



## PREVALENCE OF WHITE SPOTTING IN THE PLUMAGE OF THE FULVOUS WREN *CINNYCERTHIA FULVA* IN THE BOLIVIAN ANDES

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**Abstract** · We assessed the prevalence of white spotting in the plumage of a population of Fulvous Wren *Cinnycerthia fulva* and present evidence that this phenomenon occurs in other populations of the species. We captured and observed individuals with varying white facial patches in Cotapata National Park (La Paz, Bolivia). Fifty-two percent of the captured individuals (N = 17) showed some degree of white feathering; in all cases, white patches occurred only on the head and fitted the description of ‘white spotting’, a pattern likely associated with age, physical fitness and status. In avian community surveys, we often observed Fulvous Wrens attending mixed-species flocks, and 36% of all the flocks surveyed had at least one individual with facial white spotting. An examination of photographic records of the species on citizen science platforms showed that white spotting occurs in other populations across the distribution of the species, with most photographic records from Bolivia showing some degree of facial white spotting. Our study exemplifies the utility of citizen science platforms for documenting the occurrence of atypical plumage in wild bird populations.

**Resumen** · Prevalencia de manchas blancas en el plumaje del Cucarachero Leonado *Cinnycerthia fulva* en los Andes de Bolivia

Evaluamos la prevalencia de plumaje blanquecino (*white spotting*) en una población de Cucarachero Leonado *Cinnycerthia fulva* y presentamos evidencia de que este fenómeno también ocurre en otras poblaciones de la especie. Capturamos y observamos individuos con parches de plumaje facial blanco en una población de *C. fulva* en el Parque Nacional Cotapata (La Paz, Bolivia). Cincuenta y dos por ciento de los individuos capturados (N = 17) presentaron manchas blancas en el rostro. En todos los casos, las manchas blancas ocurrieron únicamente en la cabeza, ajustándose a la descripción de “*white spotting*”, un patrón potencialmente asociado a la edad, la adecuación física y el estatus. En evaluaciones de la comunidad en el sitio de estudio observamos que los Cucaracheros Leonados son miembros frecuentes de bandadas mixtas; el 36% de las bandadas que contenían la especie tenían al menos un individuo con este patrón de coloración facial. Adicionalmente, analizamos fotografías de la especie en plataformas de ciencia ciudadana y confirmamos que el plumaje facial blanquecino ocurre en otras poblaciones a lo largo del rango de distribución de la especie; la mayoría de los registros fotográficos en Bolivia corresponden a individuos con manchas blancas en el rostro. Nuestro estudio da un ejemplo de cómo el uso las plataformas de ciencia ciudadana puede documentar la ocurrencia y prevalencia de patrones de plumaje atípicos en poblaciones silvestres de aves.

**Key words:** Bolivia · Citizen Science · Cotapata National Park · Melanin · Plumage coloration · Troglodytidae

### INTRODUCTION

Plumage coloration is a key component of bird survival and reproduction, as atypical plumage might translate into a cost to individual fitness (Dyck 1985), and thus is likely selected against (Bensch et al. 2000). However, evidence of atypically colored individuals making it to adulthood and finding mates is increasing (van Grouw *pers. comm.*), suggesting that “aberrant” individuals might be able to persist within their populations (van Grouw & Hume 2016). Atypical plumage can result from abnormalities during the development of melanin cells, in the synthesis of melanin, or by the deposition of melanin into the feathers (van Grouw 2021). Defects in the development of melanin cells, causing “white spotting”, can result in the total absence of melanin pigments from birth (leucism and partial leucism), or can result from the progressive loss of melanin cells with age (progressive graying). In each case, the resulting whitening can either be widespread in the individual’s plumage and skin or localized, forming white patches (van Grouw 2021). However, the amount of white feathering in leucistic individuals does not vary with time, whereas the amount of plumage affected by progressive graying will likely increase during the birds’ life.

