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10/16/17

Takifugu niphobles

Introduction: The *Takifugu niphobles* or the Grass Puffer is a small fish that resides in the shallow waters of the Northwest Pacific Ocean. The scientific name of the fish comes from the Japanese words of *taki* meaning waterfall and *fugu* meaning venomous fish (Torres, Armi G., et al). The *Takifugu niphobles* is part of the family Tetraodontidae which encompasses all puffer fish and are known for their ability to inflate like a balloon. The fish do



this by quickly sucking water into their stomachs causing them to inflate and causing the flat lying spines which cover their bodies to become erect. Their diets consist of a wide array of small crustaceans and mollusks (Practical Fishkeeping, 2010). *Takifugu niphobles* are one of the two most common fish in the Northwest Pacific Ocean and are often accidentally caught by fishermen who employ the bottom longline technique (Shao K, et al., 2014). The sale of these fish, including other puffers, are banned in Japanese markets due to their highly toxic nature. Yet, puffer fish are considered a Japanese delicacy despite the fact that a wrong cut of meat can kill a fully grown man. Upwards of thirty to fifty people are affected by the toxin every year and chefs must undergo two years of training before they can legally sell the fish (Dan Bloom 2015). These fish have a very unique means of reproduction, in which they swim towards the shore and lay

their eggs on the beach. The fish then, with the help of the waves, beach themselves and fertilize these eggs. There are multiple variables which incline the *Takifugu niphobles* to lay their eggs on particular beaches which include wave size, sand granule size, and downward angle of beach (Kazunori Yamahira 1997). Grass Puffers are known to be used in clinical research pertaining to genomics due to their unusually small genomes (Practical Fishkeeping, 2010).

Ecology: The *Takifugu niphobles* is primarily found all along the coasts of the Pacific Northwest, ranging from as far north as Japan all the way down to the Philippines. They



often live in shallow water but have been recorded swimming in water reaching depths of twenty-meters. Grass Puffers prefer to be in water at approximately 20-25 degrees celsius and they mainly feed on a wide array of copepods, amphipods, isopods, mysids, and other crustaceans as well as insects (Practical Fishkeeping 2010). These fish spend almost their entire lives, including maturation and reproduction, living in seawater (Akira Kato, et al., 2010). *Takifugu niphobles* like ocean floors with sand or pebbles, yet are known to often swim into brackish water. Grass Puffers can

briefly travel into freshwater for up to 2 days (Akira Kato, et al., 2010). This is called being a peripherally freshwater fish, and there are many advantages gained from this ability

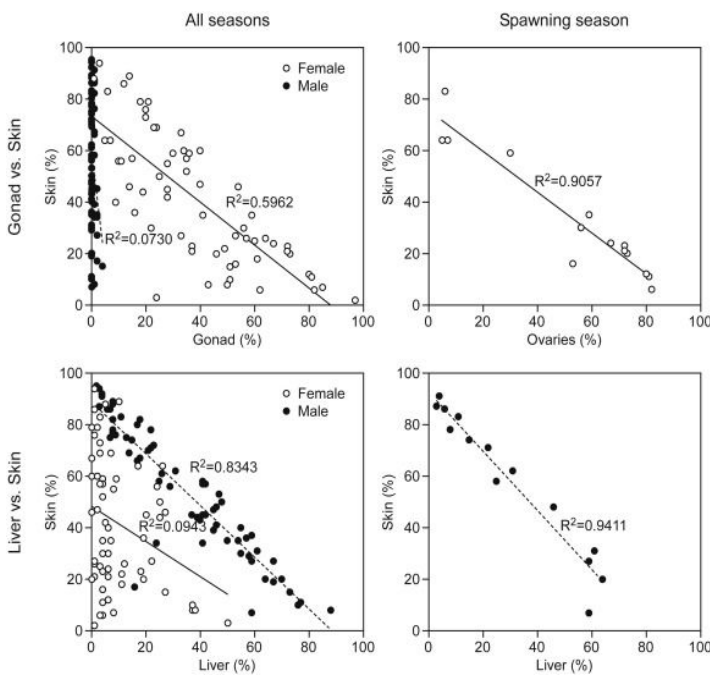
Akira Kato, Yukio Maeno, and Shigehisa Hirose carried out a study in 2010 attempting to understand the advantages the *Takifugu niphobles* would gain while actively traveling out of their primary habitat. There are three primary reasons a fish would migrate: refuge, reproduction, and feeding. Since the Grass Puffer has no

