**Supplementary Material**

Spatial and temporal differences in migration strategies among endangered European Greater Spotted Eagles *Clanga clanga*

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**Table S1.** Characteristics of the studied birds, their tracking years and wintering locations.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Name** | **Breeding population** | **Sex** | **Tracking years** | **Wintering continent** | **Wintering country** |
| Alzhusya | Belarus | F | 2018–2019 | Europe | Greece |
| Denisa | Belarus | F | 2017–2020 | Europe | Greece |
| Lana | Belarus | F | 2019–2020 | Europe | Greece |
| Zhdana | Belarus | F | 2019–2020 | Europe | Greece |
| Uzefina | Belarus | F | 2017–2020 | Europe | Greece |
| Blond | Belarus | M | 2017–2020 | Europe | Greece |
| Liadets | Belarus | M | 2019–2020 | Asia | Israel |
| Perun | Belarus | M | 2017–2020 | Africa | Egypt |
| Rad | Belarus | M | 2019–2020 | Africa | South-Sudan |
| Zhdan | Belarus | M | 2019–2020 | Africa | Sudan |
| Tihon | Belarus | M | 2017–2020 | Africa | Ethiopia, Sudan |
| Tur | Belarus | M | 2017–2020 | Africa | South-Sudan |
| Veluta | Belarus | M | 2019–2020 | Africa | South-Sudan |
| Ann | Estonia | F | 2006 |  |  |
| Iti | Estonia | F | 2009–2017 | Asia | Turkey |
| Pille | Estonia | F | 2018–2020 | Europe | Russia |
| Juku | Estonia | M | 2005 | Europe | Serbia |
| Mart | Estonia | M | 2006-2007 | Europe | Croatia |
| Sven | Estonia | M | 2020 | Europe | Greece |
| Tõnn | Estonia | M | 2016–2020 | Europe | Spain |
| Jabłonka | Poland | F | 2013 | Asia | Turkey |
| Las | Poland | F | 2019 | Africa | Sudan |
| Maria | Poland | F | 2018–2020 | Africa | Chad |
| Bruzda | Poland | M | 2012 | Europe | Montenegro |
| Henryk | Poland | M | 2011–2012 | Africa | South-Sudan |
| Hubal | Poland | M | 2011–2012 | Africa | South-Sudan |
| Kolumb | Poland | M | 2011–2012 | Africa | Sudan |
| Nil | Poland | M | 2012–2013 | Africa | South-Sudan |
| Witold | Poland | M | 2012–2014 | Africa | Sudan |

