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## Autumn migration of the Red-footed Falcon, *Falco vespertinus*, at Akrotiri Peninsula, Cyprus 2009–2019 (Aves: Falconiformes)

Nicolaos Kassinis<sup>a</sup> and Iris Charalambidou<sup>b,\*</sup>

<sup>a</sup>Game and Fauna Service, Nicosia, Cyprus; <sup>b</sup>Department of Life and Health Sciences, School of Sciences and Engineering, University of Nicosia, Nicosia, Cyprus

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Cyprus is an important stopover area for the Red-footed Falcon, a raptor of global conservation concern. We surveyed the migrant population at Akrotiri Peninsula from 2009 to 2019. Birds were counted from September to November. Annual total was on average 662 birds, ranging from 106 to 1331 birds. This exceeds 1% of the European flyway population. Peak passages occurred from late September to mid-October with a median date on 6 October. The migrating population was stable over the years with no significant overall trend ( $p>0.05$ ). Little is known on the source population migrating through Akrotiri Peninsula, and the relationship between the peninsula and other stopover areas in the eastern Mediterranean.

**Keywords:** Bird migration; stopover areas; eastern Mediterranean; Mediterranean islands; raptors

### Introduction

The Red-footed Falcon, *Falco vespertinus* (Linnaeus, 1766), is a species of global conservation concern, classified by IUCN as near-threatened, with a global population of 300,000–800,000 individuals, including 30,300–63,400 breeding pairs in Europe (BirdLife International, 2018). It breeds across European steppes, from Hungary through to Kazakhstan. The European breeding population, concentrated in Hungary, Romania, Russia and Ukraine, has experienced drastic population declines since the 1970s, mostly from loss of foraging and breeding habitats (e.g. Fehérvári et al., 2009; Palatitz et al., 2015). This species is a long-distance, trans-equatorial migrant. Most birds leave their breeding grounds in August and September, migrating in a wide front across the Mediterranean to overwinter in southern Africa (BirdLife International, 2018). Available information on migration is fragmentary and migration routes are still unclear (Bounas et al., 2020).

Cyprus is an important stop-over site for this species (Flint & Stewart, 1992) and Akrotiri Peninsula is known as a globally important flyway (Zalles & Bildstein, 2000; Hellicar et al., 2014) concentrating one of the largest migratory populations of Red-footed Falcons in Europe, with birds systematically numbering in their hundreds (Miltiadou, 2008) and thousands (Zalles & Bildstein, 2000; Davidson-Watts & Charilaou, 2009) during autumn migration. Available studies, however, are preliminary and there is a need for long-term data on migration counts. Herein, we analyse autumn migration counts for the Red-footed Falcon over an eleven-year period, from 2009 to 2019.

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\*Corresponding author. Email: charalambidou.i@unic.ac.cy

Table 1. Autumn surveys of Red-footed Falcon at Akrotiri Peninsula, Cyprus, from 2009 to 2019.

Year	Start and end dates	No. of survey days	No. of birds	Maximum (date)	Peak passage
2009	15.09–26.10	14	1,331	261 (28 Sept)	25 Sep – 5 Oct
2010	28.09–08.11	11	551	207 (15 Oct)	10 Oct – 18 Oct
2011	15.09–31.10	12	646	400 (30 Sept)	25 Sep – 5 Oct
2012	13.09–24.10	12	592	101 (12 Oct)	3 Oct – 13 Oct
2013	23.09–04.11	12	659	237 (03 Oct)	29 Sep – 7 Oct
2014	22.09–17.10	9	764	389 (03 Oct)	30 Sep – 6 Oct
2015	21.09–25.10	11	212	39 (05 Oct)	29 Sep – 7 Oct
2016	23.09–03.11	13	1,237	287 (03 Oct)	1 Oct – 15 Oct
2017	07.09–24.10	10	320	88 (16 Oct)	10 Oct – 20 Oct
2018	03.09–18.10	15	106	54 (08 Oct)	8 Oct – 15 Oct
2019	23.09–23.10	13	432	119 (14 Oct)	26 Sep – 17 Oct

## Material and Methods

**Study area.** Akrotiri Peninsula (c. 60km<sup>2</sup>) is the southernmost part of the island of Cyprus. Most of it lies within UK territory known as the Sovereign Base Area of Akrotiri. The peninsula includes an internationally important wetland complex, citrus plantations, eucalyptus forest, Akrotiri village, military installations and satellite communication sites. The wetland complex comprises Akrotiri Salt Lake and a number of adjacent internationally important saline and freshwater habitats. In 2003, Akrotiri Salt Lake and Akrotiri Marsh (previously Phassouri Reed-beds) were classified as Ramsar wetlands (Salathé, 2002) while in 2010, Akrotiri Wetlands and Akrotiri Cliffs were designated as Special Protection Areas, with the Red-footed Falcon constituting one of the qualifying species (Davidson-Watts & Charilaou, 2009). The peninsula is also a Special Area of Conservation and an Important Bird Area (Hellicar et al., 2014). Red-footed Falcons use the area, especially the citrus plantations and adjacent irrigated crops and fields, as a staging area for roosting and foraging. They also feed in smaller numbers around Zakaki and Akrotiri Marshes (Davidson-Watts & Charilaou, 2009).

