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Ranging behaviour of Eleonora's Falcons *Falco eleonorae* during chick-rearing

Ugo MELLONE[1,*], Vicente URIOS[1], Hamid RGUIBI-IDRISI[2], Rubén LIMIÑANA[1,3], Abdelaziz BENHOUSSA[4] & Pascual LÓPEZ-LÓPEZ[1]

[1]Terra Natura Biological Station, Vertebrates Zoology Research Group, CIBIO, University of Alicante, Apdo. 99, E-03080 Alicante, SPAIN
[2]Faculty of Sciences, Department of Biology, Laboratory for the Evaluation of Natural Resources and Biodiversity, El Jadida, MOROCCO
[3]Research Institute for Game Resources (IREC) CSIC-UCLM-JCCM, Ronda de Toledo, s/n. E-13005 Ciudad Real, SPAIN
[4]Department of Biology, Faculty of Sciences, Mohammed V University, Avenue Ibn Battota B.P. 1014 Rabat Agdal, MOROCCO
*Corresponding author, e-mail: ugomellone@libero.it

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Abstract. The Eleonora's Falcon is a cliff-nesting raptor that breeds on isolated small islands adjusting its breeding season to coincide with the post-breeding autumn migration of its small passerine prey migrating over the sea, between late August and early October. Two adult female Eleonora's Falcons were equipped with Argos satellite transmitters during the chick-rearing period in Morocco giving the opportunity to study the ranging behaviour of the species during at least a part of the breeding season. Results showed that the falcons spent most of the time at sea during mornings, stayed mainly inland during afternoons, and rested in the colony during nights. Interestingly, although most distances were recorded shorter than 50 km away from the colony, movements took also place to areas located more than 100 km away. Locating and protecting these inland areas used for resting and foraging may be of interest for the conservation of the species in order to avoid perturbations such as poisoning and habitat destruction.

Key words: raptors, time budget, conservation, satellite telemetry, Argos, Morocco

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Knowledge of birds' ranging behaviour during the breeding season is of great importance to assess conservation priorities. The Eleonora's Falcon *Falco eleonorae* is a long-distance migratory raptor that breeds colonially in small islands of the Mediterranean Sea, but also along the Atlantic Sea coast of Morocco and on the Canary Islands (Walter 1979). Eleonora's Falcons delay their breeding season to late summer in order to prey upon southbound migrating passerines flying over the open sea. Despite the species being currently globally listed as Least Concern (BirdLife International 2012), it is included in Annex I of the European Directive 2009/147/EC on the conservation of wild birds and hence, it constitutes a priority species for conservation along its whole distribution range (see also BirdLife International 2004). Many aspects of its biology have been studied to date, but there are no satellite tracking data concerning its ranging behaviour during the breeding season. This technology has recently been used to reveal the species' migratory routes and main wintering habitats in Madagascar (Gschweng et al. 2008, López-López et al. 2009, 2010, Mellone et al. 2011, 2012, Kassara et al. 2012). However, transmission problems affecting the performance of the Argos system in the Mediterranean basin prevented the use of this method to study ranging behaviour of Eleonora's Falcons during the breeding season. Contrary to the GPS system, which collects location data always with a similar low spatial error, the Argos system collects data of varying quality, according to an estimated error (Soutullo et al. 2007). In the case of the Mediterranean basin, the amount of locations with high probability of large errors (> 10 km) is very high, thus precluding detailed ranging behaviour studies (Anonymous 2005).

On the other hand, previous studies carried out by visual observations (Walter 1979) or with an optical range finder (Rosén et al. 1999) did not clarify what are the flight distances that the falcons can cover to hunt during the breeding season: Rosén et al. (1999) provided detailed data on the hunting behaviour but only within a range of 4 km. Here we analyze movements of Eleonora's Falcons belonging to the breeding colony of Essaouira (Morocco), using satellite telemetry in order to describe time budgets and ranging distances.

Two adult female Eleonora's Falcons were trapped on Essaouira Island (ca. 1 km of Essaouira, Morocco, 31.49°N, 9.78°W) on the 20 September 2011, when chicks were 15–20 days old (chicks leave the nest when 30–50 days old; Wink & Ristow 2000). The birds were equipped with 9.5-gram Argos solar-powered satellite transmitters (Microwave Telemetry Inc.) affixed to their backs using a Teflon harness. The transmitters were programmed to collect data on a duty cycle of 12 on/18 off (for further methodological details see López-López et al. 2009, 2010). Here, the falcons were named by the number of the PTT placed on them (#80417 and #108376). Locations were collected using the Argos system and only high quality locations (location classes 3, 2, 1; maximum estimated error: 1 km; see Soutullo et al. 2007, Mellone et al. 2012) were considered for analyses. Then, data were filtered excluding locations obtained within the same hour (using only the highest quality one), to avoid temporal autocorrelation (López-López et al. 2010). In order to analyze habitat use in relation to the period of the day, data located within 1 km around the nest were classified as "colony", while the other data were displayed on a Geographical Information System (GIS) and classified either as occurring at "sea" or "inland" (i.e., within mainland). Finally, locations were classified according to their UTC time as occurring during morning (6h–11h), afternoon (12h–18h) or night (19h–5h).

