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SHORT REPORT

Comparing the migration of Eurasian Teal *Anas crecca* from two main wintering areas of Western Europe: a long-term study from Essex, England, and the Camargue, France

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A major assumption underlying general migration theory is that migrating further or longer entails costs in terms of energy used during flight and mortality risk, so that individuals should try to stay as close as they can to the breeding grounds during winter (see *eg* Alerstam & Hedenström 1998 and Cristol *et al* 1999 for reviews of general migration theory, costs of migration, etc). This pattern is generally counterbalanced by a higher daily energy expenditure at a higher latitude in winter (*ie* closer to the breeding grounds), so that the selection of given winter quarters is generally the result of a trade-off decision made by individual birds. In this study, we compared the prenuptial migration routes, distances travelled, and breeding areas of (Eurasian) Teal *Anas crecca* wintering at two sites of different latitudes in western Europe, namely Essex (eastern England) and the Camargue (southern France).

An earlier study showed that recoveries of Teal ringed in the Camargue could occur all over western, central and northern Europe (Guillemain *et al* 2005). This suggests that the split into distinct 'North-Western European' and 'Mediterranean' Teal subpopulations (*eg* Scott & Rose 1996) was artificial, and that all birds wintering in western Europe could therefore be considered to belong to a single larger population. Birds from either the Mediterranean or the northwestern European areas could switch winter quarters between years, suggesting that they may choose between wintering quarters and that this decision may translate into different spring migration patterns and hence potentially different migration distances. However, Camargue-ringed birds were less likely to be recovered in the northwestern part of their range during the year of ringing. Thus, we expected that considering only intra-annual ring recoveries could be a means of comparing spring migration processes from southern France and eastern England in this species. The analysis by Guillemain *et al* (2005) relied on the same Camargue data set as the present study; although that paper presented a map of all recoveries, it did not assess migration routes and distances, which is one of the purposes of the present report.

In addition to the data collected in Tour du Valat, Camargue (43°30'N 4°40'E), we also relied here on the long-term Teal-ringing database of Abberton Reservoir, UK (51°49'N 0°50'E). Both regions are considered to be of major importance for wintering Teal (Scott & Rose 1996). Birds were caught with baited traps from November 1951 to December 1996 at Abberton and from January 1952 to February 1978 at Tour du Valat, yielding 36,623 and 59,086 birds ringed, respectively. Dabbling duck pairs are known to form in winter and the two birds migrate together to their breeding grounds (Paulus 1983). Afterwards, only female Teal care for the young ducklings, while males move quickly to sometimes-distinct moulting areas (*eg* Wolff 1966). Considering the male recovery data would therefore not help to elucidate the spring migration period, and could be misleading when trying to identify the breeding grounds, given the short time they spend there compared to females. Only the female recovery data were therefore used in the present analysis.

An earlier study demonstrated that the onset of spring migration from the Camargue occurs at the same date for adult and first-year Teal (Guillemain *et al* 2006; note that this paper did not study where the birds went when they had left the Camargue in spring). Nevertheless, we compared, in a preliminary analysis, the median distance from the winter ringing place at which adults and first-

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year birds were found in May (*ie* when they breed, see below). Because no significant difference was found either for Essex or Camargue birds (absolute Z values < 1.39, *P* values > 0.17), females from the two age classes were not distinguished in the analyses.

In total 494 female Teal (65 from Abberton and 429 from Tour du Valat) were recovered between March and June following the winter of ringing (*ie* 'intra-annual' or 'direct' recoveries), and constituted the sample for this study. Only direct recoveries were used, for the reasons outlined above and because the exact area where the bird spent the winter before being recovered cannot be ascertained in the case of inter-annual recoveries. We calculated the median latitude and longitude of recovery and the median distance from winter ringing place for Teal captured in UK and France per 15-day period. Distances here were orthodromes, *ie* distances along great circle routes (*eg* Newton 2008), the closest route between two positions on the globe. These distances were computed with MapInfo 7.5. Median coordinates and median distances travelled were compared using Mann–Whitney U-tests to determine whether the median position of birds from the two wintering areas differed significantly for each period of time, and whether they travelled the same distance given where they spent the previous winter. For simplicity, time periods are given in the form of *eg* May 1 and May 2 for the two halves of each month.

