


Migration routes and timing in a bird wintering in South Asia, the Common Rosefinch *Carpodacus erythrinus*

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Abstract Only few bird species from Western Europe migrate eastward to wintering areas in South Asia, and little is known about this migratory flyway. The Common Rosefinch has in the past century expanded its breeding range westward to include Western Europe and migrate along this flyway to wintering sites in South Asia. This is the first study describing the migration routes of Common Rosefinches between Europe and Asia in detail, revealed by light level geolocators. The rosefinches showed loop-migration with more northerly routes in autumn than in spring, possibly in order to shorten the flight over the Central Asian deserts, which are very inhospitable at this time of the year. In spring the deserts are less dry and richer in vegetation, which may have supported the more southerly routes. During autumn migration the birds used several staging sites in Central Asia for prolonged periods. Although the birds passed over mountain regions at this time, which potentially act as barriers to them, the length of the stops seem unrealistically long for only fuel deposition. Instead, this suggests that the birds temporarily suspended

migration to take advantage of abundant and predictable food sources in this region. During spring migration the birds made a few longer stops while still in north India or Central Asia, before migrating at fast speeds towards the breeding grounds. The birds covered 4–5000 km with only very short stopovers and thus most of the fuel used on spring migration must have been accumulated in Asia. Our results thus indicate that Central Asia, and north India, are important staging areas for this species in both autumn and spring. During winter, birds used two sites located several hundred kilometres apart, and relocation was probably a response to local food availability.

Keywords *Carpodacus erythrinus* · Common Rosefinch · Migration · Flyway · Geolocator

Zusammenfassung

Zugrouten und zeitlicher Ablauf des Zuges beim in Südasiens überwinternden Karmingimpel (*Carpodacus erythrinus*)

Nur wenige Vogelarten Westeuropas ziehen ostwärts zu Winterquartieren in Südasiens, und über diesen Zugweg ist nur wenig bekannt. Der Karmingimpel hat im Lauf des vergangenen Jahrhunderts seine Brutgebiete westwärts über Westeuropa ausgedehnt und zieht entlang dieser Route zu Überwinterungsgebieten in Südasiens. Dies ist die erste Studie, welche die Zugwege der Karmingimpel zwischen Europa und Asien mittels Daten von Hell-Dunkel-Geolokatoren detailliert beschreibt. Die Karmingimpel zeigten einen Schleifenzug, bei dem sie im Herbst weiter nördlich verlaufende Routen nutzten als im Frühjahr, möglicherweise um den Flug über die zentralasiatischen Wüsten zu verkürzen, die zu dieser Jahreszeit äußerst unwirtlich sind. Im Frühling sind die Wüsten weniger

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trocken und vegetationsreicher, was die südlicheren Routen begünstigt haben könnte. Auf dem Herbstzug nutzen die Vögel über ausgedehnte Zeiträume hinweg mehrere Rast- und Sammelpunkte in Zentralasien. Obgleich die Vögel zu dieser Zeit über Gebirgsregionen zogen, die potenzielle Hindernisse für sie darstellen, erscheint die Dauer der Rastaufenthalte unrealistisch lang, um nur dem Auffüllen der Energiereserven zu dienen. Stattdessen deutet dies darauf hin, dass die Vögel den Zug vorübergehend unterbrachen, um die reichlichen und verlässlichen Nahrungsquellen dieser Region zu nutzen. Auf dem Frühjahrszug machten die Vögel noch in Nordindien oder Zentralasien ein paar längere Rastpausen, bevor sie in raschem Tempo weiter in die Brutgebiete flogen. Die Vögel legten mit sehr kurzen Unterbrechungen 4–5000 km zurück; somit muss der Großteil der auf dem Frühjahrszug verbrauchten Energiereserven in Asien angelegt worden sein. Unsere Ergebnisse deuten daher an, dass Zentralasien und Nordindien für diese Art sowohl im Herbst als auch im Frühjahr bedeutende Rast- und Sammelregionen sind. Während des Winters nutzten die Vögel zwei mehrere 100 km voneinander entfernte Gebiete, und Ortswechsel waren vermutlich Reaktionen auf lokale Nahrungsverfügbarkeit.

Introduction

The majority of migratory bird species in Western Europe spend the winters in southern Europe or further south in Africa, and only a handful of species migrate to wintering grounds in South Asia (Moreau 1952, 1972).

