

Cleaning without being contaminated: Antenna cleaner of a honey bee is a catapult

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Abstract Insects use specific structures to maintain their antennae clean by sweeping contaminants away from surfaces of antennae, which may in turn contaminate these grooming structures. Most insects like cockroaches (100%) and southern green stink bug (89%) usually clean these grooming structures immediately with other organs such as mouthparts or forelegs after antennal grooming; by contrast, the maintenance of antenna cleaner for the honey bee occurs only at a rate of 25%. How do the honey bee keep its antenna cleaner uncontaminated? In this experimental and theoretical study, we found that the catapulting mechanism of the antenna cleaner rendered by geometric and materials characteristics allowed to launch contaminants from its surface for self-cleaning. During antennal grooming, the antenna cleaner of which diameter was 32 μm less than the antennae had to deform and consequently stored elastic energy itself owing to the high content of resilin. As the antenna cleaner scraped the antennae completely, the storage of energy was instantly released, ejecting the particles at an acceleration of 13g from the surface of the antenna cleaner. After a stroke of antennal grooming the contaminants remaining on the antenna cleaner mainly distributed in the 60% part close to the root of the antenna cleaner, hardly impairing the grooming function of the distal part. Mechanics analyses were conducted to theoretically reveal the self-cleaning mechanism of the antenna cleaner by establishing a mathematical modelling. This research may shed lights on the self-cleaning behavior in insects and inspire novel design of cleaning device that can remove contaminants from objects without requiring additional maintenance on the device itself.