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BLACK AND WHITE TAIL MARKINGS IN RUFOUS BUSH CHATS *CERCOTRICHAS GALACTOTES*: SIZE, SYMMETRY AND THE EXTENT OF SEASONAL ABRASION

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SUMMARY.—*Black and white tail markings in Rufous Bush Chats* Cercotrichas galactotes*: size, symmetry and the extent of seasonal abrasion.*

Aims: An attempt was made to understand the relationship of reproduction with the features of the conspicuous visual pattern in the tail of Rufous Bush Chats *Cercotrichas galactotes*, especially in relation to its reduction in size during the breeding season.

Location: Southwestern Andalusia (southern Spain).

Methods: In two breeding seasons the size, fluctuating asymmetry and extent of abrasion of the white terminal and black subterminal markings of male and female Rufous Bush Chats were compared until the end of reproduction.

Results: A positive relationship was found in males between the size of their white terminal markings and reproductive success and a negative one between the size of their black subterminal markings and the rate of nest depredation. The size of the white patches was positively related within pairs. Only the size of the white terminal markings is notably reduced over the breeding season.

Conclusions: Since most of the abraded white markings are beyond the point of the maximum width of the tail, the hypothesis is offered of an adaptive reduction of its dragging effect during the birds' trans-Saharan late-summer southward migration. The black subterminal markings, protected by melanin against abrasion, may function fixing a limit to erosion.

Key words: Abrasion, *Cercotrichas galactotes*, migration, reproduction, Rufous Bush Chat, visual pattern.

RESUMEN.—*Marcas caudales en blanco y negro en el Alzacola* Cercotrichas galactotes*: tamaño, simetría y grado de erosión estacional.*

Objetivos: Comprender la relación de la reproducción con las características del conspicuo diseño en blanco y negro en el extremo de la cola del Alzacola *Cercotrichas galactotes*, especialmente en relación con su reducción en tamaño durante la estación reproductora.

Localidad: Suroeste de Andalucía (España).

Métodos: Se comparó, en dos estaciones reproductivas, el tamaño, grado de asimetría fluctuante y de erosión de las marcas distales blancas y subterminales negras de machos y hembras con sus características reproductivas.

Resultados: Para el caso de los machos se halló una relación positiva entre el tamaño de las las marcas terminales blancas y su éxito reproductivo, así como una relación negativa entre el tamaño de las marcas subterminales negras y la intensidad de la depredación sobre sus nidos. Las parejas se asemejaban en el tamaño de las marcas terminales blancas. El tamaño de las marcas distales blancas es notablemente reducido a lo largo de la estación reproductora, no así el de las subterminales negras.

Conclusiones: La reducción en la resistencia al avance durante el vuelo, resultado de la erosión del área distal de la cola respecto a la línea de anchura máxima, que ocurre en mayor grado en las manchas terminales blancas por carecer éstas de protección de melanina contra la erosión, se interpreta aquí como una ventaja durante la migración del final de verano hacia los cuarteles de invierno al sur del Sáhara. Las marcas negras subterminales, protegidas por melanina, ayudarían a poner un límite a la erosión.

Palabras clave: Alzacola, *Cercotrichas galactotes*, diseño visual, erosión, migración, reproducción.

INTRODUCTION

Male and female Rufous Bush Chats *Cercotrichas galactotes* are monomorphic in plumage and have cryptic light brown plumage with a long, rufous, slightly graduated tail whose central pair of feathers has no marks, the other five pairs being boldly marked with ter-

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minal white and subterminal black patches. During aggressive and sexual encounters, as well as during the manoeuvres of distraction (while defending their nests against predators), chats display their tails by up and down movements, frequently cocking it vertically, and often fanning it and showing the distinct black and white patches.

In a previous study (Álvarez, 2000), the characteristics of the visual pattern of the tail of the chats (size of white terminal patches and bilateral symmetry in the black subterminal patches) has been shown to be related to an increase in reproductive success and a decrease in nest depredation.

As the chats arrive at the breeding area in southern Spain in spring and early summer with their plumage in good condition, and some with badly damaged tails are sometimes observed throughout the summer, it might be asked whether the conspicuous tail markings are useful at certain times during the breeding season. These markings may act as releasers (*sensu* Tinbergen, 1948) during individual evaluation in a context of mate choice at the beginning of the season (as indicators of feather quality, Fitzpatrick, 1998), or, if the tail markings would play the role of deflexion coloration in nest defence when young are specially vulnerable in their nests, helping to draw the attention of potential predators towards the displaying parent, and away from the offspring (Cott, 1940; Baker & Parker, 1979; Álvarez & Sánchez, 2003).