In either case, the prevalence and persistence of white spotting in a population might be linked to specific environmental conditions. For instance, Izquierdo et al. (2018) studied white spotting in a population of the Eurasian Blackbird *Turdus merula* in urban and suburban areas and suggested that environmental factors might trigger mutations resulting in higher rates of white spotting in urban areas; additionally, affected individuals might persist and have a high chance of survival due to the absence of predators, resulting in a population with a high prevalence of individuals with atypical plumage. Although the case described by Izquierdo et al. (2018) is presented as progressive graying and likely not linked to a specific mutation, instead reflecting plumage changes associated with aging, it exemplifies how the frequency of individuals with atypical plumage might increase in the population when environmental conditions

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(i.e., predation pressure) reduce selection against those variants. Unfortunately, knowing the causes behind atypical plumage in wild populations is virtually impossible without genetic analyses. Population-level analyses of atypical coloration are scarce, particularly in the Neotropics.

In this study we (1) assess the prevalence of white spotting in a wild population of a Neotropical insectivore, the Fulvous Wren *Cinnycerthia fulva* (Troglodytidae) from La Paz, Bolivia. Fulvous Wren has olive-brown plumage with an elongated buffy supercilium. It inhabits humid montane forests in the Andes of Bolivia and Peru and forages in dense foliage close to the ground in pairs or small family groups (Herzog et al. 2016, Kroodsma & Brewer 2020). The occurrence of “extra white” in *Cinnycerthia* wrens was first reported by Fjeldså & Krabbe (1990), but they referred to the Peruvian wren *Cinnycerthia peruana*, which was earlier considered conspecific with the Sepia-brown wren *C. olivascens* and *C. fulva*. The first description of this pattern in the face of Fulvous Wren (*sensu stricto*) was provided by Brumfield & Remsen (1996) and was later described as a characteristic of the subspecies *C. f. gravesi* (found in Bolivia and SE Peru), but not of the other two subspecies, *C. f. fulva*, from the eastern Andes of Peru, and *C. f. fitzpatricki* from the Cordillera de Vilcabamba, central Peru (Remsen & Brumfield 1998). No further information on the occurrence and prevalence of this phenomenon has been documented since these descriptions of the species and its subspecies. Additionally, we (2) examine photographic evidence from citizen science databases to further evaluate the occurrence of white spotting in other populations across the species range.

## METHODS

**Mist netting and field observations.** Between May and November 2016, we captured individuals of *C. f. gravesi* along the Silutinkara gradient in Cotapata National Park, in the western Andes of Bolivia (67°43′–68°03′W 16°05′–16°20′S; 1350–3650 m a.s.l.; Montaña-Centellas et al. 2021). The landscape in Silutinkara is dominated by evergreen humid montane and cloud forests, largely free of human intervention (Ribera 1995, Montaña-Centellas et al. 2021). We conducted three field trips. On each trip we captured birds for three consecutive days at five elevations: 2,250, 2,450, 2,750, 3,000, and 3,500 m a.s.l. (15 effective days of sampling per trip). Birds were captured using eight to ten 12m mist-nets, which were open from 6:30 to 17:00, except during periods of heavy rain and extreme heat, resulting in a total effort of ca. 36,500 mist-net hours. Captured individuals were examined, color-banded, and released at the capture site, and the presence or absence of white spotting was noted for each captured individual in the field before release. We considered a positive occurrence of white spotting if there were white patches of plumage beyond the supercilial stripe, in the forehead, crown, malar area, chin, or throat (see examples in Fig. 1).

Additionally, we collected data on plumage spotting from observations of individuals of the same population obtained in community surveys in 2014, 2015, and 2016 (Montaña-Centellas et al. 2021), and in mixed-species-flock surveys in 2016 and 2017 (Montaña-Centellas & Jones 2021). For each detected individual, we recorded the date, time of day, elevation, and number of individuals observed together, and when possible, whether white spotting was present in each observed individual.

**White spotting data from citizen science platforms.** On 4 January 2023, we conducted a Google search using the terms “*Cinnycerthia fulva*” OR “Fulvous Wren” to find photographic records of the species. Blurry, incomplete photographs (with vegetation covering parts of the bird) or those that did not clearly show the whole bird were not included in our analyses. For each photographic record, we noted if the photographed individuals had white spotting and collected metadata, including the site where the photograph was taken and, when available,

the geographic coordinates. For those photographs without coordinates, we used the available locality information and estimated the geographic coordinates using Google Earth. Because there is no sympatry among subspecies, we separated the photos for different subspecies based on their distributions and the location of each photographic record.

