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SHORT REPORT

Garden Warbler *Sylvia borin* migration in sub-Saharan West Africa

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The migratory strategies of trans-Saharan migrant passerines have generally been well described in Europe, whilst strategies south of the Sahara have received relatively little attention (Ottosson *et al* 2001, 2005). Given the strong link between population fluctuations and climatic conditions in the Sahel region of West Africa (Newton 2004), knowledge both of the regions occupied during winter and of the sites used during migration is essential if we are to understand population-limiting processes. In particular, the regions or sites used in preparation for crossing the Sahara Desert during spring migration, which generally requires large fuel loads (Wood 1989), may be vital to the success of migration and even carry over into reproductive success (Newton 2004). Amongst migratory passerines the ecology of the Garden Warbler *Sylvia borin* has been well studied (*eg* Bairlein 1991, Schaub & Jenni 2000) and a growing body of information details the migration of this species in West Africa (Ottosson *et al* 2005, Smith 2007). To add to one of the most complete pictures for a migratory passerine in sub-Saharan Africa, we present a brief summary of current knowledge and compare it to data collected in Senegal by the Wetland Trust.

Ottosson *et al* (2005) presented a range of evidence relating to the migratory behaviour, itinerancy and site use of Garden Warblers in West Africa. They concluded that Garden Warblers stop over in both the Sahel and Guinea-savannah regions of West Africa during autumn but only in the latter in spring, and that neither of these regions regularly hosts wintering birds. A further comment by Smith (2007) indicates that the data of Ottosson *et al* (2005) largely agree with those he had collected himself some 40 years earlier (Smith 1963, 1965, 1966). To add to this information we present data collected by the Wetland Trust in Parc National des Oiseaux du Djoudj in northern Senegal (16°10'N, 16°18'W) during two consecutive winters (October–May) of near daily constant-effort mist-netting. These data consist of 140 mist-net captures (96 captures in 1991/92 and 44 in 1992/93 between October and April; see Ottosson *et al* 2001 for detailed methodology), with the majority of captures being made in either seasonally inundated tamarisk scrub *Tamarix senegalensis* (42% of captures) or dry scrub dominated by acacia and salvadora *Salvadora persica* (51%).

The earliest capture at Djoudj was on 13 October, over a month later than recorded by Smith (2007) or Ottosson *et al* (2005), whilst the latest, on 20 November, was over three weeks earlier (Table 1; see Fig 1 for study site locations). The later autumn arrival at Djoudj is most likely an artefact of capture effort, as little or no effort took place in September, whilst the earlier departure is probably a reflection of the more northerly location of Djoudj relative to the other sites (see Fig 1). Birds arriving at Djoudj in autumn typically had body masses at or close to the estimate of 15 g used by Ottosson *et al* (2005) for the fat-free or lean body mass (LBM) and, as at Amurum, some birds remained at the site to refuel before departing south (Table 1). The maximum gain recorded at Djoudj was 3.1 g (2.6% LBM/day, while recorded rates at Amurum were up to 4.3% LBM/day). Garden Warblers were absent from Djoudj in December–February, as was essentially the case for all sites considered by Smith (2007) and Ottosson *et al* (2005), and did not reappear until the return migration, principally in April (Fig 2): this is further evidence that Garden Warblers do not spend the winter in the northern Sahel region.

As spring Garden Warblers trapped at Amurum in the Guinea-savannah zone carried high fuel stores and few birds were caught at the more northerly sites, Ottosson *et al* (2005) suggested that, unlike many other *Sylvia* warblers (Ottosson *et al* 2001), Garden Warblers fuel in the Guinea-savannah zone on their northward migration and not closer to the desert edge. Djoudj is situated further north than both these sites, yet 62 birds were captured there during spring migration. However, captures were concentrated in just a handful of days, with 71% of captures in 1992 occurring in two days in April, whilst in 1993 one day accounted for 68% of captures (Fig 2). This pattern of captures suggests forced landfall rather than a regular passage as observed in other *Sylvia* warblers during the same period (Ottosson *et al* 2001). The mean mass of all spring birds at Djoudj was significantly higher than those at either Vom or Amurum (t-test, test mean =

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Table 1. Comparison of body mass recordings and passage times between data collected at Djoudj and all sites considered by Smith (2007) and Ottosson *et al* (2005) in sub-Saharan West Africa during autumn and spring migration. All body mass measurements are given in grams and where measurements are absent it signifies that the data were not presented, whilst NC = no captures. For Djoudj means are given ± their standard deviation. Dates in italics indicate that the earliest/latest date was constrained by mist-netting effort. See Fig 1 for geographical locations.