The present study aims at understanding the relationship between the features of the tail visual pattern and reproduction, especially in relation to the extent and significance of size reduction of the tail markings during the breeding season.

MATERIAL AND METHODS

The study area was 90 ha at 37°09′N, 02°14′W, 12 m a.s.l., 20 km south of Seville (SW Spain), with a Mediterranean climate in a zone mostly used for intensive vineyard agriculture in which Rufous Bush Chats nearly always build their nests on vine stocks 1-1.5 m high, with orchards, greenhouses, interspersed fruit trees, and areas of kitchen gardens and vegetable growing.

Work was conducted during the breeding seasons (April to August) of 2000 and 2001. Five persons inspected the area systematically every two days, looking for new nests, number and condition of eggs or chicks, which individuals were in charge of each nest, and the number of nestlings flying from each nest. Seasonal reproductive success was considered equivalent to the total number of young flying from all nests and total seasonal nest depredation was obtained by dividing the number of nests attacked by predators (showing clear signs of predation on part or the whole brood of fertile eggs, or apparently healthy chicks disappearing at unexpected times) by the total number of nests in the season.

Immediately after the first brood of the season hatched in May and June, also including the first days of July in 2001, chat pairs were caught with mist nets, either near the nest or attracted toward a recorded song as a decoy near the usual singing posts of the males. Immediately after being captured, they were measured and ringed with a steel numbered ring and a unique combination of 2-3 coloured plastic rings in order to recognize them individually. Keel-length was used as an index of body size (Senar & Pascual, 1997).

The members of the captured pairs were sexed behaviourally as only females incubate and only males sing (Álvarez, 1996), and according to the presence of incubation patch in females, and measured (digital callipers with ±0.01 mm precision). Although information was collected for all males and females captured in 2000 and 2001, seven males and five females were captured in both years, and were included only once in the analysis (data obtained in 2000 were used).

Before the subjects were released two photographs of their spread tails, together with a length scale, were taken at a constant distance and centred on the central tail feathers and perpendicularly with respect to the base (digital Sony MVC-FD88 camera). While photographing the birds' tails, the feathers were not flattened against the flat background, but the rachis of all feathers was kept in full contact with the base (in a previous study the patches were outlined and their area measured and the feathers were flattened against the base, Álvarez, 2000). Since the stiff rachis of all feathers crosses both the terminal white and subterminal black tail patches, the length of the feather rachis intersected by each patch was measured in the photographs with the aid of Sigmascan software (Jandel Corporation, San Rafael, California) as a reliable index of patch length. The two selected measures of the tail colour pattern (total length of terminal white and of subterminal black patches) were obtained by adding the intercepted portions of the raches for all tail feathers.

Fluctuating asymmetry (FA) of patch size was computed as length difference between the sum of patch lengths (|Right-Left| for white and black patches separately), since it did not change with total length (Palmer, 1994).

The two values obtained for keel length and for size and the FA of tail patches (from the two photographs of the tail of each bird) were used to calculate the repeatability correlation coefficients, as well as to obtain the mean values used in calculations.

Since information for 2000 and 2001 relative to the variables analyzed was found to be not significantly different, data for these two years were pooled. All tests were two-tailed. The repeatability of keel-length, size and FA of white and black tail patches was high (intraclass correlations not lower than 0.76; $P < 0.001$).

Results

Neither size nor FA of white and black tail patches were related at a significant level with male or female body size. When comparing these features of the tail visual pattern with the outcome of the reproduction of each pair, significant results were obtained only for males: the sizes of their white and black patches were positively and negatively related, respectively, to reproductive success and nest depredation (Table 1).

Table 1

Spearman rank correlation between total size and FA of the terminal white and the subterminal black tail patches and body size (keel-length), reproductive success (number of fledglings flying from all nests) and total seasonal nest depredation (ratio of number of nests attacked by predators to total number of nests in the season) of male and female Rufous Bush Chats.

[Correlaciones de Spearman entre el tamaño total o la asimetría fluctuante de la mancha blanca terminal o la mancha negra subterminal, con el tamaño corporal (longitud de la quilla), éxito reproductor (n.º de volantones de todos los nidos) y la depredación total de los nidos (proporción de nidos atacados por predadores del total de nidos por temporada) en los machos y hembras de Alzacola.]

