

SUPPLEMENTARY INFORMATION

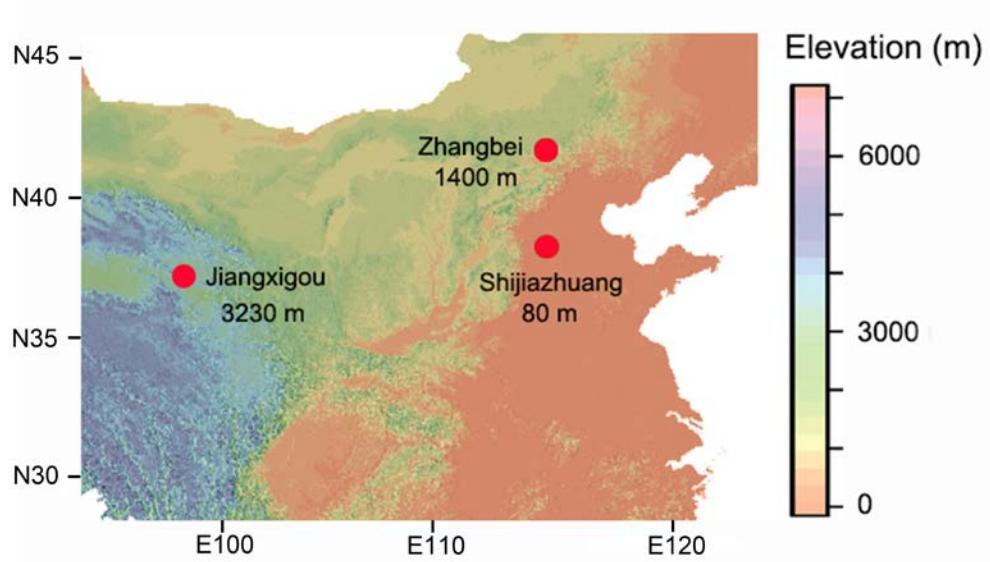


Fig. S1. Sampling sites (red dots) and altitudinal information (Shijiazhuang, Zhangbei and Jiangxigou).

