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Orientation of Trans-Saharan Passerine Migrants in Southwestern Spain

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Radar observations in the southwestern Iberian Peninsula revealed south-southwesterly directions for trans-Saharan passerine migrants (Hilgerloh 1985a, 1988, 1989). If an individual species was oriented to the southeast (Zink 1977, Gwinner and Wiltchko 1978), one would not realize it on the radar screen. Orientation tests are necessary to determine the orientation direction of different species. The questions arise, whether mean directions of species differ significantly from one another and whether they correspond to the mean directions observed by radar.

Test birds were captured in the "Algaida" pine forest near Sanlucar de Barrameda (36°48'N, 06°17'W) at the mouth of the river Guadalquivir (southwestern Spain) during August, September, and October in 1985 and 1987. I tested the most numerous species (Hilgerloh 1985b) on 52 nights. These included Pied Flycatcher (*Ficedula hypoleuca*), European Willow Warbler (*Phylloscopus trochilus*), Garden Warbler (*Sylvia borin*), European Nightingale (*Luscinia megarhynchos*), Greater Whitethroat (*Sylvia communis*), Spotted Flycatcher (*Muscicapa striata*), and European Reed-Warbler (*Acrocephalus scirpaceus*). Sample sizes varied according to the number of birds captured. I tested each bird on the night after the day on which it was captured; subsequently, I released it. Orientation tests were performed outdoors at the location of capture. I used funnel-shaped orientation cages (Emlen and Emlen 1966) to record the birds' activity; typewriter correction paper was the recording medium (Beck and Wiltchko 1981). Tests commenced shortly after sunset and lasted 90 min. The tests were performed on moonless nights with less than 3/8 overcast and with a natural magnetic field.

The data were analyzed by quantifying footprint densities in each of twenty-four 15° sectors. Nightly mean directions relative to true north were calculated by vector analysis (Batschelet 1981) and pooled for analysis of individual species. Birds with <20 scratches total activity were excluded. A mean direction of orientation was calculated for each species with >15 tested individuals. The Rayleigh test was used to test for nonuniformity of the distributions. For compar-

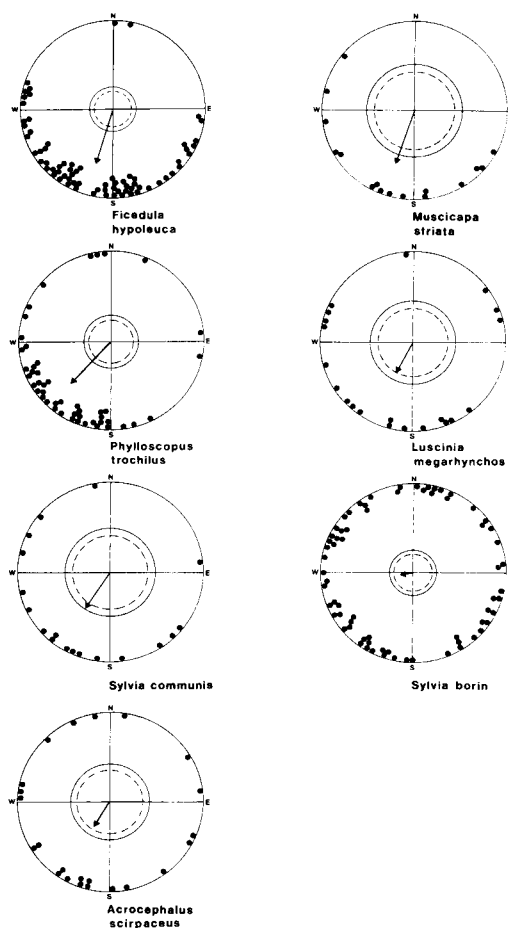


Fig. 1. Orientation of long-distance passerine migrants. Each dot represents one night's average for an individual. The arrow represents the mean vector; the two inner circles are the 5% (dotted) and the 1% significance border for the length of the mean vector (Rayleigh Test).