Between tagging and the onset of autumn migration, a total of 131 high quality locations were collected and subsequently used for the analyses (69 and 62 for each bird, respectively). One of the two falcons (#80417) performed a long southbound trip of at least 181 km, staying away from the colony for almost two days (24–25 September) and visiting the Massa River (Morocco, Fig. 1). Mean distances of sea locations for the two falcons were 8.6 km for bird #80417 (SD = 13.2, max 52.9, N = 18) and 12.7 km for bird #108376 (SD = 15.2, max 53.3, N = 29),

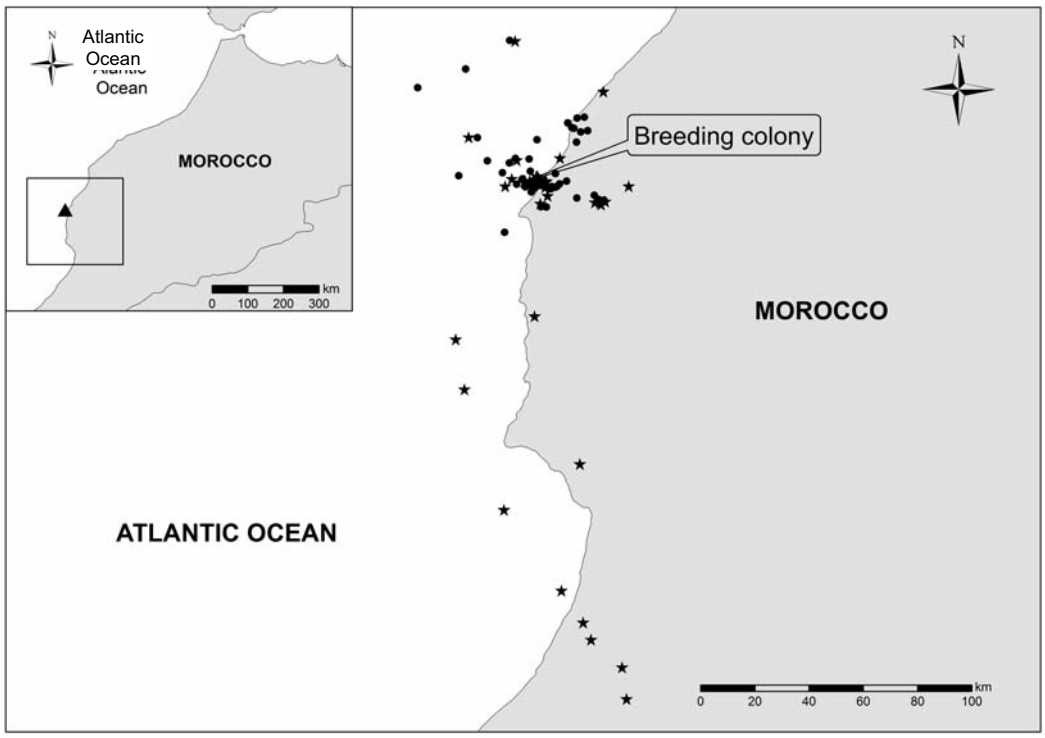

Fig. 1. Locations obtained for two Eleonora's Falcons breeding in the island of Essaouira. Individuals: stars — #80417, circles — #108376.

respectively. On the other hand, mean distances of inland locations were 14.1 km for bird #80417 (SD = 12.4, max 39.7, N = 12; excluding two locations during the long trip) and 14.3 km for bird #108376 (SD = 8.7, max 28.5, N = 24), respectively. Overall, the birds spent more time at sea during the morning, while during the afternoon they stayed inland and during the night in the colony (χ^2 = 39.05, df = 4, $p < 0.001$; Fig. 2). The first of the two falcons departed on, #80417, began the autumn migration on the 23 October, while the second one first moved northwards on the 24 October and, after having spent eight days close to Rabat, 430 km away from the colony, began the southbound autumn migration on the 2nd November. Both individuals ceased data transmission during the autumn migration for unknown causes.

