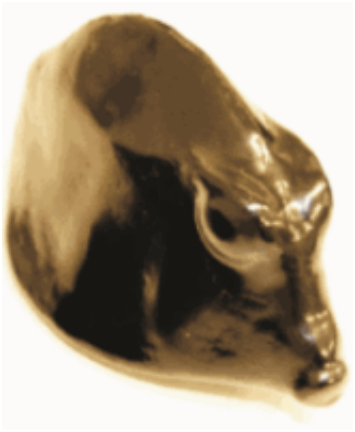
Has car manufacturer taken the corner too fast with the boxfish design?

January 6 2015



3-D print of a boxfish. Credit: University of Groningen

Billions of years of evolution have provided solutions for countless technical problems, while teaching designers and engineers a thing or two along the way. But now a car manufacturer has designed a concept model based on the supposed characteristics of the boxfish. Researchers at the University of Groningen have shown that their design is actually based on an incorrect interpretation of the characteristics of this fish. In this week's edition of the online journal *Interface* published by The Royal Society, they explain how they managed to solve the paradox surrounding the way these fish swim, together with researchers from Belgium and America.

Boxfish are covered in plate-like fused scales, which protect them from

predators. This solid carapace has two protruding ridges on the underside of the body. The triangular boxfish also has one ridge on the top, and the square variety has two ridges on the top.

Previous measurements and publications by an American research group claimed magical properties of these ridges in relation to the stability of the fish and their ability to stay on course while swimming. The supposed hydrodynamic characteristics of the fish even became the basis for a bio-inspired car design.

Paradox

Both characteristics actually contradict the lifestyle of these fish, which only swim very slowly and do therefore not need to be streamlined. As they display complex manoeuvring and take sharp corners when foraging for food on the coral reefs, they do not necessarily need to stay on course while swimming either. This apparent contradiction became known as the 'boxfish swimming paradox'. Researchers at the University of Groningen carried out tests in a flow tank, using realistic models constructed with a highly accurate 3D printer and based on 3D scans provided by their American colleagues. The tests showed that the triangular shape of the fish meant that the drag coefficient was much higher than had previously been assumed.

Course Instability

Torque measurements of the body models in the flow tank also failed to show self-stabilization in either the triangular or the square species. On the contrary, the body is very course instable and naturally tends to yaw and pitch when trying to swim straight ahead. The Belgian researcher taking part in the study supported these conclusions with computer flow simulations around the body of the boxfish, showing that the fish are

highly instable and need serious stabilization using their tail fin as a rudder in order to swim in a straight line. This finally resolves the boxfish swimming paradox: destabilizing turning moments make the boxfish highly manoeuvrable, which is entirely in agreement with their lifestyle on the coral reef.

More information: Boxfish swimming paradox resolved: forces by the flow of water over the body promote manoeuvrability. Van Wassenbergh S, van Manen K, Marcroft TA, Alfaro ME, Stamhuis EJ, 2015) J.R.Soc. *Interface* 12: 20141146. dx.doi.org/10.1098/rsif.2014.1146

Provided by University of Groningen