A Flying Mechanism of a Helicopter Like Toy, "Bamboo Dragonfly": Effect of Back Flow on a Lift Force in a Non-Stationary Condition

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With detailed analyses of flying motion of a helicopter like bamboo toy, “Bamboo dragonfly”, we revealed and analyzed a back flow effect on a lift force appeared under a non-stationary condition. Methods and apparatus originally designed and fabricated by our own work made possible precise measurements of vertical velocity and rotational angular velocity of the Bamboo dragonfly (BDF). Continuous photographs of a LED light source attached to the wing, and measurement of laser light periodic shadowing are used for the simultaneous measurements. Observed motion has been also analyzed by differential equations of motion. On the other hand, a simple horizontal air channel apparatus made with our own work is used for measurement of the propeller lift force under a stationary condition; a horizontal thrust is transformed to a vertical force by a pulley with a constant propeller angular velocity. When the propeller angular velocity is the same, we found the lift force observed in the actual BDF is systematically weaker than the lift force by the air channel experiment. This phenomenon is observed before the BDF reaches the maximum climbing velocity. The difference of the two lift forces tends to be larger in earlier time after launch, i.e., the lift force of actual BDF is depressed when its acceleration is large. The reason is ascribed to a back flow appeared in a non-stationary wing movement. In this experiment, features of non-stationary back flow effect have been clearly found and analyzed quantitatively.

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