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MONOGRAPH

Morphological differences between two subspecies of Spotted Flycatcher *Muscicapa striata* (Pallas, 1764) (Passeriformes Muscicapidae)

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ABSTRACT Four subspecies of Spotted Flycatcher (*Muscicapa striata* Pallas, 1764) (Passeriformes Muscicapidae) are usually recognized within the Western Palaearctic. We carefully analysed two of these in order to determine and quantify their morphological differences: *M. striata striata* (inhabiting most of continental Europe east to the Ural mountains and a small portion of north-western Africa) and *M. striata tyrrhenica* Schiebel, 1910 (breeding on the Tyrrhenian islands of Corsica, Sardinia and the Tuscan Archipelago). We examined total of 58 Spotted Flycatcher specimens from Italian museums (of which 18 *M. striata tyrrhenica*) and obtained data about morphological features such as wing point, length and formula, and bill length, width and depth; furthermore, we investigated plumage colour using a spectrometer. Biometric measurements and an analysis of plumage streaking confirmed the presence of important differences between the two taxa; the colorimetric analysis did not produce the expected results, although it had some interesting implications concerning the preservation of museum specimens and their use in studies of plumage colour.

KEY WORDS Spotted Flycatcher; *Muscicapa striata tyrrhenica*; morphology; museum specimens.

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INTRODUCTION

The Spotted Flycatcher (*Muscicapa striata* Pallas, 1764) is a songbird in the family Muscicapidae and is the only member of its genus in Europe, with at least twenty more species in Asia and Africa. The Spotted Flycatcher is found through most of the Palaearctic, with a continuous distribution from the Iberian peninsula to the Mongolia-China border. It is a long-distance, trans-Saharan migrant, and most of the population winters south of the Equator (Cramp & Perrins, 1993).

Seven subspecies are currently recognized in this extensive range (del Hoyo et al., 2006): *M. striata striata* (Pallas, 1764) (Figs. 1, 2) breeds in Europe east to the Ural mountains and in north-western Africa, and winters south of the Sahara; *M. striata balearica* von Jordans, 1913 (Fig. 1), breeds in the Balearic islands and winters in western and south-western Africa; *M. striata tyrrhenica* Schiebel, 1910 (Figs. 1, 2), breeds in Corsica and Sardinia and presumably winters in Africa; *M. striata inexpectata* Dementiev, 1932, breeds in Crimea and winters in Africa; *M. striata neumanni* Poche, 1904, breeds in the islands of the Aegean Sea east to the Caucasus and northern Iran and south to Cyprus and the Levant, in addition to central Siberia, and winters in eastern and southern Africa; *M. striata sarudnyi* Snigirewski, 1928, breeds from eastern Iran to northern and western

Pakistan and presumably winters in southern and eastern Africa; *M. striata mongola* Portenko, 1955, breeds from the south-eastern Altai mountains to northern Mongolia, and presumably winters in southern and eastern Africa.

Only two (*M. striata striata* and *M. striata tyrrhenica*) of these seven subspecies are regularly found in Italy, while *M. striata neumanni*, which could potentially occur in migration, has not yet been confirmed (Corso, 2005; Brichetti & Fracasso, 2008). The nominate subspecies breeds throughout continental Italy and Sicily, where it is considered common and widespread, although its distribution is somewhat patchy with gaps in high mountain areas. The core breeding range of *M. striata tyrrhenica* comprises Corsica and Sardinia, but contra del Hoyo et al. (2006) and Cramp & Perrins (1993), it also breeds in the Tuscan Archipelago (Brichetti & Fracasso, 2008), while its presence along a narrow band of the Tyrrhenian coast remains to be confirmed (Brichetti & Fracasso, 2008; Tellini et al., 1997). The authors provide some interesting information on the abundance of Spotted Flycatcher subspecies in Italy.

Although the nominate subspecies breeds almost throughout continental Italy, it is never abundant, with population densities that rarely exceed 0.2 pairs/hectare. On the other hand, as many as 0.6 pairs/hectare have been found in *M. striata tyrrhenica* (VV. AA. in Thibault & Bonaccorsi, 1999); so the species seems to fit the usual pattern on islands of densisty inflation due to lower species richness (eg MacArthur & Wilson, 1967; George, 1987; Blondel et al., 1988). Interestingly, high population densities have been recorded along the Tyrrhenian coast in Tuscany; densities are far lower only 50 km inland (Tellini et al., 1997).