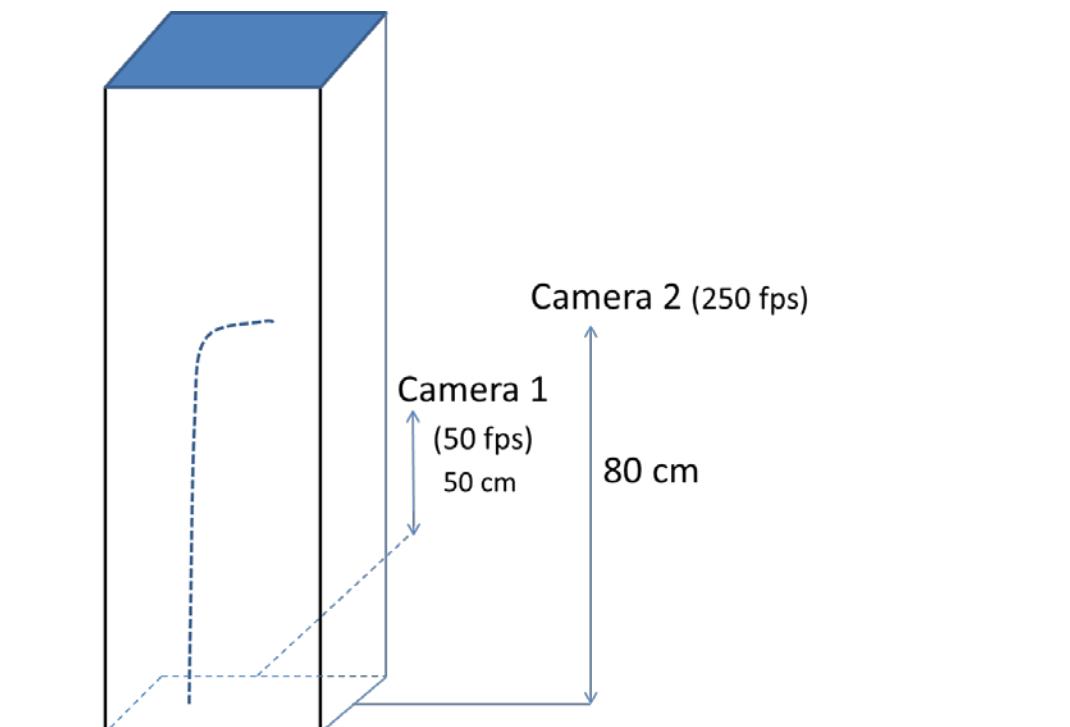


Fig. S2. Schematic diagram of the flight chamber with the two recording cameras

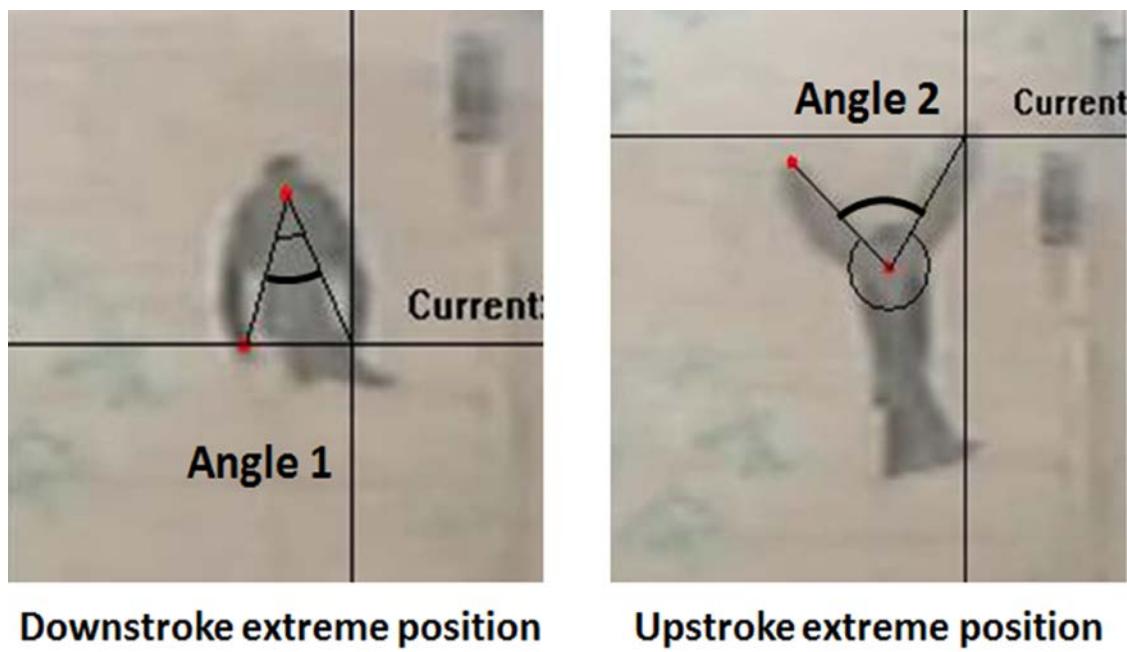


Fig. S3. Angle estimation method for stroke amplitude. We calculated the angle between the two wings at the extreme positions of downstroke (Angle 1) and upstroke (Angle 2). The angle of stroke amplitude is estimated by $[360^\circ - (\text{angle 1} + \text{angle 2})]/2$.

