Journal of Avian Biology

JAV-02515
Meier, C. M., Karaardıç, H., Aymí, R., Peev, S. G., Witvliet, W. and Liechti, F. 2020. Population-specific adjustment to the annual cycle in a super-swift trans-Saharan migrant. – J. Avian Biol. 2020: e02515

Supplementary material

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Sampling and recapture rate

Breeders usually roosted each night on their nest for as long as they attended the breeding site. By blocking their access way out of the colony we got hold of them by hand, except for the colony in Tarragona where, during the first year, birds were caught with mist nets when leaving the nest site. Geolocators were attached in Switzerland in late-August and in Turkey late-September when the broods had been completed and only adults attend the colony at night. They were again detached during nights between April and May in the following year when a good number of birds were found roosting at the colony but before egg laying had started. In the colonies in Sofia, Biel, and Solothurn it was not feasible to capture birds during pre- and post-breeding roosting periods. Instead, we attached the geolocator in late-July to mid-August, when adult birds fed their chicks and detached the loggers at around the same time one year later. In Tarragona geolocators were also attached when adult birds fed their chicks and detached the next year in April during the pre -breeding period.

Table S1 Recaptures of all returned birds corresponded to a recapture rate of 48% and was lower compared to the recapture rate of individually ringed birds without a geolocator (59%, Chi-square - test without the Spanish birds where no control was available ($X^2_1 = 4.94$, P = 0.026). Similar small effects of geolocators have been also reported in pallid swifts (Morganti et al. 2018) and might be cause by additional drag of the tag (Bowlin et al. 2010). The difference between recaptured birds and analysed tracks is the result eight birds having had lost their logger during the journey, 13 geolocator failed recording for technical reasons and the rest of the tags recorded light data in a way which FLightR was unable to deal with.

Population	AttachYear	Control	RecapContol	Attached	RecapAttached	Return	other type	lost	failed	Analysed	GDL1	GDL3pam	GDL2v2
Switzerland	2014	149	77 %	90	40 %	36	2	3	6	25	8	17	0
Switzerland	2015	125	78 %	54	72 %	39	8	2	1	28	1	1	26
Switzerland	2016	345	74 %	115	61 %	70	13	0	0	57	0	57	0
Bulgaria	2014	3	33 %	20	40 %	8	0	2	0	6	0	6	0
Bulgaria	2015	21	81 %	20	60 %	12	0	0	0	12	0	12	0
Bulgaria	2016	34	41 %	20	55 %	11	0	1	1	9	0	9	0
Spain	2014	NA	NA	8	50 %	4	0	0	0	4	1	3	0
Spain	2015	NA	NA	9	78 %	7	0	0	1	6	0	6	0
Spain	2016	NA	NA	9	78 %	7	0	0	0	7	0	7	0
Turkey	2014	202	37 %	56	45 %	25	1	0	4	20	11	9	0
Turkey	2015	85	46 %	89	35 %	31	6	0	0	25	5	7	13
Turkey	2016	125	25 %	62	26 %	16	0	0	0	16	0	16	0
Total	**All years**	1089	**59 %**	**552**	**48 %**	**266**	**30**	**8**	**13**	**215**	**26**	**150**	**39**

Tag-specific parameter values for calibration

FlightR needs for calibration the slope of the relationship between log light intensity and log sun elevation angle for a period between astronomical twilight and sunup and sundown, respectively at a known location (Rakhimberdiev and Saveliev 2016) This is an impossible precondition for a species like Alpine swifts which either are air born at an unknown location or which spend twilight time at a known breeding site but inside a in cavities (see Fig. S2). In this case the Hill-Ekström method is the only possible to calibrate such geolocator data. Therefore we had to rely on the package GeoLight where a HillEkström calibration is implemented (Lisovski et al. 2019).

We used the function changeLight to detect stationary periods during the non-breeding period between November and February. The main parameter values were set to quantile = 0.9 and days = 3. We used up to three different sites per bird, which all had last for more than 6 days. We used the function HillEkstromCalib on these periods to calculate a sun elevation angle and the coordinate of each site. To switch from the GeoLight calibration output to a calibration needed by FLightR we applied make.calibration function in the FLightR package and passed on the output from the GeoLight analysis.

