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PRELIMINARY OBSERVATIONS ON THE SAN MARTIN TITI MONKEY *PLECTUROCEBUS OENANTHE* THOMAS, 1924 (MAMMALIA: PRIMATES: PITHECIIDAE) VOCALIZATIONS AT TARANGUE, PERU.

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Introduction

Like other members of the former *Callicebus* species group (*Callicebus*, *Cheracebus* and *Plecturocebus*, *Sensu* Byrne et al., 2016), the San Martin titi monkey (*Plecturocebus oenanthe*, *Sensu* Byrne et al., 2016) engages regularly in ritualized bouts of song, defined by Moynihan (1966) as a series of rapidly and regularly repeated notes, distinctly separated from preceding and succeeding notes by long pauses. For socially monogamous, territorial species such as titi monkeys, night monkeys and gibbons (Kawai et al., 1982; Mitani 1984; Fernandez-Duque 2011), loud calls (including song) are thought to define territorial boundaries, and may strengthen and/or maintain bonds between mates (Wickler 1980; Kinzey and Robinson 1983; Robinson et al., 1987; Müller and Anzenberger 2002; Caselli et al., 2014). The vocal behavior of titi monkeys has been the focus of several studies (for example Moynihan 1966; Robinson 1979; Kinzey and Robinson 1983; Müller and Anzenberger 2002; Kitzmann et al., 2008; Cäsar et al., 2012a; Caselli et al., 2014). However, the repertoire of only one species of titi monkey, *Plecturocebus cupreus* (formerly *Callicebus moloch*), has been well-described (Moynihan 1966; Robinson 1979; Robinson 1981; Robinson et al., 1987). More recently, researchers described in detail the acoustic properties of the syllables of which the loud calls and song of *Callicebus nigrifrons* are composed (Caselli et al., 2014).

The San Martin titi monkey (*P. oenanthe*) is endemic to a small area of the department of San Martin in Northern Peru (Bóveda-Penalba et al., 2009; Shanee et al., 2011). It is classified as Critically Endangered (IUCN 2011) and has been the focus of relatively few studies (Mark 2003; Rowe and Martinez 2003; deLuycker 2006, 2007; Aldrich et al., 2008; deLuycker 2012; van Kuijk et al., 2015; Allgas et al., 2016).

During a short survey in Northern Peru, recordings were made of individual and group vocalizations of *P. oenanthe*. Suitable recordings were later analyzed in order to begin describing the species' vocal repertoire. Evidence for inter-individual differences in similar calls was sought, in anticipation of future investigation into the usefulness of vocal behavior as a censusing and monitoring tool for highly vocal primate species.

Methods

Field work was conducted on 25 days between May and August 2006 at Tarangue, a small private reserve (~ 60 ha) near Moyobamba in Northern Peru (5° 58' 28.2" S, 76° 59' 34.6" W). The reserve was then owned by French/Peruvian NGO IKAMA Peru and was composed of disturbed primary forest (48.5ha) and regenerating secondary forest (11.5ha) in addition to cleared areas slated for reforestation (Fig. 1). Data were collected at five different listening points in or near the forested areas of the reserve (Fig. 1). Fieldwork began at 06.30 and continued until 09.30 or until groups were no longer singing (whichever came last). Data were not collected on bad weather days. Information was recorded about the time and location of each bout of song, and group composition and behavior wherever possible. Audio recordings were made opportunistically by B. Aldrich using a Marantz PMD 222 Professional cassette

recorder, an Audio-Technica AT897 line and gradient condenser microphone and TDK IEC/type I 60-minute audiocassettes mounted on a tripod to reduce noise (Geissmann 2003). Recordings were made from between approx. four and 25 meters.

Recordings of suitable quality for analysis were digitized at rates between 16 and 48 kHz using Avisoft Recorder version 2.9 (Avisoft Bioacoustics). Clearly defined calls were isolated, and spectrograms were produced of each of these for description and visual comparison with previously described titi monkey vocalizations. We compared chirrup vocalizations from two individuals recorded in this study. The 35 clearest bi-syllabic chirrup notes for each individual were measured for duration, dominant frequency, maximum frequency and fundamental frequency. The recorded vocalizations were compared to those described by Moynihan (1966) and Robinson (1979) for *P. cupreus* (the red titi monkey). Mason (1966), Robinson (1979), Kinzey and Robinson (1983), Müller and Anzenberger (2002) and Caselli (2014) were also consulted for aid with comparison. Few tri- and monosyllabic chirrups were observed and were therefore not compared.