naturally occurring predators due to the tetrodotoxin which runs throughout their bodies, the function of migrational refuge can be eliminated. When placed in tanks of freshwater, saltwater, and brackish water, the *Takifugu niphobles* didn't feed in only one tank: the freshwater one, therefore migrational feeding can be ruled out. It is well documented that these fish breed in groups and on beaches, therefore migratory reproduction can be ruled out. It was concluded that there were two reasons the fish were traveling to brackish and freshwater. The first being that the exposure to brackish water cause the fish to stimulate mucus cells and secrete defense molecules. The second being that pathogens found within *Takifugu niphobles* die when exposed to freshwater. Moreover, fresh water is known to help the healing process of saltwater fish (Noga EJ 2000). Therefore, it was deduced that these health benefits gave an evolutionary advantage to *Takifugu niphobles* that could survive in brackish and freshwater (Akira Kato, et al., 2010).

Anatomy and Defense: The *Takifugu niphobles* is a part of a family of fish nicknamed Puffers due to their ability to quickly gulp water into their abdomens and ultimately increase their size by more than two fold (Seattle Aquarium 2013). The grass puffer in particular has incredibly tough skin which is covered in very small spines (Shao K, et al., 2014). This mechanism is triggered when the puffer feels threaten and is used to deter predators. Although effective, this rapid increase in size can put great stress on the fish and be very painful which is why puffers practice stretching their skin. Although a trademark mechanism of puffer fish, this is not the *Takifugu niphobles* primary form of defense against predators.



The puffer's main line of defense is one much more subtle, yet it is respected and feared throughout the animal kingdom. Almost all tetraodonis have tetrodotoxin, a powerful neurotoxin that causes paralysis, seizures and often death (Seattle Aquarium 2013). The tetrodotoxin has no known antidote and is 1,200 times more toxic than cyanide. One puffer fish contains enough poison to kill up to 30 humans (National Geographic). The *Takifugu niphobles* ovaries, intestines, and liver are incredibly toxic, the skin is very toxic, and the flesh and testes are less toxic (Shao K, et al., 2014). About 60% of individuals that are diagnosed with tetrodotoxin poisoning pass away and as little as one to four milligrams can cause death (Toxnet: Toxicology Data Network). A study carried out by Shiro Itoi, of the Department of Marine Science and Resources at Nihon University, an accomplished *Takifugu niphobles* scientist, and a group of his peers concluded that the fish can even implement tetrodotoxin into their larvae in order to fend off predators (Itoi et al., 2014). During predation experiments, organisms that tried to consume the larvae almost immediately spat them out. It was later revealed in



the study, through Liquid Chromatography-Tandem Mass Spectrometry that there was a non-lethal amount of toxin found in the eggs. Tetrodotoxin is also used by *Takifugu niphobles* to attract fertile mates (Itoi et al., 2014). Another study carried out by Shiro Itoi aimed to understand the seasonal changes of tetrodotoxin concentration in male and female Grass Puffers. It was concluded that the concentration was significantly higher in both male and

female fish during spawning and maturation periods: for males primarily in the liver and skin and for females primarily in the ovaries and liver. The cause of the increase in

concentration during these periods was inconclusive, but those who carried out the experiment believed that the toxin was not used for defense, rather as a pheromone to attract a fertile partner (Shiro Itoi 2016).