	Djoudj 1991–92	Djoudj 1992–93	Ginak 1994–2000	Malamfatori 1999–2000	Vom 1963–65	Amurum 2001–04
Autumn						
Mean mass	15.8 ± 1.7	15.8 ± 2.8	16.6	17.4	17.3	18.2
Max mass	25.5	23.3	≈ 22.4	≈ 22.2	-	25.8
First date	*19 Oct*	*13 Oct*	21 Sept	31 Aug	12 Sep	10 Sep
Last date	20 Nov	20 Nov	17 Dec	*10 Nov*	10 Dec	12 Dec
N	61	11	441	49	85	98
Spring						
Mean mass	24.4 ± 2.3	23.9 ± 2.9	NC	-	21.4	21.8
Max mass	27.4	28.0	NC	≈ 27.0	-	≈ 31.0
First date	12 Apr	09 Apr	NC	22 Apr	1 Apr	30 Mar
Last date	*19 Apr*	*01 May*	NC	*09 May*	22 May	*15 May*
N	31	31	0	14	71	196

21.8, t_{63} = 7.16, $P < 0.001$), suggesting that the fuel for the Saharan crossing had been accumulated to the south and further supporting a forced interruption. In addition, just two of these 62 individuals were retrapped, an indication that they had moved on rapidly. One bird, however, which arrived weighing 23.3 g and gained 4 g at the rapid rate of 6.67% LBM/day, may be evidence for a small percentage of the population using more northerly sites to fuel or top up their reserves. The cause of these hypothesised interruptions is likely to be the large sandstorms that occasionally pass through the area (Alan Martin pers comm), although strong headwinds could also be responsible.

Flight ranges calculated using the latest version of Pennycuick's flight program (Flight 1.17, described in Pennycuick & Battley 2003) also suggest a forced interruption to migration. These calculations imply that birds with a mass greater than 20 g and an LBM of 15 g could complete the 1,750-km journey from Djoudj to suitable stopover habitats north of the Sahara in Morocco, whilst birds with masses greater than 22 g could reach southern Europe and beyond (for calculations, wing span = 0.228 m, wing area = 0.0101 m², fat mass = 85% of increase above LBM). Indeed, the mean estimated flight range

Figure 1. Location of study sites providing data on Garden Warblers in West Africa and the approximate position of the southern limit of the Sahara Desert.

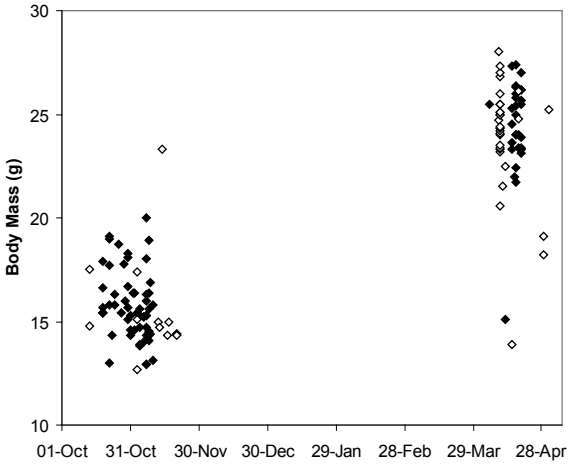

Figure 2. Body mass in relation to date of all Garden Warbler captures, excluding recaptures, at Djoudj, Senegal between October and May in 1991/92 (◆) and 1992/93 (◇).

amongst spring captures at Djoudj was in excess of 3,000 km and implies that birds could have reached northern Spain without stopping to refuel – and consequently they had no need for a strategic stop at Djoudj. The apparent lack of dependence of Garden Warblers on the Sahel zone, especially during spring migration, might explain why this species has generally shown no trend (Sanderson *et al* 2006) or even a positive population trend in the past when other species known to winter in the Sahel region have shown declines (Marchant 1992).

Finally, Ottosson *et al* (2005) suggested that spring departure masses from Amurum may be as high as 25–30 g but noted that the picture is confounded by the presence of birds in the process of accumulating fuel. The data from Djoudj indicate that mean body masses were indeed higher in actively migrating birds (Table 1) and given that Djoudj is approximately 500 km further north than Amurum (Fig 1), it seems certain that birds departing from Amurum typically had body masses >25 g. This finding highlights the problems of using the average mass of birds at stopover sites to estimate departure mass/fuel loads but also suggests that focusing on the highest masses could be a potential solution.

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