Although data were not normally distributed, for t-tests, sample sizes of 30+ normally overcome this assumption. Therefore, paired samples t-tests were performed with each pair of variables to identify consistent significant differences in parameters.

Results

A total of 420 minutes of vocalizations were recorded. Recordings from seven different occasions at three locations were of sufficient quality for analysis. A reliable count of the number of different individuals recorded or the age-sex classes of individuals was not possible due to poor visibility from listening points and possible disturbance caused by approaching non-habituated animals while recording.

Four distinguishable vocalizations that had previously been described for other titi monkey species were isolated: chirrups; pumps; resonating notes; moans (these are probably homologous to those described by Robinson (1979) and Moynihan (1966) for *P. cupreus*). Three additional vocalizations, undescribed in other titi species, were also identified: "pant hoots", so named for their resemblance (personal observation) to the *spontaneous pant-hoots* of captive chimpanzees (Goodall 1986), whines, and whinnies (see table 1 and figures 2-5). Of the digitized recordings only a single instance contained a clearly separate series of 'chirrups' from two separate individuals (of the same group).

No significant differences in duration ($t = -0.437$, $df = 34$, $p = 0.665$) or maximum frequencies ($t = 1.469$, $df = 34$, $p = 0.151$) were detected between the vocalizations of the two individuals (Table 2). There were, however, highly significant inter-individual differences in the dominant ($t =$

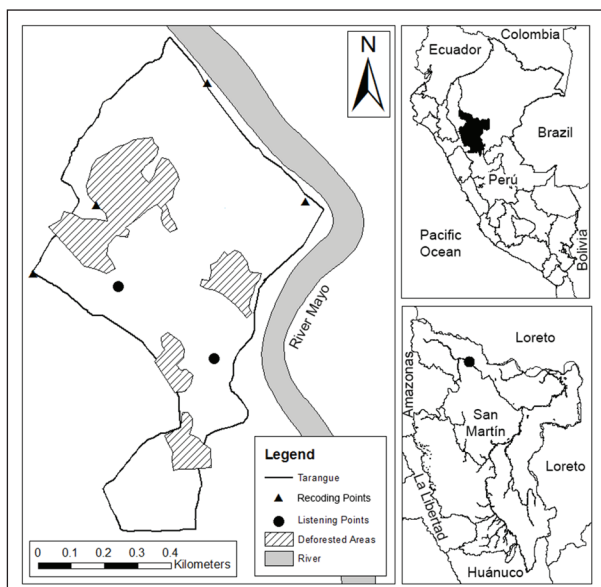


Figure 1. Map showing location of study site and listening points used during this study.

Table 1. Loud calls identified in three species of titi monkey. Comparisons based primarily on written descriptions of calls and on visual comparison of relevant spectrograms where possible - except Caselli et. al (2014). Methodological differences prohibited direct comparison between these and *P. oenanthe* vocalizations and comparisons drawn here are extracted directly from the study itself.