**Data collection.** Surveys of migrating Red-footed Falcons were conducted every autumn, from 2009 to 2019, by field staff of the Game and Fauna Service, the names of whom are mentioned in the acknowledgements. The same individuals conducted the surveys throughout the study period. As a general rule, 80–90% of migrating raptors may be recorded over 2–3 week windows, when the dates are known for the most important passage times (Bibby et al., 1992). Based on previous studies at Akrotiri Peninsula (Zalles & Bildstein, 2000; Miltiadou, 2008; Davidson-Watts & Charilaou, 2009), Red-footed Falcon counts took place from early/mid-September to late October/early November which are the most important passage times for this species.

Birds were surveyed using systematic roadside counts following a pre-determined route covering effectively the citrus plantations, irrigated crops and fields, and natural habitat including the Salt Lake. At pre-selected observation points overlooking the above habitats, teams counted Red-footed Falcons throughout the peninsula. Observers counted birds when flying overhead at high altitudes as they were migrating southwards, as well as birds actively feeding, perching on utility cables and roosting in the plantations and woodland to the north of the peninsula, effectively making a stop-over on their migration journey. It is possible some of the same birds were counted on successive days, thus inflating total numbers. Observations were performed from sunrise to late morning, usually by two teams. Each team, consisting of at least one experienced surveyor and an assistant, surveyed a specific part of the route, using a vehicle driven at low speed (average approx. 20 km/h) with stops at the observation points. The observers used binoculars and, on some occasions,, telescopes. The teams kept contact with each other to avoid double counting of

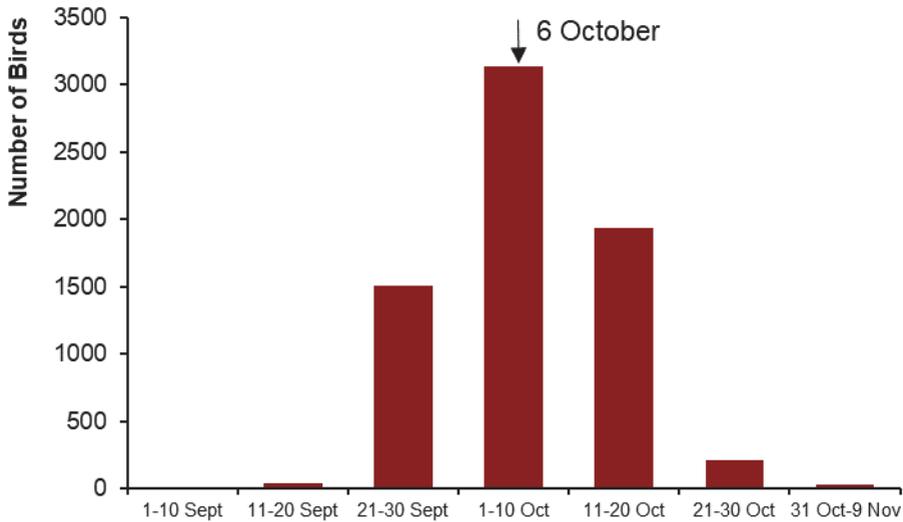


Figure 1. Seasonal migration pattern of number of birds counted per 10-day period, from 2009 to 2019.

birds moving between areas. However, birds flying at altitudes out of sight of the naked eye (Flint & Stewart, 1992) would have been missed.

**Statistical analyses.** The data consisted of daily bird counts. Data was analysed with a time series analysis, taking into account that the counts were temporally structured, i.e. that each value depended to some extent on the value at the previous time. The analysis was performed using the R package *nlme* (Pinheiro et al., 2018) in R v3.5.3 (R Core Team, 2019).

## Results

Total numbers of Red-footed Falcon observed ranged from 106 in 2018 to 1331 in 2009 (average  $622 \pm 383$  birds). Maximum day counts per year ranged from 39 on 5 October 2015, to 400 on 30 September 2011. Peak passages occurred mostly between late September and mid-October (Table 1, Figure 1). The median date is 6 October. A time-series analysis showed that the migrating population was stable with no significant positive or negative trend over the years ( $p > 0.05$ ) (Figure 2).