	Terminal white patches *[Mancha blanca terminal]*					Subterminal black patches *[Mancha negra subterminal]*				
	Size [Tamaño]		*FA [Asimetría fluctuante]*			*Size [Tamaño]*		*FA [Asimetría fluctuante]*		
	r_s	*P*	r_s	*P*	*n*	r_s	*P*	r_s	*P*	*n*
Males *[Machos]*										
Body size *[Tamaño corporal]*	–0.203	0.197	0.196	0.213	42	0.134	0.399	0.285	0.067	42
Reproductive success *[Éxito reproductor]*	0.368	0.015	0.011	0.944	43	–0.047	0.783	0.165	0.295	42
Nest predation *[Depredación del nido]*	–0.281	0.068	–0.110	0.483	43	–0.349	0.024	–0.096	0.544	42
Females *[Hembras]*										
Body size *[Tamaño corporal]*	–0.272	0.179	–0.159	0.438	26	0.114	0.580	0.358	0.073	26
Reproductive success *[Éxito reproductor]*	0.290	0.114	0.252	0.172	31	–0.169	0.363	0.254	0.169	31
Nest predation *[Depredación del nido]*	0.184	0.322	–0.186	0.318	31	0.107	0.566	–0.254	0.169	31

TABLE 2

Size and FA of terminal tail white patches and of subterminal tail black patches (mm) of male (n = 19) and female (n = 14) Rufous Bush Chats in the month of May (when patches are still not much eroded), and result of between-mates comparisons during the early stage of their first brood.
*[Tamaño y asimetría fluctuante (FA) de la mancha terminal blanca y la mancha subterminal negra caudales (mm) de machos (*n = *19) y hembras (*n = *14) de Alzacola en el mes de mayo (cuando las manchas no han sufrido desgaste), y resultado de la comparación entre los miembros de la pareja al inicio de las primeras puestas.]*

	Males *[Machos]*		Females *[Hembras]*		Correlation between mates *[Correlación entre miembros de la pareja]*			Male-female difference *[Diferencia entre machos y hembras]*		
	Md	*Quart. Range*	*Md*	*Quart. Range*	r_s [1]	*P*	*n*	T [2]	*P*	*n*
White patches *[Mancha blanca]*										
Size *[Tamaño]*	66.08	15.56	65.87	19.84	0.484	0.008	29	133.0	0.068	29
FA *[Asimetría fluctuante]*	2.23	2.81	1.01	2.17	0.072	0.709	29	155.0	0.177	29
Black patches *[Mancha negra]*										
Size *[Tamaño]*	89.88	19.21	76.91	17.80	–0.106	0.585	29	109.0	0.019	29
FA *[Asimetría fluctuante]*	1.45	2.55	1.61	2.17	–0.077	0.690	29	165.0	0.256	29

[1] Spearman rank correlation test. *[Correlación de Spearman.]*
[2] Wilcoxon signed-ranks test. *[Prueba de Wilcoxon para datos apareados.]*

Although the number of nestlings flying from successive nests in the season (first nests: X ± SD = 2.05 ± 1.87, n = 63; second nests: 2.34 ± 1.42, n = 38; third nests: 2.11 ± 1.69, n = 6; fourth nests: 3, n = 1) did not vary significantly (first vs. second: T = 121.5, n = 38; first vs. third: T = 15.5, n = 9; second vs. third: T = 9, n = 9; $P > 0.05$ for the three comparisons; Wilcoxon signed-ranks test), of 63 pairs breeding for the first time in early season, only 60.3%, 14.3% and 1.6% of them built, respectively, a second, third and fourth nest.

Since pair members were photographed within a short lapse of time (0 - 5 days), male-female comparisons within pairs (of only the subjects of those pairs in which both members were photographed) would avoid the effect of patch size reduction with time. Comparisons showed that the size of the white patches positively and significantly correlated within pairs (Table 2). Males showed significantly greater black patches than females. FA comparisons provided no significant effects (Table 2).

Male-female comparison within pairs with respect to body size (keel-length) also provided a positive and quasi-significant result (n = 36, r_s = 0.324, P = 0.054). Males presented greater body size than females (keel-length; males: n = 47, Md = 20.73 mm, *Quart. range* = 1.15 mm; females: Md = 19.60 mm, *Quart. range* = 1.01 mm; T = 37, Z = 4.65, n = 36, $P < 0.001$; Wilcoxon test).

In relation to the reduction in patch size as the breeding season advanced, their relationship with the date of observation (number of days from May 1 of 2000 and 2001 for the subjects of each of the two years) for all chats of known sex photographed was found to be negatively significant only for the terminal white patches, and not for the sub-terminal black ones (Table 3 and Fig. 1). The size reduction of the white terminal patches of a bird caught at the start of the breeding season and after 76 days is shown in Fig. 1. No significant variation with time was observed for FA of both kinds of tail patches (Table 3).