Moynihan 1966 (<i>P. cupreus</i>)	Robinson 1979 (<i>P. cupreus</i>)	Caselli et al 2014 (<i>Callicebus nigrifrons</i>)	This study (<i>P. oenanthe</i>)	Comments
Chirrup	chirrup	aa phrases	chirrup	Common vocalization that appears to be used both as an alarm call and as a prelude to song in <i>P. oenanthe</i> and similarly in <i>P. cupreus</i> . Mono- (Moynihan's "chuck notes"), bi- and occasionally tri-syllabic, the rapidity and intensity of this vocalization varies greatly and intergrades with other vocalizations during song.
chuck Notes				
resonating notes	pants	ab phrases	resonating notes	This study was unable to differentiate between pants, honks and bellows specifically. Resonating notes, as described by Robinson, form a significant part of <i>P. oenanthe</i> morning song.
	honks	bb phrases		
	bellows	bc phrases		
pumping notes	pumps	bc phrases (tentative)	pumps	Identified in <i>P. oenanthe</i> as an element of "chirrup-pump" (Robinson 1979), "chuck-pumping-gobbling" (Moynihan 1966) or "gobbling" (Mason 1966) sequences, which sound much like the gobbling of wild turkeys.
Moans	moans	/	moans (tentative)	Tentatively identified in a single recording; neither written descriptions nor available spectrograms provided sufficient information for certainty.
/	/	/	"pant-hoots"	Resembles the spontaneous pant-hoot in chimpanzees (Goodall 1986), this call may represent a transition from one "resonating note" to another.
/	/	/	whines	So named for its resemblance to the whines of a puppy. Along with "resonating notes", whines occur regularly during <i>P. oenanthe</i> morning song.
/	/	/	whinnies	So named for its resemblance to a high-pitched horse whinny. Along with "resonating notes", whines occur regularly during <i>P. oenanthe</i> morning song.
/	/	ae phrases	/	Insufficient information to compare this vocalization directly to <i>P. oenanthe</i> vocalizations.
Screams	screams	/	/	Absent or unheard in <i>P. oenanthe</i>

Table 2. Characterization of *chirrup*s in two *P. oenanthe* individuals and results of paired-sample t-tests for differences. Significant differences indicate possible 'vocal signatures', but here possibly represent differing age-sex classes (Robinson 1981).

	Individual 1 (n=35)	Individual 2 (n=35)	t-test
Duration (sec)	0.38 ± 0.03	0.38 ± 0.05	$t = -0.437, df = 34, p = 0.665$
Dominant frequency (kHz)	1.51 ± 0.03	1.28 ± 0.30	$t = 4.681, df = 34, p < 0.0001$
Maximum frequency (kHz)	18.95 ± 0.88	18.61 ± 0.81	$t = 1.469, df = 34, p = 0.151$
Fundamental frequency (kHz)	1.86 ± 0.09	1.54 ± 0.05	$t = 22.653, df = 34, p < 0.0001$

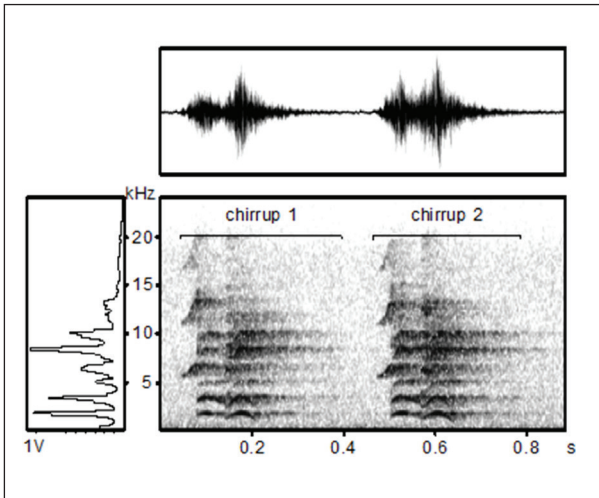


Figure 2. Two bi-syllabic chirrups from a single *P. oenanthe* individual, from a series probably given as an alarm call in response to the presence of researchers.

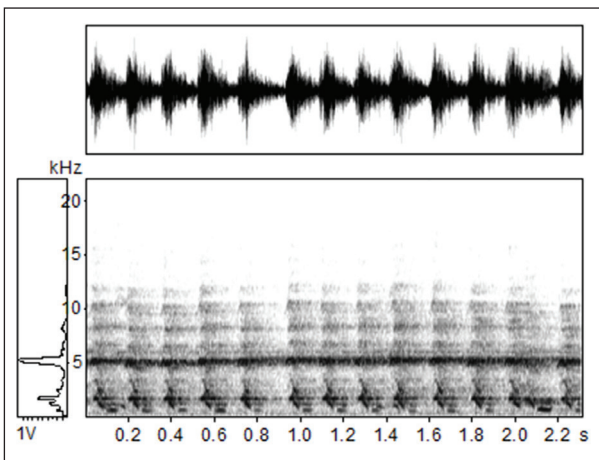


Figure 3. A rapid series of *P. oenanthe* chirrups uttered just prior to transition into song.

