Bumblebee flight in heavy turbulence

Corrigendum

September 12, 2016

In the paper [4], some confusion may arise from the definition of the Reynolds number of the bumblebee model.

Recall the definition of the conventional Reynolds number

$$Re = \frac{U_{tip} c_m}{\nu}$$

where c_m is the wing length and U_{tip} is the mean wingtip velocity, conventionally calculated as

$$U_{tip} = 2\Phi f R$$

where $\nu = 1.568\,\mathrm{m}^2/\mathrm{s}$ is the kinematic viscosity of air, Φ is the stroke amplitude (in radiant), R is the wing length and f the wingbeat frequency.

Note: in the supplementary material to the paper, we stated $\phi(t/T) = \overline{\phi} + \Phi \sin(2\pi t/T)$ for the time evolution of the positional angle, which should read $\phi(t/T) = \overline{\phi} + 0.5\Phi \sin(2\pi t/T)$

The mean chord length c_m is defined as

$$c_m = A/R$$

where A is the surface of the wing.

Our model is based on the work of Dudley [2, 3]. They give the following values for the relevant parameters

$$f = 152\,\mathrm{Hz}$$
$$R = 1.32 \cdot 10^{-2}\,\mathrm{m}$$

The wing contour was digitized from [1], since it is missing in [2, 3]. The wing surface scales to

$$A = 48.37\,\mathrm{mm}^2$$

However, we removed some parts of the wing root in order to prevent the wings from touching the body. We also re-normalized the distance wing root-tip to the value given by Dudley. Therefore, our actual wing surface (as used in the simulations) scales to

$$A_{true} = 52.96\,\mathrm{mm}^2$$

The wingbeat amplitude Φ is 115°in our paper and simulations, therefore the mean wingtip velocity is

$$U_{tip} = 8.05\,\mathrm{m/s}$$

(this value is wrong in the paper) and the mean chord length

$$c_m = 4.0121\,\mathrm{mm}$$

which yields the Reynolds number

$$Re = 2060$$

This is the actual Reynolds number used in the numerical simulations.

Note: In the main article we stated a mean wingtip velocity of 8.75 m/s, which is incorrect.

We further want to point out that the Reynolds number, based on the experimental wing surface stated in [2] (which is $48.37\,\mathrm{mm}^2$and thus yields $c_m = 3.66\,\mathrm{mm}$) is $Re = 1882$. Note that variations in the hovering Reynolds number within 10% are common due to the intra- and interindividual variability. Therefore, the slight discrepancy does not invalidate the results.

References

[1] University of Minnesota Insect Collection. http://insectcollection.umn.edu. Accessed: 2014-05-14.

[2] R. Dudley and C. P. Ellington. Mechanics of forward flight in bumblebees I. kinematics and morphology. *J. Exp. Biol.*, 148:19–52, 1990.

[3] R. Dudley and C. P. Ellington. Mechanics of forward flight in bumblebees II. quasi-steady lift and power requirements. *J. Exp. Biol.*, 148:53–88, 1990.

[4] T. Engels, D. Kolomenskiy, K. Schneider, F.-O. Lehmann, and J. Sesterhenn. Bumblebee flight in heavy turbulence. *Phys. Rev. Lett.*, 116:028103, Jan 2016.