We calibrate 21 GDL1 and 37 GDL3pam tags this way and soon realized that tags with the same sensor usually gave similar values for calibration. Hence we decided for our analysis to use fixed values for each tag type (Intercept=c(7.2, 1), LogSlope=c(0, 0.22), log.light.borders=c(3, 7), log.irrad.borders=c(-4, 1) for GDL1 and GDL2v2 tags, and Intercept=c(6.7, 1), LogSlope=c(0, 0.3), log.light.borders=c(2.5, 8), log.irrad.borders=c(-6.5, 1.5) for GDL3pam tags).

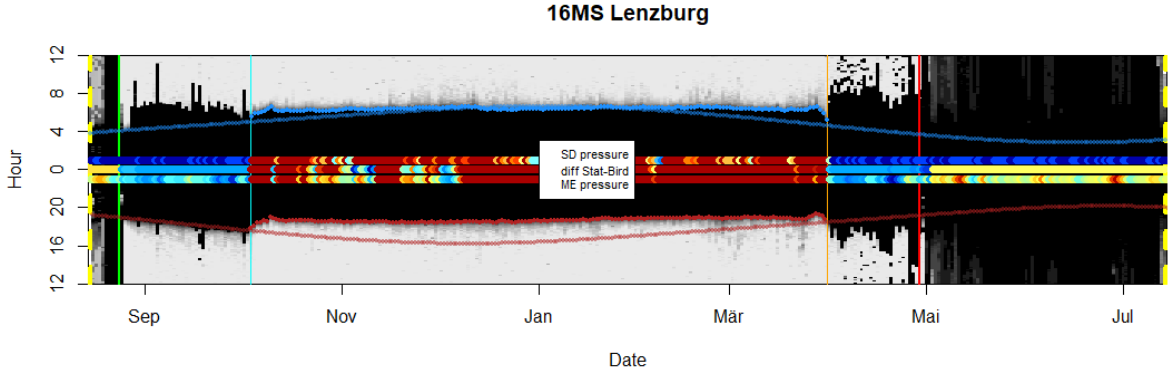
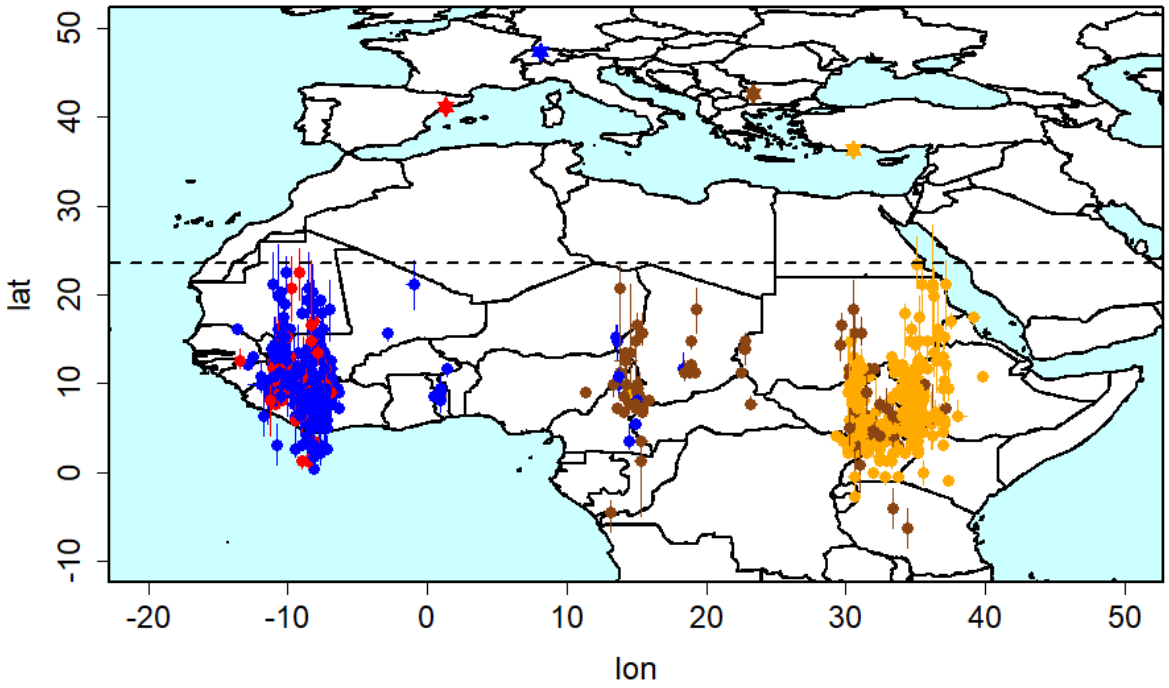


