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Wing morphology and plumage characteristics of the eastern form of Eurasian Reed Warbler *Acrocephalus scirpaceus fuscus* in Cyprus

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The breeding distribution of Eurasian Reed Warblers *Acrocephalus scirpaceus* in the Western Palearctic is highly fragmented and their taxonomy is complex. Eastern Mediterranean populations lie between the ranges of the nominate *scirpaceus* and the eastern race *fuscus*. The aim of this study was to use biometrics and plumage criteria to elucidate the racial affinities of Reed Warblers breeding at a site in Cyprus. The population appears to belong to *fuscus*, but has notably short and rounded wings. Either true emargination or a narrowing of the outer web of the fourth primary was observed in adults. The results are discussed in relation to the wing lengths of passage Reed Warblers in Cyprus.

In Cyprus, breeding populations of migrant Eurasian Reed Warbler *Acrocephalus scirpaceus* occur in scattered and localised *Phragmites*-rich habitats. As for Reed Warblers elsewhere in the Near and Middle East (Porter & Aspinall 2010), the breeding distribution is highly fragmented. The taxonomy of this species is complex and the breeding population of the eastern Mediterranean is on the boundary between the nominate race *scirpaceus* and the eastern race *fuscus* (Cramp 1992). The exact location of this boundary, and how distinct a taxonomic and morphological divide it represents, are unclear. A genetic study of the genus supports the current taxonomy of *A. scirpaceus* and establishes a genetic distance between the furthest-eastern forms of *fuscus* and western nominate birds, but does not rule out the possibility of intergradation where a geographical separation does not apply, as in Turkey (Leisler *et al* 1997).

Flint (1972) assigned the breeding population of the Akrotiri reed beds in the south of Cyprus to *fuscus*. Identification was made on the basis of the second primary feather (P2) on most birds equalling P4 or P5 (after Williamson 1968), the greyish-brown coloration to the upperparts and the light underparts. However, more detailed study of geographically close populations appears merited in the light of the finding that two Croatian populations have different wing morphologies (Kralj *et al* 2010). The taxonomy of the superspecies is becoming increasingly complex, as is exemplified by the presence of *fuscus* in western Arabia (Hering *et al* 2009) and of the short-winged 'Mangrove Reed Warbler' *A.s. avicenniae* in eastern North Africa (Hering *et al* 2011).

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The aim of this study was to elucidate the taxonomic affinities of Reed Warblers breeding at a study site in Cyprus, by comparing their biometrics, wing formula and plumage with published data from other populations and with passage birds travelling through Cyprus in spring.

METHODS

Breeding Reed Warblers (n = 55) were trapped using mist nets at a small *Phragmites* reed bed near Demirhan on the Mesarya Plain of North Cyprus, 35°20'N 33°07'E, in July of 2011 and 2012. The birds were marked with unique metal rings, and aged and sexed where possible, prior to release. The following measures of wing morphology were taken from closed wings, the primaries being numbered ascendently (distal to proximal): wing length (maximum length, after Svensson 1992, method 3); length of the notch (indentation of the inner web at the distal end of the feather) on primary 2 (P2), from the midpoint of the inflexion of the notch to the feather tip, measured with callipers to 0.1 mm (notch length); the position of the midpoint of the inflexion of the notch of P2, relative to the tips of the inner primaries or secondaries (notch P2=); the position of the tip of P2 in relation to the tips of the other primaries (P2=); the presence or absence of emargination (indentation of the outer web at the distal end of the feather) on P4; the longest primary (wing point or WP); and the distance between the wing point and the first (outer) secondary (S1 < WP). Plumage characteristics were noted and examples photographed.

Reed Warblers (n = 30) were also trapped at the study site in April during the spring passage of the same years, for the purpose of comparison. These included birds

identified as nominate *scirpaceus* by their plumage as well as those with characteristics associated with *fuscus*. Additional data for birds on spring passage were obtained from Geçitkoy Gölü and Korucam Burnu in the northwest of Cyprus in 2001. Biometric data were compared using unpaired t-tests in Excel.

