Establishing the right period to estimate juvenile proportions of wintering Sanderlings via telescope scans in western Scotland

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Telescope scanning of flocks of shorebirds to age individuals by plumage characteristics has increasingly been used to assess the proportion of first-year birds in local populations. To standardise measurements of the proportion of juveniles for a local wintering population it is necessary to know when this can be measured without possible biases due to migration or moult. We investigated how the proportion of juvenile Sanderlings *Calidris alba* changed between mid-Jul and early Nov 2009–2011 on the Island of Tiree, Scotland. We suggest measuring juvenile proportion of locally wintering Sanderlings in NW Europe between mid-September and the end of October, because migration has terminated by then and juveniles can still be aged using field characteristics. During this time of the year the proportion of juveniles at Tiree was similar between the three years (6–9%).

INTRODUCTION

Knowledge about demographic indices of annual survival, immigration, emigration and recruitment is crucial in monitoring the vitality of populations (Colwell 2010, Piersma & Lindström 2004, Sandercock 2003). For shorebird species nesting in the inaccessible High Arctic, it is easier to assess large scale population dynamics at the more southerly situated non-breeding grounds, i.e. in temperate and tropical regions. Determining juvenile proportions of wintering shorebird populations can be an effective tool to measure recruitment (Robinson *et al.* 2005). Sampling can be performed either by catching individuals to age them in the hand, or by scanning flocks through a telescope and separating juveniles from adults based on plumage characteristics (Rogers *et al.* 2005b).

Either method might be appropriate depending on the population-specific timing of moult, which affects age determination. Several factors that potentially affect true age ratios need to be accounted for in both approaches. For example, sampling effort and age-specific roosting or foraging behaviour may affect the juvenile proportion encountered (Clark *et al.* 2004, Robinson *et al.* 2005, Rogers *et al.* 2005b). Telescope scanning is practically easier and might often be the approach of choice because it can be performed on larger subsamples of local populations. Also, interactions between locations and age ratios can be taken into account by scanning different (sub)sites, whereas it is known that catching results in age-biases because juveniles tend to be more naive or risk-prone and often occur at different locations than adults (Harrington 2004, Rösner 1990, Ruiz *et al.* 1989, Townshend 1985, van den Hout *et al.* 2008).

In contrast to catching, telescope scanning flocks to determine age ratios can only be carried out reliably during a relatively short period of the year. Juveniles of arctic shorebirds often moult their typical juvenile plumage into first winter plumage soon after settling at a wintering location (MacWhirten *et al.* 2002). After this moult, juveniles are difficult to distinguish from adults in the field because only a few remaining juvenile wing coverts or tertials give away their age (Robinson *et al.* 2005). These characteristics are still useful for ageing birds in the hand, but usually not in the field. The start of the time window to reliably establish juvenile ratios of local non-breeding populations is also limited by the end of the migration period, because it is important to avoid including migrants, which may be age-biased, when sampling locally wintering birds. We investigated the migration phenology of adult and juvenile Sanderlings at a wintering site in W Scotland for three consecutive years. Here, we show how differential migration of adults and juveniles affects the age ratios of Sanderlings and give suggestions for determining the time window when field observations of age structure may consistently reflect juvenile recruitment.

METHODS

Counts of juvenile and adult Sanderlings were carried out on the Island of Tiree (56°30'N, 6°52'W; Fig. 1) in the Scottish Inner Hebrides in 2009–2011. Typically, 300–1,000 Sanderlings winter on the sandy beaches of Tiree (Bowler *et al.* 2008). The four beaches used most regularly by Sanderling in autumn (Gott Bay, Balephetrish Bay, Sorobaidh Bay and Traigh Bhagh; Fig. 1) were counted at least once a week. Normally all four beaches were visited on the same day, irrespective of the state of the tide. These beaches were all easily accessible by road and all Sanderlings present were counted and aged from a car using a window-mounted telescope. Another eleven beaches and one inland lake (Loch a'Phuill; Fig. 1) were counted on a less regular basis, either because they held fewer birds or because they were less

