TAXONOMY

Three into one will go

Rory Howlett

Striking instances of larval metamorphosis, and of adult sexual dimorphism, are not uncommon in the animal world. But especially dramatic examples of these phenomena have emerged from the deep sea.

One corner of the world of ichthyology has just become a little tidier. Writing in *Biology Letters*, Johnson *et al.*[1] report their investigations of representatives of three families of marine fish — which, they find, are in fact the larvae, males and females of a single family. The previous tripartite designation was understandable, however. Johnson and colleagues reveal that the larvae undergo extraordinary metamorphoses, through post-larval and juvenile stages, before becoming transformed into male and female adults that are themselves wondrously different in appearance and anatomy.

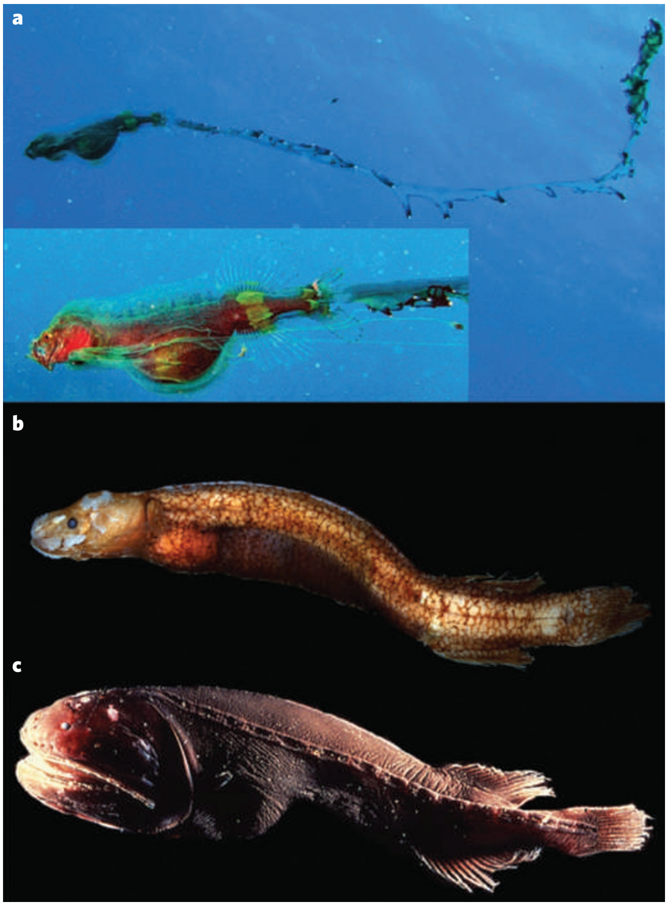

Figure 1 | All whalefish now — larval, male and female cetomimids. **a**, The post-larval stage; length is about 6 centimetres not counting the caudal streamer shown in the upper image. **b**, An adult male (5.8 cm). **c**, A juvenile female (7–9 cm).

A–C: D. HUGHES; G. D. JOHNSON; B. ROBISON/MONTEREY BAY AQUARIUM RES. INST.

The fish concerned are the tapetails, bignose fishes and whalefishes, which respectively are currently assigned to the families Mirapinnidae, Megalomycteridae and Cetomimidae. Johnson *et al.* have explored the possibility that the mirapinnids and megalomycterids are in fact pre-juvenile and adult male cetomimids, respectively. Their investigations involved study of fresh megalomycterids netted at depth in the Gulf of Mexico, as well as of museum holotypes of various forms, and molecular analyses of mitochondrial DNA (a holotype, or type specimen, is the original specimen from which the description of a new taxonomic group is made).

It turns out that the only known and holotype specimen of the deep-sea megalomycterid *Megalomycter teevani* is actually a 'transforming mirapinnid' — that is, a larva caught in the act of metamorphosis into the next stage. Its gonads are histologically male. Similarly, the holotype of the deep-sea mirapinnid *Parataeniophorus gulosus* is an early transforming male specimen, which would also have metamorphosed into a megalomycterid. It therefore seems that the previously 'missing' larvae of megalomycterids are mirapinnids.

Could it be that the larvae of cetomimids are also mirapinnids? It seems that the answer is yes. A whalefish, *Cetostoma regani*, caught in the deep southeastern Atlantic, is shown to be a late transforming female morphologically linked with larvae/post-larvae of the mirapinnid *P. gulosus* and males of the megalomycterid *Cetomimoides parri*. This implies that *P. gulosus* (larvae), *C. regani* (adult females) and *C. parri* (adult males) actually belong to a single taxon, thereby uniting the cetomimids with the two other families.

Johnson *et al.* conclude, then, that tapetails, bignoses and whalefishes are in fact larvae, males and females of members of the family Cetomimidae. This conclusion is consistent with the authors' evolutionary analysis of mitochondrial-genome sequence data. A task now — and no easy one — will be to find, identify and match up the larvae and adult males with the 20 described species of whalefish. Right now, there do not seem to be enough tapetails (mirapinnids) and bignoses (megalomycterids) to go round.

The extraordinary morphological transformations involved give rise to extreme sexual dimorphism in the adults. The differences in morphology and habit between larvae, males and females are associated with different feeding mechanisms — or lack of them.

Larvae have small, upturned mouths and feed on copepods in the food-rich, sunlit surface waters. Johnson *et al.*[1] suggest that the long streamers arising from their caudal fin (Fig. 1a) may be involved in feeding or avoiding predators. Males (Fig. 1b) live down in the nutrient-poor bathypelagic zone (depths of 1,000–4,000 metres) and lose the ability to feed: their upper jaws become immobilized, and their stomach and oesophagus disappear. Instead, a ball of copepods in the gut of a transforming male is converted into a massive liver, which then sustains the male through adulthood. Females also live at depth. But they develop specialized gill arches, large horizontal jaws and huge gapes (Fig. 1c). These adaptations allow mature females to capture larger prey and to attain larger body sizes.

Extreme sexual dimorphism is, for example, also found in certain deep-sea anglerfishes. The females look as 'normal' as anglerfishes are capable of looking, and do the angling with a lure attached to their head. But the tiny, atrophied males lack a digestive system and live parasitically on the female, with which they fuse[2]; they are nonetheless male enough to provide sperm for reproduction. An example of dimorphism from the invertebrates is that of 'zombie worms' of the polychaete genus *Osedax*[3]. Females feed on the bones of whale carcasses that have fallen to the sea floor. But the males — little more than sacks of sperm — live inside the females, and barely develop beyond the larval stage.

As Johnson *et al.*[1] point out, remarkable transformations occur in other deep-sea inhabitants, such as telescopefishes of the family Giganturidae. But a claim they make may well be justified — that the combination of radical larval metamorphosis with extreme adult sexual dimorphism in the now unified Cetomimidae is unparalleled within the vertebrates. ■

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