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ORIGINAL ARTICLE

Colour variation and taxonomy of *Picumnus limae* Snethlage, 1924 and *P. fulvescens* Stager, 1961 (Piciformes: Picidae)

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Abstract

Picumnus limae Snethlage, 1924 and *Picumnus fulvescens* Stager, 1961 are two similar species of piculets distinguished by their plumage colouration and distribution. We present here a taxonomic reassessment of these two species based on a large sample of museum specimens and photographic material. We show that the two species are highly variable in colouration, showing a clinal colour gradient. *Picumnus fulvescens* is not diagnosable from *P. limae* by any morphological features or vocalization. We thus suggest that *P. fulvescens* should be considered a synonym of *P. limae,* which presents a large variation in plumage colour.

Keywords Caatinga · Tawny piculet · Ochraceous piculet · Clinal variation · Plumage · Morphology

Zusammenfassung

Farbvariation und Taxonomie von Picumnus limae Snethlage, 1924 und P. fulvescens Stager, 1961 (Piciformes: Picidae)

Picumnus limae und *Picumnus fulvescens* sind zwei sehr ähnliche Zwergspechtarten, die typischerweise anhand ihrer Färbung und Verbreitung unterschieden werden. Auf der Grundlage einer großen Stichprobe von Museumsbelegen und fotografischen Bildmaterials stellen wir hier eine taxonomische Neueinstufung dieser beiden Arten vor. Wir zeigen, dass die beiden Arten in der Färbung sehr variabel sind und einen klinalen Farbgradienten aufweisen; weder aufgrund von morphologischen Merkmalen noch anhand von Lautäußerungen kann man *Picumnus fulvescens* von *P. limae* unterscheiden. Daher schlagen wir vor, *P. fulvescens* als Synonym von *P. limae* anzusehen, dessen Gefiederfärbung einer starken Variation unterliegt.

Introduction

To date, about 30 species are assigned to the genus *Picumnus* Temminck, 1825, distributed through Neotropics and Asia (Winkler and Christie 2002). Popularly known as piculets, the delimitation of species is particularly complex, with frequent cases of described species that are later found out to be hybrids or colour variation of a known taxa, with few studies addressing the individual variation based on a large sample of specimens (Short 1982; McCarthy 2006; Rêgo et al. 2014; Remsen et al. 2018). *Picumnus limae* Snethlage, 1924 and *Picumnus fulvescens* Stager, 1961 are good examples of poorly studied species. They are distinguished by the respective white versus ferruginous ventral colouration as well as their presumed disjunct distribution (Winkler and Christie 2002). However, individuals of both forms occur in syntopy across several locations and there are intermediate forms that cannot be reliably assigned to any of the species.

Picumnus limae was described based on light-coloured specimens from Maranguape municipality (03°58′S 38°42′W), Ceará state, NE Brazil (see below). *Picumnus fulvescens* was described a few decades later based on ferruginous specimens from Pernambuco and Alagoas states, some 600 km southeast of *P. limae*-type locality. The description

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of *P. fulvescens* occurred almost simultaneously to the description of *P. limae saturatus* Pinto and Camargo 1961, based on a single specimen of intermediate colouration from Paraíba state (midway between Alagoas/Pernambuco and Ceará states). Pinto (1978) later considered *P. limae saturatus* a synonym of *P. limae fulvescens*, which retained nomenclatural priority by just 1 day. His conclusions were, however, largely overlooked by subsequent authors (e.g. Winkler and Christie 2002).

Although the specimens used for the descriptions of *P. limae* and *P. fulvescens* are quite distinct from one another, there are syntopic individuals with different patterns of intermediate and typical colouration. These individuals are not restricted to the contact zone between the extreme phenotypes, but show a clinal pattern with lighter birds in north and darker birds in south of the distribution. This geographical conundrum challenges the specific differentiation between both taxa. Instead, they may support the existence of a single species of piculet with clinal variation in colour. The present study presents a taxonomic revision of *P. limae* and *P. fulvescens*, focusing on the colour variation and distributional patterns based on the largest sample of individuals known so far (Fig. 1).

Methods

We examined 68 specimens (see Supplementary material and Fig. 1) previously identified as *P. limae* and *P. fulvescens*, including all the related type material, deposited in the following collections: American Museum of Natural History (AMNH, New York, USA); Museu de Zoologia da Universidade de São Paulo (MZUSP, São Paulo, Brazil); Museu Nacional, Universidade Federal do Rio de Janeiro (MNRJ, Rio de Janeiro, Brazil); Museum für Naturkunde (ZMB, Berlin, Germany); Universidade Federal de Pernambuco (UFPE, Recife, Brazil); Universidade Federal do Rio Grande do Norte (COUFRN, Natal, Brazil).

