Tracking Cyprus Wheatears *Oenanthe cypriaca* with geolocators

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In 2014, 12 male Cyprus Wheatears were fitted with geolocators at breeding sites in Cyprus to investigate migration routes and wintering locations. Three males with geolocators (25%) returned in 2015 but we were only able to retrap one and obtain tracking data. Autumn migration by the tracked bird commenced 28 October 2014 and the winter destination was reached five days later on 1 November, involving a total distance of 2200 km with an intermediate stopover site used on two days. The main wintering area was in eastern Sudan, which was occupied until late March with indications of a shift in wintering site during February. Spring migration occurred during March but coincided with the equinox (when geolocator data are unreliable). However, arrival in Cyprus occurred 27 March 2015 and the bird was caught at the same breeding site 17 May 2015. The stopover on autumn migration was in contrast to the results of a previously published study which indicated a single continuous flight (obtained from six tracked individuals). The combined tracking data, from seven individuals, indicate that the winter range may be more extensive and outside the documented main range in Ethiopia. Further tracking of more individuals from more breeding sites in Cyprus, including better representation of age and sex classes, is required to provide a more complete assessment of migration strategies and winter range for this species.

INTRODUCTION

Cyprus Wheatear *Oenanthe cypriaca* is a restricted range species. It is a Cyprus breeding endemic but winters mainly in Sudan and Ethiopia (del Hoyo *et al* 2005). According to the European Red List the Cyprus Wheatear's population is estimated at between 40 000–100 000 pairs (BirdLife International 2015), its population trend is stable and its status classified as 'Least Concern' (BirdLife International 2017). However, previously reported population estimates have varied considerably with 3000–7000 pairs estimated in the 1990s (Clement & Rose 2015) and between 17 500–22 100 pairs 2001–2004 (Pomeroy & Walsh 2006).

The breeding population vacates Cyprus in winter apart from a few individuals (Flint 2011). The wintering locations of Cyprus Wheatear are poorly known in part due to the former treatment of the species as a race of Pied Wheatear *O. pleschanka*, but also due to the small number of confirmed winter records all situated in northeastern Africa (Clement & Rose 2015). The main documented wintering location, from field observations, being southern Ethiopia, with small numbers occurring much further north in southern Egypt, northern Sudan and northern Chad (Clement & Rose 2015); rather than a contiguous winter distribution indicated by del Hoyo *et al* (2005). However, little is known about the actual wintering sites or numbers using them and there is no information to link actual use of breeding and wintering sites *eg* from ringing recoveries. Some information about the timing of migration and route taken is provided by observations, which indicate birds vacate Cyprus by late October (BirdLife Cyprus 2014), most passing through Israel mid October–mid November and peak passage through Egypt in late October (Clement & Rose 2015, Shirihai *et al* 1996). Spring migration occurs in Israel and Egypt between mid February and mid April with the peak during the latter half of March, with the main arrival on Cyprus mid March–late April (BirdLife Cyprus 2014, Clement & Rose 2015, Shirihai *et al* 1996). More detailed migration information has been provided by a geolocator study carried out at the same time as ours involving six individuals tracked between the 2014 and 2015 breeding seasons (Xenophontos *et al* 2017). Also, it is not known whether birds from across the Cyprus breeding range, either geographically or altitudinally distinct, remain separate within the winter range or whether there is mixing there. In the present study we used geolocators to investigate migration routes and timings and wintering areas used by adult Cyprus Wheatears.

METHODS AND RESULTS

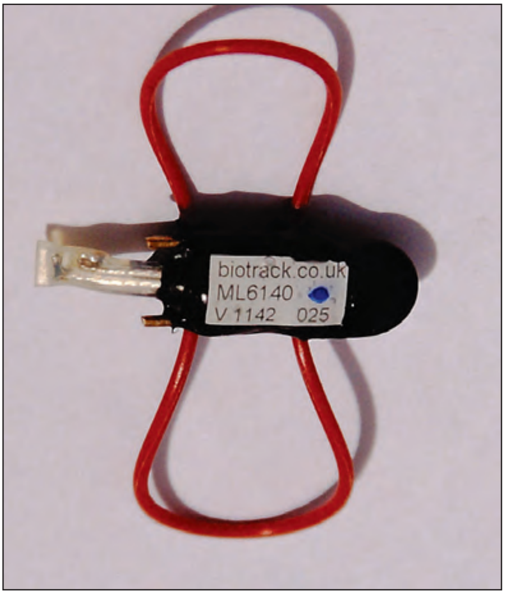

Plate 1. Biotrack Geolocator model ML6140 which was fitted on Cyprus Wheatears *Oenanthe cypriaca* with an O-ring harness. © *Alan Crabtree*

