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THE COLOR OF THE PALATE: AN ADDITIONAL AGEING CRITERION FOR THE WHITE-CRESTED ELAENIA (*ELAENIA ALBICEPS*)

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El color del paladar: un criterio adicional para la caracterización de la edad en el Fío-Fío Chileno (*Elaenia albiceps*).

Key words: Ageing, Chile, *Elainia albiceps*, mandible, palate color, Tyrannidae, White-crested Elainia, wing length.

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INTRODUCTION

Many ecological processes in natural populations are influenced by the age of individuals, affecting parameters such as survival and reproductive success (Temple & Wiens 1989). In the same way, social relations within populations could be expressed as variation in proportions and spatial distribution of age classes (Newton 1998). Furthermore, as a basic principle in population ecology it is assumed that the relative number of individuals within an age class will remain stable in a population if conditions do not change (Ricklefs 1973). It follows then that knowing the age structure of a population should allow a researcher to detect evidence of environmental disturbance. For these and other reasons it is valuable to be able to determine the age of individuals in population studies.

In Europe and North America, methods have been described to determine the age of full-grown birds of many species. Methods include morphological characters, molt patterns (affecting color, shape and wear of feathers), skull ossification, tongue marks, or the color of bare parts, such as bill, legs, etc. (Svensson 1992, Pyle 1997). However, comparatively little is known about ageing Neotropical birds (Ryder & Wolfe 2009, Wolfe & Pyle 2012); at best, for most of the passerine species, only anecdotal observations are available to separate juveniles from full-grown individuals (Pyle *et al.* 2015). The inability to distinguish first-year individuals from adults might mask the real state of Neotropical passerine populations, which might be stressed due, for example, to high rates of habitat fragmentation and loss. It is therefore important to develop this fundamental ornithological knowledge in this region and other parts of the world.

Nestling palate color in many passerine species aids the parents in feeding the chicks (Kilner 2006, Wiebe & Slagsvold 2009), but this color may change with age after fledging. Although some studies have found that the palate color of nestlings may signal health (De Ayala *et al.* 2007), this variation is less marked than the regular, age-related, changes that occur post-fledging. Consequently, in taxa such as corvids, parids, the European Robin (*Erithacus rubecula*) and related muscicapids (Svensson 1992, Pyle 1997), where the palate changes with age from a pale yellowish or pinkish color to a dark grey or black, this trait has been used to age individuals. In this paper, we investigate whether scoring the color of the palate might be used to determine the age of individual White-crested Elaenias (*Elaenia albiceps*). To test this, we hypothesized that we might expect a strong correlation between palate color and wing length, since in many passerine species the latter increases with age (Alatalo *et al.* 1984).

METHODS

The study is focused on a 7500 km^2 area of the "Roble-Hualo" forest type distributed over the Coastal range of south-central Chile, known as the Maulino forest, ranging from the Itata river (36°25'S, 72°42'W) in the south to "Altos de Licanten" (34°58'S, 72°02'W) in the north. Once a continuous cover of native forest, these temperate deciduous forests are now highly fragmented and persist only in a matrix of intensive managed exotic pine plantations. During the breeding season of 2012–2013, individual White-crested Elaenias were mist-netted in both native forest fragments and surrounding pine plantations.

All captured birds were ringed and their flattened wing length (maximum wing length) measured by a single observer using a stopped rule to a precision of 1 mm. As with many other species in Chilean forests, the White-crested Elaenia has no apparent sexual dimorphism (Pyle *et al.* 2015). Although recent studies state that males have longer wings and tails than females (Brown *et al.* 2007), sexing individuals using this criterion is not possible as ranges overlap. When possible, therefore, sexing was based on the presence of a cloacal protuberance or of a brood patch as appropriate (Cueto *et al.* 2015), although it was not always possible to determine the sex of all individuals due to a lack of reproductive features.

