Hummingbirds make flying backward look easy

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Green Violetear at a flower. Image: Wikipedia.

Animals that move backwards usually require a lot of energy, so Nir Sapir from the University of California Berkeley, USA, was surprised when he realized that hummingbirds execute this maneuver routinely. Wondering how hummingbirds perform the feat, he analyzed their flight and the amount of oxygen they consume and found that reversing is much cheaper than hovering flight and no more costly than flying forward.

Backing up usually isn't easy, yet when Nir Sapir observed agile hummingbirds visiting a feeder on his balcony in Berkeley, California, he was struck by their ability to reverse. "I saw that they quite often fly backwards," he recalls, adding that they always reverse out of a bloom after feasting. However, when he searched the literature he was

disappointed to find that there were hardly any studies of this particular behaviour. "This was a bit surprising given that they are doing this all the time', Sapir says, explaining that the tiny aviators visit flowers to feed once every 2 min. "I thought that this was an interesting topic to learn how they are doing it and what the consequences are for their metabolism," Sapir says, so he and his postdoc advisor, Robert Dudley, set about measuring the flight movements and metabolism of reversing hummingbirds and they publish their discovery that reversing is much cheaper than hovering flight and no more costly than forward flight for hummingbirds in *The Journal of Experimental Biology*.

Capturing five Anna's hummingbirds at a feeder located just inside a University of California Berkeley laboratory window, Sapir trained the birds to fly in a wind tunnel by tricking the birds into feeding from a syringe of sucrose disguised as a flower. He then filmed each bird as it hovered to feed before returning to the perch when satisfied. Knowing that the bird would return to the feeder again soon, Sapir turned on the air flow when the hummingbird arrived, directing the 3 m s flow so that the bird had to fly backwards against the wind to remain stationary at the 'flower'. Then he repeated the experiment with the syringe feeder rotated through 180 deg while the hummingbird flew forward into the wind to stay in place.

Analysing the three flight styles, Sapir recalls that there were clear differences between forward and backward flight. The hummingbirds' body posture became much more upright as they flew backward, forcing them to bend their heads more to insert their beaks into the simulated flower. In addition, the reversing birds reduced the inclination of the plane of the wing beat so that it became more horizontal. And when Sapir analysed the wing beat frequency, he found that the birds were beating their wings at 43.8 Hz, instead of the 39.7 Hz that they use while flying forward. 'That is quite a lot for hummingbirds because they hardly change their wing beat frequency', explains Sapir.

Repeating the experiments while recording the birds' oxygen consumption rates, Sapir says, "We expected that we would find high or intermediate values for metabolism during backward flight because the bird has an upright body position and this means that they have a higher drag. Also, the birds use backward flight frequently, but not all the time, so we assumed that it would not be more efficient in terms of the flight mechanics compared with forward flight." However, Sapir was surprised to discover that instead of being more costly, backward flight was as cheap as forward flight and 20% more efficient than hovering. And when Sapir gently increased the wind flow from 0 m s in 1.5 m s steps for a single bird, he found that flight was cheapest at speeds of 3 m s^{-1} and above, although the bird was unable to fly backwards faster than 4.5 m s^{-1}.

Describing hummingbirds as insects trapped in a bird's body, Sapir adds that the fluttering flight of hummingbirds has more in common with insects than with their feathered cousins and he is keen to find out whether other hovering animals such as small songbirds and nectar-feeding bats can reverse too.

More information: Sapir, N. and Dudley, R. (2012). Backward flight in hummingbirds employs unique kinematic adjustments and entails low metabolic cost. J. Exp. Biol. 215, 3603-3611. jeb.biologists.org/content/215/20/3603.abstract

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