There are currently no reliable data on the wintering range of *M. striata tyrrhenica* (Cramp & Perrins, 1993, del Hoyo et al., 2006). The *M. striata tyrrhenica* subspecies of the Spotted Flycatcher was described for the first time by Schiebel (1910) in a paper on the Corsican avifauna and a syntype taken in Aitone, Corsica, on 19 May 1910 is currently held at the Zoologisches Forschungs institut und Museum Alexander Koenig in Bonn, Germany. The identification of this subspecies is generally dealt with very superficially in the ornithological literature, with limited discussion of its distinguishing characteristics. Several examples are below:

- Arrigoni degli Oddi (1929): "*similar to the previous species [authors' note: the subspecies*

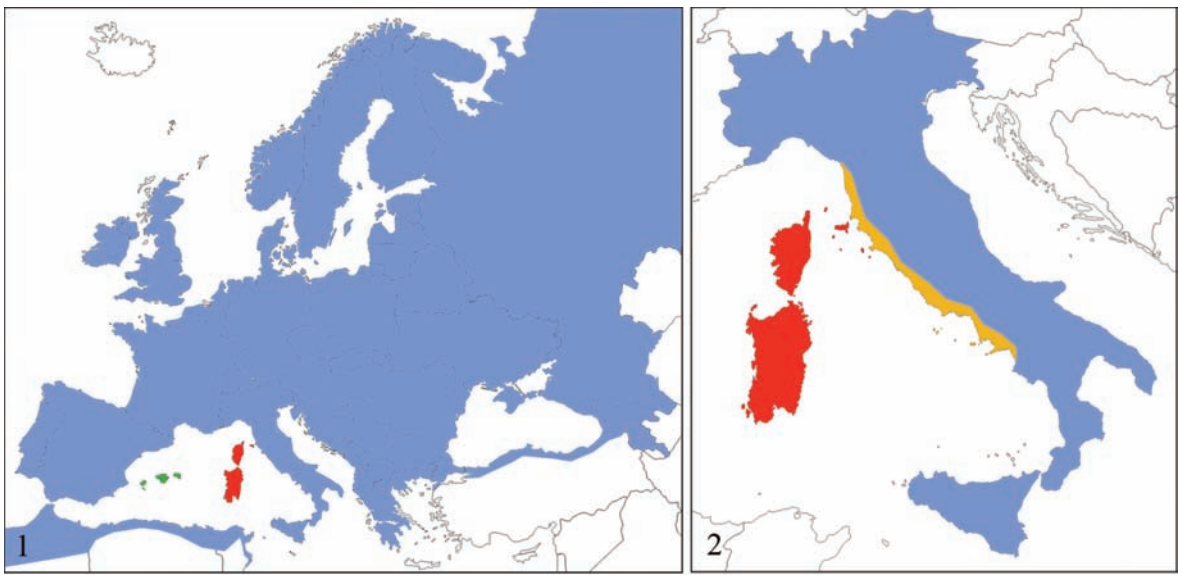

Figure 1. In Western Europe three subspecies of Spotted Flycatcher are found: *Muscicapa striata striata* (blue), *M. striata tyrrhenica* (red) and *M. striata balearica* (green). Figure 2. Two subspecies of Spotted Flycatcher breed in Italy: *M. striata striata* (blue) and *M. striata tyrrhenica* (red); *M. striata tyrrhenica* could be present in the yellow area too, but further research is needed.

striata]; central spots on the cervix and streaking on breastless distinct";

- Cramp & Perrins (1993): "*more warm brown on upperparts, distinctly less streaked on breast, streaks replaced by broader, coalescing spots*";

- Brichetti & Fracasso (2008): "*upperparts browner and warmer-toned, and streaking on the underparts less well-defined and tending to merge into spots*";

- van Duivendijk (2010): "*Primary-projection slightly shorter that* striata*; upperparts warmer brown, underparts almost unstreaked but with broad, faint spots*".

Over the last ten years we have carried out in-depth field and museum studies on the morphological differences between the two taxa in question (Figs. 3–6). In the field, the immediate impression given by *M. striata tyrrhenica* is of a paler bird with warmer tones to the back and more homogeneous underparts. The breast markings, which are generally well defined streaks in *M. striata striata*, appear faded and more spot-like. The streaking on the nape is also less well defined compared to the nominate subspecies, due to the lower contrast between the streaks and the nape's background colour. Primary projection is one of the most important characters: while the primary projection beyond the tertials is longer that the tertials themselves in continental birds, individuals from Corsica and Sardinia have a primary projection that is shorter than, or at most equal to the length of the tertials.