RESULTS AND DISCUSSION

Wing lengths of breeding and spring-passage birds

The wing-length ranges and means of Reed Warblers breeding and passing through the study site, and for spring-passage birds from the northwest of Cyprus, are shown in Table 1. The wing lengths of adults in the breeding population were relatively short; compared to a sample of Reed Warblers from the study site during the period of spring passage in the study years, the mean wing length of breeding birds was 1 mm shorter ($t_{33,\ 22} = -2.45$, $P < 0.02$). Furthermore, the mean wing length of the study breeding population was 3 mm less than for spring-passage birds from two sites in northwest Cyprus ($t_{33,\ 23} = -5.93$, $P < 0.001$). The mean wing length of juvenile birds in the breeding population was 1 mm less than for adults ($t_{33,\ 22} = 3.1$, $P < 0.01$).

These data add to a body of evidence for *fuscus* being short-winged in the south of its range (*eg* Flint 1972, Pearson 1972, Morgan 1998, Hering *et al* 2009). Although the race *avicenniae* of eastern North Africa belongs genetically to the *fuscus* group (Hering *et al* 2009, 2011), it is markedly smaller than the study population in wing, weight and tail length and appears to be a brown rather than grey-brown form (Hering *et al* 2011). There is also at least one short-winged population of nominate *scirpaceus* in the south of its range, in the Balearic Islands (Cramp 1992). These and the current study population are found around or south of 35°N. Wing length may therefore be linked to migratory distance, with longer-winged northern populations travelling further (Newton 2008). However, without knowledge of the wintering quarters of the southern *fuscus* populations, this conclusion must remain provisional.

Wing formula of breeding and passage birds

For birds in the breeding population, wing point was P3 in all birds. The mean distance between the wing point and the outermost secondary (S1 < WP) was 13.4 mm (11.1–16.9), with 0.1 mm difference between the means for adults and juveniles in the sample. Svensson (1992) gives a range of 15–19 mm, with subspecies unspecified. Passage Eurasian Reed Warblers in Lesvos, Greece, had a mean of 18.4 mm (16.0–21.1) for first-year birds and 17.2 mm (14.6–20.0) for adults (Wilson *et al* 2001). These comparators place the Cyprus study population at the short end of the range for this measure.

Measurements of the position of the tip of P2 in relation to other primaries (P2=) are given in Table 2. For the majority of the study birds, the tip of P2 fell short of the tip of P4; the observations for adults were close to Flint's (1972) findings from the south of Cyprus. On wing morphology, Pearson *et al* (2002) were able to characterise *fuscus* as populations where, for most birds, P2 fell between P4 or P5 or less; this characteristic was true of birds in the present study population. However, Pearson's northern *fuscus* were notably longer-winged than the current study population. Reed Warblers trapped during spring passage in Cyprus, away from the study site, which included birds of both races, showed a larger mean and range of wing lengths (Table 1). These data highlight the distinctiveness of the breeding population.

The point of inversion of the notch on P2 lay between level with P10 and shorter than the outer secondary, for almost all birds in the study (notch P2 = ; Tables 1 & 3). For *scirpaceus* the notch on P2 falls level with the tips of P9–10, occasionally P8 or the secondaries (Svensson 1992). Where the notch fell relative to other feathers was associated with the length of the notch itself (notch length =). The long notch of adults compared to juveniles apparently accounted for the observed differences in notch P2 = , described above. The notch on adults was longer, starting relatively closer to the proximal end of the feather, than on juveniles. The ranges did not overlap and differed significantly ($t_{23,\ 22} = 9.12$, $P < 0.001$).

Three of the adult birds (9%) showed a shallow, true emargination of the fourth primary, *ie* a stepped reduction in feather width at the outer edge of P4. With the exception of a single individual, the other adults instead had a distinct but gradual narrowing of the outer web towards the distal end of the feather. This was conspicuous because such narrowing was consistently lacking on the adjacent P5. Emargination or narrowing of P4 was lacking in all juvenile birds, where the distance between the feather shaft and the edge of the outer web changed little towards the tip of the feather. Therefore, this narrowing or emargination must appear when the primaries are replaced during the main moult in winter quarters.