Fig 1 shows the median position of female Teal ringed in Essex and in the Camargue per 15-day period, and Table 1 shows their median coordinates and the median distance they travelled from their winter ringing place. As judged from the maximum distances travelled, most birds would be present on their breeding areas during May 1 and May 2, for both Camargue and Essex groups. The analysis of their median coordinates indicates that Camargue females took a more southerly route, but eventually bred within the same area as Essex birds (Fig 1). However, it has to be noted that this area was very broad (Fig 2). As a consequence, Camargue birds were, on average, at a significantly greater distance from their wintering grounds than Essex birds when they bred in May (Table 1).

The present results suggest that birds from the Camargue and from Essex use completely different routes to and from their breeding grounds: the position of median coordinates suggests that Camargue birds are more likely to migrate south of the Alps and via central Europe, while birds wintering in Essex apparently migrate along the North Sea and Baltic Sea coasts. The present study also provides useful insights in the context of flyway delineation for this species. Indeed, we showed earlier (Guillemain *et al* 2005) that exchange rates between the so-called 'Mediterranean' and 'North-Western European' subpopulations reached 20% one year after ringing, making it doubtful whether

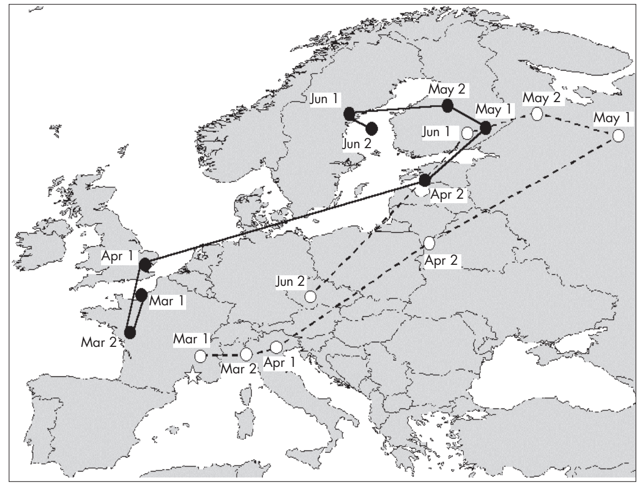

Figure 1. Coordinates of recovery for female Teal ringed in Abberton Reservoir, Essex, UK (black dots, plain line), and in Tour du Valat, Camargue, France (white circles, dashed line), per 15-day period. Abberton is close to the April 1 black dot, Tour du Valat is indicated by a star. The period to which each dot refers is indicated (*eg* MAY1 for the first 15-day period of May).

Figure 2. Recovery places in May for female Teal ringed in Abberton Reservoir, Essex, UK (black dots, plain line), and in Tour du Valat, Camargue, France (white circles).

birds from these two regions should really be split. The present observation that female Teal wintering in the two areas breed in the same geographic range strengthens the idea that there is only one Teal population in western Europe. This is also consistent with recovery data showing that birds ringed in Finland may winter either in the UK or in France (Väänänen 2000). Teal that wintered at a higher latitude (*ie* in Essex, which is also further west than the Camargue) bred at a similar longitude to Camargue-wintering ones. This result therefore contradicts earlier studies showing a more easterly breeding area for Camargue as opposed to British-ringed birds (Fig 2 in Wolff 1966, see also Ogilvie 1983). However, these studies did not provide

Table 1. Median recovery coordinates (in decimal degrees, negative longitude values indicating westward longitude) and median distance travelled (in km) per 15-day period for Essex and Camargue-ringed birds, ± SE. Numbers in brackets are sample sizes.

