

Figure S1. Screenshots from a video of *Eristalis tenax* migration on the tip of the Karpaz Peninsula, north-east Cyprus on 2 May 2019, showing the consistently horizontal body axis of migrating hoverflies.



Figure S2. (a – e) Circular histograms of spring patterns of (a) the migration track directions of hoverfly mass migrations, (b) downwind directions during all days, (c) downwind directions during non-mass migration events, (d) downwind directions during mass migrations, and (e) flight headings during mass migrations exhibiting a significant degree of common orientation, for each of the three radar locations. Each small filled circle indicates the mean direction during a mass migration or a non-migration event. The bearing of the arrow indicates the mean direction of the entire dataset, while its length is proportional to the clustering of the dataset around the mean.

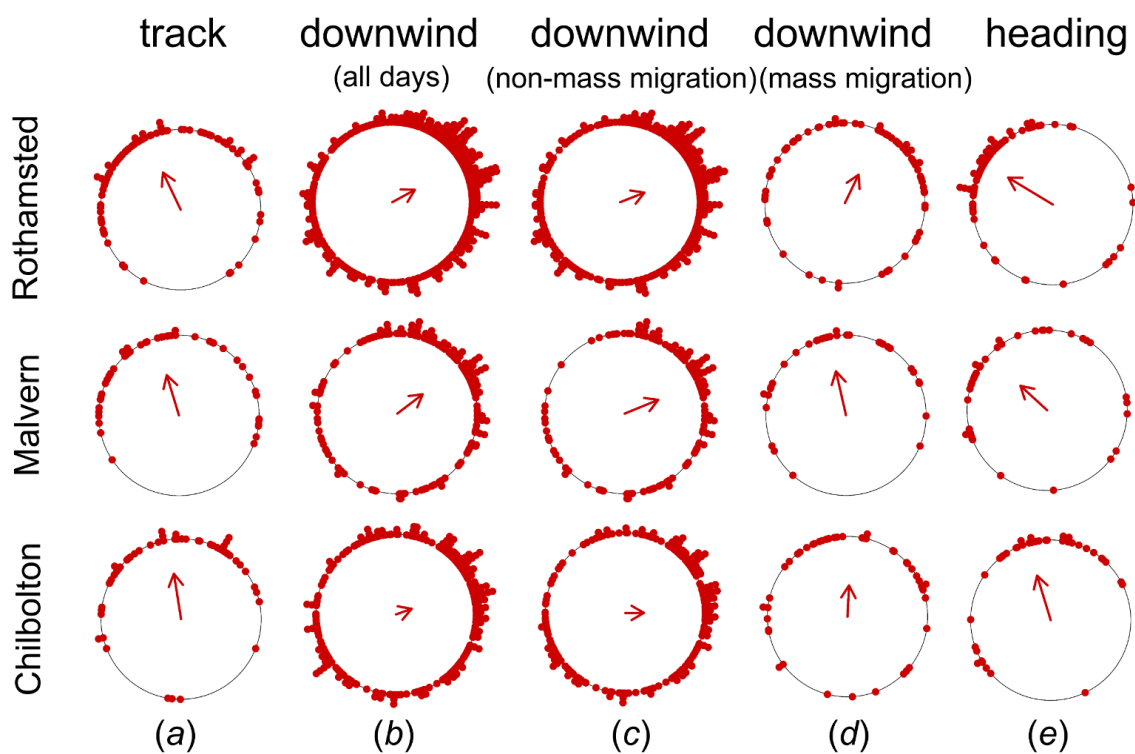


Figure S3. (a – d) Circular histograms of autumn patterns of (a) the migration track directions of hoverfly mass migrations, (b) downwind directions during all days, (c) downwind directions during non-mass migration events, (d) downwind directions during mass migrations, and (e) flight headings during mass migrations exhibiting a significant degree of common orientation, for each of the three radar locations. Each small filled circle indicates the mean direction during a mass migration or a non-migration event. The bearing of the arrow indicates the mean direction of the entire dataset, while its length is proportional to the clustering of the dataset around the mean; in cases where the distribution is not significantly different from random, no arrow is plotted.