The latter flyway has received little attention in the literature, partly because of the relatively low number of species involved and also because details about routes taken and timing of migration for birds following this migratory flyway is not well known (but see Lislevand et al. 2015). The migratory distances birds undertake when following this flyway are comparable to those in birds wintering south of the Sahara, and they also need to cross an ecological barrier, the Central Asian desert region, to reach their wintering grounds in South Asia.

The Common Rosefinch (*Carpodacus erythrinus*) is a species that breeds in western and northern Europe and migrates along the European–Asian flyway to wintering areas that stretches from Pakistan to east China (Ali and Ripley 1974; Cramp and Perrins 1994).

The species is a relatively recent immigrant to East and West Europe after a range expansion of the population towards west and northwest during the first half of the twentieth century (Bozhko 1980; Stjernberg 1985). Common Rosefinches have been breeding regularly in Sweden since the 1950s, and the population increased in size until the middle of the 1990s (Green and Lindström 2014). The

population has since been in steady decline, and the current population is a quarter of the population during the peak years, and a similar trend is evident for populations in Finland as well (Green and Lindström 2014; Piha 2014). To be able to establish the reason for population declines in migratory species, comprehensive knowledge on migratory routes and winter distribution is required in order to identify the level of threats to populations in different seasons and at widely separated locations during the annual cycle (e.g. Fransson et al. 2005; Kirby et al. 2008).

Although the breeding biology of the Common Rosefinch has been well studied (e.g. Stjernberg 1979; Björklund 1990), information on the migration of the species is less complete. Traditional ringing and recovery data have been used to assess migration routes in small passerines, but recoveries of ringed rosefinches are not common, and long-distance recaptures are very rare. Only four birds ringed in the Nordic countries and one from the east coast of the Baltic Sea in the Kaliningrad area have been reported recovered outside Europe along the migration route, but none from the wintering grounds (Paevskii 1973; Bakken et al. 2006; Bønløkke et al. 2006; Fransson and Hall-Karlsson 2008; Piha 2014).

With the development of miniature archival light-level geolocators the gaps in the knowledge of migration routes of passerine birds are rapidly shrinking as an increasing number of species are tracked throughout the annual migration cycle (e.g. Stutchbury et al. 2009; Åkesson et al. 2012; Bairlein et al. 2012; Stach et al. 2012; Salewski et al. 2013).

The aim of this project was to map migration routes and wintering areas, and to identify key stopover areas during migration of Common Rosefinches breeding in Sweden, by tracking individual rosefinches with miniature archival light-level geolocators.

Methods

Field work

We captured 37 male Common Rosefinches in their breeding territories at two sites in Sweden in 2011–2013; at Ringenäs on the west coast (56.71 N, 12.68 E) and on southern Gotland in the Baltic Sea (56.97 N, 18.25 E). All birds were marked with aluminium leg rings issued by the Swedish Museum of Natural History. We only fitted geolocators on male rosefinches since males show greater site fidelity to breeding sites than females in this species, which increased the probability for retrieval of the geolocators (Stjernberg 2014).

We used two models of geolocators; Mk12S (British Antarctic Survey, light sensor mounted on a 10 mm stalk),

and Intigeo-P65 (Migrate Technology Ltd, with a 7 mm “light pipe”). Geolocators were attached to birds with a leg-loop harness made from 1 mm EPDM rubber cord (Rappole and Tipton 1991). Geolocators with the harness attached weighed 0.8 g, which represented 3.5 % (range 1.9–4.9) of the body mass of the birds.

Data analysis

We used the threshold method for deriving positions from light level data using functions provided in the R package “GeoLight” (Lisovski and Hahn 2012). Light level thresholds were set to 3 for the Mk12S and 5 for the P65 models. Using different light thresholds for the two models gave similar sun elevation angles in the in-habitat calibration.