15-day period		Ringing site			Mann–Whitney
		Abberton Reservoir	Camargue	Z	*P*-value
MAR 1	Latitude	49.6 ± 0.6 (14)	45.0 ± 0.1 (157)	-5.66	< 0.0001
	Longitude	0.3 ± 0.8 (14)	5.3 ± 0.3 (157)	6.05	< 0.0001
	Distance	266.5 ± 59.8 (14)	383.0 ± 22.2 (157)	-0.09	0.9282
MAR 2	Latitude	46.9 ± 0.5 (15)	45.3 ± 0.1 (158)	-3.94	< 0.0001
	Longitude	-0.7 ± 1.2 (15)	9.2 ± 0.3 (158)	4.67	< 0.0001
	Distance	623.8 ± 67.7 (15)	462.4 ± 20.1 (158)	-2.83	0.0047
APR 1	Latitude	51.9 ± 0.4 (4)	45.7 ± 1.0 (25)	-1.39	0.1641
	Longitude	0.6 ± 1.6 (4)	11. 7 ± 1.6 (25)	2.97	0.0030
	Distance	91.2 ± 84.2 (4)	655.3 ± 140.3 (25)	2.91	0.0036
APR 2	Latitude	58.2 ± 1.4 (5)	53.5 ± 1.4 (23)	-1.83	0.0673
	Longitude	24.0 ± 5.1 (5)	24.4 ± 2.7 (23)	-0.87	0.3844
	Distance	1,850.2 ± 307.5 (5)	2,033.6 ± 211.9 (23)	-0.21	0.8337
MAY 1	Latitude	62.1 ± 0.8 (8)	61.5 ± 0.6 (21)	-0.39	0.6993
	Longitude	29.0 ± 4.1 (8)	40.3 ± 2.8 (21)	1.44	0.1500
	Distance	2,091.8 ± 205.1 (8)	3,044.5 ± 144.2 (21)	3.03	0.0025
MAY 2	Latitude	63.8 ± 1.1 (13)	63.2 ± 0.5 (30)	-0.16	0.8739
	Longitude	25.9 ± 4.3 (13)	33.4 ± 2.9 (30)	-0.59	0.5518
	Distance	2,039.6 ± 223.5 (13)	2,761.6 ± 142.0 (30)	-2.62	0.0088
JUN 1	Latitude	63.2 ± 5.3 (5)	61.7 ± 1.8 (8)	-0.29	0.7697
	Longitude	17.7 ± 9.5 (5)	27.7 ± 4.9 (8)	0.73	0.4642
	Distance	1,785.6 ± 458.7 (5)	2,569.6 ± 315.3 (8)	1.32	0.1877
JUN 2	Latitude	62.1 ± 2.0 (3)	49.6 ± 3.2 (5)	-1.94	0.0526
	Longitude	19.5 ± 4.2 (3)	14.4 ± 5.1 (5)	0.15	0.8815
	Distance	1,703.2 ± 315.3 (3)	991.4 ± 454.6 (5)	0.15	0.8815

statistical tests, both direct and indirect recoveries were pooled and data from the two sexes were mixed, while the early departure of males from the breeding grounds may confuse the results, a bias that was avoided in the present study by considering only female birds. It is a fact that sample sizes were small for some of our time-intervals (due to the intrinsic low return rate of rings in areas with low human density), while at the same time the locations of recoveries were scattered over large areas (see Fig 2). An increased sample size (*eg* through the use of electronic positioning devices rather than metal rings) may show that Camargue Teal use the eastern part of the breeding range slightly more, but broadly speaking the breeding area of Camargue and Essex Teal is likely to remain similar, since birds from the two wintering areas are likely to breed over a wide range of longitude. The route of Camargue birds was more straightforward than that of Essex birds, and following the median coordinates from Mar 1 to May 2 gives a journey of 3,277 km for Essex birds, and 3,459 km for those ringed in the Camargue. It is clear from Fig 1 that some birds initially moved from Essex to the southwest, while Camargue birds had already started a northeastward migration in March. For Teal, Essex may thus be more of a winter stopover while the Camargue is often more likely to be the migration endpoint. Alternatively, Essex birds may simply experience cold weather in late winter more frequently, which forces them to find temporary shelter further to the southwest (Ridgill & Fox 1990).

A comparison of January daily mean temperatures in the Camargue (data from the Météo France station 30 km from the ringing place) and in Central England (Hadley Centre of the UK Met Office, Parker *et al* 1992) from 1959 to 2000 shows that the former is considerably milder (6.7°C and 4.0°C, respectively). For an average Teal female of 290 g (body weight of Camargue Teal upon ringing), this translates into energy expenditures of 2.43 and 2.67 $J.sec^{-1}$, respectively (calculations after Kendeigh *et al* 1977). In terms of energy for thermoregulation, wintering in Essex is thus 7.4% more costly than wintering in the Camargue. The results of the present study are consistent with the hypothesis that such costs associated with wintering in colder northern areas may be at least partly compensated by a shorter migration journey in spring.

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