We analysed the general plumage colouration by comparing the specimens using a colour chart (Munsell 1994)

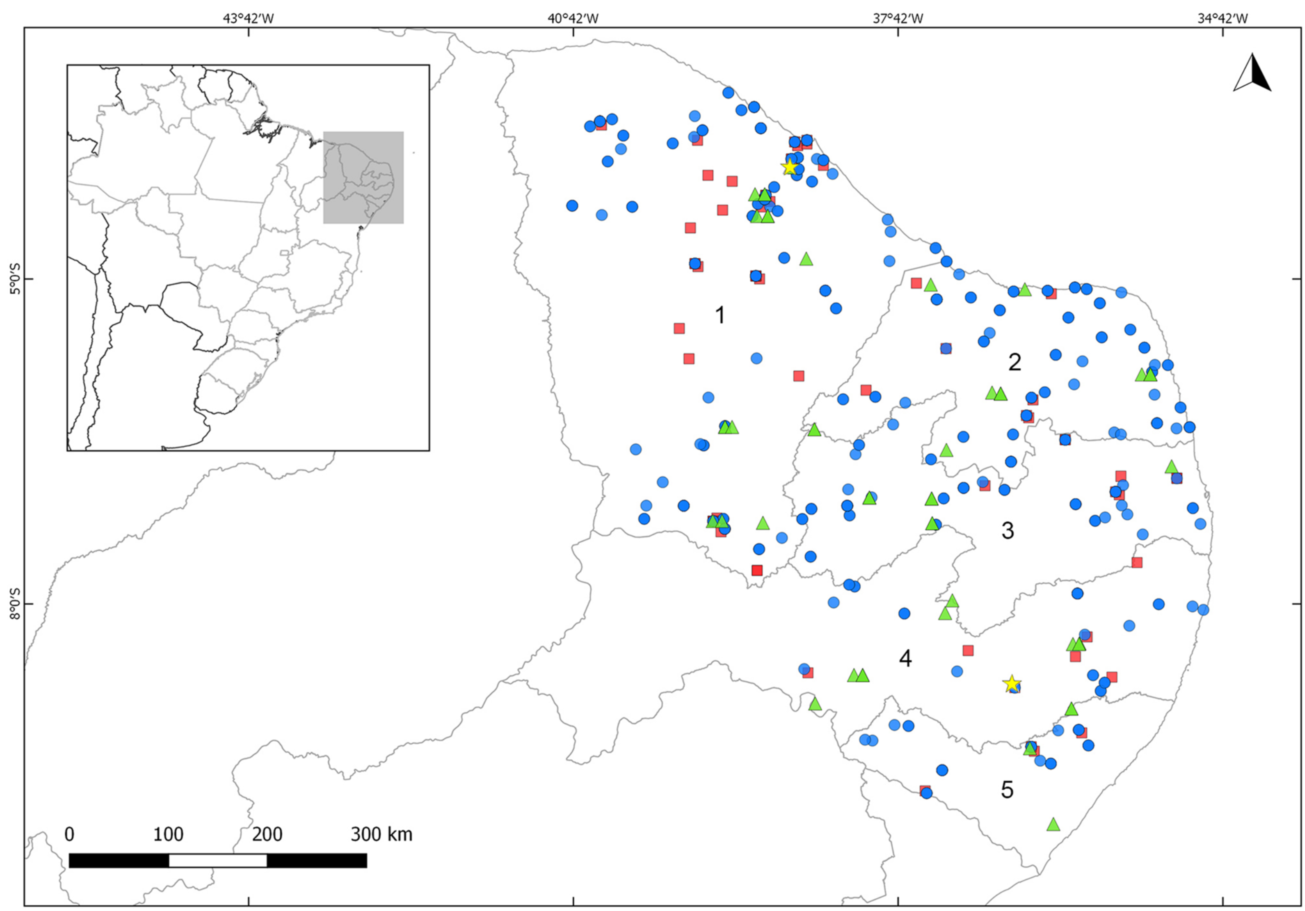


Fig. 1 Geographic distribution of examined material. Museum specimens (green triangles), photographs (blue circles) and song recordings (red squares). Stars indicate type locality of *Picumnus limae* (Ceará) and *P. fulvescens* (Pernambuco). Brazilian States indicated by numbers (from North to South): 1. Ceará, 2. Rio Grande do Norte, 3. Paraíba, 4. Pernambuco, 5. Alagoas

to standardize comparisons. We also collected the following morphometric data (Baldwin et al. 1931): tarsus length and bill length, depth and width (using callipers; nearest 0.05 mm); wing length and tail length (using a metallic ruler; nearest 0.5 mm).

Individuals were scored from 1 to 5 based on the colouration of their ventral plumage (Fig. 2): (5) brown, the typical *P. fulvescens*, with no or little white; (4) intermediate colouration, but predominantly brown; (3) intermediate colouration; (2) intermediate colouration, but predominantly white; (1) completely white or with little yellow, the typical *P. limae*.

To have a more detailed characterisation of the colouration and geographical distribution of the colour phenotypes, we also obtained 945 photographic records from the WikiAves platform (www.wikiaves.com, accessed in June 2019), which were scored in the same way as the specimens (see Supplementary material). 284 of the 945 photographs had sufficient definition for the colours to be unequivocally characterized (i.e., similar lighting conditions, with no visible digital manipulation that could have altered the bird's natural colouration).

Finally, we obtained 74 voice recordings (see Supplementary material) of the two species from the Xeno-Canto (www.xeno-canto.org, accessed on August 2019), Macaulay Library (www.macaulaylibrary.org, accessed on August 2019), WikiAves (accessed on August 2019) and Minns et al. (2010), of which 55 were song recordings, which were analysed in Raven Pro 1.5. However, only 12 (5 previously identified as *P. limae*, 7 as *P. fulvescens*) had enough quality for analyses. Due to this limited sample, we provide a qualitative description of the voice instead of a full statistical comparison.

Distribution maps of the specimens and photographs were created using the Quantum GIS 2.18.7 software (QGIS Development Team 2019). Localities were obtained from the specimens' labels and the location associated with the photographic records in WikiAves. In a few cases, a precise locality was not given, and the location was only described as the municipality, in those cases, we used the centroid of the municipality.

