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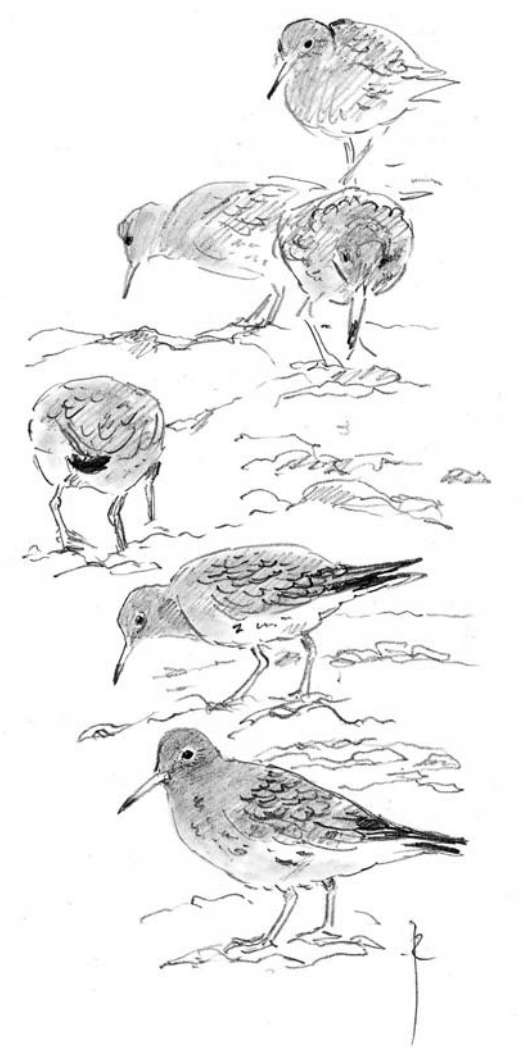
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The winter range of Nearctic Purple Sandpipers *Calidris maritima* on the East Atlantic flyway

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Iceland has a large resident population of Purple Sandpipers *Calidris maritima*, but is also believed to be a wintering area for other populations and is a stop-over site for migrants. To determine the wintering areas of those that prepare for westward migration to the Nearctic in spring, Purple Sandpipers were colour-ringed on the coast of southwest Iceland in May 2003 and 2005. We searched for colour-ringed birds along the coasts of Iceland, the European mainland and Britain, particularly in winter 2005/06. Out of 326 marked birds, 82 were re-sighted during 2003 to 2009, of which 69 were seen during winter (October to March) 2005/06. Most sightings (55) in winter 2005/06 were from southwest Iceland, extending the known winter range of this population to Iceland. Resightings from northern Scotland confirmed the evidence from biometrics that this wintering population originates from the Nearctic. The maximum number of colour-marked Purple Sandpipers in Britain and Ireland in winter 2005/06 was estimated at about 65, which was approximately a quarter of the marked sample estimated to be alive. Therefore, the majority of the colour-ringed birds must have wintered elsewhere, most likely in Iceland. There was no evidence of sexual segregation according to whether they wintered in Iceland or Britain. However, those that were colour-ringed before 15 May were more likely to be seen in Iceland than in Britain, whereas those colour-ringed after 15 May were more likely to be seen in Britain, indicating that the migration from Britain takes place mainly after mid-May. Although there have been no ringing recoveries, biometry data suggest that Purple Sandpipers that prepare for westward migration in Iceland in spring, breed in Canada. This population shows a unique winter range for a wader that includes Greenland, Iceland and northwest Europe along the East Atlantic flyway.

Key words: Britain, *Calidris maritima*, Canada, East Atlantic flyway, colour-ringing, Iceland, Nearctic, Purple Sandpiper, winter range

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The Purple Sandpiper *Calidris maritima* is the most northerly wintering wader, restricted largely to the rocky open shores of the North Atlantic (Cramp & Simmons 1983). Although it has a relatively small winter range compared to many other sandpipers, it nevertheless exhibits a wide range of migration patterns. These vary from residency, chain migration whereby one breeding population is replaced by another for wintering, and leap-frog migration whereby one population passes through an area used by another for wintering (Summers 1994).

For some breeding populations of the Purple Sandpiper, the winter range and migration route has been described from ringing recoveries and/or comparisons of the biometrics of breeding and wintering birds (Atkinson *et al.* 1981, Rae *et al.* 1986, Summers *et al.*

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1988, 1990, Dierschke 1995, Hake *et al.* 1997, Strann *et al.* 2006). For other populations, information is incomplete or speculative.