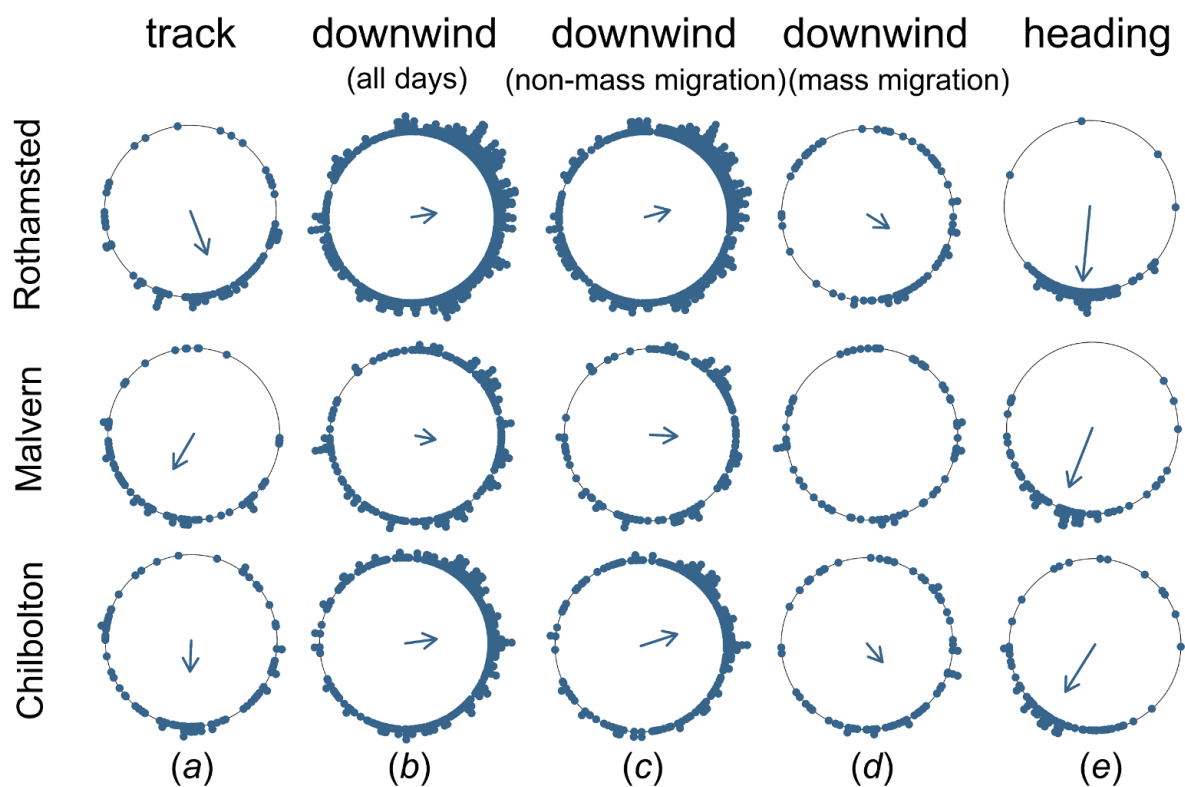


Figure S4. Diagrammatic representation of directional data during spring migrations of the hoverfly *Episyrphus balteatus*. The dashed grey line represents the presumed spring value of the PDM (preferred direction of movement), which we assume here is due north (0°). The blue arrow represented the self-powered heading vector, and the black arrow represents the track direction relative to the ground. The angle between the heading and the track is represented by α , which we call the ‘heading offset’; and the angle between the PDM and the track is represented by Φ , which we term the drift angle as it is a measure of how far the insect has been drifted off course by the wind. (a) In this case, the heading is on the anti-clockwise side of the track and so α would be assigned a negative value when used in the regression methodology of Green & Alerstam 2002 to find the slope and PDM (see Figure 2); but the heading is also closer to the PDM than the track, and so α would be assigned a positive value when used in the circular methodology to assess the degree of correction for