Swordfish lubricate heads for super-speedy swim

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Reminding us of a bygone era of duelling and chivalry, swordfish are some of the most charismatic creatures in the open ocean. Embellished with a rapier-like bill—which has been known to impale boats—and alleged to reach speeds of 100 km h-1, these animals have fascinated humans since the earliest civilisations. However, swordfish may be less fearsome than their anecdotal reputation would have us believe.

"They have no teeth", says John Videler from Groningen University, The Netherlands, who explains that they probably dine on squid. And their formidable proboscis may be less robust than you would first assume: "Last summer, an article by Maria Habegger [and colleagues] appeared in *JEB* [*Journal of Experimental Biology*]... and they were surprised to find that there is a very weak spot just at the end of the sword where it enters the head", says Videler. Intrigued by the fish's apparent vulnerability, Videler decided to revisit some MRI scans that he had collected 20 years earlier to identify the source of the fish's weakness.

The team publishes their discovery that the weakness is caused by a large oil gland situated at the base of the bill that lubricates the fish's head to reduce drag and make them super-fast in *Journal of Experimental Biology*.

Recalling that he first encountered the exotic animals in 1995 when he acquired a swordfish bill while teaching a diving course for biologists in Corsica, Videler eventually discovered that the sword reduces the amount of drag pulling on the fish as it sweeps through the ocean.

Roughness at the tip of the bill generates microturbulence in the water, to make it 'thinner' and reduce the drag, which improves performance. So, when some of Videler's fishermen friends offered him a pair of swordfish, Videler couldn't resist the urge to MRI scan an entire animal using Ben Szabo's medical MRI scanner in Groningen. "We started at 2 a.m. and went on to 4:30 a.m.", chuckles Videler, who remembers having to use large amounts of air freshener to make sure that the facility was ready for patients a few hours later.

Having returned to scrutinise the images 20 years later, Videler was astonished when the cause of the weakness was instantly apparent. "I saw this gland", says Videler, adding, "It was so big there was hardly any room for bony structure and the bone around it was very thin". However, the purpose of the gland wasn't initially clear.

Suspecting that the gland may be linked in some way to the nasal opening in the head, Videler and Roelant Snoek searched for evidence of a link with the fish's olfactory system, but found none. It was only when Snoek inadvertently dropped a lightbulb onto the fish's skin that the function of the gland was revealed. "All of a sudden he saw this network of vessels that were connected to the oil gland", says Videler. Next, Snoek, together with Deniz Haydar and Henk-Jan Hoving, examined the surface of the skin with scanning electron microscopy and discovered that the head was covered in tiny holes that were connected to the gland by the capillaries: "And then we found that by heating up the gland you could see oil come out of these tiny little holes", says Videler.

The gland that was responsible for the weakness at the base of the swordfish's appendage is probably lubricating the fish's head as it scythes through the water, and Videler suspects that the oil, in combination with microscopic rough projections on the skin, might produce a surface that is super water-repellent and could reduce the drag on the animal by over 20%. However, he admits that testing this theory would be difficult as

swordfish cannot be kept in captivity, so he is hoping instead to challenge physicists to test simulated swordfish skin to find out just how slick swordfish heads could be.

More information: Videler, J. J., Haydar, D., Snoek, R. Hoving, H.-J. T. and Szabo, B. G. (2016). Lubricating the swordfish head. *J. Exp. Biol.* 219, 1953-1956. DOI: 10.1242/jeb.139634