Iceland has a strategic location with regard to Purple Sandpipers. Not only is there a large resident breeding population (Summers *et al.* 1988, Petersen 1998), but Iceland is also thought to provide wintering areas for those that breed in northeast Greenland (Salomonsen 1950) and maybe even Svalbard (Timmermann 1949). In addition, there have been ringing recoveries linking Purple Sandpipers ringed in spring in Iceland with The Netherlands in winter (Boere *et al.* 1984), Baffin Island in spring (Peters 1944) and Newfoundland in winter (Morrison 1984). Further, two birds ringed in England and recovered in southern Greenland probably used Iceland as a stop-over site (Summers 1994, Lyngs 2003). The ringing recoveries linking Iceland with The Netherlands and Baffin Island are particularly interesting because they may represent a migration route through Iceland of a population that breeds in Canada and winters in north-west Europe, just like Turnstones *Arenaria interpres* (Branson *et al.* 1978) and Red Knots *Caldris canutus* (Wilson 1981, Davidson & Wilson 1992).

The biometrics of Purple Sandpipers that occur on the coast of Iceland in spring match those of a long-billed population that winters in Britain (Nicoll *et al.* 1988), whilst their increase in body mass indicates accumulation of migratory fuel for onward migration to the Nearctic (Summers *et al.* 2009). In this study, we focus on this group of birds to determine their winter range, look for sexual segregation, site fidelity and migration phenology, as well as to speculate where they may breed.

METHODS

The study was carried out on the coast of the Reykjanes Peninsula, southwest Iceland during 19–24 May 2003 and 5–16 May 2005 when the spring migration is under way. Birds were captured with cannon-nets at the following sites: Garðskagi, Hafurbjarnarstaðir, Sandgerði, Nesjar, Arfadalsvík and Eyrarbakki (Summers *et al.* 2009). In the analyses, the catches of birds were split into early (5–15 May) and late May (16–24 May).

Captured birds were aged first-year or adult according to the colour of the median coverts and tertials (Summers 2009). They were sexed using a combination of bill, foot (tarsus plus longest toe) and wing lengths in a Generalised Linear Model after a sample had been sexed using DNA (Hallgrimsson *et al.* 2008). This method predicted the sex correctly for all individuals molecularly sexed. The captured birds were given a unique permutation of colour rings, four on the tarsi and one on the left tibia. A metal ring was attached to the right tibia. Details of the colour marking scheme were given to many bird watchers whom were likely to check flocks of Purple Sandpiper in winter and spring.

In winter 2005/06, a concerted effort was made to look for colour-ringed birds on the coasts of the British Isles and Iceland. In Britain, about 30% of the estimated wintering population of 11,000 (Austin *et al.* 2008) was checked for colour-rings while in Iceland only about 750 birds were checked on the Reykjanes Peninsula on the southwest coast and *c*. 200 in the southeast of the country. Thus, the searching effort in Iceland was much less than in Britain. Bird-watchers in Denmark, Germany, Belgium and France were also notified. Observers were asked to count Purple Sandpipers, note the number that they had checked for colour rings and report colour rings. Winter was defined as the period from October until March.

RESULTS

Eighty-four Purple Sandpipers were colour-ringed in 2003 and 242 in 2005. The ages and sexes of the marked birds are shown in Table 1. The percentage of first-year birds was 19% in 2003 and 32% in 2005, and the percentage of males was 57% in 2003 and 68% in 2005. All but one catch in 2005 took place in early May, so splitting the catches into early and late May was almost the same as splitting according to year (Table 1). One bird, trapped in Iceland in May 2005, had been previously ringed and re-trapped at Balintore, East Ross-shire, Scotland (Figure 1).

Distribution and number of sightings

Out of the 326 birds colour-ringed, 82 were re-sighted during 2003 to 2009, of which 69 were seen during winter 2005/06. Most sightings were from southwest Iceland. The 55 individuals re-sighted in Iceland during 2005/06, and including sightings of the same individuals in different months, were seen in July (1 record), August (1), September (1), October (2), November (1), December (29), January (2), February (1), March (35) and April (1). This pattern largely reflects the search effort, which was highest in December and March, showing that many of the colour-marked birds wintered in Iceland, close to where we had marked them. The autumn sightings indicate that some were likely to moult in Iceland. There was also a sighting at Höfn,