wind drift (see Figure 3). (b) In this case, the heading is on the clockwise side of the track and so α would be assigned a positive value when used in the regression methodology of Green & Alerstam 2002 to find the slope and PDM (see Figure 2); but the heading is further away from the PDM than the track, and so α would be assigned a negative value when used in the circular methodology to assess the degree of correction for wind drift (see Figure 3).

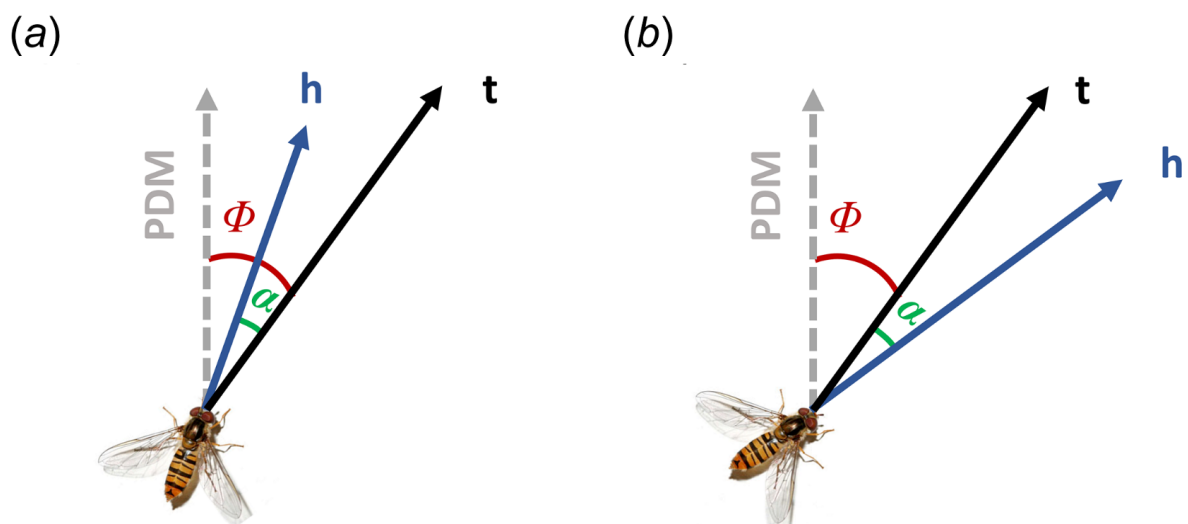


Figure S5. (a – d) Circular histograms of the migration track directions of all individual hoverflies in (a) spring (335° , $n = 46,526$, $r = 0.45$, $p < 0.001$) and (c) autumn (185° , $n = 108,976$, $r = 0.38$, $p < 0.001$); and flight headings of all individual hoverflies in (b) spring (322° , $n = 40,018$, $r = 0.37$, $p < 0.001$) and (d) autumn (198° , $n = 107,291$, $r = 0.53$, $p < 0.001$). Each coloured point indicates the direction of an individual hoverfly. The bearing of the arrow indicates the mean direction of the entire dataset, while its length is proportional to the clustering of the dataset around the mean.