To compare morphological differences, we first tested separately whether each morphological character was explained by colour and sex. For that, model selection was performed via stepwise backwards selection, dropping non-significant terms with the critical p value corrected for multiple testing (Bonferroni correction = 0.05/number of tests) in each step. We then conducted a principal component analysis on all standardized measurement values (mean centred at 0, standard error at 1). Missing values were replaced by zeros after the standardization (thus replaced by the mean value). We retained the principal components 1 and 2, which had eigenvalues of at least 1, and explained 53% of the total variance. We conducted two analyses using the obtained PCs: a multivariate analysis of variance (MANOVA) with both PC1 and PC2 as response variables and two separate regressions for PC1 and PC2 separately (similar to the first analysis testing for each character separately). Once more, we corrected the critical p value for multiple testing. All statistical analyses were conducted in R version 3.6.1 (R Core Team 2019).

To test for the effects of environmental variables on the colour variation, we collected data of precipitation and temperature for each locality from the online database WorldClim with 2.5 arc-minutes resolution using the "raster" package in R (Fick and Hijmans 2017). When we had data of more than one individual from the same location, we used the averaged colour scores across all individuals of that location. First, we used multiple regression analyses to test for the effects of latitude, longitude and the interaction between latitude and longitude on the colour variation. Then we tested whether (scaled) temperature and precipitation had an effect on colour. Because we detected a significant spatial autocorrelation in our data (p value of Moran's I autocorrelation < 0.01, calculated with the R package "ape"; Paradis and Schliep 2018), we used a general least squares method (R package "nlme"; Pinheiro et al. 2019) including a correlation term containing latitude and longitude to describe the within-group correlation structure. We tested for various

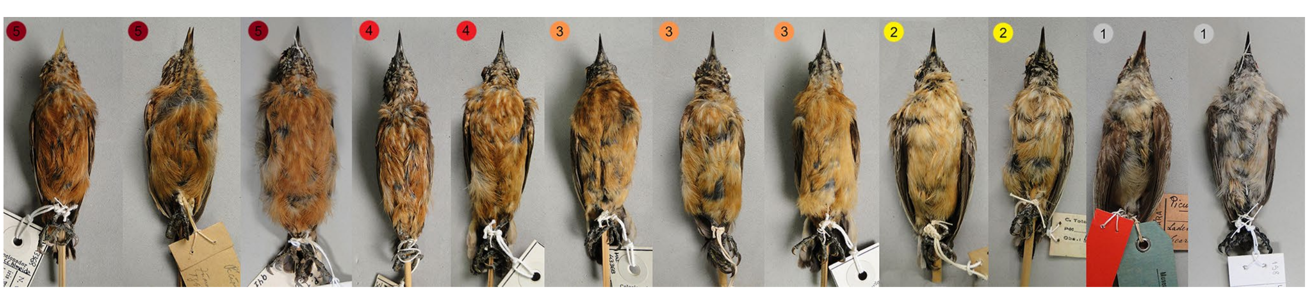


Fig. 2 Classification based on the colour scores of the ventral plumage. Score 5 = brown; score 4 = intermediate, predominantly brown; score 3 = intermediate; score 2 = intermediate, predominantly white; score 1 = white

correlation structures and defined the best model based on the models' AIC values (Pinheiro and Bates 2000). The chresonym list (see "Systematics") follows Dubois (2000).

Results

Individuals varied widely in ventral plumage colouration. Among all birds observed, 12.4% had a score 5, 12.9% a score 4, 16.7% a score 3, 31.6% a score 2 and 26.4% a score 1. We also observed a subtle variation in the dorsal plumage, but usually matching the ventral colouration (Fig. 3).

We observed an extensive overlap of colour phenotypes, which was more pronounced in the central portion of the distribution, in the supposed contact zone of the two species (Figs. 4 and 5). Such overlap was also present in other locations, revealing a weak (if any) geographical limit between the phenotypes.

We found no relationship between colouration and morphology, either when characters were tested separately or when the principal components 1 and 2 were used (Fig. 6).

When we tested the variables that explain the variation in colouration we found a significant effect of latitude in interaction with longitude ($F_{1,115} = 6.26$; p value $= 0.01$; estimate of the interaction: -0.08 ± 0.03), with a stronger effect of the latitude (estimate for the latitude: -3.54 ± 1.17; estimate for the longitude: -0.56 ± 0.19). This means that both latitude and longitude affect the colouration, but their relationship varies depending on the location: i.e., in middle-southern locations, individuals are lighter in the east and darker in the west, but the pattern reverses in northern locations (Fig. 7). Among the four models with delta AIC values smaller than 2, the first two retained only the precipitation term and the last two were the null models (all with either ratio or Gaussian correlation structures). Thus, the variation in colouration was not explained by the variation in temperature, but there was an effect of precipitation, with darker birds in locations with higher precipitation ($t = 2.68$; p value $= 0.01$; estimate $= 0.21 \pm 0.08$).

