

## Satellite tracking of two Montagu's Harriers (*Circus pygargus*): dual pathways during autumn migration

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**Abstract** Autumn migration routes of two Dutch female Montagu's Harriers (*Circus pygargus*) were documented for the first time using satellite telemetry. Both migrated to their African wintering area—one via the Straits of Gibraltar through the Mediterranean and the other via Italy/Tunisia. The rate of travel was comparable to values reported for larger raptor species.

**Keywords** Connectivity · Migration and food supply

### Introduction

Satellite tracking has proven to be a useful technique to document migratory routes of large bird species, such as White Storks (*Ciconia ciconia*; Berthold et al. 1992, 2004), Peregrine falcons (*Falco peregrinus*; Fuller et al. 1998),

Ospreys (*Pandion haliaetus*; Hake et al. 2001; Alerstam et al. 2006) and eagle species (Meyburg et al. 1995, 2003). Western European Montagu's Harriers (*Circus pygargus*) winter in different West African countries (Fransson and Petterson 2001; Arroyo et al. 2004). During the autumn migration, the proportion of Harriers passing over Gibraltar is higher than that over Italy, but the reverse pattern is observed in spring. This has led to the hypothesis of loop migration: Harriers leaving Europe via Gibraltar and returning via Italy (Agostini and Logozzo 1997; Garcia and Arroyo 1998). In 2005, Montagu's Harriers could for the first time be tracked using satellite transmitters. Two Dutch female Harriers chose dual pathways during their autumn migration.

### Methods

We used 12-g solar satellite transmitters (Microwave Telemetry, Columbia, Md.) that send signals for a 10-h period followed by a 48-h pause. Data were obtained from the Argos system via CLS (Collecte Localisation Satellites, Toulouse, France). The satellite transmitters were attached on 16 July 2005 using teflon-ribbon backpacks (M. Gschweng, personal communication; Kenward 1987; Snyder et al. 1989). The total backpack weighed less than 5% of the females' body weight. Hereafter, we refer to the first female as Marion and the second female as Beatriz. Both females successfully bred in 2005 in the northeastern part of The Netherlands (Marion: four fledglings, Beatriz: two). Based on iris colouration observed in 2005 and before (Arroyo et al. 2004), Marion was assessed as being at least in her fifth calendar year and Beatriz at least her third. STAT and MAPTOOL software were used for analyses (Coyne and Godley 2005). Only high-quality fixes with a

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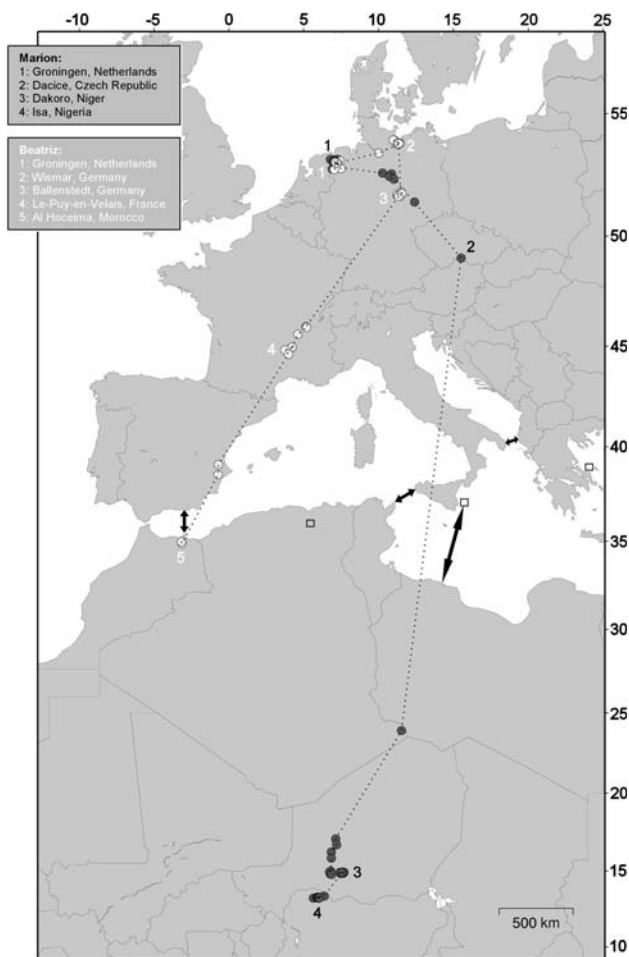
presumed error between 150 m and several kilometres (CLS) were included.

## Results and discussion

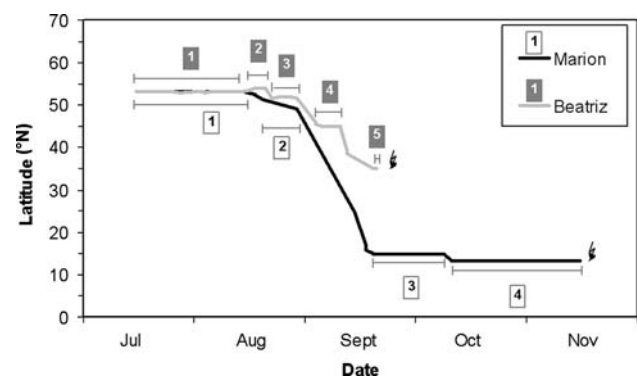
The two Montagu's Harriers used a western and a central route, respectively, through the Mediterranean during the autumn migration (Fig. 1). Marion's stay at her wintering site in Nigeria ended when she was killed by a local farmer (20 November), at which time she had been tracked for almost 5000 km. Beatriz' transmitter failed, after almost 3000 km of tracking, in Morocco (25 September). The fact that Marion left just 2 days after Beatriz may have been caused by the influence of large-scale weather systems. Both females left ahead of their mates (Marion: at least