Since it could be that late breeders with smaller patches were caught later in the season, a more definite demonstration of reduction in the size of white patches and therefore in conspi-

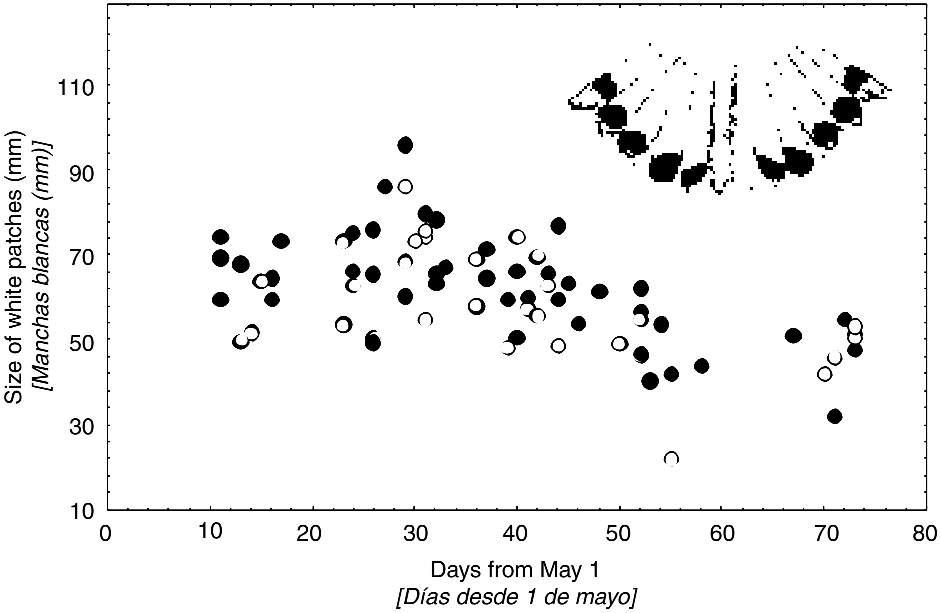

Fig. 1.—Size of terminal tail white patches in relation to date of Rufous Bush Chats breeding season (day 1: May 1 of 2000 and 2001). Males and females are represented, respectively and only once, by filled and empty dots. Insert: Reduction of terminal white tail patches of a bird photographed at the start of the breeding season (17 May 2001, dashed outline) and after 76 days (2 August 2001).
[Tamaño de la mancha terminal blanca caudal del Alzacola en relación con la fecha durante la estación reproductora (1 = 1 de mayo de 2000 y 2001). Machos y hembras se han representado una única vez por puntos llenos y vacios, respectivamente. En el interior se muestra la reducción de la mancha terminal blanca caudal de un Alzacola fotografiado al inicio de la estación reproductors (17 de mayo de 2001) y 76 días después (2 de agosto de 2001).]

TABLE 3

Spearman rank correlation between size and FA of the terminal white and the subterminal black tail patches and number of days from May 1 of 2000 and 2001 of male (*n* = 44) and female (*n* = 32) Rufous Bush Chats.
*[Correlaciones de Spearman entre el tamaño y asimetría fluctuante de la mancha blanca terminal y la mancha negra subterminal, y el número de días desde el 1 de mayo de 2000 y 2001 en los machos (*n = 44*) y hembras (*n = 32*) de Alzacola).]*

	Terminal white patches *[Mancha blanca terminal]*				Subterminal black patches *[Mancha negra subterminal]*			
	Size *[Tamaño]*		FA *[Asimetría fluctuante]*		Size *[Tamaño]*		FA *[Asimetría fluctuante]*	
	r_s	*P*	r_s	*P*	r_s	*P*	r_s	*P*
Males *[Machos]*	–0.571	<0.001	0.185	0.228	–0.009	0.956	–0.142	0.359
Females *[Hembras]*	–0.469	0.007	0.025	0.891	0.122	0.192	0.078	0.673

cuousness over time comes from the reduction of the patches of 21 subjects (10 and 11 in 2000 and 2001, respectively) which were photographed twice throughout the season (lapse in days: 28-116, X ± SD = 70.10 ± 23.60, n = 21). When size reduction per day was calculated for each subject, it was shown that total length of the terminal white patches was shortened more than three times that of the sub-terminal black patches (size reduction per day; 12 males and 9 females, pooled; white patches: 0.20 ± 0.08 mm, black patches: 0.06 ± 0.05 mm, Wilcoxon signed-ranks test: $T = 7.0$, $n = 21$; $P < 0.001$). The same result was obtained when comparing the daily size reduction of white and black patches for both sexes separately (males: $T = 4.0$, $n = 12$, $P < 0.01$; females: $T = 0.0$, $n = 9$, $P < 0.01$).