Geolocators are small archival devices that constantly record light intensity readings and time at frequent intervals throughout each 24-h period. From the changes in light intensity, sunrise and sunset can be estimated, which in turn allows day length to be calculated, and when used in combination with time of noon, global latitude and longitude can be determined (Ekstrom 2004). Through recent technological advances these devices have been miniaturised, making it now possible to track the migration of some of the smallest birds (Bairlein *et al* 2012, Bridge *et al* 2013). However, it is still necessary to re-catch the bird in order to retrieve the data. The determined latitude and longitude values do have associated error, which is typically around 50–100 km but can be greater due to the effects of weather, habitat and behaviour; but during the period either side of vernal and autumn equinox, when day length is equal across the globe, it is not possible to reliably determine global position. However, even with this location error, it is still possible to examine movement patterns at continental scales.

We obtained the geolocators from Biotrack (www.biotrack.co.uk), and used model ML6140 (Plate 1), with 7mm light stalk length, which weighed 0.54 g. These were fitted with small plastic tubes glued on the geolocator and through those we put O rings from Arcus in Germany. We used O rings that gave harness spans between 31 and 32 mm (for Cyprus Wheatear), following sizes based on the models presented in Naef-Daenzer (2007). The geolocator together with the O ring and tubes was around 0.67 g. Given that the weight of the geolocator and harness should not be more than 5% of the bird's weight (Schmaljohann *et al* 2012), we fitted geolocators only on birds weighing 14.5 g and above, so that geolocator and harness would comprise less than 5% of their weight and only on males to minimise possible disturbance to egg incubation. In order to minimise the additional weight, we did not ring or colour ring the birds on which we fitted geolocators. There was only one male caught that weighed less than 14.5 g. We fitted geolocators to 12 male Cyprus Wheatears, eleven of which were caught in Pafos district, primarily in the Androlykou area (Plate 2, around the village and quarry between 250–315 m asl) but also in Akoursos (*c*170 m asl), near Pegeia in Pafos (Figure 1). A single bird was also caught and fitted with a geolocator in Agros village (*c*1200 m asl) in Lemesos/Limassol district (Figure 1). The weights of the birds, all males, ranged from 14.7–16.0 g (Table 1).

The birds were caught using perch traps together with playback of Cyprus Wheatear song. A licence was obtained from the Republic of Cyprus' Game and Fauna Service. The licence covered the use of playback for research purposes, trapping of the birds using traps or nets and fitting geolocators.

Trapping took place on 17, 29 and 30 May 2014 (Table 1). One of these birds, V1142026, was re-trapped the same season, 19 June 2014, and the geolocator looked well fitted;