P4 is not emarginated in nominate *scirpaceus* (Svensson 1992). Although Svensson noted that some *fuscus* do have faint emargination on P4, Pearson *et al* (2002) were unable to detect this easily: they observed some individuals as

Table 1. Summary of wing morphology data from the study site in July 2011 and 2012: mean ± SD (range). Square brackets indicate minority values.

	wing length (mm)	P2 notch length= (mm)	notch:wing ratio	notch on P2 =	P2 =	S1 < WP (mm)	n
Adult breeding *fuscus*, study site	65 ± 1.33 (63–68)	12.4 ± 0.81 (11.2–14.2)	0.19 (0.16–0.21)	10– < S1 [9–10]	4/5, 4 or 5 [3–6]	13.3 (11.1–16.9)	33
Juvenile *fuscus*, study site	64 ± 1.17 (62–66)	10.6 ± 0.71 (9.6–11.1)	0.17 (0.14–0.19)	10–10/S1 9– < S1	4/5 or 4 [3–6]	13.4 (11.5–15.3)	22
All fully grown breeding *fuscus*, study site	64 (62–68)	11.5 (9.6–14.2)	0.18 (0.14–0.21)	10– < S1 [9–10]	4/5, 4 or 5 [3–6]	13.4 (11.1–16.9)	55
Adult spring *fuscus/scirpaceus*, study site	66 ± 1.89 (63–71)	–	–	–	–	–	32
Adult spring *fuscus/scirpaceus*, northwest Cyprus	68 ± 1.84 (64–71)	–	–	–	–	–	23

Table 2. Position of tip of primary 2 in relation to tips of other primaries (P2=) in adult and juvenile birds from the Cyprus study site in 2011 and 2012, compared to published sources. Values are percentages; for the study site, the numbers of birds are also given in parenthesis.

P2 =	P3	P3/4	P4	P4/5	P5	P5/6	P6	P2 < P4	n
Adults									
fuscus, study site	3 (1)	9 (3)	18 (6)	39 (13)	18 (6)	9 (3)	3 (1)	70% (25)	33
fuscus, Cyprus (Flint 1972)	0	6.5	22.5	48.5	13	10	0	71.5%	31
fuscus (Pearson *et al* 2002)	0	7	26	62	4	1	0	67%	95
scirpaceus (Pearson *et al* 2002)	0	30	30	35	5	0	0	40%	43
Juveniles									
fuscus, study site	4.5 (1)	4.5 (1)	18 (4)	59 (13)	9 (2)	4.5 (1)	0 (0)	72.5% (16)	22
fuscus, Cyprus (Flint 1972)	0	0	10	76.5	6.5	6.5	0	89.5%	30
fuscus (Pearson *et al* 2002)	0	11	17	60	9	3	0	72%	35
scirpaceus (Pearson *et al* 2002)	0	19	45	31	3	2	0	36%	117

Table 3. Location of the notch on P2 (notch P2=) in relation to tips of other primaries or outermost secondary (S1) on birds from the study site in July 2011 and July 2012. Values are numbers of birds.

Notch P2 =	P9	P9/10	P10	P10/S1	S1	<S1	%≤ S1	n
Adult breeding *fuscus*	0	2	5	1	8	17	75%	33
Juvenile *fuscus*	1	1	3	5	7	5	54%	22

only having a slight tapering towards the tip of the outer web, which may accord with the current study. At least until some comparative quantification is possible, this narrowing is given greater significance here in the light of Morgan (1998) whose Israeli population frequently showed emargination on P4.

Plumage characteristics

Quantitative observations, such as those for wing morphology described above, may not fully elucidate the taxonomic picture, particularly given the similarities between *fuscus* and the nominate subspecies (Pearson *et al* 2002), although differences in some measurements between populations may be important discriminators. Qualitative observations such as plumage colour and pattern still appear to be important (Fig 1).