This paper mainly reports the results of our museum studies, while an article on field identification criteria is forthcoming (Viganò et al., personal data).

MATERIAL AND METHODS

Our first observations on the morphological differences between the two subspecies were made in the field: *M. striata tyrrhenica* was studied in southern Sardinia near Villasimius (Cagliari) in July 2004, August 2005, July 2006, and May 2011 and on the island of Elba in July 2014. We have studied this taxon in Corsica as well, in the area of the Gulf of Calvi, in July 2007, July 2008, and May 2012. Our studies of *M. striata striata* have taken place continuously during the breeding season since 2005 in northern Italy; additionally, we have studied this taxon during spring migration on various small islands off central and southern Italy, especially Ventotene (Latina) in April 2010 and 2011 and Linosa (Agrigento) in May 2006, April 2007, and April 2009, where on good days hundreds or even thousands of individuals can be seen.

Other observations took place opportunistically elsewhere in the Western Palaearctic, both during the breeding season and in migration. Studies of museums skins complemented our field observations and were of fundamental importance for this paper (Figs. 7, 8; Table 1). There are very few specimens of *M. striata tyrrhenica* in Italian and foreign museums; indeed, there are none at all in the largest bird collection in Europe at the Natural History Museum at Tring, U.K. We arranged for all of the *M. striata tyrrhenica* specimens held at the Museo Civico di Storia Naturale in Milan, Italy (MCSM), Museo Civico di Zoologia in Rome, Italy (MCZR), and Museo di Scienze Naturali in Forlì, Italy (MSNF) to be sent on short-term loan to the Museum of the Institute for Environmental Protection and Research (Istituto Superiore per la Protezione e la Ricerca Ambientale - ISPRA) in Ozzano dell'Emilia (Bologna, Italy) so that they could be studied side-by-side along with the specimens held in the last-named institution.

We took the following measurements: wing chord, longest primary (P3), distance of each primary from P3, bill length from the nostrils, bill height and thickness at the nostrils. Measures that are generally taken during ringing activities such as tail, tarsus, and bill-to-cranium length were not taken since they vary depending on the way the specimen was prepared (Winker, 1998; Eck et al., 2011; Kuczynski, 2003). The measurements considered here are also subject to some degree of variation depending on specimen preparation; measurements taken on live animals may add a degree of precision and some additional information, but we felt that museum specimens were better suited to taking biometrical and plumage colour data together.

As concerns wing chord length, one study that looked at the wings of Rooks (*Corvus frugilegus*) measured upon capture, after 8 weeks, and again after 144 weeks found a difference in length between fresh and dried wings of about 1.84% (Knox, 1980). Measurements were taken using a stopped ruler (to the nearest 0.5 mm), callipers (to

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Figures 3, 4. Spotted Flycatcher (*Muscicapa striata tyrrhenica*), Villasimius (Cagliari), Sardinia, May 2011. Note the quite pale and warm general colour, the subtle head and breast markings and the short primary projection compared to tertials length. Figures 5, 6. Spotted Flycatcher (*Muscicapa striata striata*), Ventotene, Latina, Italy, April 2011 (Fig. 5) and Pantelleria, Trapani, Sicily, May 2009 (Fig. 6, photo by Igor Maiorano). The overall impression is of a colder and less homogeneous bird, with bold markings on breast and head; primary projection is longer than tertials length.

the nearest 0.1 mm) and a thin strip of graph paper (to the nearest 0.5 mm) strengthened by an equally thin strip of transparent plastic.

The latter tool was necessary to measure P3: this feather is usually measured using a special ruler, but due to the specimens' age, their rigidity, and their historic value, some are from the prized Arrigoni degli Oddi collection, we decided to use graph paper as it is thinner and less invasive. Colour analysis of the upperparts of Spotted Flycatcher specimens was undertaken using an Ocean Optics USB 2000 spectrometer at ISPRA.

Before proceeding with the spectrometer analysis of Spotted Flycatcher plumage we had to calibrate the instrument and its associated software, Ocean Optics Spectrasuite, which is provided by the manufacturer of the spectrometer and the lamp. The spectrometer was calibrated by reading and recording on the software two values that were to correspond with white and black. In order to do so we used Ocean Optics' WS1 Diffuse Reflectance Standard for white, while for black we placed the lighting fibreover the black square on X-Rite's Color Checker's colour scale.

