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Strategy and Mechanism for Intercepting Unpredictable Moving Targets in the Blue-Tailed Damselfly (Ischnura elegans)

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Abstract : Members of the Odonata order (dragonflies and damselflies) stand out for their maneuverability and superb flight control, which allow them to catch flying prey in the air. These outstanding aerial abilities were fine-tuned during millions of years of an evolutionary arms race between Odonata and their prey, providing an attractive research model for studying the relationship between sensory input – and aerodynamic output in a flying insect. The ability to catch a maneuvering target in air is interesting not just for insect behavioral ecology and neuroethology but also for designing small and efficient robotic air vehicles. While the aerial prey interception of dragonflies (suborder: Anisoptera) have been studied before, little is known about how damselflies (suborder: Zygoptera) intercept prey. Here, high-speed cameras (filming at 1000 frames per second) were used to explore how damselflies catch unpredictable targets that move through air. Blue-tailed damselflies - Ischnura elegans (family: Coenagrionidae) were introduced to a flight arena and filmed while landing on moving targets that were oscillated harmonically. The insects succeeded in capturing targets that were moved with an amplitude of 6 cm and frequencies of 0-2.5 Hz (fastest mean target speed of 0.3 m s^{-1}) and targets that were moved in 1 Hz (an average speed of 0.3 m s^{-1}) but with an amplitude of 15 cm. To land on stationary or slow targets, damselflies either flew directly to the target, or flew sideways, up to a point in which the target was fixed in the center of the field of view, followed by direct flight path towards the target. As the target moved in increased frequency, damselflies demonstrated an ability to track the targets while flying sideways and minimizing the changes of their body direction on the yaw axis. This was likely an attempt to keep the targets at the center of the visual field while minimizing rotational optic flow of the surrounding visual panorama. Stabilizing rotational optic flow helps in estimation of the velocity and distance of the target. These results illustrate how dynamic visual information is used by damselflies to guide them towards a maneuvering target, enabling the superb aerial hunting abilities of these insects. They also exemplifies the plasticity of the damselfly flight apparatus which enables flight in any direction, irrespective of the direction of the body.

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