A Loess filter (function “loessFilter”) was applied to remove unnatural twilight events (5–11 % of twilights were removed). Twilight events were predominately removed from the breeding and migration periods (April–September) and none during the winter months (October–March), which suggests that the birds experienced a more stable light regime during the winter months than during the rest of the year. For this reason we used different calibration methods at different stages during the year. Light levels were calibrated to a known site (in-habitat calibration, function “getElevation”) using data from the first and last (autumn and spring) stationary periods when the birds were at the breeding sites (sun elevation angle: P65 = -3.8° , MK12S = -3.6°), and was applied to breeding sites and the migration periods. For the longer stationary periods during the winter months we used the Hill-Ekstrom calibration (function “HillEkstromCalib”), which uses an iterative process to locate minima in variance in latitude when fitting different sun elevation angles to light level thresholds (sun elevation angles for the wintering sites ranged between -3.0° and -5.1° ; Lisovski et al. 2012).

During the equinoxes estimation of latitude is highly uncertain, and was thus not estimated for a period of 8–15 days on either side of autumn and spring equinoxes.

Geographical positions were calculated with the function “coords”. A speed filter, set to 30 km/h, was applied to remove outlying positions (function “distanceFilter”, 11–17 % of positions were removed). We used the function “changeLight” to identify stationary periods longer than 5 days (probability threshold for bird R1 and G1: 0.1 and for bird G2: 0.09). The level of the probability thresholds were chosen for each bird so that the detected stationary periods during the migratory periods agreed with apparent movements in longitude in plots on position in longitude during the migratory periods (see Online Resource 1).

Longitude was preferred over latitude since it is less affected by shading and time of year, and also because most of the migratory movements took place along the east–west axis. When timing of movement events did not conform exactly between the two methods information from longitude plots were given priority. The use of “changeLight” particularly allowed us to detect migration movements during the equinox periods, but it also assisted in determining migratory movements that were orientated in the north–south axis. Geographical positions of longer stationary periods were estimated as the median longitude and latitude. Positions of shorter stopovers (2–5 days) were identified from plots on longitude alone as the median of smaller clusters of a minimum of three points with similar longitude (light-level geolocators give a maximum of two locations per day). The migration routes taken by the birds were estimated as the shortest distance (great circle) between consecutive stopovers and longer stationary sites. Migration distance was calculated as the cumulative great circle distances between the median positions of consecutive stopover and stationary sites, although the actual routes taken by the birds may have been longer. Migration speed was calculated as the distance travelled divided by the number of days of travel.

Geolocation by light is heavily influenced by shading, e.g. from weather or vegetation, which introduces irregularities in estimation of sun rises or sun sets which results in errors in derived positions. We calculated the observed error in latitude and longitude from the true site for the period the birds were at the breeding site (P65; latitude = 66 ± 47 km, longitude = 86 ± 71 km, MK12S; latitude = 78 ± 58 km, longitude = 135 ± 81 km; mean \pm SD).

Kernel density analysis was applied on wintering sites using the R package “adehabitat HR”, with “href” as smoothing parameter (Calenge 2006).

Results

Three geolocators were retrieved from returning birds. One bird from Ringenäs (R1) was recaptured in 2012 and two birds from Gotland (G1 and G2) were recaptured in 2014. An additional three recaptured birds had lost the geolocators (one was recaptured after 2 years) and four birds were sighted but not recaptured, two of which were sighted 2 years after deployment. Thus, at least 27 percent of the birds that had received a geocator survived and returned at least 1 year after deployment, although it is not known for how long the birds that had lost the geolocators had carried them. The three retrieved geolocators were still active upon retrieval and all gave intact information from the entire migration journey.

Timing and speed of migration

The birds began migration and left the breeding sites in late July–early August (21 July–5 August). The first part of the migration consisted of a rapid movement to the foothills of the mountain ranges in east Central Asia, a journey of approximately 3800–4500 km (Fig. 1). The movement was accomplished in 18 days for R1 and G2, but 27 days for G1 which made a 6 days stopover north of the Aral Sea before crossing the northern Central Asian desert in Kazakhstan (Fig. 1). R1 and G2 did not make any discernible longer stops before crossing the desert region. Average migration speed for this part of the journey was 206 km day⁻¹ (Table 1). The second part of autumn migration proceeded in a southward direction and at a much slower pace through a series of two to four staging sites (average speed: 39 km day⁻¹, Table 1). The migration route of G1 and G2 led them through the western Tien Shan and the Pamir mountain ranges while R1, following a more westerly route, passed over the Hindu Kush mountain range (Fig. 1). The average duration time at the staging sites in the second part of autumn migration was 16.3 days (Table 1), and at half of the sites the birds made prolonged stops between 19 and 28 days (Table 1). “Geolight” detected one (R1 and G1) and two (G2) stationary sites during the autumn equinox periods when only time of arrival and departure, but not location, could be determined.