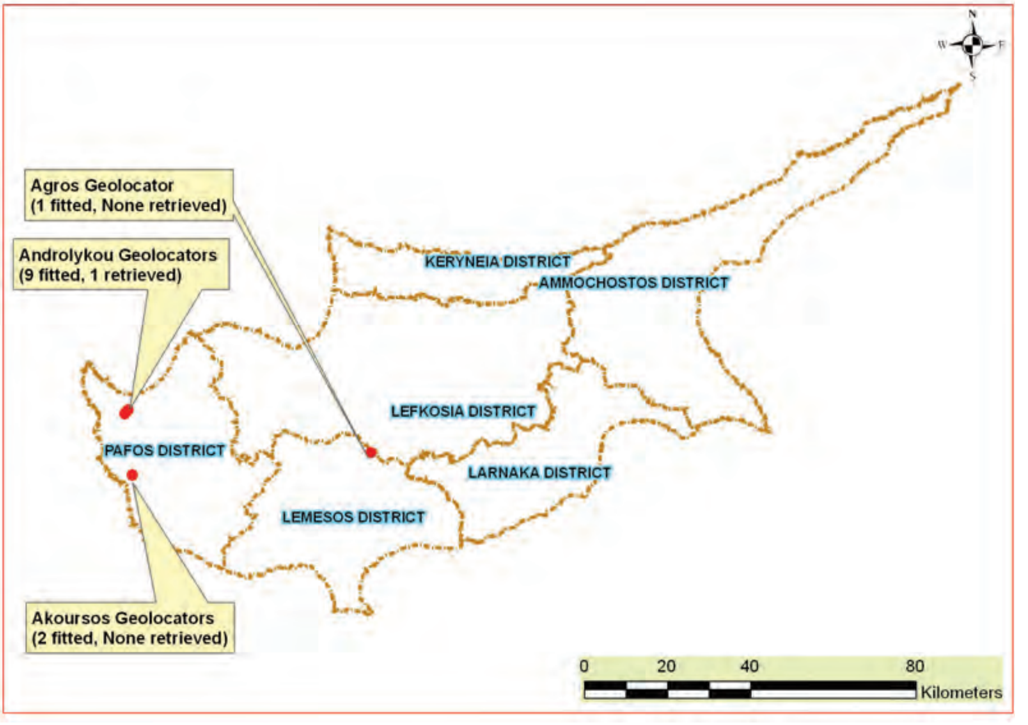

Figure 1. Locations on Cyprus where geolocators were fitted to Cyprus Wheatears (map produced using ESRI's GIS Mapping software ArcMap).

Table 1. Dates, weights, age (EURING code), sex and locations of Cyprus Wheatears fitted by us with geolocators in 2014 and harness span used.

Date (2014)	code	harness span (mm)	age[1]	sex	wing (mm)[2]	Weight (g)	Location
17 May	V1142???	32	4	M	-	14.8	Androlykou village
17 May	V1142005[3]	32	6	M	89	15.8	Androlykou village
17 May	V1142006	32	5	M	-	14.8	Androlykou village
17 May	V1142009	32	5	M	-	15.8	Androlykou village
17 May	V1142010	31	4	M	-	15.1	Androlykou quarry
18 May	V1142004	31	6	M	-	14.7	Agros
29 May	V1142008	31	6	M	85	14.8	Androlykou quarry
29 May	V1142021	31	6	M	85	15.7	Akoursos
29 May	V1142023	31	5	M	82	14.9	Akoursos
30 May	V1142003	31	5	M	85	15.3	Androlykou quarry
30 May	V1142011	31	5	M	89	15.7	Androlykou quarry
30 May	V1142026[4]	31	5	M	88	16.0	Androlykou quarry

[1] 4 = adult (hatched 2013 or earlier), 5 = first year adult (hatched 2013), 6 = adult (hatched 2012 or earlier)
[2] wing lengths were not routinely recorded for all birds
[3] re-trapped in 2015 and geolocator retrieved
[4] also observed with family 19 June 2014

the bird was behaving normally having bred successfully and was feeding young in the nest at the time. The data on the single geolocator recovered in 2015, on individual V1142005, was downloaded by using BASTrak Communicate Interface on 3 June 2015.

Plate 2. Adult male Cyprus Wheatear *Oenanthe cypriaca* tagged with geolocator in typical Androlykou breeding habitat, 19 May 2014. © *Panicos Panayides*

Data decompression using BASTrak Decompressor Interface was done 14 July 2015. The TransEdit application was used to remove false dawn and dusk events prior to analysis and calculation of latitude and longitude for noon and midnight location, which were then plotted on ArcGIS (ESRI) 10 September. Data was excluded during ten day periods either side of both the autumn (23 September) and spring (20 March) equinoxes, when location calculation is unreliable. This is unfortunate as the timing coincides with one or more migration periods. However, change in longitude, which is not affected by the equinox, was examined to determine if any movement had occurred during this period. To determine whether single, or multiple, wintering sites were used, mean latitude and longitude were calculated, along with standard deviation, for each month within the wintering period (November–February) but excluding locations from migration periods.

In 2015, we tried to catch new birds and re-catch the birds fitted the previous year in the same places. We were only able to locate three of the 12 birds caught in 2014: two in Androlykou (one in the village and one around the quarry area) and one Akoursos (Table1). However, we only managed to recapture one of these three (Plate 3), in Androlykou village (34° 59′ 53.79″ N, 32° 23′ 04.00″ E, bird V1142005). This gave a minimum return rate of 25%

for male Cyprus Wheatears (n=12). The birds were exceedingly difficult to catch, displaying trap shyness. The one caught took three attempts on different days before it was finally caught. The fact that one of the authors had found its nest helped.

V1142005 was an adult male (hatched 2012 or earlier), which was first caught and fitted with the geolocator 17 May 2014 and was located at the site 11 May 2015 and, after three attempts, was finally re-caught exactly one year after it had been marked (17 May). In 2015, the bird was ringed with a metal ring and a white plastic ring and released after the geolocator was removed. The bird weighed 15.8 g in 2014 when first caught and 16.2 g (without the geolocator) in 2015. There were no indications of effects on health. The bird was caught at its nest site while feeding young, *c*100 m from where it was caught in 2014. The mean latitude and longitude calculated during the breeding season (April, June–August, as May was excluded due to major data anomalies) was *c*55 km away from the actual breeding site.