Once the programme was launched, only two parameters needed to be set. Scan-to-average was set at 5: for each colour reading of a given point, five scans are automatically made, and their average is recorded as the final value. Integration time was set at 300 in order to prevent peaks in the graph above the upper margin when the scanner was placed above the white standard; in other words, to ensure that reflectance on a white standard would not return excessively high values that would have led to a loss of information on the portion of the graph falling outside the margins.

Once calibration was completed, we sampled colours on each specimen as follows: three measurements were taken from the mantle (usually two from the right-hand side and one from the left) and three more from the rump (by moving the scanner along a vertical line from the top to the bottom of the rump).

This means that for each specimen, the data reported in the Table 2 comprises the averages of 15 measurements on the mantle and 15 on the rump. In accordance with the instructions reported by Hill & McGraw (2006) we selected and ranked the data before analyzing them: we only considered values with wavelengths between UV and red ($299.74 \leq \lambda \geq 700.28$), then sub-divided them into intervals of approximately 10 nm, e.g. from 410nm to 420nm.

The values we calculated (for both mantle and rump) are as follows:

- Total Reflectance: the sum of all intervals
- UV Component: the sum of values falling between 300nm and 400nm

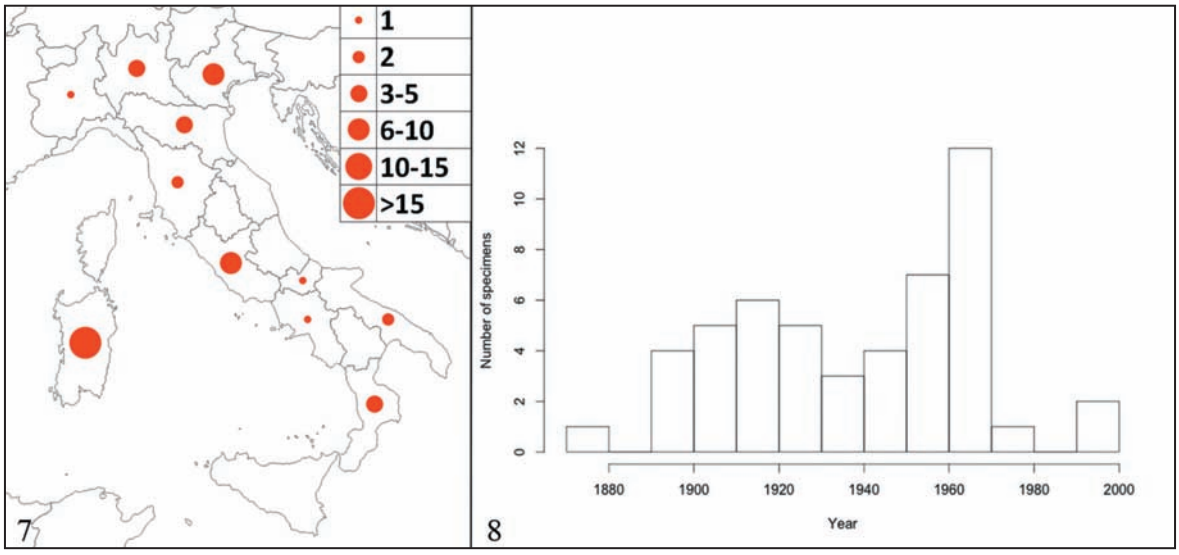

Figure 7. The provenience of the museum specimens analysed. Figure 8. The number of birds collected per decade.

Museum	*M. striata striata*	*M. striata tyrrhenica*
MCSM	10	7
MCZR	15	6
MSNF	5	4
ISPRA	8	1
Total	**38**	**18**

Table 1. This table summarizes the number of specimens studied, the museum they belong and their subspecific identification.

- UV Chroma: UV Component to Total Reflectance ratio
- RED Component: the sum of values falling between 600nm and 700nm
- RED Chroma: RED Component to Total Reflectance ration

The results are reported in the Tables 2 and 3 in the following chapter. In order to better investigate the results obtained with the colorimeter, we made subsets of the original data (Figs. 9–20): we began by removing from the sample of *M. striata striata* all individuals from the narrow strip of Tyrrhenian coastline in Tuscany, Latium, and Campania where *M. striata tyrrhenica* may be breeding; we did not remove two individuals captured on Ventotene Island (Latina) and Capri (Naple) because they matched *M. striata striata* in every regard and we considered them to be spring migrants of *M. striata striata* with a reasonable degree of certainty. A second subset was made comparing the usual sample of Sardinian specimens with a subset (n=6) of *M. striata striata* specimens that show particularly cold plumage tones on visual inspection. We also divided the sample into old "pre-1960" and recent "post-1960" subsets, meaning that 'recent' specimens were no more than fifty years old, following Armenta et al. (2008).