White-crested Elaenias were aged as either "juvenile" (hatched during the 2012–2013 season), "first-year" (approximately one year old), or "adult" (older than first-year). We identified all juveniles with certainty on the basis of beige color of wing bars and the absence of the coronal patch (Fitzpatrick *et al.* 2004). Although it is sometimes possible to age first-year individuals by the color of the primary coverts (Pyle *et al.* 2015), we were only able to age 8 out of 315 individuals using this method. To test the applicability of the palate color as an ageing criterion we therefore photographed the palate of most captured individuals in the field. This was done under natural light using a Panasonic DMC-F5 digital camera with a 14.1 MP sensor and 28 mm wide-angle lens. We opened the bill by gently pulling down the lower mandible while gently raising the upper mandible with a finger on the bill-tip. Having observed the range of colors present in the field, the palate color

TABLE 1. Number of individuals for every palate score class, and wing lengths (mm) for each sex category of White-crested Elaenias in Maulino Forest, Chile. Palate score 0: Whole upper mandible reddish yellow; Palate score 1: Distal third of the upper mandible grey or pale-pink; Palate score 2: Half or more of the upper mandible grey or pale pink.

Sex	Palate score			Wing length		
	0	1	2	Range	Mean	SE
Male	0	83	40	71-81	75.04	0.21
Female	0	35	29	72-82	77.35	0.26
Unsexed	8	26	19	70-82	76.22	0.51

of non-juvenile White-crested Elaenia individuals was later classified into three categories by a single observer (RT) from the unedited photographs using the following criteria (see also Figure 1): Category 0: Whole palate yellow-reddish or yellow; Category 1: Distal third of the palate grey or pale-pink; Category 2: Half or more of the palate grey or pale pink.

Given that wing length increases with age in many passerines (Alatalo *et al.* 1984, Gosler *et al.* 1998) we expected that, if differences in palate color are related to age, we should see differences in wing length between the two categories. However, the existence of sexual dimorphism in wing length in this species (Brown *et al.* 2007) means that we have to control for this factor in the model. We therefore carried out an ANOVA with wing length as the response variable, and assessed the effect of palate color while controlling for sex. We checked model assumptions by the use of diagnostic plots and found no significant violations. All analyses were done in R (R Core Development Team 2012).

RESULTS

In total, 4 juveniles and 335 non-juvenile individuals were banded during the whole season. The color of the palate in all of the juveniles was reddish-yellow (Category 0), but with yellow gape flanges still visible. Of the non-juveniles, we were able to score the palate of 246 birds, of which 187 had been sexed in the field (Table 1).

Taking only the data subset of sexed individuals (Fig. 2), a significant and consistent difference was found in the wing length of non-juvenile individuals scored in palate score 1 and 2 ($\beta_{score\ 2}$ = 1.21, SE = 0.34, $P < 0.001$) after controlling by sex (β_{Male} = 2.14, SE = 0.34, $P < 0.001$). The effect size for sex (Cohen’s d [95 %CI] = 1.01 [0.69, 1.33]) was found to exceed Cohen’s (1988) convention for a large effect while the effect of Age (d [95 %CI] = 0.39 [0 , 0.77]) was of medium size.

DISCUSSION

There is a clear relationship between the color of the palate and the wing length in full-grown White-crested Elaenias. The soft tissue in the palate of juveniles of this species is reddish-yellow. As the birds age the fleshy tissue is absorbed, and in the White-crested Elaenia this gradual morphological change appears to be accompanied by a change in the color of the palate, which gradually turns to a greyish-pink (Fig. 1). While we recognize that the lack of recaptures, which would allow us to study the duration of trait pro-gression within individuals, imposes some limitations on our study, we believe nevertheless that our results are compelling.