Plate 3. Male Cyprus Wheatear *Oenanthe cypriaca* V1142005 the day he was re-caught and the geolocator retrieved, 17 May 2015. He had been fitted with the geolocator exactly one year before on 17 May 2014. © *Alan Crabtree*

In 2014, autumn migration of our tagged (and the following year recaptured) Cyprus Wheatear commenced 28 October and arrival in the wintering area was 1 November, a total duration of five days. However, it appears that a stopover site was used for two days, 30–31 October, located on the western shore of the Red sea close to the Egypt/Sudan border (Figure 2). The entire distance between the breeding and wintering site was 2200 km, completed in two stages comprising *c*1490 km and 730 km. The wintering site was occupied from 1 November, and it appears that the bird remained in the same location November–January, occupying the Al Qadarif area in southeast Sudan close to the Eritrean and Ethiopian borders (Figure 2). However, during February there appeared to be a movement to a more northerly location (Figure 3), prior to spring migration. Spring migration fell within the equinox period so the exact timing and duration cannot be determined, however, examination of longitudinal locations indicate that arrival in Cyprus had occurred by 27 March 2015. On May 17 the bird was recaptured in the same area where the geolocator was originally fitted.

CONCLUSIONS

The Cyprus Wheatear is a restricted-breeding-range species that nests only in Cyprus and almost entirely winters in Africa, apart from a few individuals observed in Cyprus (Flint 2011, Clement & Rose 2015). Previous observations indicate that the species winters in Ethiopia, and less commonly in Chad, southern Egypt and northern Sudan (Clement & Rose 2015). The analysis of data from the recovered geolocator confirmed that the bird had wintered in southeast Sudan close to the borders of Eritrea and Ethiopia in an area called Al Qadarif. This wintering location is toward the centre of the wintering locations found for

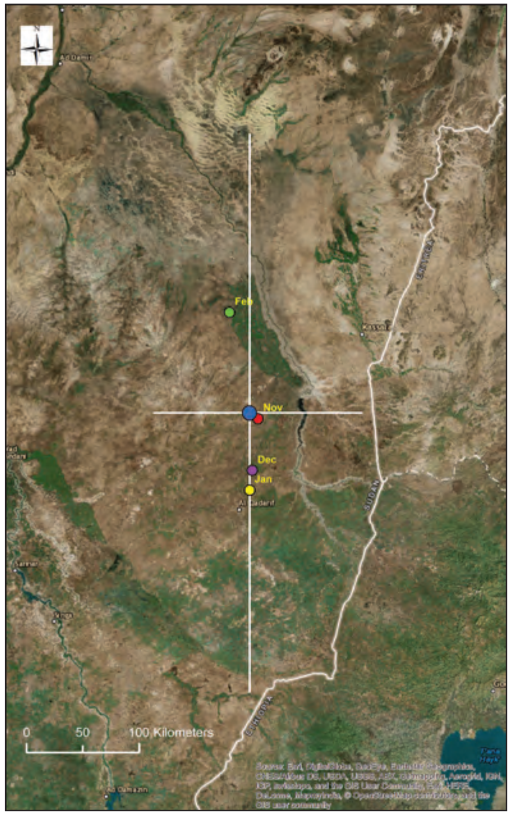

Figure 2 (left)**.** Mean locations of Cyprus Wheatear V1142005, derived from geolocator data from the breeding (orange) and wintering (blue) seasons, with standard deviation for latitude and longitudes (white lines). The autumn migration track (yellow dashed line) is shown with estimated noon (white dots) and midnight (black dots).

Figure 3 (right)**.** Mean monthly locations of Cyprus Wheatear V1142005 during winter period (coloured dots: Nov, Dec, Jan, Feb) and mean winter location (blue) with standard deviation for latitude and longitude (white lines).

the six geolocator-tracked birds by Xenophontos *et al* (2017). When all seven locations are combined they occupy a relatively small area, close to the borders of Sudan/South Sudan with Eritrea and Ethiopia (7°–19° N, 32°–37° E). Interestingly, the combined wintering locations from the seven tracked birds are located centrally within the large contiguous wintering area suggested by del Hoyo *et al* (2005), but at a considerable distance (*c*500 km) from the geographically distinct known main and previously-observed wintering area in Ethiopia and other, minor, wintering sites to the north and west reported in Clement & Rose (2015). The distance travelled by our bird to the mean wintering location was 2200 km, compared to 2190–3070 km (n=6) found by Xenophontos *et al* (2017).