In order to evaluate the differences in nape and breast streaking between the two subspecies, we compared the specimens visually (see, for example, Galeotti et al. 2009). After an initial evaluation of all specimens, we established categories that could represent in sufficient detail the variability present in the two taxa. We scored breast streaking on a 0 to 6 scale (0 indicating no streaking and 6 the heaviest streaking) and nape streaking on a 0 to 5 scale. We assigned those values to each specimen; when necessary, we compared the specimen under observation directly with the reference specimens.

RESULTS

Biometric analyses found significant differences in wing morphology. Differences in maximum wing chord were found to be statistically significant using a t-test (t = 9.4407, p = 6.079e-12), confirming our field observations of a shorted primary projection in *M. striata tyrrhenica*.

Similar wing measurement data are reported in the literature (e.g. Cramp & Perrins, 1993; Brichetti & Fracasso, 2008). On the other hand, in a study of birds ringed between mid-April and mid-May at Capo Caccia, Sardinia (Marchetti & Baldaccini, 1995) did not report such a difference, although the authors themselves suggested that such comparisons were better made using birds caught on their breeding grounds during the reproductive season in order to ensure correct subspecific identification. In addition to the wing chord, significant differences were found in the wing formula as well. The values calculated for each primary are summarized in figure 22, which shows wing formula for each taxon. The most significant difference concerns the relative distance between the longest primary (P3) and P2; this characteristic is also depicted in figure 21, which shows the distance (in mm) between P2 and P3 in each taxon. The t-test reveals significant differences between the two subspecies concerning this character (t = -5.1674, p = 6.536e-06), as well as in the distance between P3 and P4 (t = 5.8634, p = 6.768e-07). Differences in wing shape of this type and extent are highly interesting. Similar discrepancies have been found between sister species in which one is a short-distance migrant and the other a long-distance migrant (Chandler & Mulvihill, 1988;Mönkkönen, 1995), or where there is a gradient between more or less migratory subspecies of the same species (Arizaga et al., 2006; Winkler et al. 2010) or again in similar species where one is migratory and the other sedentary (Chandler & Mulvihill, 1990; Milá et al., 2008).

Figures 9–14. A value for underpart markings was given to each specimen; seven categories were determined (one central category not depicted), ranging from least marked (value 0) to boldly marked (value 6).

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Figures 15–20. A value for head streakings was given to each specimen; six categories were determined, ranging from least marked (value 0) to boldly marked (value 5).

This phenomenon is known as "Seebohm's rule" and can be summed up as follows: long-distance migrants have more pointed wings (shorter inner primaries and longer outer primaries) compared to short-distance migrants or non-migratory species, since longer and more pointed wings make for more powerful flight compared to shorter, more rounded wings (Seebohm, 1901; Calmaestra & Moreno, 2001).

We also found differences in bill length measured from the distal end of the nostrils to the tip of the bill, with p = 0.01582 and t = 2.5203, with *M. striata striata* showing on average a longer bill; we did not use the commonest bill measurement method, from the tip of the bill to the base of the skull, because for museum specimens it is less reliable than the parameter used in this study (Winker, 1998; Kuczynski et al., 2003). Our scores for breast and nape streaking also confirmed our field observations, namely that nape and breast streaking is less well defined in Sardinian and Corsican birds.

Colour analysis did not reveal any statistically significant differences except in the sum of λ falling between 300 and 400nm, or within the UV spectrum. These differences fade away if one considers the UV chroma, namely by dividing the UV value by total reflectance. In order to better understand the reasons for this, we carried out a number of tests by modifying the data sample used in the analysis in an attempt to remove the effect of certain parameters that may have generated background noise and muddled the results. The first subset excludes all individuals from the narrow strip of Tyrrhenian coastline where *M. striata tyrrhenica* may breed: using this sample, differences in mantle UV are no longer significant, but differences emerge in terms of total reflectance and the red component of the mantle, with *M. striata tyrrhenica* slightly redder and paler than *M. striata striata*, albeit with low statistical significance. However, further manipulation of the sample for colorimetric analysis, comparing *M. striata tyrrhenica* specimens with six particularly cold plumaged *M. striata striata* specimens did not find statistically significant differences for any variable.