11 days, Beatriz: no precise estimate available). Marion left The Netherlands in a southeastern direction, crossing breeding areas of neighbouring German harrier populations (rate of travel: 56–114 km day<sup>-1</sup>) (Fig. 2). Beatriz left in a northeastern direction (80 km day<sup>-1</sup>). After two stop-overs in Germany, Beatriz continued to south-central France (Le-Puy-en-Velay, Haute-Loire, 190 km day<sup>-1</sup>) and stayed 7 days in this part of the French Montagu's Harrier breeding range (Millon et al. 2004) (Fig. 2). A possible explanation for the initial movements in easterly directions is the visiting of neighbouring Montagu's Harrier breeding areas and "prospecting" for future breeding sites. Hake et al. (2001) reported that a female Osprey bred at her first autumn migration stop-over site in the following year. It is also possible that the females originated from more Eastern populations and visited their native sites, which has also been observed in the Osprey (Hake et al. 2001). Whether the choice of migratory route is mainly based on contemporary cues (weather, food abundance, body condition) or on the past origin and inherited traits of the birds remains open.

Both females seemed to choose relatively narrow sea crossings near Gibraltar and Italy, respectively. Beatriz may have crossed the Mediterranean East of Gibraltar (140 km over the open sea; Fig. 1), as 65% of Montagu's Harriers migrating through this region do cross here (Meyer et al. 2000). High-quality fixes of Marion between the Czech Republic and Niger were lacking. A low-quality fix of 8 September indicated a position in Italy, with its mirror image in Greece (Fig. 1). A low-quality fix in Algeria (11 September) suggests that Marion took the route via Italy. To reach Italy via the Adriatic Sea required at least a 80-km flight over the open sea. Taking the location in Algeria into account, we assume that Marion did not fly



**Fig. 1** Migratory routes of two satellite-tracked Montagu's Harrier females in 2005 (dotted lines). Circles represent fixes, numbers represent staging areas (black Marion, white Beatriz; see Fig. 2). The three fixes that are not included in Marion's migratory route represent the low-quality locations in Italy with its mirror image in Greece (8 September) and in Algeria (11 September). Arrows indicate the minimum distances the Harriers had to fly over the sea



**Fig. 2** Timing of autumn migration of two Montagu's Harrier females. Numbers indicate staging or stop-over areas, corresponding to Fig. 1. Marion: 1 Groningen, The Netherlands, 2 Dacice, Czech Republic, 3 Dakoro, Niger, 4 Isa, Nigeria. Beatriz: 1 Groningen, The Netherlands, 2 Wismar, Germany, 3 Ballenstedt, Germany, 4 Le-Puy-en-Velay, France, 5 Al Hoceima, Morocco. Scale bars indicate length of stay, lightning bolt indicates transmitter failure

the 480 km from Italy to Libya but arrived in Tunisia first, which means a 140-km sea crossing.

Based on studies on the Peregrine falcon and Osprey, it is known that migration is faster in the middle phase than in the beginning and at the end (Fuller et al. 1998; Kjellén et al. 2001). We observed the same seasonal pattern in terms of daily distances covered for the two Harriers: whereas in August they covered maximally just above 100 km day<sup>-1</sup>, the distances became longer in the first half of September. Marion reached her highest rate of travel above the Sahara, as has been found for Ospreys (Kjellén et al. 2001), when she travelled up to 623 km day<sup>-1</sup> (1247 km on 16–17 September) before slowing down before she reached her first destination, Dakoro (Niger) on 21 September. Assuming a straight travel route and a constant rate of travel between Italy and Niger, crossing the Sahara would have taken her 8 days. The average daily distance Marion covered on travel days was 168 km. The average over both travel and stop-over days during the migration period was 143 km day<sup>-1</sup>. If we assume that the low-quality fixes in Italy and Algeria were correct, this travel rate would have been 160 km. Both estimates are similar to those found for heavier raptor species, such as the Greater Spotted Eagle (*Aquila clanga*; 150 km day<sup>-1</sup>; Meyburg and Meyburg 1999), Lesser Spotted Eagle (*Aquila pomarina*; 166 km day<sup>-1</sup>; Meyburg and Meyburg 1999), Peregrine falcon (172 km day<sup>-1</sup>; Fuller et al. 1998) and Osprey (183 km day<sup>-1</sup>; Alerstam et al. 2006). Marion's maximum daily distance of 623 km was again similar to the 537 km day<sup>-1</sup> reported for the Lesser Spotted Eagle (Meyburg and Meyburg 1999). Taking this into account, it seems likely that Montagu's Harriers are able to migrate at similar rates of travel as the larger and heavier raptors.

Marion apparently did not engage in loop migration (at least not in the predicted direction), and this behaviour could not be evaluated for Beatriz due to the early lack of signals. The exact proportions of Western European Montagu's Harriers that use the western or central route through the Mediterranean and the extent of migratory connectivity between different breeding and wintering areas will have to be investigated using larger sample sizes of tracked birds and ring recoveries.

## Zusammenfassung

Satellitentelemetrische Studie von zwei Wiesenweihen (*Circus pygargus*): unterschiedliche Routen auf dem Herbstzug

Der Herbstzug zweier niederländischer Wiesenweihenweibchen wurde zum ersten Mal mittels Satellitentelemetrie dokumentiert. Einer der Vögel zog über Gibraltar

durch das Mittelmeergebiet, der andere zog über Italien/Tunesien in das afrikanische Überwinterungsgebiet. Tagesetappen waren vergleichbar mit Werten, die für größere Greifvögel dokumentiert sind.

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