There does not appear to be any segregation on the wintering grounds among the seven tracked birds which were from geographically/altitudinally different breeding locations. The sample size is relatively small and more birds would need to be tracked to fully validate this observation. However, as the seven tracked individuals are all located at a distance from the known wintering locations reported in Clement & Rose (2015), this raises an immediate question about the origin of the birds using those main suggested wintering areas in Ethiopia to the south, and the minor African wintering locations to the north and west. Tracking of birds from more breeding areas could address this question.

The 25% (n=12) return rate achieved for males with geolocators was lower than overall return rate of 58% (n=24) for males and females combined, and 58% (n=12) for males only, achieved at the contemporaneous study in the Troodos area (Xenophontos *et al* 2017). This figure is relatively low considering that this species is very site faithful with one study indicating that 87% of individuals returned to the same territories in subsequent years and annual apparent survival for males is between 50 and 70% (Xenophontos & Cresswell 2016). However, of the three male birds of ours with geolocators sighted upon return in spring 2015 only one was caught and the geolocator retrieved so the 33% retrieval rate (n=3) of our study, three being the number of males seen with geolocators, was similar to the retrieval rates obtained by Xenophontos *et al* (2017), *ie* 14% (n=7) for males and 43% (n=14) for both sexes combined. The low geolocator retrieval rate of our study seems largely due to 'trap shyness' following initial capture, limited catching opportunities and low response by males to song playback, so future studies should allow greater time for recapture throughout the breeding season and employ the latest catching techniques.

Although assessing return rates was not a purpose of this study, there are several factors that would need to be controlled in future studies in order to determine return rates. Firstly, the time spent searching for returned birds was relatively limited in the current study and the population was not a regularly 'studied' population, so familiarity with the population was not high. Furthermore, other studies have suggested that Cyprus Wheatears might be experiencing population decline in the Pafos area (Peter Flint pers comm) so such factors would need to be examined in a better targeted study, including the possible effect of climate change, which in turn could impact insect prey, as well as changing land uses or changes in agriculture and farming. Additionally, the quarry area in Androlykou offers a highly changeable environment for nesting Cyprus Wheatears as the extent and outlines of the quarry change all the time as quarrying progresses. This could be creating an environment with less continuity and more disturbance, compared to sites like Troodos which experience less change from year to year. Birds nesting in more changeable sites have to be more adaptable, requiring some movement between nest sites each year, and that too could contribute to lower return rates.

The timing of autumn migration, our tracked adult male departed on 28 October, corresponds to the latest of the six departure dates (14–28 October) recorded by Xenophontos *et al* (2017). Xenophontos *et al* (2017) recovered data from five females and one first year male (in 2014), whereas our bird was an adult in 2014. However, our tracked bird took *c*5 days to reach the wintering locations, on 1 November, compared to an average of 2.1 days found by Xenophontos *et al* (2017). The considerably longer duration appears to be due to a stopover on two days in southeast Egypt, which wasn't found for any of the six birds tracked by Xenophontos *et al* (2017), all of which were considered to have made the journey in a single flight. Our bird was an adult male in 2014, so it would be expected that an experienced bird would make a rapid non-stop migration as found by Xenophontos *et al* (2017), as opposed to a stop-over. Given the non-stop migration strategy found by Xenophontos *et al* (2017), albeit based on a small number of birds, we queried whether weather conditions had grounded our bird. However, no weather related event appears likely, as throughout the days around 30 and 31 October 2014 there were consistent northerly winds (tail winds) and no precipitation (Nir Sapir & Paolo Becciu pers comm). This result suggests that some birds may employ an alternative autumn migration strategy which involves a stopover.

Our bird remained within the same wintering area November–January, but appears to have moved during February (Figure 3), a pattern observed in most birds tracked by Xenophontos *et al* (2017). No useable data was available for much of the spring migration but the bird appears to have returned to Cyprus by 27 March 2015, at the later end of the range of spring migration dates determined by Xenophontos *et al* (2017).

The modest result of the present study, in combination with those of Xenophontos *et al* (2017), greatly improves our knowledge of actual migration timings, routes and wintering locations used by Cyprus Wheatears. The importance of protecting the breeding sites of the birds also is confirmed by this study as the species exhibits high breeding philopatry (Xenophontos & Cresswell 2016). In addition, the concentration of birds within a relatively small portion of the indicated winter range indicates the importance of that particular area for this species. However more birds would need to be tracked from more breeding locations across the island, including good representation of all age and sex classes, to investigate this further and determine the full conservation significance of that region. In addition, the combined tracking results have indicated that the actual winter distribution may be more extensive than previously recognised.

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