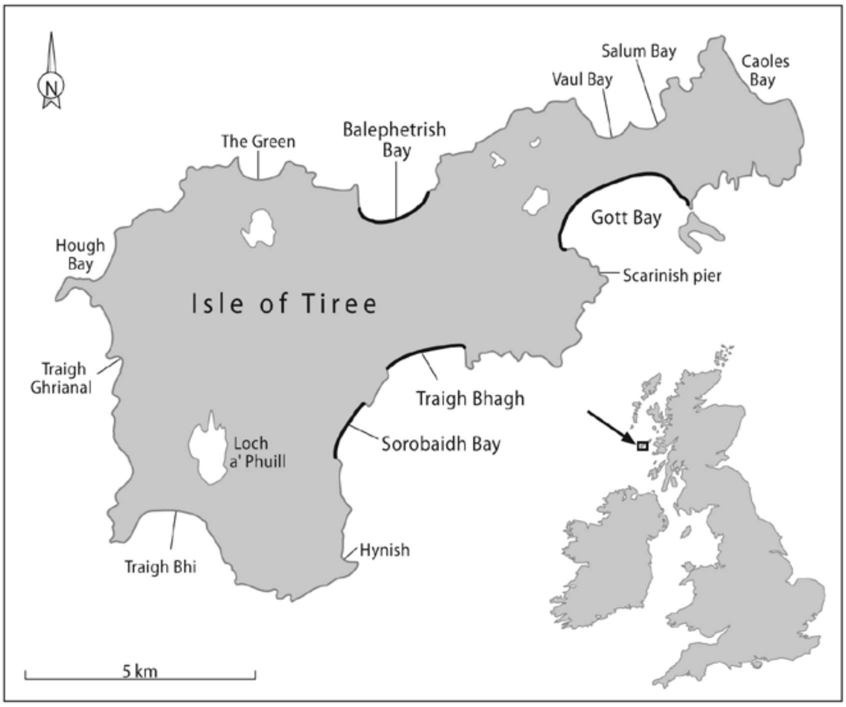

Fig. 1. Map of Tiree, W Scotland, showing the four beaches that were surveyed (in bold) and other sites used regularly by Sanderlings.

accessible. We only used data collected from sites that were all counted on the same date. All Sanderlings observed were counted and aged. Previous investigations suggest that there is negligible exchange of individuals between Tiree and the adjacent island of Coll (Bowler *et al.* 2008). Sanderlings were counted and aged by plumage characteristics (e.g. Hayman *et al.* 1986). Both roosting and feeding individuals were counted to minimise potential bias in juvenile proportions due to different behaviours (Rogers *et al.* 2005b). Over the three years, the period during which we counted and aged Sanderlings ranged between 12–17 Jul and 5–15 Nov. We examined the overall migration phenology and age ratios in all three years to determine when migration had terminated and if the measured age ratios changed due to the progression of moult in the juveniles. These events were used to determine the time window when juvenile proportions may consistently reflect recruitment into the wintering population.

RESULTS

In all years, adult Sanderlings were recorded to return from their breeding grounds from mid-Jul onwards and their numbers peaked (in 2009 and 2010) between late Aug and mid-Sep. The numbers of adults usually stabilised around 11 Sep (Fig. 2). The first juveniles arrived in late Aug and peaked around 8 Sep (Fig. 2), indicating that the migration of juveniles had ended by then as well. In all three years, juveniles were outnumbered by adults throughout the whole study period (Fig. 2). In 2009, the juvenile proportion peaked in early Sep. In 2010 there was only a weak peak in early Sep (Fig. 2). In 2011, fewer birds were recorded compared to the previous two years, and juvenile proportions, as well as adult numbers, did not show an obvious peak. In all years, juvenile proportions remained rather stable from mid-Sep onwards until the last counts in Oct/Nov (Fig. 2) suggesting that from mid-Sep onward the majority of the wintering population, including adults and juveniles, was present on Tiree and no new migrants were passing through. We did not see a clear drop in the juvenile proportion after mid-Sep, indicating that we were still able to age all individuals reliably until late Oct. Between 18 Sep and 26 Oct, the mean juvenile proportion recorded in 2009, 2010 and 2011 was 6.1% (SD±1.5, n = 4), 8.2% (SD±5.6, n = 4) and 8.8% (SD±2.6, n = 2), respectively. Therefore they were very similar in all three years. Because of the likelihood of pseudoreplication (Hurlbert 1984) in our intra-annual scans, we only report the mean juvenile proportion for each year. We believe that performing several scans each year increased the reliability of the calculated mean proportion.

DISCUSSION

In common with many High Arctic breeding waders, adult and juvenile Sanderlings migrate southwards over different periods due to the sequence of Arctic breeding phenology. Failed breeders are the first to migrate, followed by a usually greater number of adults that successfully hatched eggs and/or raised young. These are followed in turn by the juveniles about two weeks later (cf. Meltofte *et al.* 2007). The different timing of adult and juvenile migration usually results in two peaks in numbers at stopover sites as they move south (Meltofte 1996, Reneerkens *et al.* 2009).