This unexpected result, involving striata specimens that showed clear differences in mantle tones compared to *M. striata tyrrhenica* on visual inspec-

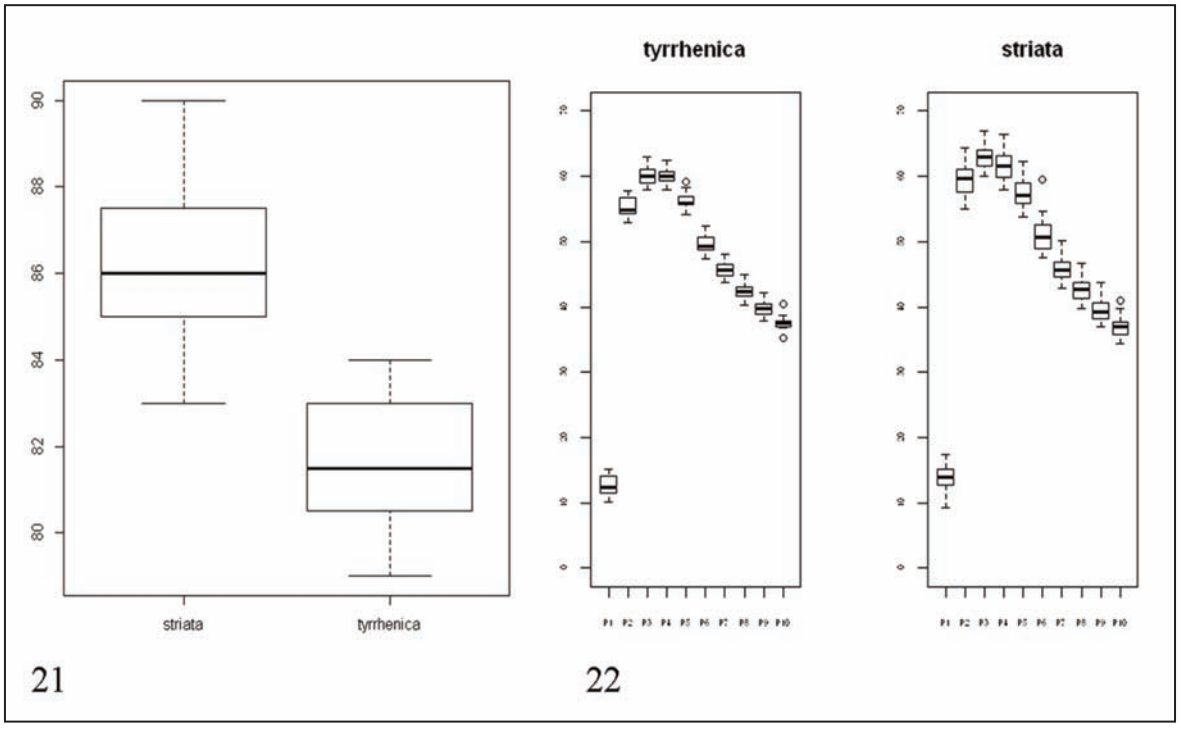

Figure 21. Chord values (in mm) recorded on *Muscicapa. striata striata* and *M. striata tyrrhenica* specimens.
Figure 22. Wing formula for both subspecies; note the rounder shape of *M. striata tyrrhenica* birds.