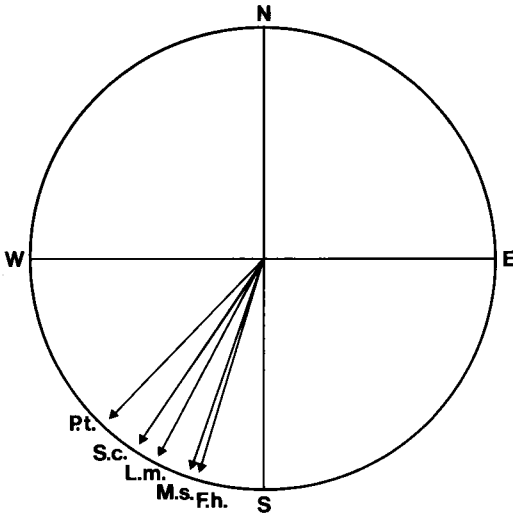


Fig. 2. Mean migration directions (arrows) of *Ficedula hypoleuca* (F. h.), *Muscicapa striata* (M. s.), *Luscinia megarhynchos* (L. m.), *Sylvia communis* (S. c.) and *Phylloscopus trochilus* (P. t.).

isons between groups, I used the Mann-Whitney U-Test and the Watson-Williams Test.

Of the 7 species studied, 5 revealed a significant preferred direction (Fig. 1): Pied Flycatcher ($\alpha = 197^\circ$, $r = 0.64$, $n = 71$, $P < 0.001$), Spotted Flycatcher ($\alpha = 199^\circ$, $r = 0.63$, $n = 16$, $P < 0.001$), European Willow Warbler ($\alpha = 224^\circ$, $r = 0.64$, $n = 48$, $P < 0.001$), European Nightingale ($\alpha = 208^\circ$, $r = 0.39$, $n = 21$, $P < 0.05$), and Greater Whitethroat ($\alpha = 214^\circ$, $r = 0.49$, $n = 18$, $P < 0.05$). All species oriented to the southwest (Fig. 2). A significant difference was found only between mean direction of European Willow Warbler and Pied Flycatcher (Mann-Whitney U-Test, $P < 0.05$; Watson-Williams Test, $P < 0.05$). The average direction of all species was 208° . Mean directions of the individual years varied (Appendix), but all significant directions were southwesterly. The Garden Warbler ($\alpha = 260^\circ$, $r = 0.15$, $n = 70$, $P > 0.05$) and European Reed Warbler ($\alpha = 212^\circ$, $r = 0.33$, $n = 23$, $P > 0.05$) did not show a significant mean direction. The mean directions of the species studied were within 27° of one another. Thus, the species exhibited similar orientation direction.

Radar studies in this area also indicated a southwesterly direction of migration. Radar data at Beja in southern Portugal, about 190 km northwest of Sanlucar, showed a mean direction of 205° (Hilgerloh 1988); in the Straits of Gibraltar, about 120 km to the southeast, the mean direction was 211° (Hilgerloh 1989). Seasonal direction for radar observations was calculated from nightly mean directions. Because orientation tests were performed in the first part of the night, I have recalculated radar observations during the same part of the night. During this time period,

the mean direction on radar was generally directed farther to the south. In Beja, birds were directed towards 200° and in Gibraltar towards 210° . Hence, all species had a significant mean direction to the southwest and the mean directions of these species were similar to each other. The direction in Emlen cages corresponded to mean directions observed by radar in this area.

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APPENDIX. Orientation data (1985 and 1987) for each species. Levels of significance: * = $P < 0.05$, ** = $P < 0.01$, *** = $P < 0.001$.

Species	1985			1987		
	n	α	r	n	α	r
<i>F. hypoleuca</i>	43	182***	0.60	28	215***	0.81
<i>M. striata</i>	5	219	0.38	11	202***	0.76
<i>P. trochilus</i>	26	237***	0.56	22	213***	0.75
<i>L. megarhynchos</i>	17	216*	0.45	4	239	0.40
<i>A. scirpaceus</i>	12	217*	0.30	11	191*	0.40
<i>S. communis</i>	6	252	0.38	12	210**	0.60
<i>S. borin</i>	68	250	0.14	2	263	0.38