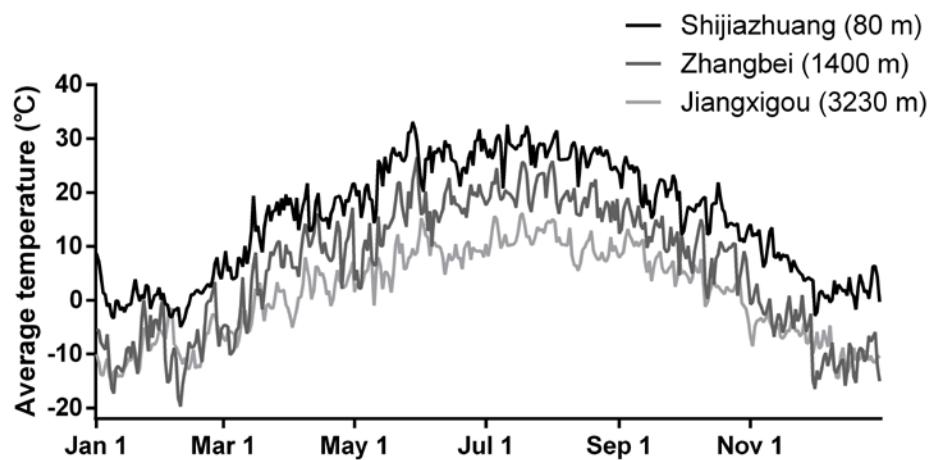


Fig. S4. Mean daily temperature of 2014 at the three sampling sites (Shijiazhuang, Zhangbei and Jiangxigou).

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Table S1. Geographical and sampling information for three populations of Eurasian tree sparrows.

Sampling site	GPS location	Altitude (m)	Sampling dates	Average air pressure	Sample size
Shijiazhuang (Hebei Province)	N37°59.898', E114°31.090'	80 m	January 16–18, 2015	100 kPa	17 (male, 5; female, 12)
Zhangbei (Hebei Province)	N41°10.169', E114°46.711'	1400 m	January 6–10, 2015	86 kPa	28 (male, 10; female, 18)
Jiangxigou (Qinghai Province)	N36°37.098', E100°16.690'	3230 m	January 24 to February 14, 2015	70 kPa	17 (male, 11; female, 6)

Table S2. Bonferroni adjusted *P*-values for post-hoc comparisons of morphological and functional variables between sites in Eurasian tree sparrows using a linear mixed model based on model-predicted estimated marginal means.

Variable	Altitude	80 m	1400 m
Body mass	1400 m	0.002	-
	3230 m	<0.001	<0.001
Wing length	1400 m	0.199	-
	3230 m	0.020	<0.001
Wingtip shape (C2)	1400 m	0.001	-
	3230 m	<0.001	0.295
Wing area	1400 m	1.0	-
	3230 m	0.001	<0.001
Wing loading	1400 m	0.042	-
	3230 m	0.069	1.0
Flight muscle mass	1400 m	0.001	-
	3230 m	<0.001	0.013
Mass of pectoralis major	1400 m	<0.001	-
	3230 m	<0.001	0.027
Mass of pectoralis minor	1400 m	0.663	-
	3230 m	0.253	0.005
Mass ratio of p. major to p. minor	1400 m	<0.001	-
	3230 m	0.082	0.298
Heart mass	1400 m	<0.001	-
	3230 m	<0.001	0.620
Lung mass	1400 m	0.069	
	3230 m	<0.001	<0.001
Heart index	1400 m	0.001	
	3230 m	0.165	0.254
Lung index	1400 m	0.966	
	3230 m	0.012	0.062
Wingbeat frequency *	1400 m	0.029	
	3230 m	0.022	0.765
Maximum load /body mass	1400 m	0.578	-
	3230 m	0.027	0.289

* Unadjusted p-value from Least-significant Difference (LSD) method



Movie 1. Loading lift video of Eurasian tree sparrow (Camera 1 for framing loading beads set at 50 fps).



Movie 2. Loading lift video of Eurasian tree sparrow (Camera 2 for amplitude and wingbeat frequency set at 250 fps).