Male seahorses are nature's Mr. Mom, researchers say

Male seahorses are nature's real-life Mr. Moms – they take fathering to a whole new level: Pregnancy. Although it is common for male fish to play the dominant parenting role, male pregnancy is a complex process unique to the fish family Syngnathidae, which includes pipefish, seahorses and sea dragons.

Texas A&M University evolutionary biology researcher Adam Jones and colleagues in his lab are studying the effects of male pregnancy on sex roles and sexual selection of mates and are trying to understand how the novel body structures necessary for male pregnancy evolved. By doing this, the researchers hope to gain a better understanding of the evolutionary mechanisms responsible for changes in the structure of organisms over time.

"We are using seahorses and their relatives to address one of the most exciting areas of research in modern evolutionary biology: the origin of complex traits," Jones said. "The brood pouch on male seahorses and pipefish where females deposit eggs during mating is a novel trait that has had a huge impact on the biology of the species because the ability for males to become pregnant has completely changed the mating dynamics."

When seahorses mate, the female inserts her ovipositor into the male's brood pouch (an external structure that grows on the body of the male) and deposits her unfertilized eggs into the pouch. The male then releases sperm into the pouch to fertilize the eggs. "It wouldn't be that interesting if the brood pouch were just a flap of skin where the females put regular fish eggs and they developed in the bag instead of on the sea floor," Jones said. "But the male pregnancy in some species of seahorses and pipefish is physiologically much more complex than that."

After the female deposits her unfertilized eggs into the male, the outer shell of the eggs breaks down, and tissue from the male grows up around the eggs in the pouch. After fertilizing the eggs, the male closely controls the prenatal environment of the embryos in his pouch. The male keeps blood flowing around the embryos, controls the salt concentrations in the pouch, and provides oxygen and nutrition to the developing offspring through a placenta-like structure until he gives birth.

Male pregnancy has interesting implications for sex roles in mating, Jones explained, because in most species, males compete for access to females, so you usually see the evolution of secondary sex traits in males (for example, a peacock's tail or antlers in deer). But in some species of pipefish, the sex roles are reversed because males become pregnant and there is limited brood pouch space. So females compete for access to available males, and thus secondary sex traits (such as brightly colored ornamentation) evolve in female pipefish instead of males.

"From a research standpoint, it's interesting because there aren't very many species in which there is a sex role reversal," Jones said. "It provides a unique opportunity to study sexual selection in this reversed context."

To study the mating behavior of seahorses and pipefish, Jones' lab uses molecular markers for forensic maternity analysis to figure out the mother of a male's offspring. The lab found that gulf pipefish mate according to the "classic polyandry" system, where each male receives eggs from a single female per pregnancy, but females can mate with multiple males. Because attractive females can mate multiple times,

this system results in very strong competition in sexual selection, and female gulf pipefish have evolved strong secondary sexual traits, Jones said.

Seahorses, however, are monogamous within a breeding season, and each seahorse only mates with one other seahorse. In this system, if there are equal sex ratios, there is not as much competition among females because there are enough mates for everyone, Jones explained. So seahorses have not evolved the strong secondary sexual traits that pipefish have.

Male pregnancy also results in a reversal in sex-related behaviors, Jones said. “Females exhibit a competitive behavior that’s normally a male-type attribute, and males end up being choosy, which is normally a more female-type attribute,” he said. His lab studies the evolutionary steps leading to that reversal in behavior and the role that hormones play in the change.

Jones’ lab also studies how the brood pouch first evolved in seahorses and pipefish. “A big question in evolutionary biology is how a novel structure gets all of the necessary genes and parts to function,” Jones said. “So we are trying to understand how the brood pouch and the genes required for male pregnancy arose over evolutionary time.”

One of the interesting things about the brood pouch is that it appears to have evolved independently multiple times. There are two major lineages of seahorses and pipefish – trunk-brooding and tail-brooding – and the brood pouch structure independently evolved in each of these groups, Jones said.

Another area Jones’ lab is researching is the evolutionary steps that led to the unique overall shape of seahorses. “How do you go from just being a regular-old looking fish to being something really unusual like a seahorse?” Jones said. “There are a lot of evolutionary steps involved in that.”

Jones explained that the first step in the evolutionary process was the elongation of the fish’s body, which the lab is currently studying. The next step was the addition of other unique structural features that seahorses possess, such as the bending of the fish into its unique shape. The head of a seahorse is unusual because unlike most fish, a seahorse’s head is at a 90-degree angle to its body, Jones explained. Seahorses also have a prehensile tail, meaning that, unlike most fish, they can use their tail to grasp onto things.

“These are all interesting changes, and we’re interested in studying how these novel traits arose and the evolutionary steps that led to them,” Jones said. “Ultimately, we hope to gain deeper insights into some of the evolutionary mechanisms responsible for the incredible changes in the structure of organisms that have occurred during the history of life on Earth.”

Source: Texas A&M University