Numerical investigation of water-running locomotion in the basilisk lizard using Smoothed Particle Hydrodynamics

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Abstract

Compared with aquatic animal swimming and aerial animal flight, running over the water accomplished by some moderately sized animals such as shore birds and basilisk lizards, as shown in Fig. 1(a and b), is a more challenging natural locomotion [1]. Beginning with a foot slaps the water surface, and then continues to stroke downwards, finally, pulls upwards (recover) and prepares for the next step, the fundamental phenomenon of water-running locomotion for those animals can be divided into three phases: 1) slap, 2) stroke, and 3) recover. In previous literatures [2-3], the qualitative description about water-running locomotion can be found, which usually focused on the experimental measurements based upon theoretical or mechanical model. But it is still not clear what the hydrodynamic response of the foot entering water is and how the complex mechanism of fluid flow works when those animals accomplish this marvelous feat.

This paper presents a study based on weakly compressible smoothed particles hydrodynamics (WCSPH) scheme, aiming at a detailed understanding of hydrodynamic mechanism involved in lizards' water-running locomotion and further quantitatively evaluating the effects of kinematic parameters that control lizard's water-running locomotion, such as foot length, stroking frequency and incident angle. A two-link rigid plate is considered as the leg-foot model mimicking the lizard's water-running locomotion. Then, a new method that incorporates the skinned-mesh technique into dynamic boundary condition of SPH scheme is introduced, by which the trampling motion of lizard's lower limbs is described. Through the obtained numerical results as shown in Fig. 1 (c and d), a new insight into understanding how the basilisk lizard runs over the water and their size-dependence of water-running ability is given. Moreover, based on the results of quantitative analysis, this study also suggests that the effects of incident angle on the lizard's water-running ability is not significant as that of the stroke frequency.

Keywords: Water-running locomotion; WCSPH; Basilisk lizard.

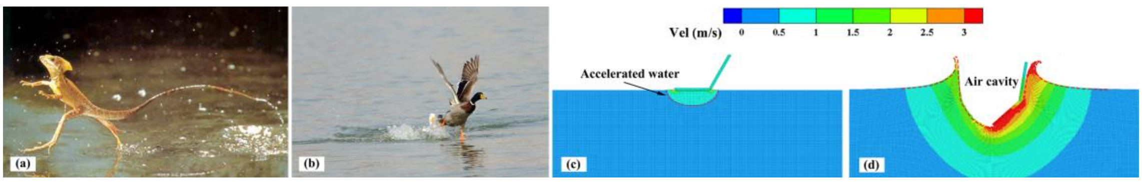

Figure 1 – Several moderately sized animals that have water-running ability and the numerical results. (a) Basilisk lizard; (b) Anas platyrhynchos; (c) slap; (b) stroke.

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