Discussion

The size of the black and white tail patches in males may have important implications for reproduction. The effect may take place in a context of mate choice or of inter-male competition at the start of the breeding season when tail markings are whole and are exhibited during tail displays in courtship and territory defence (Álvarez, 1996, 2000). Alternatively, it may help to reduce the intensity of nest depredation during the rest of the season, the black and white releaser acting as deflexion colouration (Cott, 1940) when birds fan their tail feathers while quickly raising and lowering the tail during the distraction manoeuvres (Álvarez & Sánchez, 2003). The results of the present study support this hypothesis although only in the case of males, the size of their white patches being positively related to reproductive success, and that of their black patches negatively to nest depredation.

However, since both the breeding success and the size of the white tail patches decrease as the breeding season progresses, it is not possible without experimentation to separate a genuine effect of patch size from a calendar effect on breeding success.

The disagreement between the lack of relationship of the FA of colour patches to reproduction in the present study and its relationship with several measures of reproduction in the same population of chats in 1995 and 1997 (Álvarez, 2000) can be attributed to the different techniques used. While in the present study FA was measured as the difference between the sums of patch lengths (actually of the portion of the feather stiff rachis crossing each patch), Álvarez (2000) measured FA as the difference between |Right-Left| sum of patch areas and measured on outlined patch sketches.

The positive correlation of white patches size within pairs probably results from non-random mating. Such plumage-based pairing (Johnston & Johnson, 1989; Roulin, 1999) could be related to the higher reproductive output of birds with larger white tail patches.

The intense erosion of the terminal white patches of the tail over the breeding season, probably resulting to a great extent from the long tail rubbing against the sandy ground of the study area during the comings and goings of the birds, and from absence of melanin in the white feather tips (Burtt, 1979; Bonser, 1995), causes a reduction in the conspicuousness of the visual pattern over time. According to the results, the tails would be most conspicuous at the time of arrival on the breeding grounds when males establish territories and pairs are formed. Conspicuousness would then gradually decrease during the breeding season when markings are shown mostly during nest defence (Álvarez, 1996), and be at its minimum at the end of the season when birds are ready to migrate to their winter quarters in Africa at a time when the visual pattern and the associated tail display are presumably needed less.

Therefore, the pattern of decreasing conspicuousness over time apparently accommodates to the possible functions of the tail marking as amplifying handicaps for end-of-tail abrasion and acting as potential indicators of feather quality (Fitzpatrick, 1998), and/or as deflexion colouration during the distraction displays of nest defence (Cott, 1940; Baker & Parker, 1979; Álvarez & Sánchez, 2003).

Baker & Parker (1979) predicted a restriction of deflexion colouration when vulnerable young are in need of protection, since conspicuous colouration out of the breeding season would maintain the cost of predation for the bearer with no benefit whatsoever. Nevertheless, this prediction would apply to subjects continuously exhibiting deflexion colouration (i.e., colouration of contour feathers). In the case of Rufous Bush Chats, the contrasted tail patches do not represent a disadvantage in front of predators as they are usually hidden in the folded tail and are shown only when the tail is fanned during the tail display, the birds remaining basically cryptic most of the time.

If the pattern of decreasing conspicuousness has an adaptive value, it may have to do more with a reduction of tail length, and therefore of its drag effect during flight in the long, trans-Saharan, late-summer, southward migration (Fitzpatrick, 1999), since most of the abraded portion of the tail is beyond the point of maximum continuous width which contributes to increasing drag and does not generate lift (Thomas, 1993).

The FA of patch size not changing in time may contribute to efficiency in flight. The same would apply to the lack of size reduction of the subterminal black patches over time, which, by their protection from wear by the melanin deposit on them (Burtt, 1979; Bonser, 1995) could be setting a limit to tail abrasion.

The contrasted, recently moulted, and therefore longer-tailed spring migrants flying northward from northern tropical Africa to the Mediterranean basin (Keith *et al.*, 1992) obviously face more difficulty, but could be rewarded with higher access to reproduction as males with greater white terminal patches attain higher reproductive success (Álvarez, 2000, and this study), and those with longer tail pair earlier (Álvarez, 2000), and perhaps have a more efficient nest defence mechanism.

The importance of a shorter tail reducing the effort involved in trans-Saharan migration is also supported by the low tail/tarsus ratio shown by *C. galactotes*, which is the only migrant of the 10 congeneric African species. In a range of 2.55 to 3.75, it shows the lowest value (body measures in Keith *et al.*, 1992). High costs of elongated tails to migratory birds have been pointed out by Fitzpatrick (2000).

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