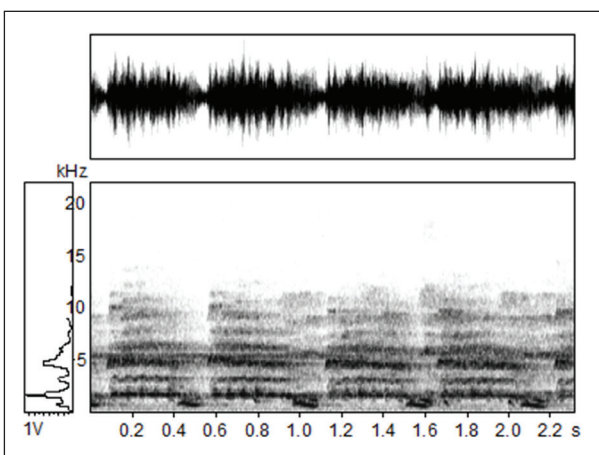


Figure 4. A series of *P. oenanthe* whines, for which no parallel was found in the existing literature on titi monkey vocalizations.

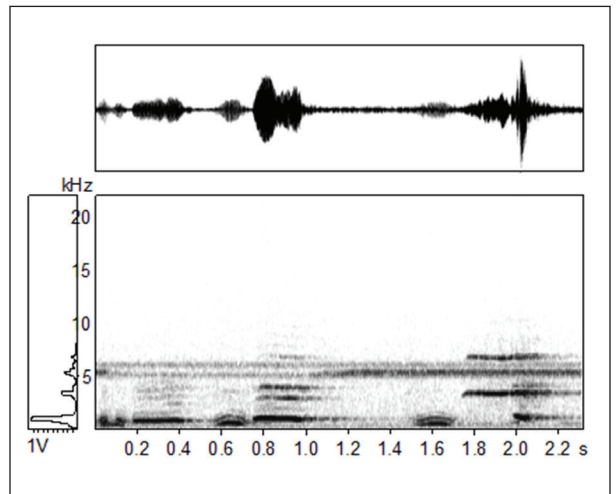


Figure 5. The distinctive *P. oenanthe* “pant-hoot”. It could not be assigned to any of the vocalizations described for *P. cupreus*.

4.681, $df = 34$, $p < 0.0001$) and fundamental frequencies ($t = 22.653$, $df = 34$, $p < 0.0001$). Very little intra-individual variation was found for the dominant or fundamental frequencies.

Discussion

Zimmermann (1995) notes that a description of the vocal repertoire of a given species is a prerequisite to any detailed analytical study. This study, although brief and preliminary, isolated seven loud-call vocalizations of the Critically Endangered *P. oenanthe* and tentatively identifies differences in calls specific to individual animals. The dominant and fundamental frequencies of the *chirrup* calls of two differentiated individuals remained stable for each individual and differed significantly between these individuals, suggesting that these frequencies could be useful in the study of vocal individuality or signatures (Table 2). It is possible, however, that these differences are a reflection of size, sex or developmental stage; Robinson (1979) found measurable differences in pitch and dominant frequency between the chirrups of individual *P. cupreus*, but concluded that the vocalization, although it could be used to distinguish between age-sex classes, was not sufficiently different between members of the same age-sex class to identify individual callers.

Inter-species differences in vocalizations exist throughout the primate order, including differences in organization and/or acoustic structure between closely related species, for example: gibbons, macaques, langurs, galagos, tarsiers (Geissmann 1984; Hohmann 1989, 1990; Bearder et al., 1995; Nietsch 1999). Though our data are minimal, they indicate that there are both strong similarities and marked differences between the vocal repertoires of congeneric *P. cupreus* (Moynihan 1966; Robinson 1979), and *P. oenanthe*.