A visual inspection of spectrograms (Fig. 8) did not reveal differences between the two taxa in terms of song structure. Individuals vary in length or number of phrases, also with variation within the same individual, though the general structure is maintained (Table 1). The song starts with longer (mean duration of the longest phrase: 0.25 ± 0.03 s) and higher frequency (mean frequency of the longest phrase 6244 ± 270 Hz) phrases and ends with shorter (mean duration of the shortest phrase 0.06 ± 0.01 s) and lower frequency (mean frequency of the shortest phrase 5590 ± 278 Hz) phrases. This song structure is exclusive of *P. limae/fulvescens* and distinct from all other *Picumnus* (Fig. 8). In addition, we have observations of northernmost

Fig. 3 Dorsal and ventral variation in plumage. From left to right: UFPE 993, 968, 1302, 4016, 4013 and 1352

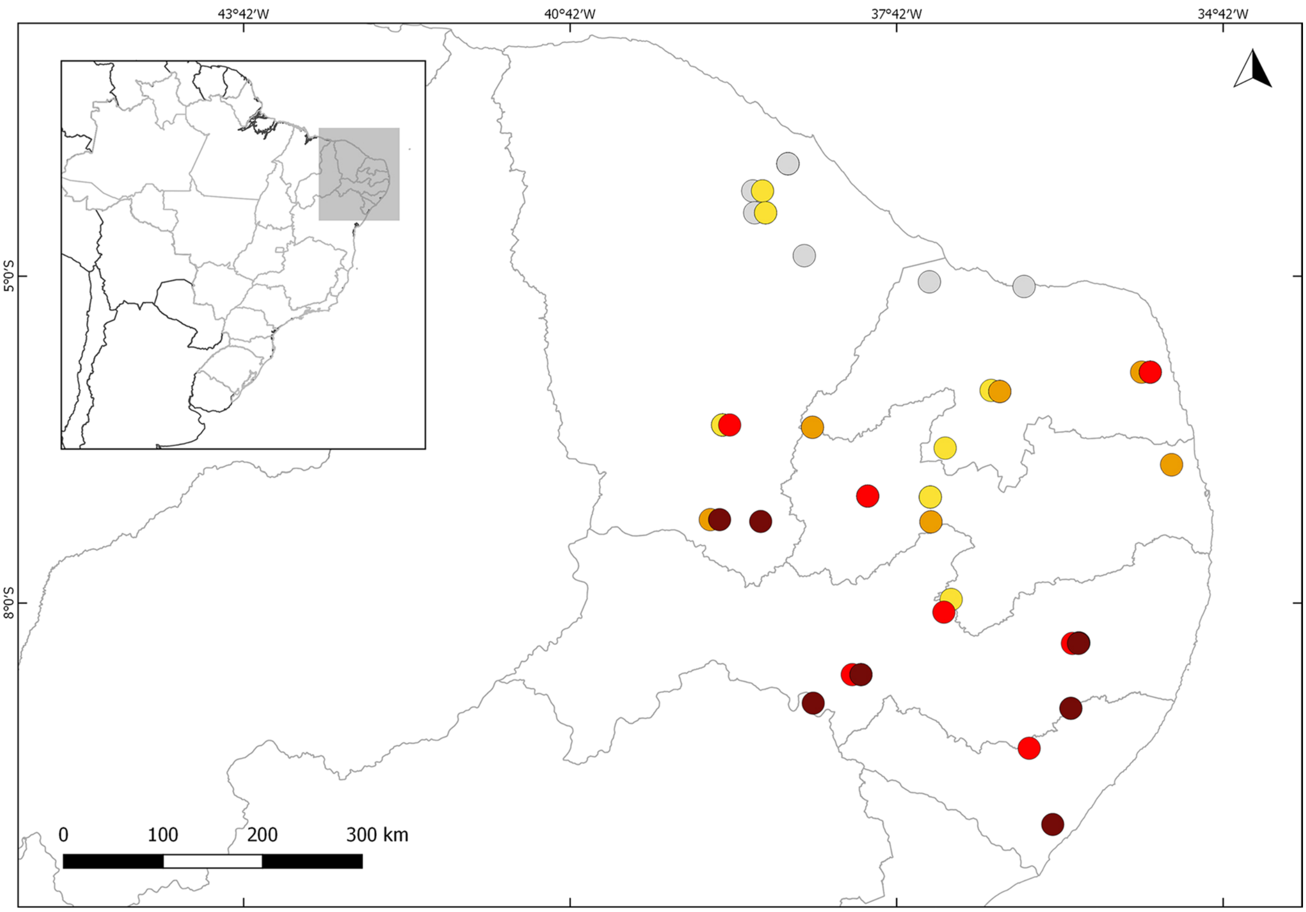


Fig. 4 Distribution of the phenotypes showing the variation in ventral plumage colouration of the museum specimens analysed ($n=66$). The classification into colour morphs follows Fig. 2 (colour figure online)

white birds readily responding to recordings of brown birds from the south-eastern extreme of the distribution, and vice-versa. This suggests that interpopulation song recognition exists between extreme phenotypes.

Discussion

The recognition of the two *Picumnus* as separate species was due to sampling gaps associated to small sample sizes. Our results, using a much larger dataset of museum specimens and photographs, show that both *P. limae* and *P. fulvescens* present a high variation in plumage colouration with a clinal distribution. Moreover, *P. fulvescens* is not diagnosable from *P. limae* in size or vocalization. Thus, we suggest that they should be treated as a single species.

Picumnus limae was described by Emilie Snethlage (1924) based on seven specimens (syntypes) collected in August 1915 by Francisco de Queiroz Lima in two localities in northern Ceará state: Serra do Castello and Ladeira Grande, both near Maranguape municipality (03°58′S 38°42′W). The syntypes were originally deposited in the Museu Paraense Emílio Goeldi (MPEG, nos. 11,439–11,445), but were transferred to other museums after description (Snethlage 1926; Gonzaga 1989): five of them went to the MNRJ (current nos. 5447–5451) and two to the Museum für Naturkunde, Berlin (ZMB, current nos. 311,505 and 311,506). The species was named in honour of the collector, Snethlage's assistant, F.Q. Lima.