## Discussion

We systematically recorded high concentrations of Red-footed Falcons at Akrotiri Peninsula, confirming the international importance of this area and providing a baseline for assessing migrating population numbers. Annual totals (Table 1) regularly exceeded 1% of this species' European flyway population of 30,300-63,400 pairs (BirdLife International, 2018). Numbers of birds were similar to previous studies (Table 2) in which systematic (Miltiadou, 2008; Davidson-Watts & Charilaou, 2009) and non-systematic (Flint & Stewart, 1992, Zalles & Bildstein, 2000) data were collected. Peak passages were concentrated from late September to mid-October, similarly to Israel (Alon et al.,

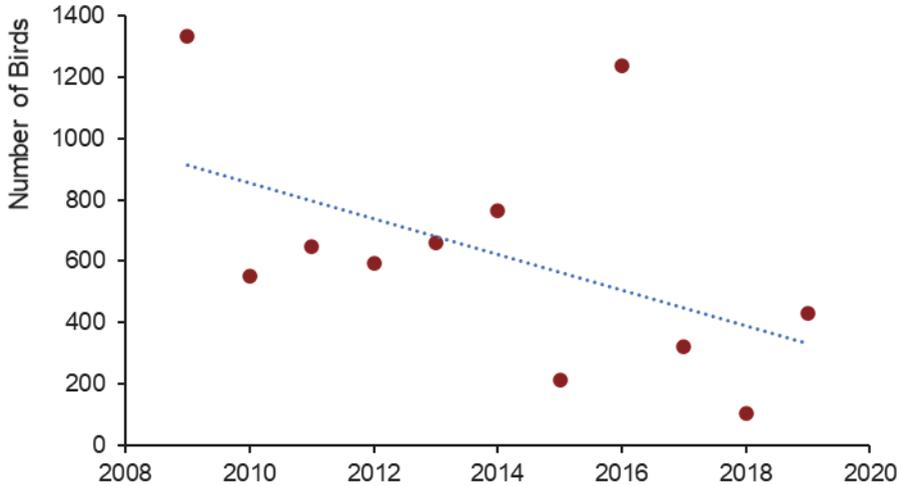


Figure 2. Total number of birds counted per year, from 2009 to 2019.

2004) where 90% of migrating Red-footed Falcons passed within 18 days (Leshem & Yom-Tov, 1996).

Migrating populations remained relatively stable, despite declines in key European breeding populations, in some cases exceeding 30% in 17.1 years (three generations) (BirdLife International, 2018). Bensusan et al. (2007) suggested to compare trends of migrating raptors at bottlenecks with trends on breeding grounds for monitoring the population sizes. However, this requires knowledge of source populations, which is not known for Akrotiri Peninsula. Red-footed Falcons engage in clockwise loop migration, using different outbound and return routes to and from their wintering and breeding grounds (Bounas et al., 2020). Southbound migration from Hungary through to central Asia includes evidence of broad-front migration across the Mediterranean as well as funnelled flight through the Levant (Katzner et al., 2016). Birds tagged in Hungary migrated southwards by crossing the Mediterranean Sea from Turkey and Greece, west of Cyprus (Béltekiné et al., 2010), while birds breeding in Russia, Ukraine and central Asia follow southbound routes through the Caucasus, into Turkey and the Middle East. Birds tagged in Kazakhstan flew overland, east of Cyprus, with no evidence of a southbound open water crossing (Katzner et al., 2016). According to Bounas et al (2020), this species shows high annual variation in its southbound migration routes in the eastern Mediterranean. It seems that migration routes are adjusted in an east-west axis to locate the most suitable stopover areas with ideal resource opportunities or weather conditions, and this may account for high annual fluctuations at specific sites such as our observation area.

Although our counts may have been inflated by double-counting birds stopping-over on migration, while birds flying at altitudes out of sight may have been missed, Bensusan et al. (2007) showed that also partial counts of migrating raptors provide useful information on population trends, provided sufficient observations cover a long-enough period which is the case in this eleven-year study.

Albeit birdwatching in Cyprus has a long tradition, standardized counts have only been implemented in the last two decades. The migration counts at Akrotiri Peninsula are currently the best method for monitoring population changes of this species. It is

Table 2. Autumn surveys of migrating Red-footed Falcons at Akrotiri Peninsula, Cyprus derived from published sources. \* = 3,722 raptors counted of which one third appeared to be Red-footed Falcons (Zalles & Bildstein, 2000).

Year	Start and end dates	Survey duration	No. of birds	Peak passage	Citation
1992	19.09–09.10	21 days	432	n/a	Zalles & Bildstein (2000), Flint & Stewart (1992)
1996	21.09–11.10	116 hrs	*c.1,241	n/a	Zalles & Bildstein (2000)
2006	20.08–10.11	82 days (747 hrs)	740	Betw. 21 Sept. and early Oct.	Miltiadou (2008)
2007	20.08–10.11	82 days (747 hrs)	833	early to mid-Oct.	Miltiadou (2008)
2008	15.09–21.10	21 days (3-3.5 hrs/day)	(5,237) 5,366	Betw. 26 Sep and mid-Oct.	Davidson-Watts & Charilaou (2009)

paramount to standardize counts of migrating Red-footed Falcons at other areas too, such as Cape Greco (Roth & Corso, 2007), Pafos Plain and Cape Andreas (Hellicar et al., 2014), thus we highlight the urgency of establishing Cyprus-wide monitoring of this species. We also consider that a combination of migration and roost site counts, based on a roost count protocol developed by Palatitz et al. (2015), will increase the accuracy of migration counts.

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### Disclosure Statement

No potential conflict of interest was reported by the authors.

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