Nine Sanderlings, individually colour-ringed on breeding grounds at Zackenberg, NE Greenland (2) and during spring migration in Iceland (7), were recorded exclusively on Tiree between mid-Oct and the end of Mar, suggesting that there is no or limited exchange of Sanderlings between Tiree and adjacent islands or the mainland coast (cf. Bowler *et al.* 2008). Nevertheless, the numbers of Sanderlings and the age ratios encountered varied even after the migrants had left the island. This variation is probably caused by individuals that move between sites on Tiree that were, or were not, regularly counted. This reinforces the need for multiple scans at several sites each year to obtain reliable estimates of the proportion of juveniles in a local wintering population (Rogers *et al.* 2005a, b).

The date from which not all juveniles can be distinguished from adults in the field marks the end of the period during which age proportions can be determined reliably. In Sanderlings juvenile body moult usually starts with the upperparts and flanks from mid-Sep to early Oct in temperate regions, but is delayed for up to a month in populations that winter in the tropics and in the Southern Hemisphere (MacWhirten *et al.* 2002). Juvenile Sanderlings wintering in California, USA, became inseparable from adults after mid-October (Myers *et al.* 1985). In Australia, a telescope age study of Curlew Sandpipers *Calidris ferruginea*, Red-necked Stints *Calidris ruficollis* and Sharp-tailed Sandpipers *Calidris acuminata* showed that it is possible to age the great majority of juveniles until at least the end of Nov, with some variation between species (Rogers *et al.* 2005a). This shows that sandpipers that winter in the southernmost parts of their non-breeding range retain their juvenile plumage until the end of Nov. In NW Europe juvenile Sanderlings start moulting into winter plumage from mid-Oct onwards (authors' unpubl. obs.).