In order to properly explore the vocal repertoire for *P. oenanthe* more recordings must be obtained, including high

quality recordings of individual contributions to song sequences. Although this study did not conclusively demonstrate individuality in the loud calls of *P. oenanthe*, it was useful in making a preliminary, if tentative, description of common elements of the species' loud vocalizations. Further studies are needed to clarify the elements of its vocal repertoire and confirm individuality in vocalizations.

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- 1977; Boesch and Boesch, 1983, 1984, 1989; Goodall, 1986; McGrew *et al.*, 1997; De Waal, 2016) and bonobos (Jordan, 1982; Ingmanson, 1996; McGrew and Marchant, 1997) but in the last two decades there has been an increase of studies and experiments of tool use by monkeys including macaques (Huffman *et al.*, 2010; Leca *et al.*, 2012; Leca *et al.*, 2016), baboons (van Lawick-Goodall *et al.*, 1973) and capuchins (Fernandes, 1975; Antinucci and Visalberghi, 1986; Westergaard and Fragazsy, 1987; Boinski, 1988; Ritchie and Fragazsy, 1988; Anderson, 1990; Chevalier-Skolnikoff, 1990; Visalberghi, 1990; Anderson and Henneman, 1994; Phillips, 1998; Jalles-Filho and Grassetto, 2008).
- Panger *et al.* (2002) describe some tool-use behaviors that include the “leaf wrap” processing technique, where monkeys wrapped objects such as *Automeris* spp. caterpillars and *Sloanea terniflora* fruits in leaves before rubbing them against a substrate. Fragazsy *et al.* (2004) stated “it is probable that monkeys wrap these objects to reduce the contact with chemical and mechanical defenses that both *Automeris* caterpillars and *Sloanea terniflora* fruit have” (Fragazsy *et al.*, 2004). However there also have been reports of capuchins (*Cebus capucinus*) rubbing *Sloanea terniflora* fruits and *Automeris* caterpillars directly without first wrapping them in leaves (Shumaker *et al.*, 1980; Panger *et al.*, 2002). Similarly Katz and Katz (1936) observed six captive monkeys (3 *Chlorocebus sabaues* and 3 *Cebus capucinus*) wrapping sticky bananas in leaves before picking them up. Huffman *et al.* (2010) observed Japanese macaques (*Macaca fuscata*) wrapping leaves around stones, metallic and plastic objects as a pattern of stone handling behavior (Nahallage and Huffman, 2007; Huffman *et al.*, 2010).
- Persea americana* Mill. (avocado) is a tree native to Central America (Vinha *et al.*, 2013), cultivated in tropical and subtropical climates around the world, belonging to the family Lauraceae. This species has long been divided into three botanically distinguishable groups designated as horticultural races, namely Mexican, Guatemalan and West Indian. The Mexican race is the only one with anise scented leaves (Bergh *et al.*, 1973). The leaves of anise avocado (as it is commonly known in the region) range in size from 8 cm to over 15 cm long with widths varying according to the form of the leaf. This race is distributed from 1,600 to 2,000 meters above sea level (m.a.s.l.) and is characteristic of subtropical wet forest (Mendizabal, 1998). These leaves also have a strong anise smell and flavor due to their estragole content, which is less toxic than anethol, the major volatile component of the characteristic scent of anise (*Pimpinella anisum*) that contains higher levels of toxicity (Marcus and Lichtenstein, 1979; King and Knight, 1992; Sagrero-Nieves and Bartley, 1995; Ozcan and Chalchat, 2006).

USE OF LEAF-WRAPPING AS A FEEDING TECHNIQUE BY CAPTIVE WHITE-FACED CAPUCHIN MONKEYS (*CEBUS CAPUCINUS*) AT THE “ROSY WALTHER” METROPOLITAN ZOO, HONDURAS

Judith M. Luna Lainez

Introduction

Benjamin B. Beck gives us the best-known definition of tool-use as “the external deployment of an unattached environmental object to alter more efficiently the form, position or condition of another object” (Shumaker *et al.*, 2011). Many observations on tool use have been described in chimpanzees (McGrew and Tutin, 1973; McGrew,

Methods

During a study of fur rubbing behavior (Luna, in prep.) in captive white-faced capuchin monkeys (*Cebus capucinus*