## RESULTS

**Prevalence of white spotting in a population of *C. f. gravesi*.** We found a relatively high proportion of individuals with some degree of white spotting in the studied population of *C. f. gravesi*. Nine of the 17 captured individuals showed some degree of white spotting on the face and head. In most cases they had broader and more accentuated white supercilial lines than individuals with typical plumages, but a few individuals had an entirely white face and head (Figure 1A–D). Individuals with atypical plumages were captured above 2,450 m a.s.l. and represented 67–75% of the total captures per elevation (Figure 1E). None of the four individuals captured at 2,250 m showed signs of white spotting.

Fulvous Wren is a frequent member of mixed-species flocks at our study site, with 2–10 or more individuals observed per flock (Montaña-Centellas & Jones 2021). During our four-year surveys, we noted no major differences in the behavior of individuals with or without white spotting within the flock (Montaña-Centellas et al. 2021; Montaña-Centellas & Jones 2021). Although it was not possible to determine the exact number of individuals with atypical plumage in each flock, we registered at least one individual with noticeable white spotting in each of the 15 independent flocks (36% of all mixed flocks that included at least one Fulvous Wren), further indicating a high prevalence of white spotting in our population.

**White spotting in other populations of Fulvous Wren.** Our image search resulted in 39 photographs of different individuals of Fulvous Wren that were suitable for inclusion in our analyses (Supplementary Materials). Of the 22 photographed individuals of *C. f. gravesi* (one from Peru and 21 from Bolivia), 15 (68%) had facial white spotting (all from Bolivia; Figure 2), further suggesting a potentially high prevalence of white spotting in populations of *C. f. gravesi*. As expected, based on the original description of the subspecies (Remsen & Brumfield 1998), we found no evidence of white spotting in *C. f. fulva*, and none of the 17 photographed individuals of this subspecies showed atypical plumage. The only evidence of white spotting potentially occurring in this subspecies is presented in one illustration (not a photograph) of H. Burn, found in Kroodsma & Brewer (2020) that shows an individual of *C. f. fulva* with a white forehead, yet no reference in the text is made to the original source of this representation. No photographs of *C. f. fitzpatricki* were found during our search.

## DISCUSSION

The white spotting patterns we observed in Fulvous Wren are likely caused by progressive graying, resulting in the loss of melanin cells in specific skin areas with age. Progressive graying as the potential cause of white spotting in other *Cinnycerthia* wrens has been previously suggested (e.g., Gochfeld 1979, Graves 1980, Fjeldså & Krabbe 1990), but no quantification of its prevalence in any of these species exists. The causes of progressive graying are varied, and might or might not be heritable (van Grouw 2021). Although we cannot rule out the possibility of white spotting resulting from a specific mutation in *C. fulva*, some aspects of our population argue against it. Atypical plumages resulting from genetic mutations have been suggested to prevail when populations are small and prone to inbreeding and genetic drift (Bensch et al. 2000) or if the population is exposed to environmental factors that may increase the rate of mutations (Møller et al. 2013). We found no evidence