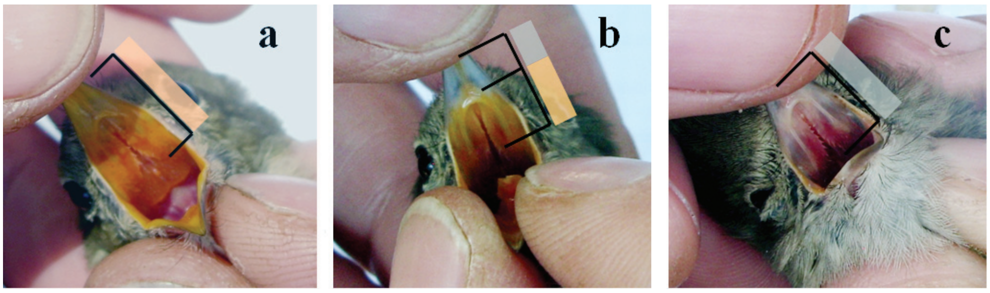

FIG. 1. Change in the color of the palate in White-crested Elaenia in Maulino Forest, Chile highlighted with lines and color bars. Illustrations for (a) Palate score 0, whole upper mandible reddish yellow; (b) Palate score 1, distal third of the upper mandible grey or pale-pink; (c) Palate score 2, half or more of the upper mandible grey or pale pink. Photographs by R. F. Thomson.

We suggest that it is unlikely that our findings could have arisen through any mechanism other than age-related changes between first-year birds and adults. For example, elsewhere we demonstrate that adults had a significantly higher prevalence of blood parasites (Thomson & Gosler in prep.), a pattern that has been reported for many forest bird species (Norris *et al.* 1994, Deviche *et al.* 2001). Although we found a weak correlation between palate color and the level of infection by blood parasites, we are confident that this was not a causal relationship because infection was a much weaker predictor of palate color than was the wing length (Thomson & Gosler in prep.). It appears therefore that any relationship between infection and palate color resulted from the fact that both co-varied with age. Similarly, the body condition of individuals, estimated as the residuals of mass and body size, showed no correlation with the color of the palate (Thomson & Gosler in prep.).

While not directly pertinent to the present paper, it is notable that classifying post-juvenile birds as first-years and adults, according to palate scores, allowed us to recognise important ecological effects acting on the study populations. For example, a significant difference in age structure was found in populations inhabiting native and exotic forests (Thomson & Gosler in prep.). Thus, the results of our study have clear implications for future studies of the Neotropical avifauna. We suggest that this finding should be considered as a basic foundation for further studies among the 18 species comprising the genus *Elaenia* (Fitzpatrick *et al.* 2004). Given their close relatedness (Fjeldså & Krabbe 1990) palate color might prove to be applicable as an ageing criterion for other Elaenia species. However, we recommend that our methods are validated by following changes in palate color in known-age individuals.

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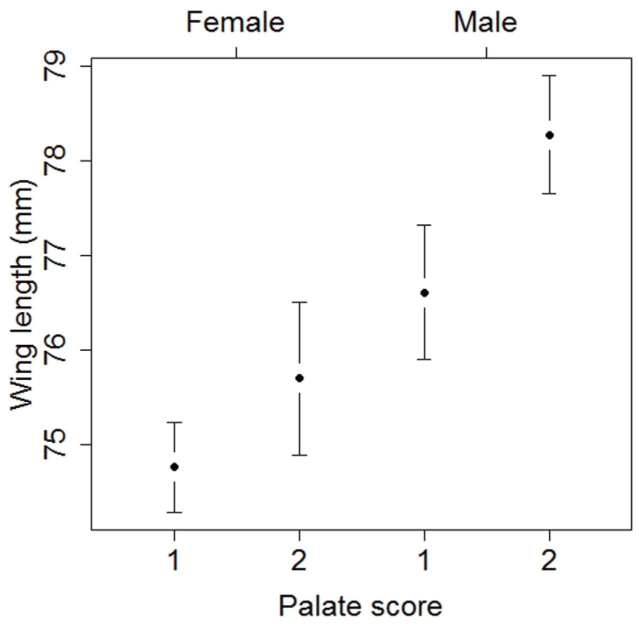

FIG. 2. Mean (± 95% CI) wing length of male and female White-crested Elaenias in Maulino Forest, Chile, classified as different age groups by the color of the palate.

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