	Muscicapa striata striata			***Muscicapa striata tyrrhenica***				
variable	**mean + sd**	**n**	**range**	**mean + sd**	**n**	**range**	**t**	**p**
P1	13.75926 ± 1.931572	27	9.3-17.4	12.67500 ± 1.438286	16	10.2-15.1	1.9448	0.05868
P2	**59.57778 ± 2.469247**	**27**	**55.0-64.4**	**55.33125 ± 1.520841**	**16**	**52.9-57.8**	**6.2002**	**2.245e-07**
P3	**62.96429± 1.914509**	**28**	**60-67**	**60.12500 ± 1.258306**	**16**	**58-63**	**5.3003**	**3.996e-06**
P4	**61.64074 ± 2.176670**	**27**	**58.0-66.5**	**60.06250 ± 1.223043**	**16**	**58.0-62.5**	**2.6544**	**0.01126**
P5	57.36667 ± 2.300000	27	53.8-62.2	56.26154± 1.413352	13	54.2-59.1	1.5879	0.1206
P6	50.97407± 2.695094	27	47.5-59.5	49.61250± 1.433353	16	47.4-52.4	1.8645	0.06943
P7	45.86667± 1.840568	27	42.9-50.2	45.67333± 1.258381	15	43.7-48.1	0.3616	0.7195
P8	42.66296± 1.784581	27	39.7-46.6	42.35625± 1.175284	16	40.2-44.9	0.6118	0.544
P9	39.69259± 1.836369	27	36.9-43.8	39.73125± 1.151068	16	36.9-43.8	- 0.0757	0.9401
P10	36.84074± 1.727662	27	34.3-40.9	37.56000± 1.136913	15	35.2-40.4	-1.444	0.1565
chord	**86.14286± 1.603567**	**28**	**83-90**	**81.50000 ± 1.505545**	**16**	**79-84**	**9.4407**	**6.079e-12**
bill L	**8.392593± 0.2758566**	**27**	**8.0-8.9**	**8.140000 ± 0.3680062**	**15**	**7.2-8.6**	**2.5203**	**0.01582**
bill W	3.496429± 0.1990387	28	3.1-3.9	3.420000± 0.1373213	15	3.2-3.7	1.3244	0.1927
billT	4.357143± 0.2379365	28	3.6-4.8	4.353333± 0.3888934	15	3.6-5.1	0.0399	0.9683
breast	**4.096774± 0.7897189**	**31**	**3-6**	**1.466667 ± 0.9904304**	**15**	**0-3**	**9.7384**	**1.504e-12**
head	**3.586207± 0.7327659**	**30**	**2-5**	**1.333333 ± 0.8164966**	**15**	**0-3**	**9.2998**	**9.361e-12**
f_R_tot_refl	385.2981± 74.04245	36	263.55-603.68	397.1140± 55.03810	15	316.97-486.38	-0.556	0.5807
f_R_UV	59.08778± 15.51324	36	36.00-99.42	61.77267± 13.38254	15	41.97-85.83	-0.5849	0.5613
f_R_CROMA_UV	0.151982± 0.0151761	36	0.11943-0.18782	0.154283± 0.0155461	15	0.1324-0.1910	-0.49	0.6263
f_R_RED	141.8281± 22.45401	36	100.9-200.3	148.8973± 20.66444	15	114.11-181.89	-1.0476	0.3
f_R_CHROMA_RED	0.370492± 0.0201814	36	0.331798-0.41221	0.375287± 0.0162703	15	0.35564-0.4098	-0.815	0.419
f_M_tot_refl	303.9143± 33.40160	36	236.78-344.78	329.1888± 40.71543	16	290.13-405.80	-1.5784	0.1302
f_M_UV	**44.53722± 6.774240**	**36**	**31.52-57.73**	**49.10250± 7.547965**	**16**	**39.27-65.49**	**-2.1659**	**0.03512**
f_M_CHROMA_UV	0.144340± 0.0137475	36	0.11600-0.171272	0.147015± 0.0119409	16	0.13113-0.1696	-0.6728	0.5042
f_M_RED	112.1264± 9.672242	36	92.18-126.12	120.3400±11.764493	16	108.76-141.91	-1.773	0.09145
f_M_CHROMA_RED	0.376839± 0.0175326	36	0.338173-0.40683	0.375442± 0.0206807	16	0.34161-0.4047	0.2508	0.803

Table 2. All the statistical results from our study are here summarized; the variables highlighted in boldface are those for which the t-test found values <0.05.

	Muscicapa striata striata			***Muscicapa striata tyrrhenica***				
variable	**mean + sd**	**n**	**range**	**mean + sd**	**n**	**range**	**t**	**p**
M_tot_refl	**309.2468 ± 31.11327**	**29**	**236.78-365.09**	**329.1888 ± 40.71543**	**16**	**290.13-405.80**	**-2.2777**	**0.0279**
M_UV	45.6875 ± 6.037829	29	35.20-56.61	49.10250 ± 7.547965	16	39.27-65.49	-1.6468	0.1071
M_CHROMA_UV	0.1476630 ± 0.0113407	29	0.123644-0.171272	0.147015 ± 0.0119409	16	0.13113-0.1696	0.179	0.8588
M_RED	**115.6518 ± 10.24447**	**29**	**92.18-126.12**	**120.3400 ± 11.764493**	**16**	**108.76-141.91**	**-2.5046**	**0.01623**
M_CHROMA_RED	0.3748562 ± 0.0180199	29	0.338173-0.399920	0.375442 ± 0.0206807	16	0.34161-0.4047	-0.0983	0.9222
R_tot_refl	388.8814 ± 78.95214	29	263.55-603.68	397.1140 ± 55.03810	15	316.97-486.38	-0.3589	0.7215
R_UV	60.81893 ± 16.22125	29	36.00-99.42	61.77267 ± 13.38254	15	41.97-85.83	-0.1947	0.8466
R_CHROMA_UV	0.1549453 ± 0.0141347	29	0.121704-0.187822	0.154283 ± 0.0155461	15	0.1324-0.1910	0.1413	0.8884
R_RED	141.9193 ± 23.99409	29	100.9-200.3	148.8973 ± 20.66444	15	114.11-181.89	-0.9519	0.3468
R_CHROMA_RED	0.3674105 ± 0.0197631	29	0.331798-0.408994	0.375287 ± 0.0162703	15	0.35564-0.4098	-1.3203	0.1941