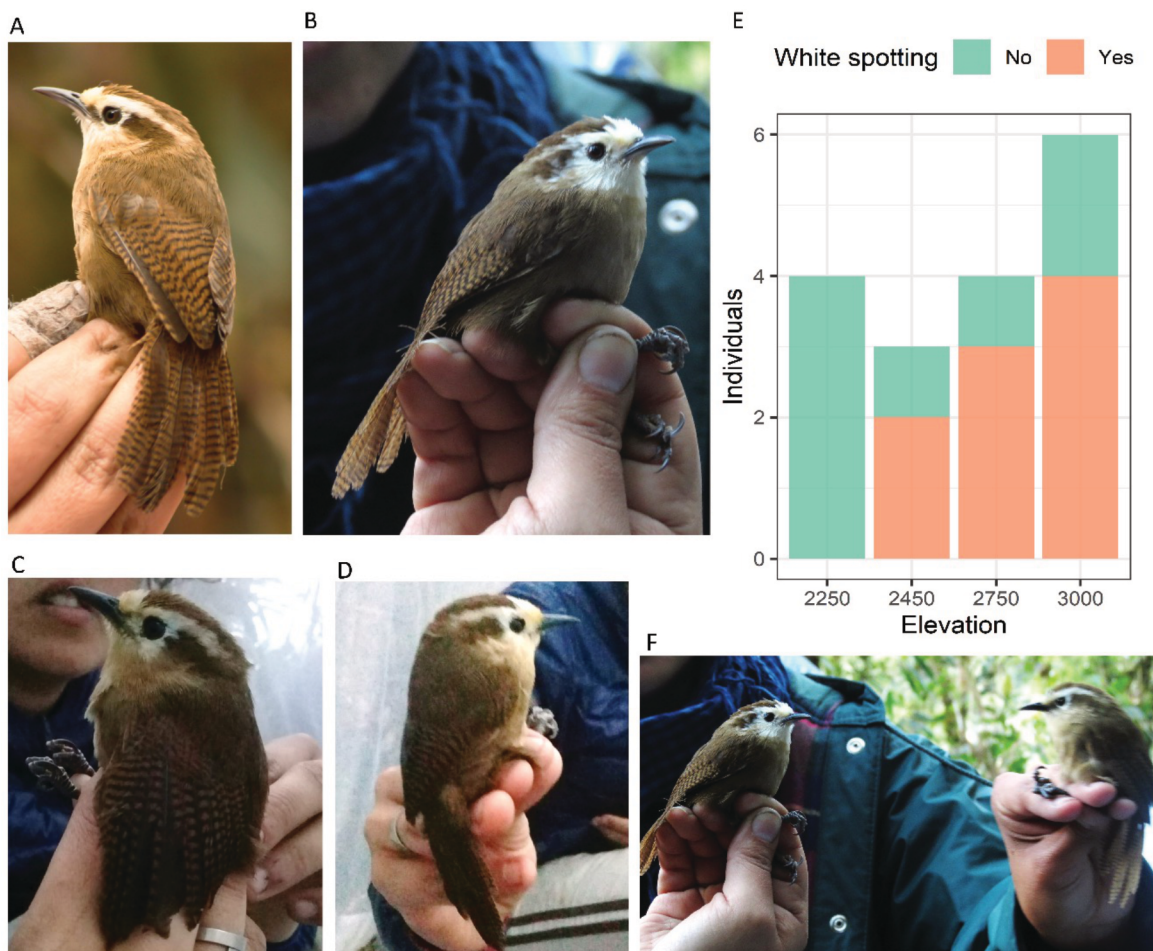
suggesting that the Fulvous Wren population at our study site is small (we had only one recaptured individual and recorded up to 12 individuals in a single flock). Furthermore, the study site is relatively pristine, and there is no reason to consider singular environmental conditions associated with high levels of mutation (Ellegreen et al. 1997).

Costs associated with atypical plumages may include an increase in detection by predators (Ellegreen et al. 1997) or a reduction in reproductive success by altering mate choice (Møller & Mousseau 2003). Alternatively, given that the typical coloration of the species has evolved in a pattern that includes white superciliary stripes, atypical white spots might accentuate these markings, potentially having a positive effect on sexual behavior. Although our data cannot rule out differences in sexual selection among individuals with or without white spotting, our casual observations of individuals participating in feeding flocks suggest that white spotting has no deleterious effect on the social behavior of *C. fulva* in the studied population, at least in terms of their participation in flocks and the benefits derived from flocking behavior (i.e., access to feeding resources and reduced predation pressure). Interestingly, the fact that we did not capture or observe individuals with white spotting at the lower limit of the species' elevational distribution (<2400 m a.s.l.) suggests that if a deleterious effect of white spotting exists in this population, it likely occurs in the distributional limits (i.e., not in their optimum). Alternatively, this geographical pattern might be consistent with a center of origin of white-spotted individuals, as suggested for the White-winged Brushfinch *Atlapetes leucopterus* (Fitzpatrick 1980).