With respect to plumage characteristics in adults, Figs 1a and 1b show a retrapped *fuscus* known to belong to the study breeding population, in fresh spring plumage compared to a passage *scirpaceus* (wing 69 mm, P2 = P3/4, S1 < WP 16.6 mm) trapped the same day (Fig 1c). The *fuscus* had lighter underparts, colder- and darker-toned upperparts, and greyness to the head and nape, contrasting with the more vivid brown of the fringes to wing feathers. All rectrices were conspicuously tipped whitish, with narrow pale fringing to the primary tips. This type and extent of fringing was not present in *scirpaceus* which, excluding the rump, had more uniform upperparts, lighter-hued brown to the upperparts, particularly to the fringes of the wing feathers, and slightly darker, more uniformly toned, buff underparts.

Both the structural integrity and colour of adult feathers was modified through the breeding season by the effects of wear and bleaching. Heavily worn body feathers of the adults were beginning to be replaced by July and the flight feathers were usually heavily worn. Compared to spring, adults which had wholly old feathers appeared to have paler, off-white underparts and a grey-brown head to less vivid olive-brown upperparts in cooler hues than in spring (Figs 1d & 1e). Adults that had replaced a large proportion of their body feathers had fresh and lightly buff-hued underparts (as in spring), though retained their worn and bleached upperparts. The tail feathers were usually heavily worn in adults, largely removing the pale fringes observable in spring. Almost all of the study birds fell within the scope of these descriptions; however, one adult female had much darker-toned upperparts.

Figure 1. Plumages of Reed Warblers at Demirhan Pools, North Cyprus: a, and b, *A.s.fuscus*, Demirhan Pools, North Cyprus, 13 April 2012,: first trapped as a breeding adult female at the site in July 2011; c, passage nominate *A.s.scirpaceus*, Demirhan Pools, North Cyprus, 13 April 2012; d, adult *A.s.fuscus*, Demirhan Pools, North Cyprus, 7 July 2011; e, adult *A.s.fuscus*, Demirhan Pools, North Cyprus, 25 July 2012; f, juvenile *A.s.fuscus*, Demirhan Pools, North Cyprus, 25 July 2012.

During the July periods of trapping all the season's fledged birds were in juvenile plumage (Fig 1f), most undertaking a partial post-juvenile moult of the body feathers only. These new feathers were almost indistinguishable from the juvenile body feathers they were replacing, in colour and tone. Overall the juvenile *fuscus* were closer in appearance to *scirpaceus* but had lighter-toned buff underparts than juvenile *scirpaceus* and, as in adults, there was a darker tone of warm brown on the upperparts and wing feathers. By August, the upperparts of early fledged birds had become appreciably lighter in tone than juveniles fledged more

recently, with a vivid sandy-brown hue, as a result of bleaching.

Descriptions of characteristics associated with *fuscus* can be found in Cramp (1992), in Svensson (1992), and in a salient analysis of the subject by Pearson *et al* (2002). Inconsistencies in nomenclature of plumage colour in the literature show how difficult it can be to replicate qualitative descriptions of colour, hue and tone. For the purposes of this study, the colour descriptions are expressed largely in relative terms in order to avoid some of the difficulties with subjective descriptions. A further important but usually neglected consideration in attempts to define and categorise subtle colour and tonal differences is the effect of colour temperature on both observation and recording by photography. The colours of birds in the study observed in lower (yellow) colour temperatures appeared warmer, darker and more vivid than when observed in higher (blue) colour temperatures where they appeared cooler, greyer and more muted. Nonetheless, the study birds were attributable to *fuscus* on plumage criteria, in particular the presence of greyness in the head, light underparts, colder darker browns on the upperparts, and whitish tips to the tail feathers.

In summary, this short-winged breeding population shows the characteristics of *A.s. fuscus*, particularly the relative position of the tip of P2, the relative position of the notch on P2 and plumage colours. These observations appear to conform to the emerging taxonomic map of breeding Reed Warblers in the Near and Middle East and eastern North Africa. DNA analysis of this population would no doubt enhance our understanding.

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