Although the distances were much shorter to cover in the second part of autumn migration, 1200–3000 km, this part of the journey took much longer time to cover than the first part, 39–69 days, which corresponds to 59–79 % of the entire autumn migration (Table 1). The birds completed autumn migration (from the breeding sites to the first winter sites, range 5800–6800 km) in 9–13 weeks, with an average migration speed of 85 km day⁻¹ (Table 1).

The birds arrived at their first wintering sites in October (2–16 October). The wintering site of R1 was close to the coast in south Pakistan while G1 and G2 wintered in the western inland of India. In the second half of January (24–27 January), all birds relocated to a second wintering area located 300–850 km from the first wintering area (Fig. 1). R1 moved southeast along the coastline and probably crossed the border to India, G1 relocated in a southerly direction while G2 moved to an area further north.

Spring migration began in mid April when the birds left their second wintering sites. During spring migration the birds followed a more southerly route back to the breeding sites than in autumn migration. In the first part of spring migration the birds made one (R1) or two (G1 and G2) longer (8–11 days) stops north and northwest of the second wintering sites, while still in northern India or Central Asia

(Table 1). Average migration speed for the first part of spring migration was 107 km day⁻¹ (Table 1). The subsequent migratory journeys back to the breeding grounds proceeded at a much higher speed as the birds covered 4000–5200 km in 11–18 days, with an average migration speed of 321 km day⁻¹. The birds completed spring migration (from the second wintering sites to the breeding sites, range 6200–6700 km) in 4–5 weeks, with an average migration speed of 203 km day⁻¹ (Table 1). Birds arrived at the breeding sites in the second half of May (17–19 May).

The overall spring migration speed was on average 141 % (range 102–173) faster than the overall autumn migration. When only comparing the rapid movements between the breeding sites and Central Asia, and from Central Asia to the breeding sites, migration speed was 62 % (range 15–99) faster in spring than in autumn.

