DECODING THE BIOMECHANICS OF FLIGHT-TONE BASED ACOUSTIC COMMUNICATION IN MOSQUITOES

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Abstract text

The aerial courtship dance of mosquitoes involves controlled variations in the wingbeat frequency (WBF) and intensity of flight-tones, with concurrent changes in flight speed and direction. This behavior enables acoustic detection of conspecifics in mating swarms, leading to a competitive chase between the female and the male copulation. However, despite >150 years of research, it is not clear how the 6-D soundscape (3D space, time, intensity, and WBF) generated by flying mosquitoes is actively modified during courtship.

A novel experimental setup has been installed to record free-flying mosquitoes during mating behavior (figure 1). This includes 3 high-speed cameras (resolution: 22500 frames/second) that can record micrometer-level deformations in the wing. Simultaneously, an array of 12 microphones surrounds the swarming area to capture sound directivity.

The wing kinematics for each mosquito were digitally reconstructed by tracking the deformation of vein crossings. They were then fed to a state-of-the-art computational biomechanics suite, which then provided spatio-temporal predictions of aerodynamic & aeroacoustic loads. Our acoustic analysis confirms that wingtones are highly directional with a symmetrical bimodal shape (figure 2). A harmonic decomposition of the sound pressure reveals that there would be some optimal locations for the male (horizontal plane) to hear the chased female. We further learn that mosquitoes generate max lift during upstroke as the wing pronates. The existence of force peaks when wing rotation changes signs reflects an increased dependece on aerodynamic mechanisms like rotational circulation and wake capture. This is confirmed by instantaneous flow structures (figure 3). A scaling analysis permits the identification of dynamically relevant parameters, e.g., the wing rotation factor.

The success of this novel approach could be transformative for methods for population control of many pest species of flying insects that employ similar modes of mating communication; our results help understand WBF related observations in mating swarms and potentially could form the scientific foundation for exploitation of sound-stimuli by diminishing mating success in vectors of malaria, Zika & other mosquito-borne diseases.

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Supporting figures

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