Deep-sea anglerfish reproduction

Nature's Example of a Total Reduction in the Role of Males: A Review on Deep-sea Anglerfish Reproduction

Introduction

The Deep Ocean

Waters that cover ocean basins constitute the largest living space on earth. This immense environment is home to the largest animal communities on the planet-largest in terms of biomass, numbers of individuals, and area extent (Robison, 2004). Despite its obvious significance to the biosphere, the ocean's deep interior remains an unexplored frontier. Although physical and chemical properties of oceanic water vary greatly within the upper kilometer, at greater depths these properties remain relatively constant (Robison, 2004).

The deep pelagic habitat is a vast volume of cold, dark water where food is scarce and bioluminescence is the principal source of light and communication.

Physical Appearance

Anglerfish belong to the order Lophiiformes. Named after their unique mode of predation, in which they use a fleshy outgrowth sprouting from the middle of their head to attract prey, much like a fishing lure. This act is similar to the act of angling, thus the name anglerfish.

Deep sea anglerfish has a vicious appearance; however they are not too big in size. They have earned the name " common black devil" due to their unsightly features. They have a large mouth with sharp, fang-like teeth. They can reach to about 12cm in length (Bora, 2010). Their bodies are globular and they are not adapted for sustained rapid swimming, these are designed for remaining motionless most of the time (different reference). Their body color ranges from dark gray, brown, or black. Their skin reflects blue light, which helps them remain invisible to other deep sea creatures, as most of them emit blue light. Their bodies are fragile and have no scales. In fact, their thin skin can slip off their bodies whenever touched by human hands when they are retrieved from deep sea nets. Their muscles are flabby and they have weak skeletons. Their C-shaped gill slits are very small and are placed below the pectorals (different reference).

The eyes of the deep sea anglerfish are too small. They possess one or more long filaments that spring from the center of its head. These so-called filaments are modified spines of the anterior dorsal fin. The longest filament is usually the first spine, or the illicium, which protrudes above the eyes and terminates in an irregular mass of flesh at the tip of the spine, the esca. This filament, which serves as a lure, can be moved back and forth (Bora, 2010).

Predation

In the deep ocean, food is rare and unpredictable compared to the more reliably available food in the open water. Thus, deep sea animals develop certain strategies to find food and ways of eating whatever food they may encounter with as little effort as possible. Most of the deep sea animals prefer to wait for the arrival of their prey or food particles rather than searching actively for them. Moreover, most of these animals are not selective in their diet and cope up with amazingly large prey (Bora, 2010).

Female anglerfish are the classic lurk-and-lure predators. They have a huge mouth and their teeth are large compared to their body size. They rely on their luminous lure to attract their prey instead of searching actively for them. Moreover, these animals can accommodate very large prey through their expandable jaws, which can open up twice as wide, and elastic stomach, which allows them to eat any prey available (Bora, 2010).

Their most amazing feature is their bioluminescent lure. The lure of deep sea anglerfish are more elaborate compared to shallow water species, since these are used to attract prey in the dark. These lures are modified dorsal fins and bioluminescence is caused by bacteria, which produce a bluish, greenish light (Bora, 2010).

The light and movement of the lure attract the prey to within reach of the gaping jaws. The anglerfish Cryptopsaras can slide the rod part of the apparatus back into a groove, drawing the lure and prey closer to the mouth. It can rotate the lure tip and produce a flash from it as well as a glow. All this is controlled by enzymes and the contraction of chromatophores.

These lures have sensory filaments, papillae, light pipes, and shutters.

The lures of deep sea anglerfishes are extraordinary elaborate, with sensory filaments, papillae, light pipes and shutters. It may be that different species mimic different kinds of small prey like shrimps to attract larger prey. One anglerfish (Caulophryne) has a lure ornamented with many filaments but it is not luminous. An other (Linophryne) has not only a luminous lure on the head but also a multibranched barbel hanging from the lower jay. The barbel filaments contain many more bioluminescent organs.

Some position their lure inside their mouths.

Some deep sea anglerfish have positioned their lure inside the mouth. The wolftrapangler Thaumatichthys axeli is a sit-and-wait ambush predator with a luminescent lure hanging from the roof of his overshot mouth, which is fringed with hooked sharp teeth. This anglerfish hovers just above the substrate (not sitting on it).

To attract in prey, it waves its lure back and forth till the prey comes closer to its mouth. There is a specialized spine attached to the lure, which can be moved in any direction. When the prey touches the mouth, the esca, which is connected with the mouth reflex, causes the anglerfish to instantly snap the prey with its powerful jaw and swallow it. Moreover, the teeth of the prey are bent inwards so as to prevent the prey from escaping once it enters the mouth. They can take in prey twice their size due to their thin and flexible bones causing the jaw and stomach to extend to an incredible size (Singha, 2010).

Reproductive biology

Sexual Dimorphism

Sexual dimorphism describes animals where there is a physical difference between males and females of the same species (BBC).

In most species the female deep sea anglerfish is much larger than the male anglerfish, actually they are real dwarfs compared with their mate. For example the largest females of the genus Gigantactis grow to 40cm in length, whereas the largest males only grow to 2cm. Unlike their sluggish partners they have muscular bodies for active swimming. For many years fish biologists were very confused by these differences and misidentified male and female anglers as completely different species (Zubi, 2010).

Sexual Maturity

The male deep sea anglerfish mature sexually soon after reaching metamorphosis, in females it takes a much longer time (Zubi, 2010).

Extremely young parasitized females of Cryptopsaras couesii indicate that females of this species are able to elicit a search response in a conspecific male, as well as provide cues for specific identification by the male at a very early age (Pietsch, 2005).