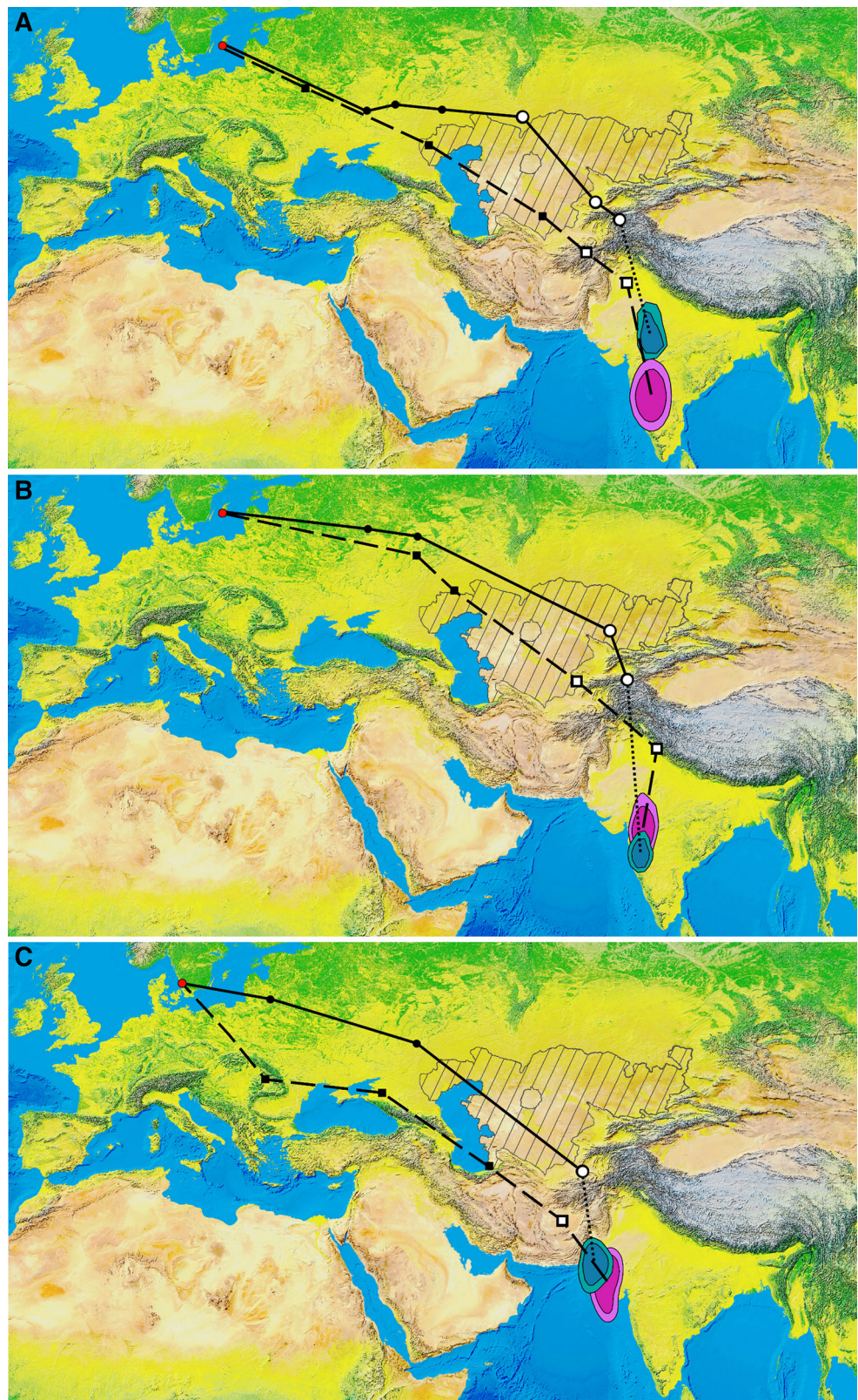
Discussion

Loop migration

The tracks of all three birds in this study indicate loop-migration with more northerly routes in autumn than in spring. The Central Asia desert region stretches between the Caspian Sea and the mountain ranges of Tien Shan and the Pamirs. It is a serious environmental barrier for European-Asian migrants in autumn when the deserts are at the driest annual conditions and very inhospitable to migrating birds (Dolnik 1990; Chernetsov et al. 2007). Migratory birds often avoid long desert crossings in autumn. Species following the Siberian–African flyway have been found to detour the deserts to the north and west while Siberian–Indian migrants migrate through the mountains east of the deserts, which have mild weather during this period and provide better feeding opportunities (Dolnik 1990; Bolshakov 2003; Bulyuk and Chernetsov 2005; Chernetsov et al. 2008). Birds following the European–Asian flyway, however, cross the deserts (Dolnik 1990; Chernetsov et al. 2007), but the more northerly routes taken by the rose-finches in autumn may shorten the crossing over inhospitable land and might also provide better fuelling opportunities before the crossing. However, only one bird (G1) showed an extended stopover in front of the desert, which indicates a less demanding desert crossing compared to the Saharan desert (Fransson et al. 2008). Furthermore, the track of R1 indicates that this bird chose to cross the full length of the desert region (approx. 2000 km).

In spring the Central Asian desert region is much less of a barrier since the rains in winter gives rise to short lived vegetation, offering much better fuelling opportunities for migrating birds passing over this area (Dolnik 1990;

Fig. 1 Maps show migration routes of three Common Rosefinches with geolocators, G1 (a), G2 (b), R1 (c). Migration routes were estimated as the shortest distance between stationary sites. *Solid lines* indicate autumn migration routes and *broken lines* indicate spring migration routes. *Dashed lines* indicate migration movements during autumn equinoxes when latitude could not be estimated. *Open circles* (autumn) and *squares* (spring) show median position of longer staging sites, (used >5 days). *Filled black circles* (autumn) and *squares* (spring) show median position of shorter stops (2–5 days). All birds used two wintering sites. Kernel densities encompass 50 and 70 % of the estimated positions during the two wintering periods. *Hatched area* show the extent of the deserts of Central Asia. Map projection: Miller cylindrical



Chernetsov et al. 2007). The more southerly routes taken in spring can probably be attributed to the better conditions in the desert areas at this time, and several of the staging sites

used in spring seems to have been situated in highly arid areas. This is supported by field data from the desert area showing lower body masses of Common Rosefinches in