**Table S2.** Quantitative characteristics of breeding sites, wintering sites and migration timing in the three populations and the total sample. Mean ± SD (based on means of individual values) as well as min–max and number of studied birds in brackets are presented.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variable | Estonia | Poland | Belarus | Total |
| Breeding longitude | 24.4 ± 0.5  (23.8–25.1; 7) | 22.7 ± 0.1  (22.5–22.9; 9) | 27.4 ± 0.3  (26.7–28.0; 11) | 25.0 ± 2.1  (22.5–28.0; 29) |
| Breeding latitude | 58.9 ± 0.2  (58.8–59.3; 7) | 53.5 ± 0.2  (53.2–53.7; 9) | 52.1 ± 0.2  (51.7–52.7; 11) | 54.0 ± 2.7  (51.7–59.3; 29) |
| Winter longitude | 22.1 ± 13.4  (0.7–38.2; 6) | 28.4 ± 6.8  (15.6–35.0; 9) | 29.9 ± 5.5  (22.6–37.1; 11) | 27.2 ± 8.3  (0.7–38.2; 28) |
| Winter latitude | 40.8 ± 4.7  (35.4–45.3; 6) | 16.6 ± 13.0  (8.9–42.3; 9) | 24.4 ± 14.6  (8.8–40.8); 11 | 26.5 ± 15.0  (8.8–45.3; 28) |
| Direction (degrees) | 184 ± 24  (151-217; 6) | 173 ± 11  (155–191; 9) | 179 ± 12  (162–197; 11) | 179 ± 15  (151-217; 28) |
| Direct distance (km) | 2186 ± 591  (1576–2913; 6) | 4174 ±1440  (1243–5028; 9) | 3122 ± 1621  (1261–4895; 11) | 3143 ± 1554  (1243-5028; 28) |
| Flight distance | 2588 ± 893  (1700–3570; 6) | 4994 ± 1874  (1508–7550; 9) | 4023 ± 2028  (1626–6567; 11) | 3865 ± 1961  (1508–7550; 28) |
| Start of autumn migration | 4 Oct ± 10 days  (19 Sept–15 Oct; 7) | 30 Sept ± 5 days  (22 Sept–10 Oct; 9) | 25 Sept ± 4 days  (17 Sept–1 Oct; 11) | 28 Sept ± 7 days  (17 Sept–15 Oct; 29) |
| End of autumn migration | 27 Oct ± 12 days  (5 Oct–5 Nov; 6) | 6 Nov ± 17 days  (11 Oct–11 Dec; 9) | 17 Oct ± 8 days  (4 Oct–29 Oct; 11) | 24 Oct ± 16 days  (1 Oct–11 Dec; 28) |
| Duration of autumn migration (days) | 24 ± 9  (16–30; 6) | 38 ± 18  (16–80; 9) | 23 ± 7  (14–32; 11) | 27 ± 14  (7–80; 28) |
| Speed of autumn migration (km / day) | 108 ± 22  (81–143; 6) | 151–91  (52–365; 9) | 176 ± 75  (68–324; 11) | 153 ± 75  (52–365; 28) |
| Start of spring migration | 22 Mar ± 10 days  (12 Mar–1 Apr; 4) | 9 Mar ± 4 days  (3 Mar–16 Mar; 6) | 12 Mar ± 6 days (4 Mar–23 Mar; 11) | 13 Mar ± 8 days  (2 Mar -1 Apr; 23) |
| End of spring migration | 9 Apr ± 4 days  (4 Apr–12 Apr; 4) | 13 Apr ± 4 days  (10 Apr–22 Apr; 6) | 1 Apr ± 8 days  (17 Mar–14 Apr; 11) | 5 Apr ± 9 days  (17 Mar–22 Apr; 23) |
| Duration of spring migration (days) | 17 ± 10  (10–31; 4) | 35 ± 8  (27–50; 6) | 20 ± 8  (6–31; 11) | 23 ± 11 days  (6–50; 23) |
| Speed of spring migration (km / day) | 162 ± 42  (102–198; 4) | 174 ± 23  (147–204; 6) | 204 ± 64  (120–306; 11) | 180 ± 57  (77–306; 23) |

**Table S3.** Differences between means of wintering locations according to the multinomial (populations) and ordinary (sex) logistic regression models.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Intercept** | **Latitude** | **Longitude** |
| Belarus – Estonia | -4.30 ± 4.94  z = - 0.87, P = 0.384 | 0.14 ± 0.11  Z = 1.36, P = 0.174 | -0.05±0.07  Z = -0.82, P = 0.410 |
| Belarus – Poland | 3.01 ± 2.60  Z = 1.16, P = 0.248 | -0.06±0.04  Z = -1.44, P = 0.149 | -0.07±0.07  Z = - 0.96, P = 0.338 |
| Estonia – Poland | 7.30 ± 4.98  Z = 1.46, P = 0.142 | -0.20±0.11;  Z = -1.84, P = 0.066 | -0.01±0.07  Z = - 0.14, P = 0.885 |
| Females – Males | 4.62 ± 2.59  Z = 1.16, P = 0.248 | -0.07 ± 0.03  Z = -2.11, P = 0.034 | -0.07 ± 0.07  Z = -1.00, P = 0.319 |

