



Seahorses are the only bony fishes that permanently swim upright. Photo: Robert Harcourt

The Rise of Seahorses

BY PETER TESKE and LUCIANO BEHEREGARAY

Genetic data indicate that tectonic changes in Australasia and the associated formation of vast seagrass meadows may have driven the evolution of upright posture in seahorses.

Seahorses (genus *Hippocampus*) are unique among the bony fishes as they are the only ones that swim with an upright posture, with their heads held at a right angle to their bodies. When this unique feature evolved has been a complete mystery. Whereas the fossil record of their relatives, the horizontally-swimming pipefishes (genus *Syngnathus* and others), is reasonably good, seahorse fossils are exceptionally rare.

For a long time the only known seahorse fossils were those of *Hippocampus guttulatus*, a species that still lives in the Mediterranean and in the north-eastern Atlantic. In 2005, fossils of two much older and now extinct species were discovered in the Tunjice hills of Slovenia but these, too, were fully formed seahorses rather than primitive

transitional forms, suggesting that seahorses must have evolved earlier.

While the discovery of a fossil of the “missing link” would clarify the transition from a horizontally-swimming pipefish-like fish to the upright-swimming seahorse, such a fossil is not necessary to understand how seahorses evolved. Many pipefishes have changed little since their earliest appearance in the fossil record, and it is very likely that the “missing link” that gave rise to seahorses also has living descendants that still look very much like their ancestor.

Pygmy Pipehorses

Shallow algal reefs of the Indo-Pacific and Caribbean are home to creatures that look remarkably like what we would expect such a “missing link” to look like.

Just like seahorses, they have a prehensile tail that they use to hold onto vegetation, a tough exoskeleton consisting of bony rings, and fused jaws used to suck in small prey items. Like male seahorses, their males have a brood pouch in which they fertilise the eggs they collect from the females and in which they then brood their young. There is only one major difference – they do not swim upright.

Aptly named “pygmy pipehorses” to reflect that they look like a cross between a pipefish and a seahorse, the significance of these small fishes as a surviving evolutionary link between pipefishes and seahorses has largely been overlooked.

The pygmy pipehorses themselves can be divided into two major groups that seem to reflect different stages of evolution on the way to the seahorse. One occurs in the Indo-West Pacific (genus *Acentronura*) and the Caribbean (genus *Amphelikurus*), and its species look like short pipefishes. The other group (*Idiotropiscis*) has so far only been found in temperate Australian waters and, with the exception of an upright posture, its three species resemble seahorses to even the tiniest detail, even having a distinct neck region and a coronet (the crest or keel that seahorses have on top of their heads).

Late Oligocene Plate Tectonics

The similarity of the *Idiotropiscis* species to seahorses suggests that seahorses are really just upright-swimming pygmy pipehorses, and that the evolution of the upright posture must have occurred when the two groups split from their common ancestor. Also, the fact that *Idiotropiscis* is endemic to Australia suggests that this is where the first seahorses evolved.

Using “molecular dating”, a method that dates genetic differences that have accumulated between living species since they last shared a common ancestor, we found that the most recent ancestor of *Idiotropiscis* and *Hippocampus* lived during the late Oligocene, approximately

25 million years ago. Interestingly, this date coincides with the onset of some momentous tectonic changes in the region between northern Australia and Indonesia that may have had a strong influence on the establishment of the first seahorses as a new species.

The most important event during this time was the collision of Australia and New Guinea with the Eurasian continental plate, which resulted in the formation of vast shallow-water areas where there had previously been deeper water. The fossil record indicates that the fauna and flora of the region changed as seagrass meadows quickly established themselves throughout these new habitats.

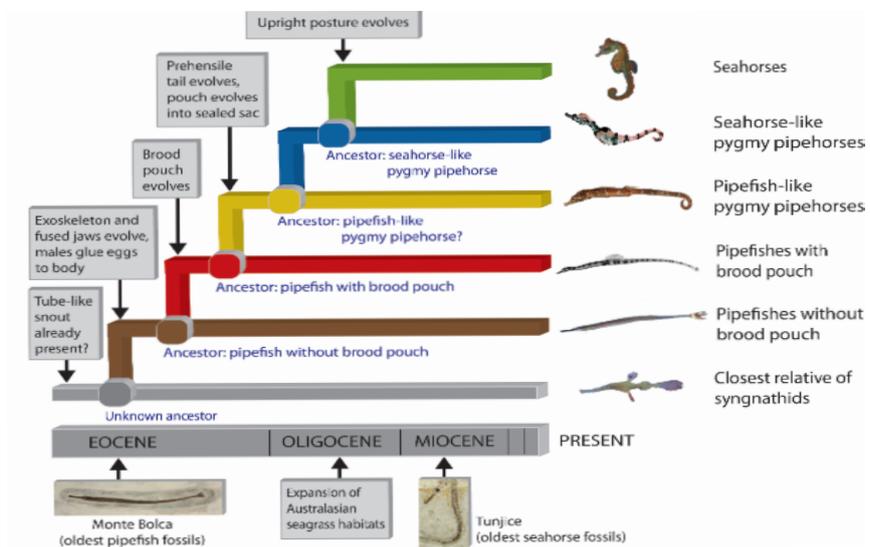
Moving into the Seagrass

How would the expansion of seagrass habitats have driven seahorse evolution? It is generally agreed that the most likely way in which new species can establish themselves is to be isolated from the species that gave rise to them. Not only does this prevent mating between the two, but it also prevents competition for the same resources and in that way allows the new species to increase in numbers and establish a viable population.

The new habitat that became available during the late Oligocene provided an opportunity for the new, upright seahorses to establish themselves permanently because the upright seagrass blades would have provided excellent camouflage for their bodies and in that way improved their ability to ambush prey and avoid detection by predators. Experimental data also indicate that seahorses can manoeuvre with ease through these highly complex habitats without getting entangled.

Seahorse Success Story

After benefitting from the rapid expansion of seagrass meadows in Australasia, seahorses gradually established themselves in tropical and temperate regions throughout the world. How they did this



A simplified reconstruction of the evolution of seahorses from a pipefish-like ancestor based on a combination of genetic data, fossils and the body structure of living species. Although some species have become extinct, the major stages of evolution are still represented in living species. The timing of only two evolutionary events is known with some certainty: the evolution of the first pipefishes and the evolution of seahorses. The placement of the pipefish-like pygmy pipehorses has yet to be confirmed by genetic data.

Photos: J. Zolohar, K. Havenstein, P. Heemstra, P. Teske; image of *Acentronura tentaculata* © Kanagawa Prefectural Museum of Natural History (Photo: Toshiyuki Suzuki). The image is available from FishPix (<http://fishpix.kahaku.go.jp/fishimage-e/index.html>)

is by itself extraordinary, seeing that they are exceptionally poor swimmers.

But perhaps exactly that was the secret to their success. Let's imagine a scenario in which a displaced pregnant male seahorse uses its prehensile tail to hold onto a clump of floating seaweed. This animal can potentially disperse to a new habitat at a great distance from its source habitat, and the large number of young in its pouch (hundreds in most species) can immediately establish a large, viable population. And although many seahorses today are still extremely common in

seagrass beds, many have diversified and can be found in a range of other habitat types such as coral reefs, which were still uncommon in Australasia during the time when seahorses evolved.

The seahorses' success in establishing themselves globally and in a variety of habitats stands in stark contrast to that of their *Idiotropiscis* relatives, which have remained in their temperate Australian algal reef habitats to this day.

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