The description of *Picumnus fulvescens* occurred 37 years later, by Kenneth Stager (1961), based on five female specimens; three of these, including the holotype, were collected by Emil Kaempfer in 1927 in the municipalities of Garanhuns, Palmares and Brejão, all in Pernambuco state. Those birds were deposited in the AMNH (nos. 242765–242767). The two other paratypes were collected by Emilio Dente in 1957 at Engenho Riachão, Quebrangulo municipality, Alagoas state, and were deposited in the Los Angeles County Museum (LACM, nos. 38068 and 38069).

In his description, Stager (1961) compared *P. fulvescens* with four other species: *P. cinnamomeus* and *P. rufiventris*, which present uniformly brown breast and abdomen

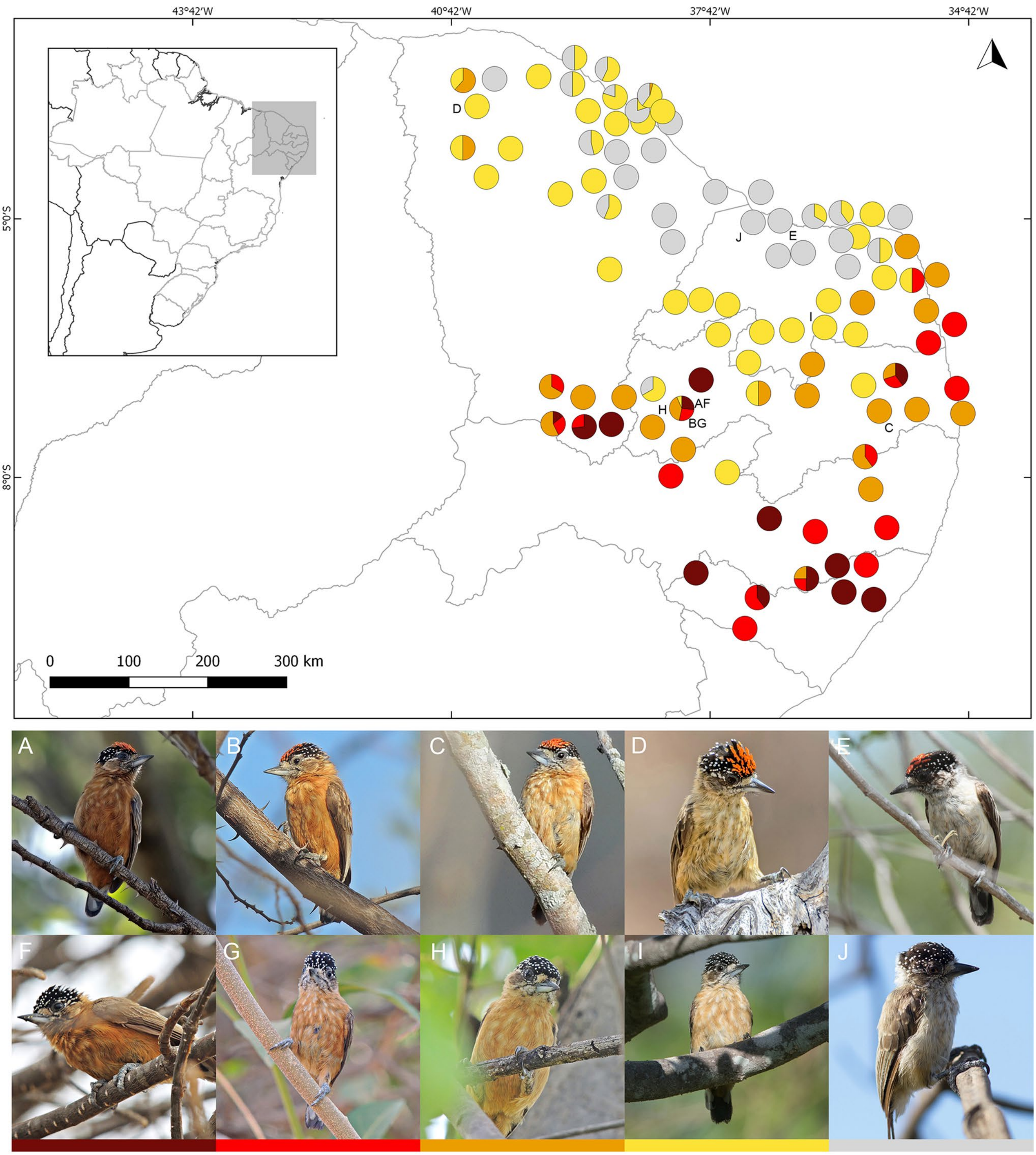


Fig. 5 Distribution of the phenotypes showing the variation in ventral plumage colouration of the photographed birds ($n=284$). Photos by Paulo B. Nunes (**a**, **f**, **g** and **h**), Pablo C. Nunes (**b**), André Adeodato (**d**), Bruno Rennó (**c**), Tiago Elis (**i**), Jan Van den Bosch (**e**) and RDL (**j**) (colour figure online)

(although distantly distributed in northwestern South America); and *P. pernambucensis* and *P. pygmaeus*, which are closely distributed but very distinct morphologically. Stager (1961) did not compare *P. fulvescens* with *P. limae*.