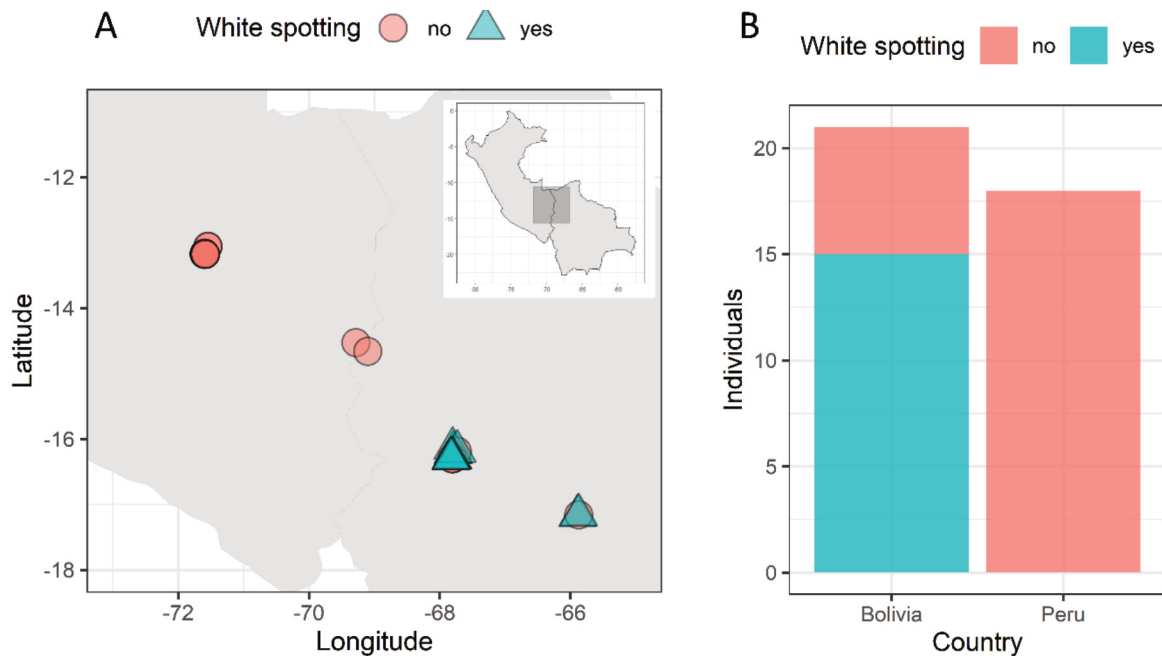
Altogether, our results indicate that white spotting in Fulvous Wren is caused by progressive graying, a pattern likely associated with age, and potentially with physical fitness and status (Catry et al. 2006). If so, atypical head and facial plumages might be under positive selection, possibly by enhancing a sexually selected trait such as a white supercilium or colored chest that acts as a badge that might relate to dominance in birds (i.e., Møller 1987, González-García et al. 2018). Facial white feathering is also frequent in the Peruvian Wren congener. Although it has been suggested that it might relate with social status and age (Graves 1980), the function or effects of facial color variation in this species are unknown (Schulenberg et al. 2010).

Overall, our results show that the occurrence of white spotting in *C. f. gravesi* is widespread throughout its distribution. Surprisingly, despite the early documentation of this phenomenon (Brumfield & Remsen 1996; Remsen & Brumfield 1998) and its apparent high prevalence in populations throughout its range, the occurrence of white spotting (or any atypical plumage) is not mentioned in Birds of Bolivia (Herzog et al. 2016) or in Birds of Peru (Schulenberg et al. 2010). Moreover, it is not mentioned in the description of the species in Birds of the World (Kroodsmas & Brewer 2020), where most of the photographs included in our analyses are available.

Our study exemplifies the importance of citizen science platforms in documenting the occurrence of atypical plumage in wildlife populations. Although the data available for our study species were scarce, we gathered evidence suggesting



**Figure 1.** White spotting in a population of Fulvous wren *Cinnycerthia fulva gravesi* from the Sillutinkara trail, Cotapata National Park (La Paz, Bolivia). (A–D) Examples of captured individuals; (A) individual with typical plumage; (B–D) individuals with varying degrees of white spotting; (E) number of individuals with and without white spotting captured at different elevations (in m a.s.l.); (F) two individuals captured together while participating in the same mixed-species flock, the one to the left shows white spotting, and the one to the right has a typical plumage. Photos: (A) Edgar Mayta, (B, F) Karen Losantos, (C) Rhayza Cortes, (D) Camila Agurto.



**Figure 1.** Photographic evidence of white spotting in Fulvous wren *Cinnycerthia fulva*, summarizing data obtained from photos from citizen science platforms: (A) geographical coordinates of the photographic records of individuals with and without white spotting; (B) frequency of individuals photographed with and without white spotting in Bolivia and Peru. Details of each photograph included in the analyses can be found in the Supplementary Materials.

that white spotting is relatively common in Bolivian populations of Fulvous Wren. Further studies on the prevalence of white spotting across latitudinal and elevational ranges of animal species might help disentangle the little-known mechanisms by which these atypical plumages persist in natural habitats.

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