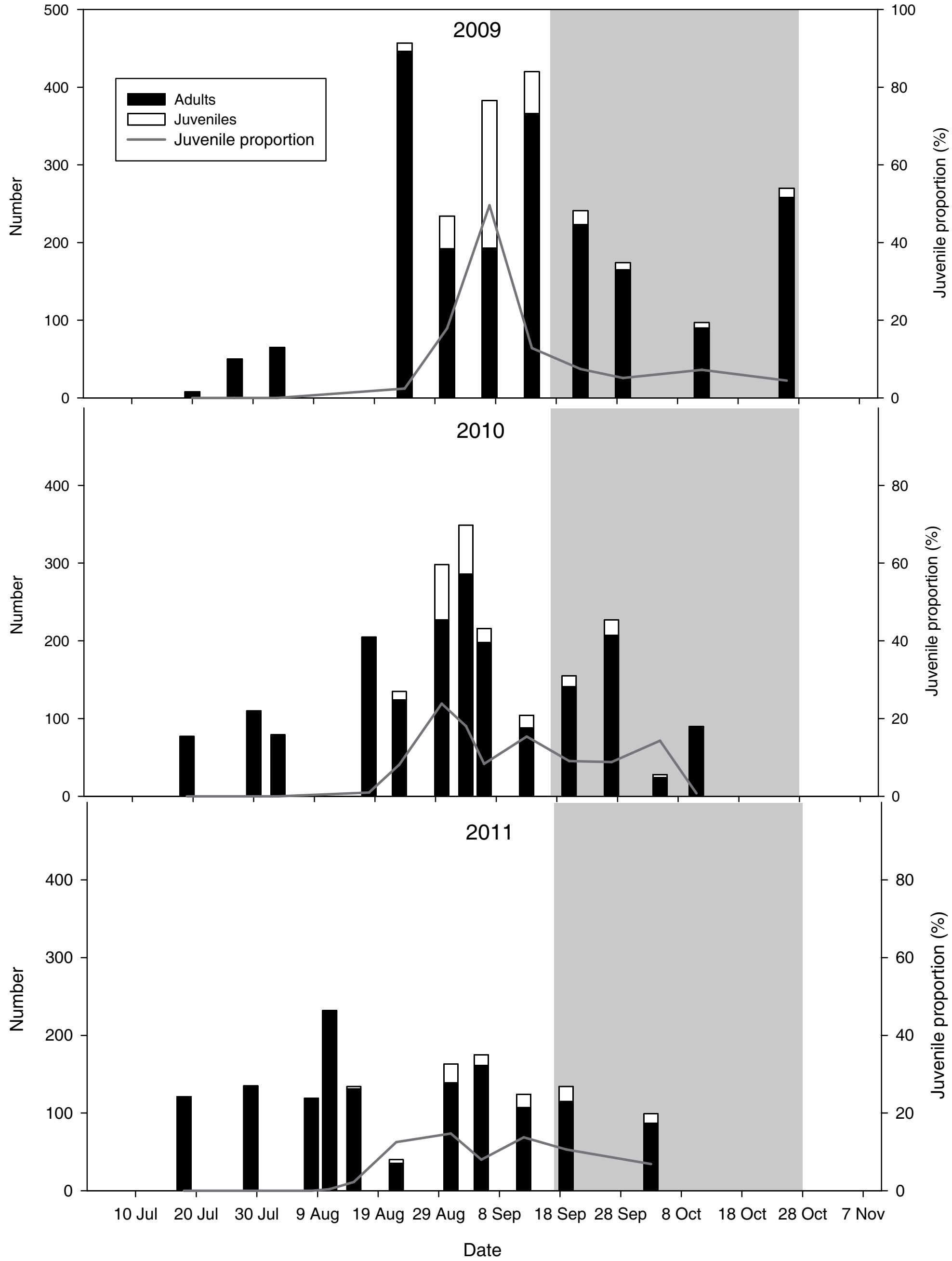

Fig. 2. Total number of adult (black bars) and juvenile (white bars) Sanderlings and the juvenile proportion (line) at four beaches on Tiree, W Scotland, between 12 Jul and 15 Nov 2009–2011. The grey area depicts the period during which we suggest recruitment is best measured on Tiree.

We are not aware of studies on the timing of migration of adult and juvenile Sanderlings in the more southern parts of the East Atlantic Flyway, but we would expect it to be later than on Tiree. That the migration peaks differ within the flyway can be seen from the different timing of migration of Sanderlings through Iceland compared to Tiree. In Iceland, adult Sanderlings stop over from the end of Jul to early Aug (Gunnarsson 2006) and juveniles about 2–3 weeks later (Reneerkens *et al.* 2009). This is 1–2 weeks earlier than we observed on Tiree (Fig. 2).

We suggest that recruitment of Sanderlings at study locations in NW Europe can best be assessed between mid-Sep and late Oct (cf. Fig. 2), but this will be later in more southerly locations. Because juveniles tend to select different sites than adults and group together, also called "bunching" (Harrington 2004, Rogers *et al.* 2005a), it is highly recommended to cover several sites during field scans. This bunching effect has been observed on Tiree and on some occasions there was more than a tenfold difference in the proportion of juveniles on different beaches. Moreover this effect was not consistently predictable for any of the sampled beaches. Therefore it is preferable that all sampling sites are visited on the same day. Furthermore, to obtain a reliable indication of juvenile proportion at a particular site, such as a beach, it is advisable to conduct at least 2–4 scans (Rogers *et al.* 2005b).

Juvenile proportions have been widely used to assess breeding success (Blomqvist *et al.* 2002, Summers & Underhill 1987) and juvenile recruitment into local non-breeding populations (cf. Rogers *et al.* 2004). Striking differences in breeding success in successive years have been observed in other Siberian sandpipers, often in a cyclic pattern reflecting the cyclic abundance of Lemmings, Microtinae, on the breeding grounds which in turn affects predation pressure on sandpiper nests/chicks (Blomqvist *et al.* 2002, Soloviev *et al.* 2006, Summers & Underhill 1987). Sanderlings that winter and stop over at Tiree breed in Greenland and NE Canada (Reneerkens *et al.* 2009). The four year lemming cycle in this area (Gilg *et al.* 2003) is (currently) asynchronous between areas within the breeding range of Sanderlings or even absent (Gilg *et al.* 2009). This may be one of several possible explanations why we, in contrast to earlier studies on Siberian waders, failed to find marked annual differences in the proportion of juveniles in Sanderling flocks. Furthermore, all these studies on wader recruitment have been based on data from cannon-net catches, which may lead to an increase in the observed variation between years because of bunching (Clark *et al.* 2004). Unfortunately there are no long-term studies on recruitment rates based on telescope scans with which our results can be compared.

It is notable that the total numbers and the proportions of juveniles during the migration period in 2009 were higher than in the other two years (Fig. 2). This could have been the result of higher reproductive output by the Greenlandic population in that year, but this seems unlikely since Sanderling breeding success was rather low around Zackenberg, NE Greenland, in 2009 (Hansen 2009). Instead, local weather events could have forced a higher number of Sanderlings to stop on Tiree that year. Additional data on juvenile proportions from more southerly areas would be needed to demonstrate whether juvenile proportions recorded before mid-Sep on Tiree reflect those found after that time further south in the wintering range. Linking phenological data with meteorological data would help to assess the effect of local weather events on the staging behaviour of Sanderlings. However, high turnover of individuals during the migration period is likely to complicate reliable estimations of juvenile ratios. Future studies in other locations along the East Atlantic Flyway are needed to show whether juvenile proportions differ between non-breeding areas.

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