Almost simultaneously to Stager (1961), Pinto and Camargo (1961) described *Picumnus limae saturatus*, based on one specimen collected in Coremas municipality, Paraíba state, deposited in the MZUSP (no. 39689). Those authors

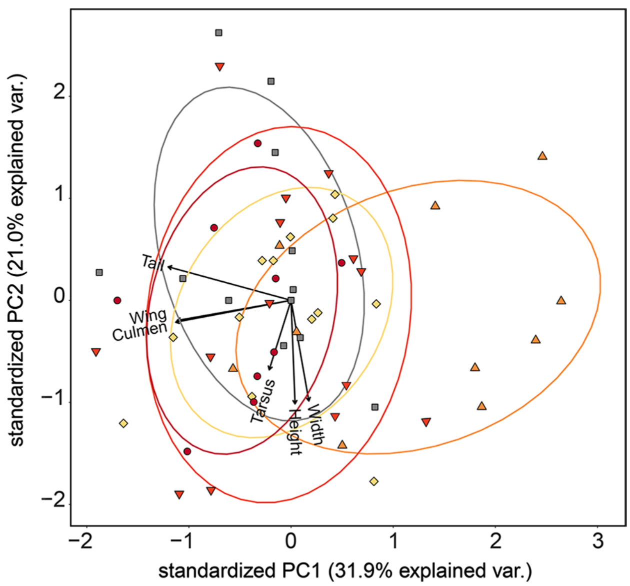


Fig. 6 Biplots showing the results of the principal component analysis looking at morphological differences. Colours of symbols and ellipses represent the colour score of the bird (dark red circles = score 5, red triangles (upside down) = score 4, orange triangles = score 3, yellow diamonds = score 2, gray squares = score 1). Ellipses are normal data ellipses (68% probability for each group). Size is not related to plumage colour and sexes do not differ in size. A table with factor loadings is given in the Supplementary material

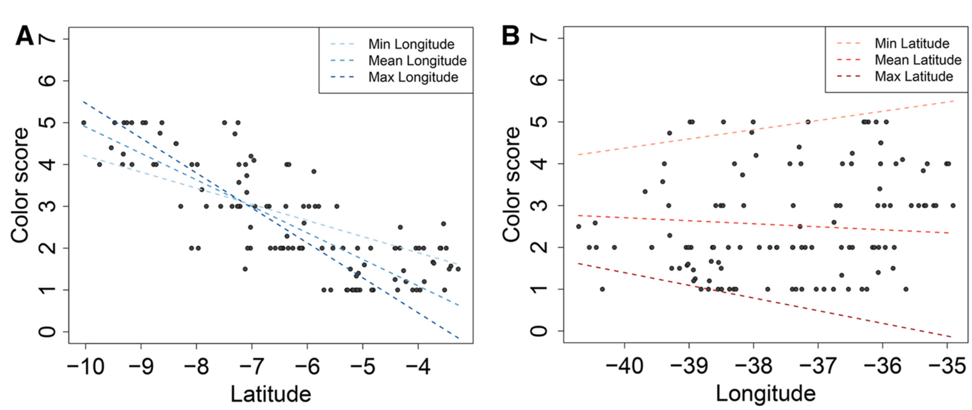
compared their new taxon with nominate *P. limae*, suggesting *P. l. saturatus* differed by "the intensely ochraceous, almost ferruginous, underparts" (Pinto and Camargo 1961: 235–236). Later, however, Pinto (1978) realized *P. l. saturatus* had the same diagnostic characters as (and hence was a synonym of) *P. fulvescens*. Nonetheless, Pinto (1978) still considered both taxa as subspecies: *P. l. limae* and *P. l. fulvescens*.

It could be argued that Pinto's synonymy action was apparently incorrect, since Pinto and Camargo's paper is dated 31 August 1961, while Stager's paper is dated 21 December 1961. However, Pinto (1978) justified his action saying that Pinto and Camargo's paper was distributed on a later date than Stager's paper, regardless of the former's printed date. Indeed, Pinto and Camargo's paper, despite bearing the publication date 31 August 1961, was not distributed until 22 December 1961 (Dione Seripierri pers. comm.), and there is no evidence that the printed date on Stager's paper did not correspond to the actual date of its distribution (Kimball Garrett pers. comm.). Thus, Stager's paper was published at least 1 day before Pinto and Camargo's paper and hence the name *Picumnus fulvescens* has priority over *Picumnus limae saturatus* (ICZN 1999: Art. 21.4).

The variation in plumage colouration of *Picumnus limae* and *P. fulvescens* is not randomly distributed; rather, darker coloured specimens are more commonly located in the southern portion of the distribution, while light-coloured ones are more predominant in northern locations (Figs. 4 and 5). This is also supported by the significant interaction between latitude and longitude explaining the variation in colour (Fig. 7). In the centre of the distribution, particularly in Paraíba and southern Ceará states, we also observe a large overlap in phenotypes, sometimes with three to four colour scores in the same area. This suggests that *P. limae* and *P. fulvescens* are a single species with large clinal variation in colouration, which is also supported by the lack of vocal discrimination between the species, even in the extremes of their distribution. Moreover, we observed just a single case of co-occurring extreme scores (individual WA963270 of score 1 in Paraíba, in a locality dominated by birds of score 5). This pattern also weights against a hybrid zone hypothesis and more in favour of a polymorphic species with clinal variation (e.g. Amar et al. 2019).