Takifugu niphobles are easily identifiable by their dark green and white polka dotted tops and white underbellies (Flickriver, 2010). This is an example of countershading: the dark green top allows them to blend into the ocean floor and hiding from predators from above. Whereas the white bellies blend in with the



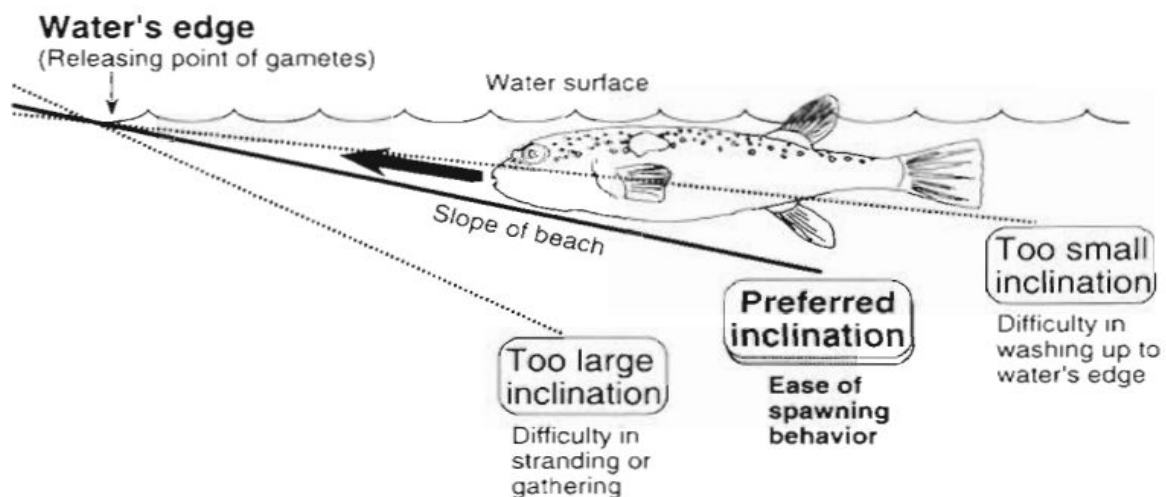
rays of light coming from above and allow them to sneak up on prey. *Takifugu niphobles* is one of the smallest kinds of fish in the genus *Takifugu* and only reaches sizes of 10-17 cm long (Akira Kato, et al., 2010).

Reproduction: The *Takifugu niphobles* is known as an intertidal breeder meaning that it releases eggs and sperm on beaches with pebbles and rocks (Shao K, et al., 2014).



The fish use waves in order to propel themselves on the beach and then use tides to bring themselves back in. Mating season usually lasts a little more than a month yet the time of year is widely dependent on the area in which the *Takifugu niphobles* is spawning. At Fukiage Beach, Aikawa Town on Sado Island in the sea of Japan,

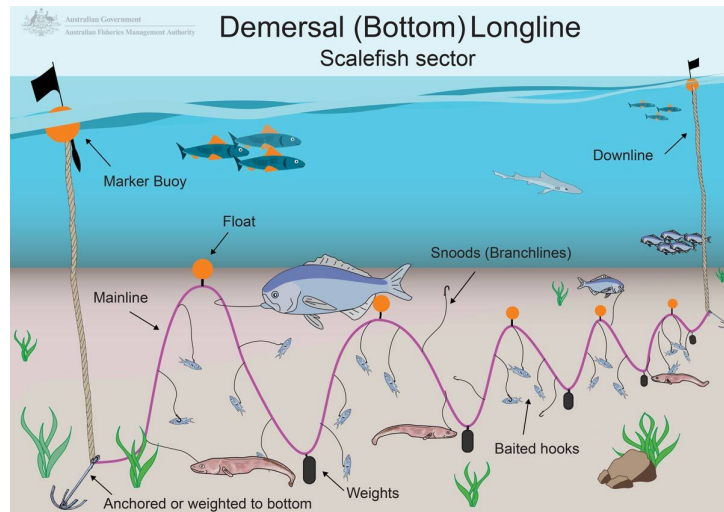
the mating season was recorded to be between early June and late July (Yoshiharu Honma 1979). Males generally tend to outnumber females during spawning seasons and therefore group around one female. The fertilized eggs are also brought back to the water by the tides, yet they often become stuck under rocks and cannot find their ways back to the ocean (Shao K, et al., 2014). There are many different factors which make a beach attractive to fertile *Takifugu niphobles*. This was explored by Kazunori Yamahira of the Amakusa Marine Biological Laboratory at Kyushu University Tomioka. Yamahira looked at seven different beaches used by *Takifugu niphobles* as spawning grounds and compared each, looking for both similarities and differences. The first conclusion he drew was that the *Takifugu niphobles* were attracted to beaches with varying angles of inclination with the mean being 6.68° to 11.30° . This was classified as a moderate slope and was concluded to be the optimal. Beaches with slopes being too small would prove too difficult for *Takifugu niphobles* to strand themselves on. Beaches with slopes being too great would prove to be difficult to stay stranded on. Therefore, moderate beach slope was proved to be optimal for *Takifugu niphobles* spawning (Shao K, et al., 2014). The second variable Yamahira tested for was substrate type at the beach. He concluded that this had no effect on *Takifugu niphobles* spawning due to the wide array of tested spawning site substrate types. Every kind of substrate from beaches with