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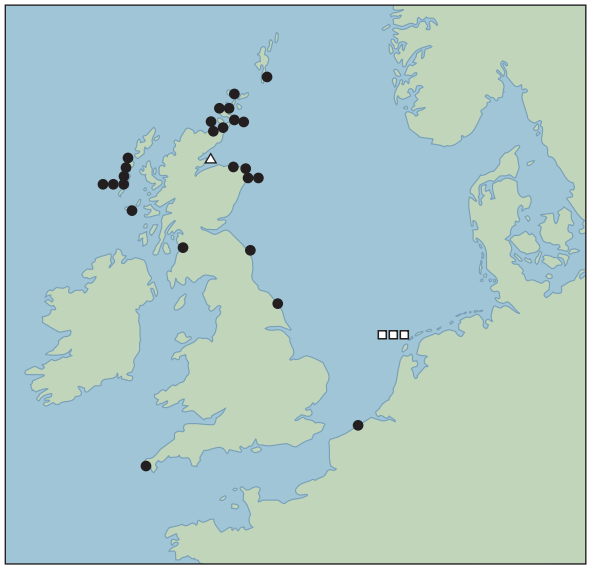


Figure 1. Locations in Britain and Belgium where Purple Sandpipers were seen after colour ringing in May 2003 and 2005 on the coast of southwest Iceland. All birds were sighted during October to March apart from the Shetland sighting (the most northerly one), which was in May. This bird may have wintered elsewhere. Each dot represents one individual and multiple records at a site extend out from the coast. The open triangle shows the location where a bird had been ringed in Scotland that was retrapped in Iceland. The open squares refer to the ringing or recapture area in The Netherlands for three Purple Sandpipers captured or ringed in southwest Iceland in May (from Boere *et al.* 1984).

southeast Iceland, in February and March in two consecutive years, showing that not all birds wintered in southwest Iceland. Finally, there was a sighting in May at Melrakkaslétta, northeast Iceland, of a bird marked in southwest Iceland, indicating lack of fidelity to southwest staging areas during the spring migration.

Twenty-four colour-ringed birds were sighted in Britain and Belgium during October–May, 14 of these in winter 2005/06 (Figure 1, Table 2, Coiffait *et al.* 2008). Two of the latest sightings in spring were from the most southerly locations. An adult male was still in Cornwall, England, on 8 May, and an adult female was in Belgium on 18 May. The only other May record was from Shetland, Scotland, (4 May).

Sex ratios and percentage of marked birds

In winter 2005/06, 3,003 Purple Sandpipers were checked for colour-rings in Britain and Northern Ireland (Table 2). The percentage of marked birds varied from 0% to 16.6% in different regions. The high value for Ayrshire was due to the small number of birds observed. Overall, the percentage of marked birds was 0.47%.

Table 1. Numbers of Purple Sandpipers, split according to age and sex, colour-ringed in southwest Iceland in 2003 and 2005, in early (5–15) and late (16–24) May.

	Marking period				
Age/sex	2003	2005	Early May	Late May	Total
Adult males	41	112	108	45	153
First-year males	7	52	52	7	59
All males	48	164	160	52	212
Adult females	27	52	50	29	79
First-year females	9	26	25	10	35
All females	36	78	75	39	114
Total	84	242	235	91	326

Table 2. Counts of Purple Sandpipers in Scotland, northeast England and Northern Ireland in winter 2005/06, numbers checked for colour rings and number and percentage of colour-ringed birds.

Region	Number of birds seen	Number checked	Number colour-ringed	Percentage colour-ringed
Dumfries-shire	58	58	0	0
Ayrshire	6	6	1	16.6
Tiree	368	300	1	0.33
Outer Hebrides	794	649	3	0.46
Shetland	196	196	(1 in May)	0
Orkney	484	469	4	0.85
Caithness	103	75	2	2.67
East Sutherland	73	67	0	0
East Ross-shire	91	91	0	0
Moray	154	142	1	0.70
Aberdeen-shire	714	643	1	0.16
Kincardine-shire	73	73	0	0
Angus	27	23	0	0
Northumberland	255	179	1	0.56
Northern Ireland	32	32	0	0
Total	3428	3003	14 (1)	0.47

Comparing the percentages of the sexes of the birds seen in Britain in winter 2005/06 (Table 3) with what one would expect from the numbers of males and females marked (Table 1), there was no evidence that a disproportionate number of one sex wintered in Britain (Yates' corrected $\chi^2 = 0.04$, $df = 1$, $P = 0.84$). Likewise, in a comparison between the percentages of males and females seen in winter in Britain compared to Iceland, there was no significant difference (Table 3).

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Table 3. Numbers of Purple Sandpipers of different sex marked in Iceland in early and late May sighted in Britain and Iceland in winter (October–March) 2005/06. Percentages are in brackets.

