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Supplementary material

Supporting information to MS

ACTIVITY AND MIGRATORY FLIGHTS OF INDIVIDUAL FREE-FLYING SONGBIRDS THROUGHOUT THE ANNUAL CYCLE: METHOD AND FIRST CASE STUDY.

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Appendix 1: Hardware components

Appendix 2: Geolocation map

Appendix 3: Geographic interpretation of travel episodes during autumn and spring migration of a red-backed shrike.

Appendix 4: Datafile containing detailed accelerometer data. Temporarily available at *http://canmove-dev.ekol.lu.se/red-backed-shrike-data/red-backed_shrike_accelerometer_data.txt* as well as uploaded file together with submitted manuscript.

Appendix 1. Hardware components

All hardware components were selected to minimize energy consumption and mass, and to maximize reliability and flexibility in functionality. The size of the datalogger was approximately 9x20x2 mm, including battery.

Battery

A button cell primary battery based on AgO chemistry is the most common non-rechargeable cell type for small portable devices with low power consumption, e.g. wrist-watches or remote car-keys. We used the smallest possible battery that our energy budget calculations allowed for and selected a 24mAh battery from Varta AG (V361) with a mass of about 0.43g and an energy content of 130J.

Microcontroller

The microcontroller is the central electronic control component which performs all the control tasks of the datalogger. This includes configuration of the sensors used, reading sensor data, current time and writing measured values to the memory. Any standard low-power microcontroller will perform the necessary tasks.

Real-time clock

The RTC was equipped with a 20 ppm crystal, resulting in a timing error of less than 10 minutes per year. The RTC was configured to activate the microcontroller at pre-programmed 5 minute intervals. This allowed all other components of the datalogger to be completely inactive between measurement events and consume a minimal amount of power.

Memory

The memory we used was a non-volatile memory, meaning that its content remained even when power was removed completely. To keep size and power requirements small, our memory had a limited storage capacity. Typically, memory devices of this kind can store in the order of 10k-100k measurements.

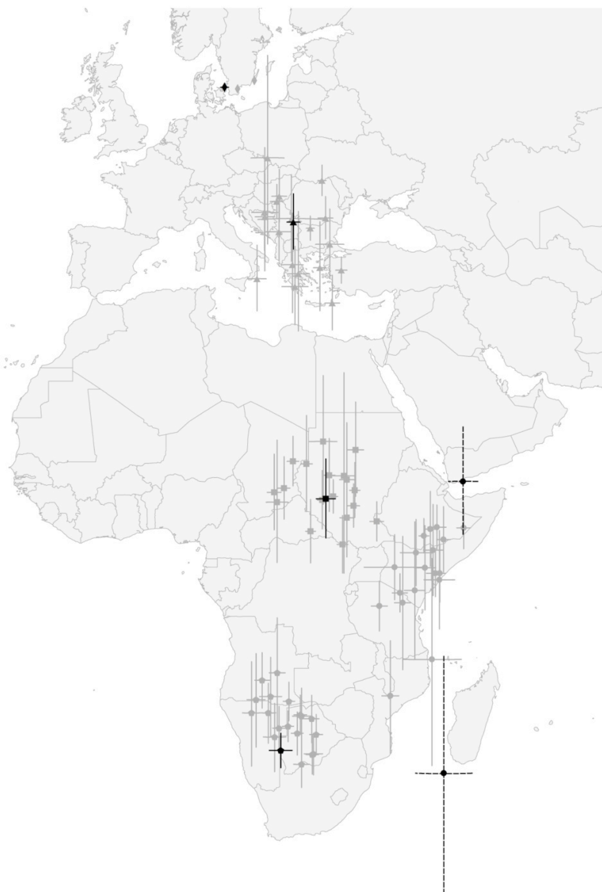
Accelerometer

The accelerometer was a microelectromechanical (MEMS) sensor with a small physical size and ultra-low power consumption. We measured acceleration in only one dimension – lateral to the body axis of the bird and approximately parallel to gravity when the bird was flying. We used a sample rate of 100Hz.

Light sensor

In order to achieve a good position estimate by the geolocation-by-light method, it was important to detect the very beginning of dawn and the very end of dusk. We used a sensitive light-sensor with a spectral sensitivity that roughly corresponded to the human eye.

Appendix 2.



