Steady flight of kestrels could help aerial safety soar

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A Nankeen Kestrel. Credit: RMIT

A new joint study by RMIT and the University of Bristol has revealed secrets to the remarkably steady flight of kestrels and could inform future drone designs and flight control strategies.

The study, "Steady as they hover: kinematics of kestrel wing and tail morphing during hovering flights," was published in the *Journal of Experimental Biology*. It is a collaboration between Mario Martinez Groves-Raines, George Yi, Matthew Penn, Simon Watkins, Shane Windsor and Abdulghani Mohamed.

Making drones safer and more stable in turbulent conditions, or in cities where wind gusts from tall buildings make flying more difficult, makes applications like parcel delivery, food delivery and environmental monitoring more feasible, more often.

The study conducted in RMIT's Industrial Wind Tunnel facility—one of the largest of its kind in Australia—is the first to precisely measure the stability of a Nankeen Kestrel's head during hovering flight, finding movement of less than 5mm during hunting behavior.

"Typically, aircraft use flap movements for stabilization to achieve stability during flight," said RMIT lead researcher Dr. Abdulghani Mohamed.

"Our results acquired over several years, show birds of prey rely more on changes in surface area, which is crucial as it may be a more efficient way of achieving stable flight in fixed wing aircraft too."

Anatomy of steady flight

Kestrels and other birds of prey are capable of keeping their heads and bodies extremely still during hunting. This specialized flight behavior, called wind hovering, allows the birds to 'hang' in place under the right wind conditions without flapping. By making small adjustments to the shape of their wings and tail, they can achieve incredible steadiness.

A Nankeen Kestrel hovering in the RMIT University wind tunnel. Credit: RMIT

Thanks to advancements in camera and motion capture technology, the research team was able to observe two Nankeen Kestrels, trained by Leigh Valley Hawk and Owl Sanctuary, at high resolution.

Fitted with reflective markers, the birds' precise movements and flight control techniques during non-flapping flight were tracked in detail for the first-time.

"Previous studies involved birds casually flying through turbulence and gusts within wind tunnels; in our study we tracked a unique wind hovering flight behavior whereby the birds are actively maintaining extreme steadiness, enabling us to study the pure control response without flapping," said Mohamed.

By mapping these movements, the researchers gained insights that could be utilized to achieve steadier flight for fixed wing aircrafts.

"The wind hovering behavior we observed in kestrels is the closest representation in the avian world to fixed wing aircraft," said Mohamed.

"Our findings surrounding the changes in wing surface area could be applied to the design of morphing wings in drones, enhancing their stability and making them safer in adverse weather."

Martin Scuffins from the Leigh Valley Hawk and Owl Sanctuary and RMIT's Dr. Abdulghani Mohamed fitting sensors to the kestrel in RMIT's wind tunnel facility. Credit: RMIT

The issue with current drones

Associate Professor of Bio-Inspired Aerodynamics at Bristol University and joint last author, Dr. Shane Windsor, said the usefulness of current fixed wing unmanned aerial vehicles (UAV's) was significantly decreased by their inability to operate in gusty wind conditions.

"UAV's are being used in the UK to deliver post to remote islands, but their operation time is limited because of regular gusty conditions.

"Current commercial fixed wing aircraft have to be designed with one fixed geometry and optimized to operate at one flight condition.

"The advantage of morphing wings is that they could be continually optimized throughout a flight for a variety of conditions, making the aircraft much more maneuverable and efficient."

Next steps

The team now aims to further their research by examining the birds under gusty and turbulent conditions, which would see further learnings in stable flight with the goal of allowing UAVs to operate more safely and more often.

While initially focused on smaller aerial vehicles, the team hopes to simplify the data collected so that it can be adapted for larger scale aircraft.

The team acknowledges Mr. Martin Scuffins from the Leigh Valley Hawk and Owl Sanctuary, for sharing expertise and knowledge critical to the project's success.

More information: Mario Martinez Groves-Raines et al, Steady as they hover: kinematics of kestrel wing and tail morphing during hovering flights, *Journal of Experimental Biology* (2024). DOI:

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