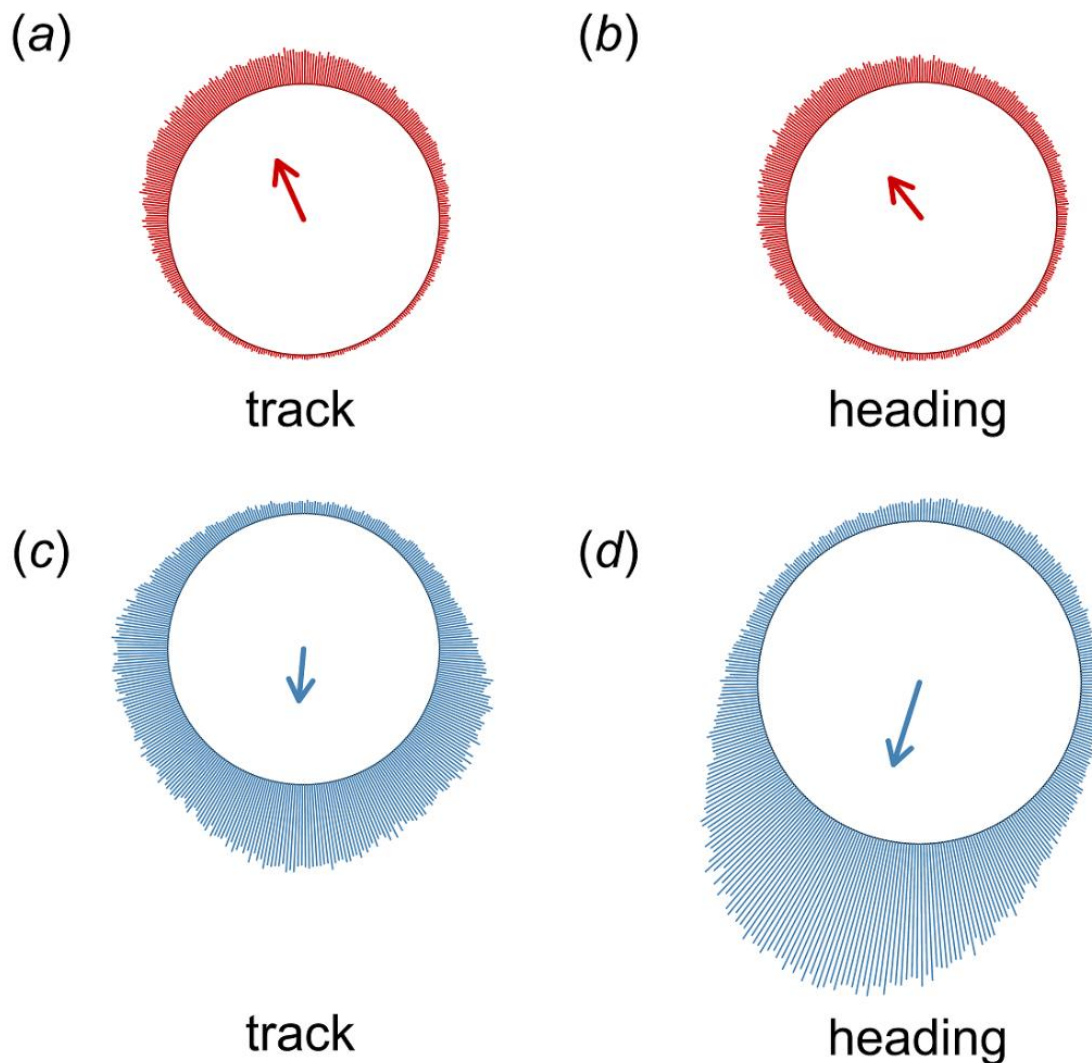


Figure S6. Mean hourly track directions (a) and heading directions (b) of hoverfly mass migrations in the autumn. The dotted red horizontal lines show the overall mean value of (a) the autumn track (180°) and (b) the autumn heading (198°). The horizontal solid black lines represent the hourly mean and whiskers indicate the 5th and 95th percentiles.