Mean individual positions ± SD of the red-backed shrike during stationary periods throughout the annual cycle based on data from the data logger (black) and previously published geolocator data (grey) (Tøttrup et al. 2012a, b). Diamonds represent breeding areas (Denmark and southern Sweden), triangles the staging area in southern Europe, squares the staging area in the Sahel region during autumn migration, pentagons the wintering grounds and circles the spring migration staging area in north-eastern Africa. Dashed SD lines surrounding data logger positions on spring migration corresponds to light measurements of particularly poor quality, resulting in unrealistic positions. For the measurements from the present datalogger (black) we calibrated the sun elevation angle to match the breeding ground position and the known staging area sites for individuals previously tracked with geolocators, respectively (Tøttrup et al. 2012a,b) . This resulted in a sun elevation angle at -4 at the breeding grounds and 0 at the subsequent staging areas. The change in sun elevation angle could be due to e.g. changes in the environment (Fudickar et al. 2012; Lisovski et al. 2012). However, as the stalk of the datalogger exposing the light sensor had fallen off at some point during the year, we consider it more likely that this event may have caused the change in sun elevation angle. The longitudinal data corresponded well to the staging areas for previously tracked individuals during autumn migration. Light level data obtained from two measurements during spring migration were poor. This might have been caused by the individual moving during light measurements, an overlap with a period around vernal equinox and an overlap with a short period of general tag failure.

Appendix 3.

Geographic interpretation of travel episodes during autumn and spring migration of a red-backed shrike. This rather coarse interpretation is estimated from light-level geolocation data for the individual with activity data in combination with earlier geolocator tracking results for red-backed shrikes from the same population (Appendix 2 and Tøttrup et al. 2012a). Distances have been calculated assuming a mean ground speed of 50 km/h during autumn migration and 45 km/h during spring migration (see text).

	Travel episode	Geographic movement[1]	Comment
Autumn	1	Breeding area to SE Europe	Eight flights on eight successive nights 4-11 Aug. Total flight duration 33.43 h, corresponding to a distance of about 1700 km (using 50 km/h) or 15 deg lat (from 56N to 41N). On 1 Sep the bird advanced by a 4.5 h flight about 200 km further south.
	2	SE Europe to Sahel	Six flights during a period of nine nights 8-16 Sep. Total flight duration 63.32 h, corresponding to a distance of about 3200 km or 29 deg lat (from 40N to 11N). The bird flew on 3 nights (33.2 h flight time, about 1700 km, 15 deg lat), then made a stopover during a period of 3d (activity indicates daytime foraging 11-13 Sep) and completed the Sahara crossing by flights on 3 nights (30.2 h, about 1500 km, 14 deg lat). The bird apparently made a 3d stopover in the Egyptian desert (at an oasis about 25N). The bird moved in Sahel by 2 short flights 6-7 Oct and a longer flight 8.5 h (about 400 km) on 22 Oct.
	3	Sahel to South Africa	Nine flights during a period of ten nights 1-10 Nov. Total flight duration 77.35 h, corresponding to a distance of about 3900 km or 35 deg lat (from 8N to 27S). Winter latitude at about lat 25S (Suppl 2).
Spring	4	South Africa to Mozambique	Four flights on four successive nights 23-26 Mar. Total flight duration 29.66 h, corresponding to a distance of about 1300 km (using 45 km/h in spring) or 12 deg lat (from 25S to 13S).
	5	Mozambique to S Ethiopia	11 flights during a period of 12 nights 2-13 Apr. Total flight duration 64.4 h, corresponding to a distance of about 2900 km or 26 deg lat (from 13S to 13N; final latitude probably overestimated. A final latitude of 6N is more reasonable based on earlier tracking data, indicating a slow ground speed during this travel episode).
	6	S Ethiopia to Arabia	Four flights during a period of five nights 20-24 Apr. Total flight duration 21.34 h, corresponding to a distance of about 1000 km or 9 deg lat (from 6N to 15N). Stopover during 3d 25-27 Apr.
	7	Crossing of Arabian desert to Iraq	Five flights on five successive nights 28 Apr – 2 May. Total flight duration 48.71 h, corresponding to a distance of about 2200 km or 20 deg lat (from 15N to 35N). Missing data for following 7 nights 3-9 May.
	8	Turkey to breeding area	13 flights during a period of 14 nights 12-25 May (after ≥ 2d stopover 10-11 May). Total flight duration 78.6 h, corresponding to a distance of about 3500 km or 32 deg lat (must be overestimated since reasonable distance Turkey 38N –Denmark 56N is about 2500 km indicating opposed winds and a slow ground speed of about 32 km/h).

[1] Place names refer to approximate regions