Therefore, we here propose that *Picumnus limae* and *Picumnus fulvescens* comprise a single species with a high degree of colour variation and a clinal distribution (Huxley 1938a,b). Colouration gradually changes from white (north) to brown (south), with several locations presenting more than one colour morph (Figs. 4 and 5). Since the former vernacular names of the species were related to colour (English: "Tawny Piculet", "Ochraceous Piculet"; Portuguese:

Fig. 7 Plots showing the relationship between the colour scores with latitude (**a**) or longitude (**b**). There was a significant interaction between latitude and longitude and the different lines represent the predictions of the models for the maximum (darker colour), mean (intermediate colour) and minimum (lighter colour) values of latitude (**a**) or longitude (**b**)



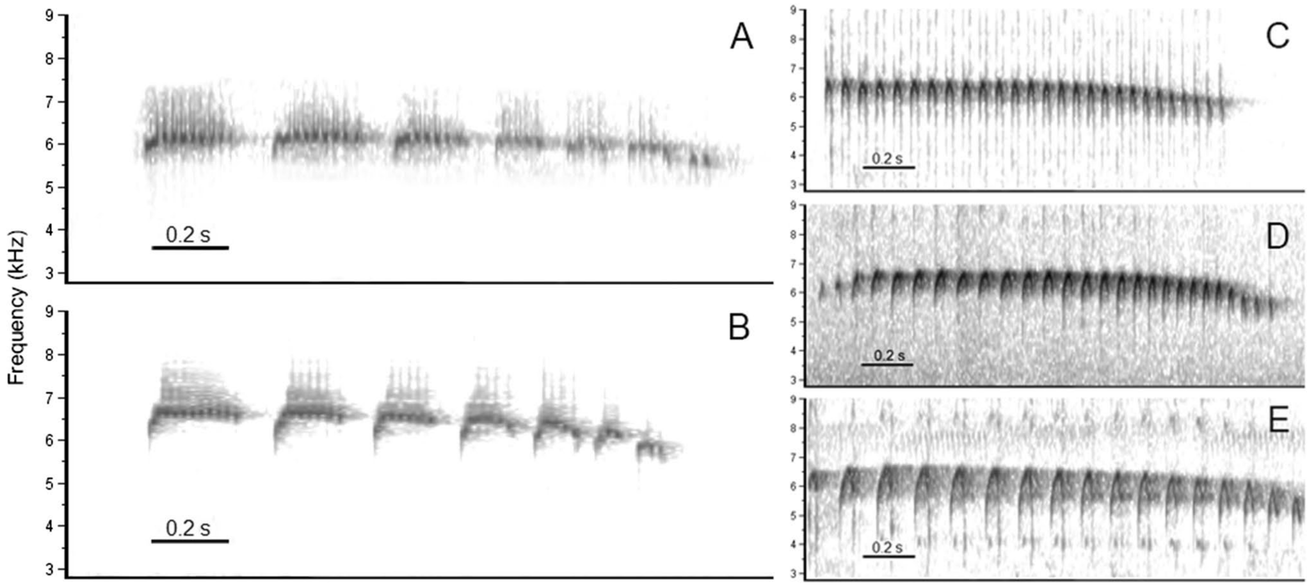


Fig. 8 Spectrograms of the song of *Picumnus fulvescens* and *Picumnus limae* and some of the most similar species. **a** *P. fulvescens* recorded at União dos Palmares, Alagoas (9°10′S 35°60′W) (record #3 by Andrew Whittaker, in Minns et al. 2010); **b** *P. limae* recorded at Quixadá, Ceará (4°53′S 39°08′W) (WA127049 by Ciro Albano); **c** *Picumnus pygmaeus* (Lichtenstein, 1823) (XC427806); **d** *Picumnus dorbignyanus* Lafresnaye, 1845 (XC349096); **e** *Picumnus spilogaster* Sundevall, 1866 (XC122698)

Table 1 Vocal measurements. Mean ± S.D. (minimum and maximum)

Character	*Picumnus fulvescens* (*n* = 7)	*Picumnus limae* (*n* = 5)
Duration of the longest phrase	0.25 ± 0.02 (0.22–0.29) s	0.26 ± 0.04 (0.19–0.34) s
Duration of the shortest phrase	0.06 ± 0.01 (0.05–0.09) s	0.07 ± 0.01 (0.06–0.09) s
Frequency of the longest phrase	6290 ± 199 (6028–6874) Hz	6163 ± 366 (5564–6638) Hz
Frequency of the shortest phrase	5655 ± 241 (5341–6077) Hz	5480 ± 319 (5075–5924) Hz

"picapauzinho-canela") or distribution (Portuguese: "picapauzinho-da-caatinga") we also propose that the bird should be commonly referred to "picapauzinho-da-caatinga" in Portuguese and "Caatinga Piculet" in English, reflecting its distribution mostly in Caatinga biome.