**Table S4.** Quantitative characteristics of breeding sites, wintering sites and migration timing in the two sexes and the eagles travelling within and between the two continents. Mean ± SD (based on means of individual values) as well as min–max and number of studied birds in brackets are presented.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Variable | Males | Females | Intra-European | European-Asian | European-African |
| Breeding longitude | 25.2 ± 2.2  (22.6–28.0; 18) | 24.7 ± 2.0  (22.5–27.6; 11) | 25.2 ± 1.7  (22.6–27.6; 12) | 24.6  (22.6–27.0; 3) | 24.9 ± 2.5  (22.5–28.0; 13) |
| Breeding latitude | 53.8 ± 2.7  (51.7–59.1; 18) | 54.0 ± 2.7  (51.9–59.3; 11) | 55.1 ± 3.4  (51.9–59.3; 12) | 54.8  (52.1–58.8; 3) | 52.8 ± 0.8  (51.7–53.7; 13) |
| Winter longitude | 27.2 ± 9.0  (0.7–37.1; 18) | 27.2 ± 7.5  (15.6–38.2; 10) | 21.3 ±8.4  (0.7–38.2; 12) | 34.4  (33.8–35.5; 3) | 30.9 ± 5.4  (15.6–37.1; 13) |
| Winter latitude | 22.2 ± 15.1  (8.8–45.3; 18) | 34.2 ± 12.0  (11.2–44.9; 10) | 41.0 ± 3.0  (35.3–45.3); 12) | 35.1  (32.5–36.4; 3) | 11.1 ± 3.6  (8.8–22.3; 13) |
| Direction (degrees) | 180 ± 14  (162–217; 18) | 177 ± 17  (151–197; 10) | 190 ± 15.6  (151–217; 12) | 161  (156–164; 3) | 173 ± 5.3  (166–188; 13) |
| Direct distance (km) | 3619 ± 1488  (1243–5028; 18) | 2285 ± 1336  (1262–4706; 10) | 1667 ± 544  (1261–4895; 12) | 2332  (2103–2607; 3) | 4693 ± 449  (3326–5028; 13) |
| Flight distance | 4383 ± 1791  (1509–6567; 18) | 2931 ± 1991  (1662–7550; 10) | 2033 ± 701  (1508–3570; 12) | 2847  (2342–3150; 3) | 5791 ± 728  (4402–7550; 13) |
| Start of autumn migration | 29 Sept ± 8 days  (17Sept–15 Oct; 18) | 28 Sept ± 7 days (19 Sept–15 Oct; 11) | 30 Sept ± 9 days  (19 Sept–15 Oct; 12) | 27 Sept (25 Sept–29 Sept; 3) | 26 Sept ± 5 days (17 Sept–5 Oct; 13) |
| End of autumn migration | 26 Oct ± 12 days  (4 Oct–18 Nov; 18) | 23 Oct ± 20 days  (1 Oct–11 Dec; 10) | 20 Oct ± 14 days  (1 Oct–8Nov; 12) | 24 Oct (18 Oct–28 Oct; 3) | 30 Oct ± 17 days (11 Oct–11 Dec; 13) |
| Duration of autumn migration (days) | 27 ± 10  (10–50; 18) | 26 ± 20  (7–80; 10) | 20 ± 9  (7–39; 12) | 27  (23–30; 3) | 34 ± 17  (16–80; 13) |
| Speed of autumn migration (km / day) | 170 ± 83  (52–365; 18) | 125 ± 50  (68–240; 10) | 114 ± 47  (52–240; 9) | 107 ± 78  (85–132; 3) | 200 ± 78  (94–365; 13) |
| Start of spring migration | 12 Mar ± 7 days  (4 Mar–29 Mar; 15) | 14 Mar ± 9 days  (2 Mar -1 Apr; 8) | 17 Mar ± 10 days  (2 Mar–1Apr; 9) | 11 Mar (10 Mar–12 Apr; 2) | 11 Mar ± 5 days  (3 Mar -23 Apr; 12) |
| End of spring migration | 7 Apr ± 7 days  (17 Mar–14 Apr; 15) | 3 Apr ± 11 days  (23 Mar–22 Apr; 8) | 29 Mar ± 8 days  (17 Mar–12 Apr; 9) | 7 Apr  (3 Apr–12 Apr; 2) | 11 Apr ± 6 days  (1 Apr–22 Apr; 12) |
| Duration of spring migration (days) | 25 ± 7  (10–37; 15) | 19 ± 15  (6–50; 8) | 13 ± 5 days  (6–23; 9) | 27  (24–31; 2) | 30 ± 8  (22–50; 12) |
| Speed of spring migration (km / day) | 190 ± 47  (120–298; 15) | 162 ± 71  (77–306; 8) | 170 ± 66  (77–306; 11) | 114  (102–127; 2) | 199 ± 45  (147–298; 12) |

**Table S5.** Characteristics of the best logistic regression models (superior to null model) describing differences in timing in autumn between sexes. No model describing spring migration in the two sexes outcompeted null model.

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| --- | --- | --- | --- |
| **Predictors** | **R2** | **AICc** | **Weight** |
| Onset + speed | 0.19 | 36.5 | 0.17 |
| Speed | 0.09 | 37.7 | 0.12 |
| End + speed | 0.16 | 37.6 | 0.10 |