boulder substrates to sand substrates were tested and there was no notable contrast between each. The third variable Yamahira tested for was wave size. He found that

although small variations in wave size had no effect on spawning rates, during stormy days no spawning was observed, implying there is an upper limit at which when reached halts reproduction (Shao K, et al., 2014). Moreover, the Grass Puffer is able to determine optimal condition for beaching and mating while waiting in deeper waters.

Human Interaction: The *Takifugu niphobles* is by no means a game fished and is never caught for sport or for food. These fish are often caught accidentally by fishermen employing the long line technique (Shao K, et al., 2014). This entails a long rope with many different baited hooks



along the sea bed. However, Yu-Ru Huang, Mei-Chin Yin, You-Liang Hsieh, Yen-Hung Yeh, Ya-Chen Yang, Yun-Lung Chung, and Cheng-Hong Euan Hsieh carried out an experiment in which they tested for *Takifugu niphobles* and other kinds of puffers in processed fish products found in Taiwanese fish markets. Of the fifty different products tested and twelve different species of puffer fish (*Takifugu niphobles* being one) a total of fourteen percent contained puffer fish when clearly marked otherwise. Moreover, twenty eight percent of the puffers found in these products were poisonous puffer fish. This study was carried out to further improve testing methods of food products in order to control false labeling (Yu-Ru Huang 2014).

Takifugu niphobles are not known to be targets of aquaculture, yet since a decrease in the populations of *Takifugu* due to overfishing, their demand has gone up (Shao K, et al., 2014). The efforts of those in east asia have focused on repopulation through aquaculture and have produced genetically distinct fish from those found in the wild. Yet, breeding proves difficult due to the nature of their reproductive mechanisms

and due to their carnivorous nature. Grass Puffers are aggressive fish and don't do well in tanks (Practical Fishkeeping, 2010).

Conclusion: The *Takifugu niphobles* is one of the most common and small fish on the eastern shores of Asia. It has an array of defenses that allow it to survive against predators. These fish contain tetrodotoxin which is vital to their survival. The neurotoxin not only protects the adults and allows them to live longer and therefore reproduce more, but it also is implemented into their eggs, preventing predators from feasting on offspring. Their ability to swim into fresh and brackish water is also very useful and aids in their survival. There are a plethora of advantages gained from the *Takifugu niphobles'* ability to enter different habitats including, stimulation of mucus cells which secrete antibodies and the sanitation of pathogens from the fish's body. The Grass Puffer also has a unique way of mating in which eggs are fertilized on the beaches and not in the water. This requires them to stay in shallow water and in close vicinity to land. Over time the fish have learned which beaches have optimal inclination and wave activity for breeding. Although small, the *Takifugu niphobles* is packed full of evolutionarily advanced features and proves to be a formidable survivor and breeder in the teeming waters of the Pacific Southwest.

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