Table 1 Migration speed and duration of migration, stopover and wintering

Individual	Year	Autumn migration duration (days)		Spring migration duration (days)		Autumn migration speed (km day ⁻¹)		Spring migration speed (km day ⁻¹)		Autumn staging sites: numbers and duration (days)	Spring staging sites: numbers and duration (days)	Wintering sites: numbers and duration (days)
R1	2011–2012	69	30	83	207	2 (25, 24)		1 (11)		2 (104, 84)		
		18 ^a	51 ^b	12 ^a	18 ^b	251 ^a	24 ^b	85 ^a	289 ^b			
G1	2013–2014	66	35	94	191	4 (6, 12, 5, 19)		2 (10, 9)		2 (113, 78)		
		27 ^a	39 ^b	21 ^a	14 ^b	158 ^a	50 ^b	108 ^a	314 ^b			
G2	2013–2014	87	30	78	213	4 (23, 6, 5, 28)		2 (9, 8)		2 (102, 81)		
		18 ^a	69 ^b	19 ^a	11 ^b	209 ^a	44 ^b	128 ^a	359 ^b			

Both autumn and spring migration could be divided into two parts based on migration speed; upper figures in migration duration and migration speed columns show values for the complete autumn or spring migration, lower figures show values when separated into first and second part of autumn or spring migration. Values in brackets indicate duration of stay at corresponding staging and wintering sites. Only stops at staging sites longer than 5 days are included

^a Values for the first part of autumn or spring migration

^b Values for the second part of autumn or spring migration

autumn compared to spring (V. N. Bulyuk pers. comm.). A stronger advancement of spring at more southerly latitudes, and hence better feeding conditions en route, may also favour more southerly routes in spring.

The loop-migration of the rosefinches may thus be driven directly by environmental conditions in the Central Asian deserts. There is also a possibility that birds follow genetically controlled migratory directions that retraces the recent westward expansion of the population. The routes of migration are often conservatory when new areas are colonized even if shorter routes could be achieved, particularly if intermediate routes are unfavourable due to few refuelling possibilities (Newton 2008; Chernetsov et al. 2008). The more direct spring migration routes in rosefinches may thus have evolved due to favourable conditions in the desert region in spring whereas autumn migration, to a larger extent, is “trapped” in the original migration routes.

The few long-distance ring recoveries available from the western populations of Common Rosefinches do not support unambiguously the hypothesis of loop-migration in this species. Although a bird ringed in Finland was recovered in the steppe region in northeast Kazakhstan (49.80°N), showing that they can take even more northerly routes in autumn (Piha 2014), a bird ringed in Denmark was recovered in autumn in Iran (29.67°N), which is several degrees of latitude further south than our most southerly bird in spring (Bønløkke et al. 2006). Spring recoveries are more uniform and more closely resembles the spring migration of the three birds in this study; a bird ringed in Norway was recovered in southern Uzbekistan (Bakken et al. 2006), a bird ringed on the east coast of the Baltic Sea was recovered in Turkmenistan (Paevskii 1973), and a bird ringed in

Sweden was found 2 years after ringing in Armenia, between the Black Sea and the Caspian Sea (Fransson and Hall-Karlsson 2008).

Since estimates of latitude is challenging when using geolocation by light, routes that appear to be different with respect to latitude could be an artefact of the technology used. The accuracy of estimates can be influenced by shading and weather conditions, but latitude is also very dependent on the calibration (Hill and Braun 2001). In-habitat calibration from the breeding site may not always be suitable for the migration periods if light conditions differ significantly, e.g. if the birds use more dense or open habitats on migration compared to the breeding site (Mckinnon et al. 2013). However, since autumn and spring migration occurs on the same side of the equinoxes (i.e. boreal summer) the error will be in the same direction and would probably not cause the tracks to diverge. However, if the calibration is unsuitable for only one season, this could cause the tracks to diverge in latitude. Since the entire track then would be affected, the end of the track would not converge with the trapping site, which is not the case for the rosefinches (see Online Resource 1). Also, the variation in estimated latitude during migration periods were not extremely large and did not overlap during the parts of the tracks that made up the loops and should thus not be a major concern here. For these reasons we are convinced that the loop-migration shown by the tracks of these three birds are genuine.

