Unveiling the wake of a surface swimming snake

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Research on animal surface swimming has mainly focused on small insects or on animals that use limb-surface interactions for propulsion, such as ducks or geckos (see [1] , for a review). For the case of snakes, apart from the pioneering observations of Hertel [2] (cf. Fig. 1.A), no measurements appear to have been made.

We report here the results from a surface swimming experiment performed with *Natricidae* snakes (cf. Fig. 1.B), where the surface waves produced by the swimming snakes have been quantified by measuring the water surface elevation perturbation (cf. Fig. 1.B). Measurements were performed using a synthetic Schlieren imaging method that gives an instantaneous non-intrusive measurement of the height of the free surface η at every location in space.

Using a filtering technique based on the dispersion relation of capillary-gravity waves on the measured wave field we show that, remarkably, a significant percentage of the waves that compose the wake pattern travel in a direction opposite to the swimming direction . A contribution to the propulsive force of the animal from the waves is thus expected, so the surface wave wake of the snake is not solely a drag wake, despite its similarity with the Kelvin wake of a ship or a duck.

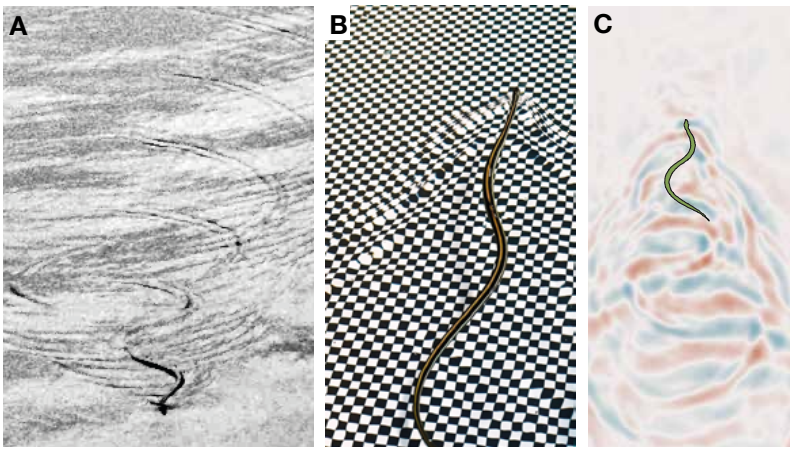

Figure 1. (A) Observation of the surface swimming of Natrix natrix by Hertel [2]. (B) Adult *Natricidae* snake swimming at the surface of the experimental tank at PMMH, ESPCI Paris (Photo: R. Godoy-Diana). The waves produced by the passage of the snake are visible on the checkerboard pattern used to measure the water surface height perturbation. (C) Example of the surface wake measured in the experiment.

References

1. J. W. Bush & D. L. Hu, Walking on water: biolocomotion at the interface, *Annu. Rev. Fluid Mech.*, **38**, 339 (2006).
2. H. Hertel, Structure, form, movement, (Reinhold Publishing, 1966) pp. 178-184..