	Sighted in Britain	Sighted in Iceland
Male	10 (71.4)	36 (65.5)
Female	4 (28.6)	19 (34.5)
Yates' corrected $\chi^2 = 0.11$, $df = 1$, $P = 0.92$		
Ringed early May	8 (57.1)	52 (94.5)
Ringed late May	6 (42.9)	3 (5.5)
Yates' corrected $\chi^2 = 10.7$, $df = 1$, $P = 0.001$		

Phenology, site fidelity and mass

A higher percentage of birds marked in late May were seen in Britain than in Iceland during winter 2005/06, compared to those marked in early May (Table 3). This indicated that migration from Britain took place largely in late May.

Several birds were re-sighted in more than one month within a winter indicating site fidelity. In addition, eight of the birds seen in Britain and Belgium were reported at the same site in more than one winter. One bird was re-sighted in England in January 2004 but in southwest Iceland in February 2006, showing that some birds were not site-faithful.

Three birds were recaptured in Scotland and one bird was re-trapped in Iceland after ringing in Scotland. Their mean mass in winter was 69.0 g (range 65.0–71.3 g), whereas the mean mass in Iceland was 81.8 g (range 79.6–85.4 g), showing that they were accumulating fat and protein for onward migration whilst in Iceland during May.

DISCUSSION

The winter range and breeding origin

Our study showed that Purple Sandpipers that occur on the coast of Iceland in May prior to migrating to the Nearctic to breed comprise birds that spend the winter in Iceland, but also in Britain and Belgium. The sightings in northern Scotland matched with the known distribution and abundance of long-billed Purple Sandpipers wintering in Britain, long suspected as originating from the Nearctic (Nicoll *et al.* 1988). The sightings down the east coast of England and Belgium showed that some also wintered along the coast of the southern North Sea, supporting the earlier records from The Netherlands (Boere *et al.* 1984, Figure 1). The autumn sightings in Iceland indicate that some were likely to moult in Iceland as birds from this population have already completed moult when they arrive on the wintering grounds in Scotland (Summers *et al.* 2001).

The large number of colour-ring sightings from Iceland in winter was unexpected, but shows that Iceland is a major part of the winter range of this Nearctic population. Bill lengths of the Icelandic breeding population and the presumed Nearctic population wintering in Scotland do not differ but these populations can be distinguished by wing length. Icelandic males have average wing length of 137.2 mm (SD 2.3, $n = 135$) and females 143.0 mm (SD 2.7, $n = 47$) compared to 132.3 mm (SD 2.1, $n = 96$) and 137.2 (SD 2.4, $n = 40$) respectively, for males and females wintering in Scotland (Summers *et al.* 1988). The wing lengths of the 36 males and 19 females resighted in Iceland in this study were 132.0 mm (SD 2.6) and 135.9 (SD 4.5) respectively, indicating that these birds were not of Icelandic origin.

There is also evidence from biometrics that some of the Purple Sandpipers wintering in Greenland are also derived from this Nearctic population (Summers 2007). Therefore, the winter range of this population includes Greenland, Iceland and northwest Europe on the East Atlantic flyway. This winter distribution is not known for any other wader population.

Observations of westward flights in spring from southwest Iceland led us to conclude that the potential breeding areas for these Nearctic Purple Sandpipers are either Greenland or Canada (Summers *et al.* 2009). The Purple Sandpipers that breed in southwest Greenland are resident (Salomonsen 1967) and the biometrics of the migrants in Iceland match better with the Canadian population (Summers 1994). This led us to the conclusion that the migrants in Iceland originate from Canada.

Site fidelity and division between areas

There were re-sightings of the same individual in England and Iceland during different winters. In addition, a record of a Purple Sandpiper colour-ringed in southwest Iceland in March 2001 and re-sighted in Scotland in November four years later (G.T. Hallgrimsson unpubl.) shows they may switch wintering areas within this range.

In 2005/06, 14 sightings of colour-ringed birds were made in Britain out of about 3,000 checked (i.e. 0.47% marked). This is likely to be an overestimation of the percentage of colour-ringed birds in the population because we were more likely to receive counts from people who also saw a colour-ringed bird.