Figure S3. Plot showing is showing the light and pressure data over the course of the year which was used to determine the migration period for analysis with FLightR. Pixels of the grey scale are

summarizing the light level over time from black(no light) to white (full day light). With this data we infered the exact time for sun rises (cornflower blue) and sun sets (brick red). To highlight the deviation of the bird's position from its breeding colony we also superimposed theoretical time of sun rise (light cornflower blue) and sun sets (light brick red) at the location of the breeding colony. To determine the precise departure and arrival date at the breeding colony, we made use of the pressure data recorded by GDL3PAM geolocators (Meier et al. 2018). We used pressure level only during the period between 2200 pm to 0400 am as this is most informative of whether the birds were roosting on the ground at its nest for the night. Pressure levels per day were summarized in pixels on the horizontal lines. The top line shows standards deviation in pressure, the central line show the difference between the pressure on the bird's tag and the next ground truething weather station, and the bottom line is showing the median pressure level. For all pressuer values we used a color scale from blue (small values) over yellow, green to red (large values). The turkis and orange vertical line indicate the moment of departure and arrival of the bird with tag 16MS based on the abruptly changing pressure values at this moment. The green and the red line are indication the moment of tag attachement and detachment. The pressure values between attachement of the tag and departure from the breeding colony and between arrival at the breeding colony and the detachment of the tag all appear in blue confirming that the bird was on the ground while attending the colony. The plot was generated using the SGAT pakage in R (Lisovski et al. 2019).



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65 Figure S2. Location of all stationary sites where birds spend minimum two weeks south of the
66 Tropical cancer during the non-breeding period. In all populations most birds changed sites at least
67 once during the non-breeding period usually moving a few hundred kilometres further South at
68 around December.

69

Table S4. Summary of observed migration dates for all populations. For each migratory event we provide the earliest date, the median date, and the latest date when the event was observed during the three years of our study.

	Switzerland			Bulgaria			Spain			Turkey		
Event	first	median	last	first	median	last	first	median	last	first	median	last
Departure breeding site	26.08.	26.09.	20.11.	26.09.	09.10.	01.11.	06.10.	30.10.	16.11.	16.09.	17.10.	04.11.
Arrival non-breeding site	13.09.	02.10.	31.10.	03.10.	16.10.	08.11.	12.10.	07.11.	23.11.	02.10.	20.10.	09.11.
Departure non-breeding site	12.03.	27.03.	06.05.	20.03.	31.03.	02.05.	01.03.	21.03.	28.04.	26.02.	15.03.	15.04.
Arrival breeding site	25.03.	07.04.	14.05.	31.03.	08.04.	24.05.	14.03.	30.03.	05.05.	06.03.	25.03.	22.04.

References

Bowlin, M. S., Henningsson, P., Muijres, F. T., Vleugels, R. H. E., Liechti, F. and Hedenström, A. 2010. The effects of geolocator drag and weight on the flight ranges of small migrants. – Methods in Ecology and Evolution 1: 398–402.

Lisovski, S., Bauer, S., Briedis, M., Davidson, S. C., Dhanjal-Adams, K. L., Hallworth, M. T., Karagicheva, J., Meier, C. M., Merkel, B., Ouwehand, J., Pedersen, L., Rakhimberdiev, E., Roberto-Charron, A., Seavy, N. E., Sumner, M. D., Taylor, C. M., Wotherspoon, S. J. and Bridge, E. S. 2019. Light-level geolocator analyses: A user's guide. – The Journal of animal ecology.

Meier, C. M., Karaardıç, H., Aymí, R., Peev, S. G., Bächler, E., Weber, R., Witvliet, W. and Liechti, F. 2018. What makes Alpine swift ascend at twilight? Novel geolocators reveal year-round flight behaviour. – Behav Ecol Sociobiol 72: 45.

Morganti, M., Rubolini, D., Åkesson, S., Bermejo, A., La Puente, J. de, Lardelli, R., Liechti, F., Boano, G., Tomassetto, E., Ferri, M., Caffi, M., Saino, N. and Ambrosini, R. 2018. Effect of light-level geolocators on apparent survival of two highly aerial swift species. – J Avian Biol 49: jav-01521.

Rakhimberdiev, E. and Saveliev, A. 2016. FLightR: SSM for solar geolocation.