These are the first detailed data on the ranging behaviour of the Eleonora's Falcon during the breeding season. These results confirm that falcons can fly tens of kilometers away from the colony during the breeding period, as it was supposed according to the amount of time that individuals from the colony of San Pietro (Italy) spent outside the colony. Assuming continuous straight flight, on the basis of the period of absence from the nest, Rosén et al. (1999) estimated hunting excursions at an average distance of 24 km (maximum 70 km). Such long flights are not surprising given that Eleonora's Falcons are able to perform non-stop flights of hundreds of kilometers (Mellone et al. 2011). Long foraging distances during the chick rearing period have been rarely described for raptors (but see Meyburg & Meyburg 2009 and Houston et al. 2011), while it is well known that seabirds can make long foraging trips of hundreds of kilometers lasting for several days (e.g. Weimerskirch et al. 1993). During the breeding season Eleonora's Falcon prey mainly upon passerines in active migration (Walter 1979), hunting regularly at altitudes higher than 1000m, where passerines are more abundant and have lower chances of escape (Rosén et al. 1999). Since those passerines migrate mainly during night (Newton 2008), Eleonora's Falcon probably take advantage of the last "wave" of migrants early in the morning, as shown by the time budget reported here. Also Rosén et al. (1999) described that the colony is much more active before midday. On the other hand, inland locations, which occurred mostly over scrubland areas during the afternoon, were probably mostly due to search for alternative prey other than migrating passerines, such as insects or local/resting birds. Nevertheless, some locations that were recorded close to water bodies may suggest that falcons could perform inland trips also for drinking freshwater, as observed also on Mediterranean islands (U. Mellone pers. obs.). Similar to this, Walter (1979) reported sporadic observations of Eleonora's Falcons in inland Crete (20–30 km from Paximada colony) during windless days. Ristow (2001) showed that several deaths and a strong decline in a breeding colony close to Crete were caused by Eleonora's Falcons drinking water at inland polluted pools. Therefore, it would be important to identify and protect those areas where Eleonora's Falcons search for freshwater, especially considering the scarcity of this resource at the end of the summer (dry season). Spatial data on ranging behavior are particularly important for the conservation of the species. As shown here, movements during the chick rearing period may take place within areas ranging more than 100 km away from the nesting colonies, which should be considered when assessing the potential threats during the breeding period. Finally, additional data from different individuals and colonies are needed, preferably collected with a higher spatial (altitude) and temporal resolution, in order to assess the influence of hunting behaviour on breeding performance and population dynamics.

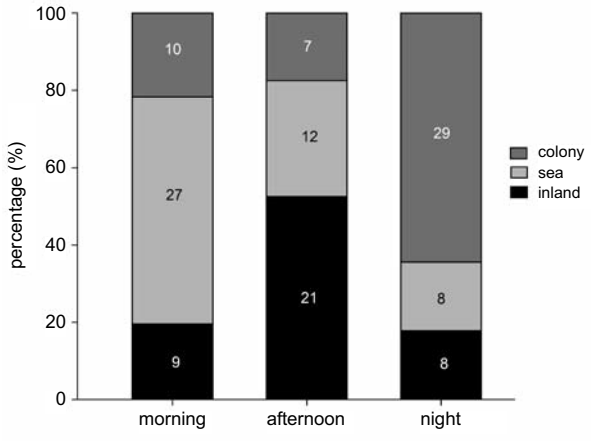

Fig. 2. Time budget of two Eleonora's Falcons breeding in Essaouira island (Morocco). Locations were classified according to their UTC time as occurring during morning (6h–11h), afternoon (12h–18h) or night (19h–5h). Numbers given in the bars refer to the sample size of the locations.

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STRESZCZENIE

[Przemieszczanie się sokołów skalnych w okresie karmienia piskląt]

Sokół skalny gniazduje na niewielkich wyspach Morza Śródziemnego i płn.-wsch. wybrzeżach Afryki. Jego późny okres rozrodu — od końca sierpnia do początku października — związany jest z terminem wędrówki jesiennej drobnych ptaków wróblowych. Sokoły chwytają przelatujące ptaki najczęściej nad otwartym morzem, ale dotychczasowe metody obserwacji nie pozwalały na określenie, na jakie odległości od gniazda mogą przemieszczać się polujące ptaki.

Dwie samice sokoła skalnego, gniazdujące na wyspie Essaouira u wybrzeży Maroka (Fig. 1), wyposażono w nadajniki satelitarne. W analizach pominięto dane o słabej jakości (błąd większy niż 1 km) i te pochodzące z tej samej godziny, uzyskując łącznie 131 lokalizacji ptaków. Określoną pozycję ptaka przypisywano do jednej z trzech kategorii: nad morzem, w kolonii lęgowej, nad stałym lądem. Obserwacje podzielono na te z godzin porannych (godziny 6.00-11.00), popołudniowych (12.00-18.00) i nocnych (19.00-5.00). Stwierdzono, że w godzinach porannych sokoły obserwowane są nad morzem, zaś w godzinach popołudniowych — nad stałym lądem. Noc spędzają w kolonii (Fig. 2). Większość zanotowanych przemieszczeń w badanym okresie odbywała się w odległości do 50 km od gniazda, natomiast wykazano także takie na odległość ponad 100 km, w kierunku stałego lądu i nad stałym lądem (Fig. 1). Odnalezienie terenów będących celem tych dalekodystansowych przemieszczeń, używanych przez ptaki prawdopodobnie jako miejsca odpoczynku i dostarczające słodkiej wody do picia, jest szczególnie ważne z punktu widzenia ochrony gatunku.