Hindwings Play a Critical Role in Takeoffs and Flight in Cicada (Graptopsaltria nigrofuscata)

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In aerodynamics of cicada’s flight, forewing and hindwing have been treated as one wing, and the hindwings were considered only to increase the gross wing area (Wan et al., 2015). In order to elucidate the role of hindwings during flight in the cicada (Graptopsaltria nigrofuscata), repeated observations were done of their takeoffs from a vertical posture on a tree by precise recordings with a high-speed camera. Cicadas bearing wings with various surgical operations were used. Without hindwings they always failed to take off. All cicadas that took off successfully had at least one pair of forewing and hindwing hooked each other at rotation. During takeoffs, they rotated efficiently by moving their left- and right-wings independently. When they lost the driving and lifting forces due to touching a tree, they gained the forces again by only stroking one side wing. When hindwings were not coupled with forewings, hindwings did not flap for waiting to connect with the flapping forewings. Hindwings played a role for rotation during takeoffs, and forewings were to gain the driving and lifting forces. The link between forewing and hindwing was necessary for takeoffs. It is considered that cicadas control their takeoffs and flight by generating twist from the linked point by stopping the movement of hindwings with continued flapping of the forewings. This finding will contribute to the development of small flying robots which can take off in smaller spaces in a variety of positions.

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