Sexual Parasitism

In sexual parasitism, the dwarfed males become permanently attached to much larger females. This is a remarkable mode of reproduction unique to some members of the deep sea anglerfish suborder Ceratioidei (Pietsch, 2005).

There is no mechanism that prevents additional males from becoming attached to a previously parasitized female, but Linoohryne (and perhaps Caulophryne), in which multiple attachments have so far not been found, might be a nexception to this rule. Multiple attachment is rare in Ceratias and Borophryne (only a single record of two males in each case), but common in Cryptopsaras and Haplophtyne, which are known to have as many as eight and six males, respectively (Pietsch, 2005).

Males are almost invariably attached upside down and facing forward with respect to the female, and almost always on the ventral midline of the belly of the female, somewhat anterior to the anus; exceptions include those of

Cryptopsaras, Haplophryne, and Photocorynus, which may be found almost anywhere on the head and body, and oriented in any direction (Pietsch, 2005).

Six of the seven known parasitically attached males of Neoceratias spinifer lack openings to the pharynx leading to the gills and opercular openings, which are present in the area of attachment of nearly all previously described examples of attached males (exceptions include several attached males of Haplophryne mollis). The gills of these Neoceratias males, however, are as well developed as those of free-living males of other ceratioid families, indicating that sufficient oxygen is probably not available via the blood of the female and that this gas is extracted by water that is pumped in and out through the opercular openings (Pietsch, 2005).

A dual mechanism for mate location and speciesspecific selection probably functions in most ceratioids, in which both eyes and olfactory structures of the freeliving males are well developed, but it is highly unlikely to function in the ceratiid genera Ceratias and Cryptopsaras, in which the nostrils are surprisingly small and undeveloped, and in Centrophryne and the gigantactinid genera Gigantactis and Rhynchactis, in which the eyes are very much reduced. The mechanism by which males of Neoceratias (in which the eyes and nostrils are especially small and degenerate) find females (which apparently lack bioluminescent structures) remains a mystery (Pietsch, 2005).

Modes of Reproduction

Temporary nonparasitic: Melanocetus johnsonii and Melanocetus murrayi

Males of the Melanocetidae, Himantolophidae, Diceratiidae, Gigantactinidae, and several of the better known oneirodid genera (for example, Oneirodes, Microlophichthys, Dolopichthys, Chaenophryne, and Lophodolos, each now known from well over 50 females), probably never become parasitic. Spawning and fertilization may take place during a temporary sexual attachment that does not involve fusion of male and female tissues (Pietsch, 2005).

The parasitic mode of reproduction is apparently obligatory in Ceratias, Cryptopsaras, Borophryne, Haplophryne, and Linophryne, and, although sufficient data are lacking to say for certain, probably in Neoceratias as well. Males of those taxa in which sexual parasitism is obligatory apparently never mature unless they are in parasitic association with a female, and, likewise, females never become gravid until stimulated by the permanent parasitic attachment of a male. That sexual maturity is determined not by size or age in these fishes, but by parasitic sexual association, may well be unique among animals (Pietsch, 2005).

Among those taxa in which parasitism seems to be obligatory, the number of parasitized females in collections around the world is surprisingly small compared to the total number of known specimens: about 6% in Cryptopsaras, 11% in Ceratias, 16% in Photocorynus, 33% in Haplophryne, and 40% in Borophryne (Pietsch, 2005).

Sexual parasitism is probably facultative in Caulophryne and in the oneirodid genera Bertella and Leptacanthichthys (Pietsch, 2005).

The remaining ceratioid families, Thaumatichthyidae and Centrophrynidae, are still so poorly known that little can now be concluded concerning their mode of reproduction (Pietsch, 2005).

Reproductive Cycle

The deep sea is a vast area and with a small number of animals spread thinly in such an area, it can be difficult to find a mate. Thus, deep sea anglerfish have devised a way through the process of evolution, to continue the propagation of their species through sexual parasitism (Zubi, 2010).

Once a male anglerfish is born it directly searches out for a female. Male anglerfish probably do not feed due to the lack of a bioluminescent lure. Instead their eyes and olfactory organs are large (Zubi, 2010).

Once the male anglerfish finds a female, he will attach himself to her body usually by biting her belly. Once attached, the teeth and jaws draw back and the skin and blood systems of the male and female merge. Now the male becomes a parasite to the female, not needing to find food for him. Thus, the intestine regress and the only important organ within the male is his large testis. This time the female has a guaranteed supply of sperms while the male relies on the female for food and living (?).

It is the female who probably controls the sperm delivery via her hormones, therefore, it is connected with the moment she ejects her eggs from her body. The fertilized eggs contain large oil droplets for buoyancy for floating to the surface of the ocean (Zubi, 2010).

As soon as the male detects the presence of a female in his vicinity, he bites or latches onto her with his sharp teeth. Thereafter, the male releases an enzyme that works to digest the body of the female and the skin of the male's mouth. Overtime, this process goes on to a physical fusion of the pair down to the blood-vessel level. Then begins the process of the male undergoing atrophy or degeneration. Meaning, the male starts losing his digestive organs, its brain, heart, eyes and all other internal organs, until he is left only with his pair of testicles. These testicles are used to release sperm in response to the female's hormones indicating egg release. In this way, about 6 male angler fishes can be borne by a single female, throughout its life time, providing her a lifetime supply of sperm for fertilization (Singha, 2010).

The female anglerfish can carry up to six males on her body. This bizarre method of reproduction makes sure that when the female is ready to spawn, she does not have to look for the male, as he is already available. After fertilization, the female lay the eggs in a thin sheet of transparent gelatinous material, which can be 2 to3 feet wide and about 25 to 30 feet long. This sheet with the eggs floats in the sea, till the eggs hatch into larvae. The larvae usually feed on the surface of the sea, until they mature (Bora, 2010).