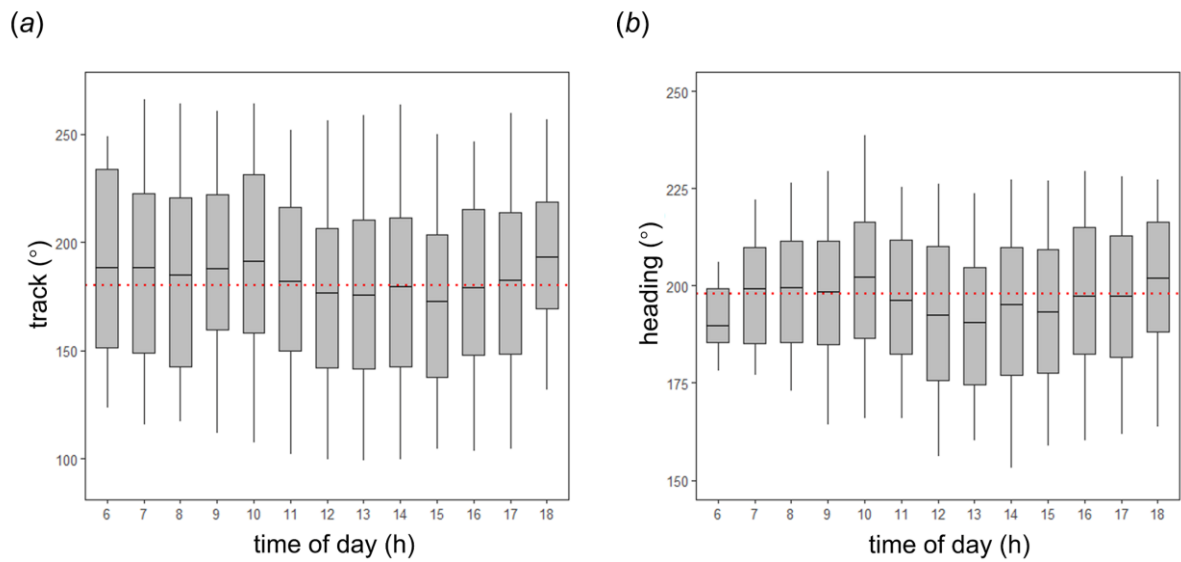


Figure S7. The distribution of wind speeds during all days in the study period with available data. The horizontal solid black line represents the median for each category, the dashed black line represents the mean, whiskers indicate the 5th and 95th percentiles, while the small circles show the outliers.

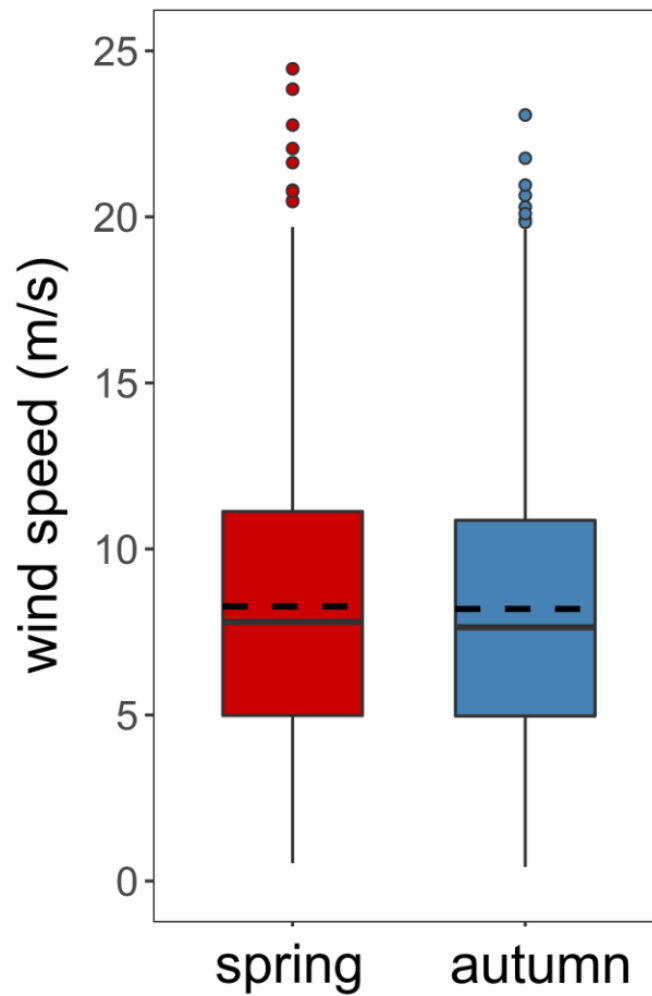


Table S1. Number of migration events and individual migrant hoverflies, and degree of common orientation, during spring and autumn migrations at each radar location.