The colour variation is often related to environmental variation (Huxley 1955; Galeotti et al. 2003), and, in *P. limae,* colour seems to be related to precipitation, with darker morphs found in locations where precipitation is higher, following the Gloger's ecogeographical rule. The rule describes the pattern that darker coloured individuals are found in more humid and warmer regions (Gloger 1833; Delhey 2019). *P. limae* is found from northeastern Caatinga to the Atlantic Forest, strikingly distinct environments. The Caatinga is characterized by seasonally dry forests, with abundant solar incidence and low humidity (Andrade et al. 2017; Silva et al. 2017), while the Atlantic Forest presents dense and humid vegetation with milder temperatures (Nimer 1972). In the Caatinga's higher altitudes, there are enclaves with semi-deciduous or ombrophilous forests (Andrade-Lima 1982) with distinct climates due to the orographic rainfall effect (Andrade et al. 2017). In a few of these enclaves (e.g. Guaramiranga, Ceará), the humidity may be higher than in the coastal Atlantic Forest. Our initial analysis suggests that on a large distribution scale, *P. limae* plumage colouration is correlated to the environmental variables and explained by precipitation but not by temperature. Darker individuals occur in the eastern and southern portions of the distribution (Atlantic Forest domain) while lighter individuals are present in the north (Caatinga domain). However, on a smaller scale, such effect is less clear because lighter morphs occur both in dry-warm localities (e.g. Tibau, Rio Grande do Norte; at sea level), as well in humid-cold localities (e.g. Guaramiranga, Ceará; 1,100 m). Darker morph also occurs in both types of localities (e.g. Aguiar, Paraíba vs Murici, Algoas). Thus, while the birds may follow Glogler's rule, other mechanisms (e.g. Delhey 2017; Ribot et al. 2019) may also play a role and merit future investigations. With the resolution of the taxonomy of this piculet, it now become an attractive model to further explore the effects of environmental variables on bird colouration.

Fig. 9 Adult male (left), adult female (middle) and juvenile male (right), recorded in Mossoró/RN (Photos by RDL)

Systematics

Order Piciformes

Family Picidae

Genus *Picumnus* Temminck, 1825

Picumnus limae Snethlage, 1924

Picumnus limae Snethlage, 1924. Journal für Ornithologie, 72, p. 448–449. Serra do Castello and Ladeira Grande [Maranguape municipality], Ceará, Brazil. 7 syntypes: MNRJ 5447, 5448 5449, 5450, 5451, ZMB 311505 and 311506.

Picumnus limae–Meyer de Schauensee (1970): 184; Short (1982): 91; Sick (1997): 513; Teixeira (1990): 1; Winkler et al. (1995): 185, pl.7, Fig. 22; Winkler and Christie (2002): 433, pl. 25, Fig. 23.

Picumnus limae limae: Pinto and Camargo (1961): 235.

Picumnus limae limae – Pinto (1978): 270.

Picumnus fulvescens Stager, 1961. Contributions in Science, Los Angeles County Museum 46, p. 1–4. Garanhuns, Pernambuco, Brazil. Holotype AMNH 242,765.

Picumnus fulvescens–Short (1982): 91; Sick (1997): 512; Winkler et al. (1995): 184, pl.7, Fig. 21; Winkler and Christie (2002): 433, pl. 25, Fig. 22.

Picumnus limae fulvescens: Pinto (1978): 270.

Picumnus limae saturatus Pinto and Camargo, 1961. Arquivos de Zoologia da Universidade de São Paulo, 11, p. 235–236. Curema [sic; Coremas], Paraíba, Brazil. Holotype MZUSP 39689.

Description

Adults: lower ventral portion of the body plumage varies from white and light yellow to brown, while the upper ventral portion varies from dull yellowish brown to dark brown. Greater coverts plain dark brown to plain brownish black. Crown black with white speckles in adults of both sexes. Males: forehead orange; Females: forehead black. Bill short and dark with a light coloured mandible. Juveniles: crown brown without white spots. Nape and eye stripe white and the sides of the head striated with white (Fig. 9). Rest of the plumage like adult birds (Silva et al. 2012). The juvenile (FCJ, Johnson and Wolfe 2017) male has the first red/orange feathers on the forehead. This species varies widely in plumage colour, from light-coloured individuals (white to light brown) to dark coloured ones (rusty brown) and various intermediate coloured individuals. Ventral plumage is plain or streaked. Measurements (mean ± S.D.): bill length 12.34 ± 0.64 mm (n = 63); bill width 5.29 ± 0.35 mm (n = 61); bill depth 4.87 ± 0.29 mm (n = 59); tarsus length 11.94 ± 0.5 mm (n = 49); wing length 51.71 ± 1.64 mm (n = 65); tail length 29.97 ± 2.11 mm (n = 62).

Diagnosis

Differs from all other *Picumnus* found in northeast of Brazil by the absence of spots or horizontal stripes in the ventral or dorsal plumage.

Geographic distribution

Northeast Brazil, in Piauí (Olmos 1993), Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas and Sergipe (Ruiz-Esparza et al. 2011) states. Found in Caatinga and Atlantic Rainforest environments, from sea level to altitudes reaching 1.200 m. The scarce number of studies led to decades of underestimated distribution of *P. limae*, restricted to just a few humid mountain ranges in Ceará (Pinto and Camargo 1961; Olmos et al. 2005; Albano and Girão 2008). It was only recently that the real distribution of the species became clearer, with an increase in the number of records in various locations in Northeast Brazil, including urban areas. This boost in sightings followed the development of online bird observation databases, such as WikiAves (www.wikiaves.com.br) and eBird (www.ebird.org), demonstrating the importance of citizen science in improving the bird distribution knowledge (Lees 2016; Araujo and Silva 2017).

Remarks

Picumnus limae is believed to be related to *P. nebulosus* Sundevall, 1866 (Short 1982; Sick 1997; Winkler and Christie 2002), however, morphology and vocal characters support a relationship with *P. spilogaster* Sundevall, 1866. This is also suggested by molecular analysis, which placed all piculets with trilled voice within the same group (Shakya et al. 2017; Lima 2018).

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