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Given this likely overestimate and that the wintering population in Britain is about 11,000 (Austin *et al.* 2008) and 3,300 in Ireland (Crowe *et al.* 2008), there may have been a maximum of about 65 colour-ringed birds in Britain and Ireland. The sizes of the wintering populations on the European continent are small and/or comprise birds from other breeding populations: Spain 500 (Diaz *et al.* 1996), France 2,500 (Dubois *et al.* 2000), Belgium 300 (Becuwe *et al.* 1983), The Netherlands 350 (Meininger & Becuwe 1979), Germany 200 (Dierschke 1995), Denmark 200–300 (Lange *et al.* 2002), and Sweden 2,000 (Hake *et al.* 1997). Norway has a substantial wintering population, but this is concentrated in north Norway where most birds are from Russia (Strann *et al.* 2006). Therefore, there may have been another 6,000 birds on mainland Europe which could have been part of our study population. Assuming the same proportion of ringed birds as in Britain, these areas could potentially have contained a maximum of another 30 colour-ringed birds.

Of birds ringed in 2003 and 2005 there would probably have been about 260 remaining by winter 2005/06, given a survival rate of about 80% (Summers *et al.* 2001). Thus, the (over)estimate of 65 marked birds wintering in Britain and Ireland represented a quarter of the marked population that was still alive. Further, the potential for another 30 marked birds on the European mainland does not even account for half the birds. Therefore, given the high number of colour-ringed birds seen in Iceland in spite of the low searching effort, most of the colour-ringed birds must have wintered in Iceland.

Migration phenology

There have been several ringing recoveries in Orkney and the Outer Hebrides (northern Scotland) in May of Purple Sandpipers that occurred further south in Britain, The Netherlands and Germany during winter (Summers 1994). These show that there is a movement to these northern isles, minimizing the distance to Iceland before they make the over-seas crossing. However, the late sightings in Cornwall (southern England) and Belgium in May also suggest that some Purple Sandpipers may depart for Iceland from southerly localities and may not move up through Britain in order to make the shortest possible sea crossing to Iceland.

The reason why a higher percentage of 2003 marked birds (from late May) was seen in Britain (Table 3) was probably because the 2005 catches (from early May) comprised a greater percentage of birds that wintered in Iceland, and many of those that wintered in Britain had not yet arrived in Iceland when we captured birds in 2005. The sightings of colour-ringed birds in Belgium as late as 18 May and 8 May in Cornwall support this idea.

There are still some further questions to be answered with regards to the Purple Sandpipers that winter and migrate across the North Atlantic. Confirmation is required that the Nearctic birds that winter on the East Atlantic flyway are Canadian breeding birds. The number of birds belonging to this presumed Canadian population at different localities within the winter range presented in this study is unknown. Also, the relative numbers of Purple Sandpipers from different breeding populations (from Iceland, Canada and probably northeast Greenland) that winter in Iceland is unknown.

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SAMENVATTING

Op IJsland komen naast een standvogelpopulatie van de Paarse Strandloper *Calidris maritima* ook populaties van deze soort voor die er alleen overwinteren of een tussenstop maken tijdens de trek. Om te bepalen waar de vogels overwinteren die in het voorjaar naar het westen vertrekken, werden in mei 2003 en 2005 aan de zuidwestkust van IJsland Paarse Strandlopers van kleurringen voorzien. Vervolgens werden, voornamelijk in de winter (oktober–maart) van 2005/06, naar kleurringen gezocht langs de kusten van IJsland, Groot-Brittannië en het Europese vasteland. Tussen 2003 en 2009 werden 82 van de 326 gekleurringde vogels teruggezien, waarvan 69 in de winter van 2005/06. De meeste terugmeldingen (55) uit de winter van 2005/06 waren afkomstig uit het zuidwesten van IJsland, wat een uitbreiding betekent van de bekende winterverspreiding van de onderhavige populatie. Terugmeldingen uit Noord-Schotland bevestigen de aanwijzingen op grond van de biometrie dat deze winterpopulatie afkomstig is uit Canada. Het maximumaantal gekleurringde Paarse Strandlopers dat in de winter van 2005/06 aanwezig was in Groot Brittannië, werd geschat op *c.* 50, naar schatting een kwart van de gekleurringde vogels die nog in leven waren. Hieruit volgt dat het grootste deel van de gekleurringde vogels dus ergens anders overwinterde, waarschijnlijk op IJsland. Er waren geen aanwijzingen voor sekseverschillen in de keuze om in IJsland of Groot-Brittannië te overwinteren. De vogels die werden geringd tot en met 15 mei, werden echter vooral teruggezien in IJsland, terwijl meldingen van vogels geringd na 15 mei vooral uit Groot-Brittannië afkomstig waren. Dit geeft aan dat de meeste vogels Groot-Brittannië verlaten vanaf half mei. De Canadese populatie heeft een voor steltlopers unieke winterverspreiding bestaande uit Groenland, IJsland en de Noordzeekusten van Europa. (PW)

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