season	site	migration occasions	total hoverflies	mass migrations	total hoverflies	common orientation	heading r-value (± s.d.)
spring	Rothamsted	451	27,136	85 (19%)	19,478 (72%)	69/85 (81%)	0.340± 0.126
	Chilbolton	263	20,970	54 (21%)	15,589 (74%)	39/54 (72%)	0.313 ± 0.126
	Malvern	217	14,648	47 (22%)	11,495 (78%)	36/47 (77%)	0.249 ± 0.100
	Total	931	62,754	186 (20%)	46,562 (75%)	144/186 (77%)	0.310 ± 0.125
autumn	Rothamsted	554	58,088	93 (17%)	39,231 (68%)	88/93 (95%)	0.545 ± 0.134
	Chilbolton	314	46,233	85 (27%)	35,930 (78%)	78/85 (92%)	0.484 ± 0.166
	Malvern	231	42,223	70 (30%)	33,815 (80%)	65/70 (93%)	0.450 ± 0.162
	Total	1,099	146,544	248 (23%)	108,976 (75%)	231/248 (93%)	0.498 ± 0.158
TOTAL		2,030	209,298	434 (21%)	155,538 (75%)	375/434 (86%)	

Table S2. Mean track, heading and wind directions during spring and autumn migrations at each radar location. Non-significant distributions are highlighted in blue text.

season	site	directional data	n	mean direction (°)	r	p
spring	Rothamsted	track	85	334.51	0.513	<0.001
		wind (all days)	465	61.32	0.322	<0.001
		wind (non-mass migration)	395	68.46	0.325	<0.001
		wind (mass migration)	70	25.71	0.392	<0.001
		heading	69	301.04	0.652	<0.001
	Malvern	track	47	343.08	0.524	<0.001
		wind (all days)	178	52.81	0.398	<0.001
		wind (non-mass migration)	145	67.77	0.451	<0.001
		wind (mass migration)	33	347.06	0.561	<0.001
		heading	36	312.42	0.452	<0.001
	Chilbolton	track	54	350.94	0.572	<0.001
		wind (all days)	264	70.24	0.206	<0.001
		wind (non-mass migration)	217	89.83	0.232	<0.001
		wind (mass migration)	47	2.75	0.389	<0.001
		heading	39	342.97	0.581	<0.001
autumn	Rothamsted	track	93	158.85	0.537	<0.001
		wind (all days)	502	80.84	0.289	<0.001
		wind (non-mass migration)	429	74.62	0.302	<0.001
		wind (mass migration)	73	121.86	0.293	0.002
		heading	88	185.58	0.869	<0.001
	Malvern	track	70	210.33	0.471	<0.001
		wind (all days)	190	100.74	0.236	<0.001
		wind (non-mass migration)	215	93.02	0.315	<0.001
		wind (mass migration)	61	--	--	0.440
		heading	65	201.59	0.735	<0.001
	Chilbolton	track	85	182.14	0.359	<0.001
		wind (all days)	285	82.08	0.366	<0.001
		wind (non-mass migration)	129	72.05	0.443	<0.001
		wind (mass migration)	70	140.15	0.279	0.004
		heading	78	212.10	0.648	<0.001

Table S3. Watson-Wheeler tests between mean track, heading and wind directions during spring and autumn migrations for each radar location. Significant differences between pairwise comparisons are highlighted in red text.

