27	20/11/2011	Cristalina (GO)
P. oreades	Pithecopus_araguariCristalGO2g	100	19	22	21:27	20/11/2011	Cristalina (GO)
P. oreades	Pithecopus_araguariCristalGO2h	500	19	22	21:27	20/11/2011	Cristalina (GO)
P. oreades	Pithecopus_araguariCristalGO2i	100	19	22	21:27	20/11/2011	Cristalina (GO)

P. oreades	Pithecopus_araguariParacatuMG1a	500	24	-	20:03	08/01/2013	Paracatu (MG)
P. oreades	Pithecopus_araguariParacatuMG1b	500	24	-	20:05	08/01/2013	Paracatu (MG)
P. oreades	Pithecopus_araguariParacatuMG1c	500	24	-	-	08/01/2013	Paracatu (MG)
P. oreades	Pithecopus_araguariParacatuMG2a	500	24	-	20:32	08/01/2013	Paracatu (MG)
P. oreades	Pithecopus_araguariParacatuMG2c	500	24	-	20:54	08/01/2013	Paracatu (MG)
P. oreades	Pithecopus_araguariParacatuMG2d	100	24	-	21:03	08/01/2013	Paracatu (MG)
P. palliatus	ML 198678	100	25.2	-	23:16	09/01/1989	Madre de Dios (Peru)
P. palliatus	ML 198680	100	23.8	-	23:50	06/01/1989	Madre de Dios (Peru)
P. palliatus	ML 198714	-	-	-	20:10	11/01/1989	Madre de Dios (Peru)
P. palliatus	ML 198885	-	-	-	23:30	01/12/1990	Madre de Dios (Peru)
P. palliatus	ML 222290	-	-	-	-	04/01/1989	Madre de Dios (Peru)
P. palliatus	FZ 7293	-	-	-	-	05/05/1969	Santa Cecilia (Equador)
P. palliatus	FZ 7413	-	25	-	-	02/05/1969	Santa Cecilia (Equador)
P. palliatus	FZ 7825	-	25	-	-	30/04/1969	Santa Cecilia (Equador)
P. rohdei	FNJV 31162	100					Ubatuba (SP)
P. rohdei	Pithecopus_rohdeiSalesopolisSP1a	100	22	23	20:32	27/12/2015	Salesópolis (SP)
P. rohdei	Pithecopus_rohdeiSalesopolisSP1b	100	22	23	23:18	27/12/2015	Salesópolis (SP)

P. rohdei	Pithecopus_rohdeiSalesopolisSP1c	100	22	23	23:27	27/12/2015	Salesópolis (SP)
P. rohdei	Pithecopus_rohdeiSalesopolisSP2a	100	22	23	23:11	27/12/2015	Salesópolis (SP)
P. rohdei	Pithecopus_rohdeiSalesopolisSP2b	100	22	23	23:13	27/12/2015	Salesópolis (SP)
P. rohdei	Pithecopus_rohdeiSalesopolisSP3a	100	23	-	20:34	28/12/2015	Salesópolis (SP)
P. rohdei	ASUFRN 445	100	23.7	-	20:43	14/11/2021	Ilhéus (BA)
P. rohdei	ASUFRN 447	100	23.8	-	21:38	14/11/2021	Ilhéus (BA)
P. rohdei	ASUFRN 448	100	23.5	-	22:31	14/11/2021	Ilhéus (BA)
P. rohdei	ASUFRN 449	100	23.3	-	23:42	14/11/2021	Ilhéus (BA)
P. rohdei	ASUFRN 450	100	23.4	-	00:12	14/11/2021	Ilhéus (BA)
P. rohdei	ASUFRN 451	100	23.2	-	00:31	14/11/2021	Ilhéus (BA)
P. rohdei	CBUFV 161	100	-	-	-	-	Marliéria (MG)
P. rusticus	FNJV 36566	100	16	-	-	30/11/2013	Água Doce (SC)
P. rusticus	FNJV 36567	100	16	-	-	30/11/2013	Água Doce (SC)
*P. rusticus**	1004	100	17.6	-	20:45	06/12/2016	Água Doce (SC)
*P. rusticus**	1011	100	-	-	-	06/12/2016	Água Doce (SC)
*P. rusticus**	1013	100	17.5	-	21:10	06/12/2016	Água Doce (SC)
*P. rusticus**	1016	100	17.1	-	21:25	06/12/2016	Água Doce (SC)

*P. rusticus**	1018	100	-	-	-	06/12/2016	Água Doce (SC)
*P. rusticus**	1019	100	-	-	-	06/12/2016	Água Doce (SC)
*P. rusticus**	1020	100	-	-	-	06/12/2016	Água Doce (SC)
*P. rusticus**	1022	100	16.6	-	21:50	06/12/2016	Água Doce (SC)
*P. rusticus**	1023	100	-	-	-	06/12/2016	Água Doce (SC)
*P. rusticus**	1024	100	-	-	-	06/12/2016	Água Doce (SC)
*P. rusticus**	1026	100	15.9	-	22:15	06/12/2016	Água Doce (SC)
*P. rusticus**	1027	100	16.1	-	22:05	06/12/2016	Água Doce (SC)
*P. rusticus**	1028	100	-	-	-	06/12/2016	Água Doce (SC)
*P. rusticus**	1029	100	16.1	-	22:10	06/12/2016	Água Doce (SC)
*P. rusticus**	1002	100	-	-	-	24/10/2016	Água Doce (SC)
*P. rusticus**	1004	100	-	-	-	24/10/2016	Água Doce (SC)
*P. rusticus**	1027	100	19	-	-	24/10/2016	Água Doce (SC)
*P. rusticus**	1033	100	-	-	-	24/10/2016	Água Doce (SC)
*P. rusticus**	1034	100	19	-	21:00	24/10/2016	Água Doce (SC)
*P. rusticus**	1037	100	19	-	22:04	24/10/2016	Água Doce (SC)
*P. rusticus**	1038	100	19	-	22:12	24/10/2016	Água Doce (SC)

*P. rusticus**	1041	100	19	-	22:30	24/10/2016	Água Doce (SC)
*P. rusticus**	1042	100	19	-	22:30	24/10/2016	Água Doce (SC)
*P. rusticus**	1043	100	19	-	22:37	24/10/2016	Água Doce (SC)
*P. rusticus**	1046	100	18	-	20:40	26/10/2016	Água Doce (SC)
*P. rusticus**	1052	100	17.5	-	21:45	26/10/2016	Água Doce (SC)
*P. rusticus**	1018	500	19	-	20:45	15/11/2023	Água Doce (SC)
*P. rusticus**	1007	100	19	-	20:15	15/11/2023	Água Doce (SC)

APPENDIX II – Link to article published with data derived from the Master’s dissertation.

Full article: Evidence of escalated aggressive calling behavior in a male agonistic interaction of the reticulated leaf frog Pithecopus ayeaye