Prolonged staging sites during autumn migration

All three birds used multiple staging sites of varying length after the desert crossing in autumn before appearing at the first wintering sites. Up to three quarters of the time on

autumn migration was spent in Central Asia, and five out of the ten recognised staging sites in this area were used between 19 and 24 days. Prolonged stopovers have been linked to strategic stops along the routes, in areas with abundant food resources (Jones 1995; Stach et al. 2012). However, it is also possible that very long stopovers could indicate very low refuelling rates, e.g. for birds arriving late in the season when food has been depleted by earlier migrants (Newton 2008). The birds in this study did not, however, arrive particularly late in the season to the foothills of the mountains in Central Asia (August 8–August 24), and although they at that time were passing over mountain regions, which potentially can act as barriers, the stationary periods seem unrealistically long for fuel deposition being the only reason (cf. Fransson et al. 2008). This suggests that conditions in the area were such that the benefits of staying outweighed that of continuing migration. The prolonged stops could thus be part of a strategy in which the birds temporarily suspend migration in order to optimise resource use during non-breeding season, based on predictable food sources available in this region (e.g. Arlt et al. 2015).

Speed of migration

Migration speeds were up to two-and-a-half times faster in spring than in autumn. Autumn migration was greatly slowed down by the prolonged staging periods in Central Asia, but also when comparing only the migration between the breeding sites and Central Asia, speed was much faster in spring than in autumn. Higher migration speeds in spring than in autumn are common among migratory species (Nilsson et al. 2013) since early arrival at the breeding grounds can be of decisive importance in the competition for good territories and acquisition of mates, while early arrival to wintering grounds is not as obviously linked to selective benefits (Smith and Moore 2005; Gunnarsson et al. 2006).

The rosefinches used one or two long stopovers in the beginning of spring migration before migrating at high speeds towards the breeding grounds. The birds made only very short stops when passing through Europe and thus most of the fuel spent on migration must have been accumulated while still in north India or Central Asia. This is a surprising result since migrating birds should be able to find ample feeding opportunities in Europe. The speed estimates found in the Common Rosefinches during return migration from Central Asia to the breeding sites are exceptionally high, taken into consideration the long distances and that they do not cross any large barriers. It is possible that this somewhat unorthodox migration strategy is a result of the range expansion to the west for the westernmost population, with considerable increase in

migration distance, which may have altered the migratory schedule for the birds in this part of the migration in order to arrive in time for breeding. Furthermore, since we only studied adult males, that normally arrives about 1 week earlier than females (Stjernerberg 1979), thus suggesting a high selection for early arrival to the breeding site (Morbey and Ydenberg 2001), we might receive a higher estimate of migratory speed than is representative for the whole population.

Wintering sites

The studied birds spent the winter months in Pakistan and India, in the westernmost part of the known winter range for this species. This fits the interpretation that it was the western part of the historical population that expanded the breeding range westward (Bozhko 1980). All three birds used two separate sites during the winter months which were located several hundred kilometres apart. Their first sites were used for just over a 100 days, while the second sites were used around 80 days, but there was no consistency between the birds in the distance and direction taken between the first and second wintering sites. The redistribution of the rosefinches is probably related to available food resources. Information about dietary preferences of rosefinches during autumn and winter is lacking (Björklund 1992), but seeds of various plant species probably form an important food source (Cramp and Perrins 1994). Rosefinches can form large flocks during winter (Cramp and Perrins 1994) and it is reasonable to assume that relocations during winter is a response to local shortage in food supplies due to overgrazing of seeds.

This finding adds to the increasing number of passerine species that in recent years have been shown to use multiple wintering sites in response to local conditions in the wintering areas (e.g. Heckscher et al. 2011; Stach et al. 2012; Jahn et al. 2013; Lemke et al. 2013; Arlt et al. 2015).

Conclusion

Our study describes the migration pattern of three male Common Rosefinches from Sweden, and is the first study to shed light onto the hitherto unknown migration routes and wintering sites in the western population of the species. The results provide details about routes taken, indicating a pattern of loop-migration with more northerly routes used in autumn than in spring. Furthermore, our study significantly contributes to the knowledge of the relatively unknown flyway between Western Europe and Asia, by providing information about timing of various stages of the migration and location of important staging sites and wintering areas for the Common Rosefinch.

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