season	group 1	group 2	directional data	<i>w</i>	<i>p</i>
spring	Rothamsted	Chilbolton	track	4.015	0.134
			wind (all days)	4.883	0.087
			wind (non-mass migration)	4.520	0.104
			wind (mass migration)	2.169	0.400
			heading	26.265	<0.001
	Rothamsted	Malvern	track	0.171	0.918
			wind (all days)	2.301	0.317
			wind (non-mass migration)	2.911	0.233
			wind (mass migration)	6.303	0.042
			heading	4.686	0.096
	Chilbolton	Malvern	track	2.235	0.327
			wind (all days)	9.543	0.008
			wind (non-mass migration)	8.686	0.013
			wind (mass migration)	1.628	0.443
			heading	8.223	0.016
autumn	Rothamsted	Chilbolton	track	6.844	0.033
			wind (all days)	2.321	0.313
			wind (non-mass migration)	5.530	0.063
			wind (mass migration)	0.927	0.629
			heading	32.358	<0.001
	Rothamsted	Malvern	track	15.651	<0.001
			wind (all days)	2.166	0.339
			wind (non-mass migration)	1.343	0.511
			wind (mass migration)	--	--
			heading	11.967	0.002
	Chilbolton	Malvern	track	6.176	0.046
			wind (all days)	4.608	0.010
			wind (non-mass migration)	4.008	0.135
			wind (mass migration)	--	--
			heading	4.230	0.121

Table S4. Mean track direction, mean heading and estimated PDM for each hour during hoverfly mass migrations.

	Mean track (95% CI)	Mean heading (95% CI)	Number of events	Number of individuals
6 a.m. - 7 a.m.	188.46 (123.36,249.19)	189.97 (175.45,211.12)	25	3161
7 a.m. - 8 a.m.	188.41 (115.94,265.92)	199.30 (171.08,267.74)	51	6028
8 a.m. - 9 a.m.	185.22 (117.13,264.00)	199.51 (165.61,255.40)	84	8147
9 a.m. - 10 a.m.	188.11 (111.68,260.90)	198.38 (159.25,233.98)	107	9357
10 a.m. - 11 a.m.	191.19 (107.61,263.96)	202.27 (158.64,245.61)	107	9670
11 a.m. - 12 a.m.	182.17 (102.16,252.10)	196.36 (149.26,238.77)	111	9858
12 a.m. - 1 p.m.	176.59 (99.74,256.39)	192.37 (145.78,235.50)	116	9857
1 p.m. - 2 p.m.	175.81 (93.39,258.61)	190.60 (153.78,235.42)	114	10676
2 p.m. - 3 p.m.	179.70 (99.73,263.87)	195.15 (152.41,234.80)	120	10611
3 p.m. - 4 p.m.	172.84 (104.55,250.18)	193.28 (156.38,232.94)	112	10131
4 p.m. - 5 p.m.	179.05 (103.39,246.44)	197.40 (155.64,237.30)	101	9266
5 p.m. - 6 p.m.	182.76 (104.33,259.55)	197.28 (156.28,242.93)	86	7423
6 p.m. -7 p.m.	193.45 (132.08,256.79)	201.96 (163.80,233.41)	56	4267

Table S5. Magnitude and direction of heading offsets during spring and autumn hoverfly mass migrations.

season	drift angle ϕ (°)	n	ratio of positive to negative values of α	mean heading offset α (°)	95% c.i. (°)	p
spring	<10	15	11:4 (73%)	+13.84	-8.23, +35.91	>0.05
	>10	129	67:62 (52%)	+0.80	-7.34, +8.95	>0.05
	total	144	73:71 (51%)	+2.16	-5.44, +9.76	>0.05
autumn	<10	22	13:9 (59%)	+2.43	-4.84, +9.71	>0.05
	>10	209	182:27 (87%)	+30.42	+25.96, +34.88	<0.05
	total	231	191:40 (83%)	+27.76	+23.54, +31.98	<0.05