Table 3. Same colorimetric variables analyzed in the previous table, but with a different subset of data: birds collected from the narrow strip of Tyrrhenian coastline in Tuscany, Latium, and Campania, where *M. striata tyrrhenica* could occur, were removed.

tion, suggests that the method we used for our colorimetric analysis is not ideal for detecting such subtle differences in plumage pigmentation.

Additional comparisons looked at the effects of time on the state of preservation of specimen. In accordance with other works that tested colour deterioration in museum specimens (Armenta et al., 2008; Doucet & Hill, 2009), we found highly significant differences between old (pre-1960) and recent (post-1960) specimens.

We used this data to build a linear model to identify the variables that most affected colour variation. As expected, taxon did not have a statistically significant effect, while year of collection did ($F(1.46) = 7$, $P = 8.408e\text{-}05$). In other words, specimens that were more than fifty years old showed a statistically-significant higher total reflectance, and thus appeared paler.

The biometric and colorimetric data collected in this study is summarized in Table 2, which also indicates sample size (n), the minimum and maximum values recorded (range) and the t and p values for the t-test as applied to each variable for the two taxa. The variables highlighted in boldface are those for which the t-test found values <0.05, meaning that the differences between the two taxa for

the variable in question were statistically significant. The variables "P1" to "P10" indicate primary length from the outermost to the innermost; "chord" indicates the length of the maximum wing chord, namely the closed wing measured from the carpal joint; "bill L, H, and T" respectively indicate bill length, height, and thickness; "breast" and "head" indicate the amount of streaking in these two areas scored after a visual examination.

Colorimetric data follows: variables initialed with an M refer to the mantle, and those with an R to the rump; tot_refl refers to total reflectance, UV and RED respectively refer to the sum of λ falling between 300 and 400 and between 600 and 700; UV_CHROMA and RED_CHROMA indicate the ratio between these two variables and total reflectance.

DISCUSSION AND CONCLUSIONS

The objective of this study was to test the differences observed in the field between the *M. striata striata* and *M. striata tyrrhenica* subspecies of Spotted Flycatcher as objectively as possible, by using methods that would not be influenced by differences in perception of colour and proportions on the part of different observers. The results confirmed the morphological differences observed in the field and cited in the literature, and the different intensity and extent of streaking on the underparts and the nape. Nevertheless, to better assess these parameters a larger sample, in both quantitative and qualitative terms, would be preferable, and would ideally include a larger number of birds captured on their breeding grounds. Differences in wing-shape are important not only from an identification perceptive, but also in light of the relationship between wing morphology and migratory distance (Baldwin et al., 2010; Mönkkönen, 1995).

The shorter, more rounded wings of *M. striata tyrrhenica* suggest that birds breeding in Corsica and Sardinia may have a shorter migration compared to birds from continental Italy and Europe. This is all the more interesting given that there is no solid data in the literature on the non-breeding range of *M. striata tyrrhenica* (Cramp & Perrins, 1993; del Hoyo et al., 2006), that should anyway be sub-saharan, given the absence of evidence of winter sightings north of the Sahara.On the other hand, our colorimetric analyses failed to confirm the differences observed in the field and reported in the literature. To conclude, biometric measurements and an analysis of plumage streaking confirmed the presence of some important differences between the two taxa, including characters that can be seen in the field, while the colorimetric analysis did not produce the expected results, although it had some interesting implications concerning the preservation of museum specimens and their use in studies of plumage colour.

There are several other instances of taxa that have similar distributions to *M. striata tyrrhenica* Spotted Flycatchers and are morphologically very similar to the taxa breeding elsewhere in Italy and Europe being recognized as full species after in-depth analyses of morphology, voice, ecology and DNA: examples include Corsican Finch (*Carduelis corsicana*) (Cramp & Perrins, 1993; Sangster, 2000; Förschler & Kalko, 2007, Förschler et al. 2009) and Moltoni's Warbler (*Sylvia subalpina*) (Brambilla et al., 2008), both recently recognized as full species; further research on *M. striata tyrrhenica* Spotted Flycatcher is needed.

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