

# 10

## Tadpoles That School Like Fish



Schooling *Phyllomedusa vaillanti* tadpoles. Photo by Bill Magnusson.

When I returned to Manaus after my first trip to Santarém, I met Lyn Branch, who had been working as a Peace Corp volunteer with the Brazilian conservation and forestry agency IBDF. Although she had been in Brazil only about a year, her experience and command of Portuguese were much greater than mine. She had been doing a survey of the fauna of the Amazon National Park near Santarém for IBDF, and had brought her specimens to be deposited in the collections of the National Institute for Amazonian Research - INPA in Manaus, where I worked.

Lyn was thinking of writing a popular account of the fish markets in Manaus and invited me to accompany her on one of her visits. I had been to the commercial center of Manaus and sometimes ate at the restaurant in the Adolpho Lisboa Municipal Markets that are said to have been based on the Mercado de Les Halles in Paris. The wrought iron facades and view over the Rio Negro make it one of the most popular tourist destinations in Manaus. However, I had only been there during the day and early evening, and Lyn wanted to go late at night.

The tropical heat of Manaus was a problem for the fish markets in the late 1970s because refrigeration was based on ice chests, and few establishments had refrigerators. The Council had a rule that the fish to be sold that day could only be disembarked after midnight. The small wooden boats with their cargoes of fish were anchored close to shore and everyone waited for the bell to ring at midnight to indicate that they could bring in the fish.

We went well before midnight and had dinner at one of the little stalls that had been erected beside the road. I would never consider eating uncooked food at such a place, but the fish baking over the coals in the little barbecue made from a car wheel had obviously been heated well above the temperature that would kill any bacteria. The jaraqui served with farinha on an aluminum plate was very tasty. Like many freshwater fish, jaraquis are so bony that you cannot

eat them without prior treatment. The fish had been *ticada*, which means that parallel cuts had been made every few mm along the sides, extending from both sides to the backbone, so that all the small bones had been cut into tiny pieces that could be swallowed.



**Photo 10.1** Fishermen waiting for midnight so they could bring their fish to the Manaus market in 1979. Photo by Bill Magnusson.

The vender washed the plates and cutlery in a plastic bucket beside the stall. I didn't think about where the water came from until the cook's assistant threw out the water and went to the shore to get more. Carefully pushing aside the dead fish and human feces floating on the surface, he dragged up a pail full of water. I looked down at the heat sterilized fish lying on the plate that had just been washed in that water and realized that I would have to rely on the resistance of my gut flora rather than any sterilization process if I was to eat at the market.

The distance from the boats to the trucks and stalls where the fish would be sold varied depending on the height of the Rio Negro. At some times of the year, the beach was over 100 m wide, and at others the buyers had to move back as the river water flooded the low lying streets. On my first visit, there was about 50 m of sand between the edge of the river and the steps leading up to the Adolpho Lisboa market.

Athletic looking men holding what looked like towels stood in small groups and others, including much fatter men, who looked like Chinese Budhas, lay on cardboard boxes that had been spread open to serve as mats. When the bell rang at midnight, the muscley men hurried towards the boats carrying plastic fish crates. I accompanied one of the crate carriers who waded into the knee-deep water beside a boat and handed up his crate. He then coiled the towel in the form of a turban and put it onto his head, cocked slightly to one side. The fishermen piled the crate full of small fish and two of them carefully lowered it onto the turban, at which point the carrier turned, marched across the sand, up the steps and across the street to a van that was parked beside the road.

Two men beside the van helped lower the crate onto a large weighing scale and a very fat man, who was presumably the owner of the van noted the weight. That crate load of fish only weighed 45 kg, but we saw loads of up to 70 kg balanced on the turbans. I was astounded that these small men could carry loads that weighed more than they did, but they showed no signs of exhaustion and scurried back and forth between the boats and the market like ants. Each buyer had a team of carriers to transport the fish and their wealth was shown by the large amounts of fat they carried around their midlines.

Lyn asked one of the carriers if he had advice to give about the best way to carry the fish, and she thought that he would explain how so much weight could be carried without damaging bone or muscle. However, he said that the main thing was to put the turban slightly off center. Otherwise carrying such heavy

loads could cause baldness!



**Photo 10.2** An unusually thin arapaima specialist. Photo by Bill Magnusson.

Almost everybody was scurrying around at full speed and it was obvious that they were being paid in proportion to the amount of fish that was processed. Dozens of men, who appeared to be as athletic as the carriers, were busy cleaning the fish, removing scales and guts, and *ticando* the smaller fish. However, a dozen or so of the Budha-like men continued to lie on the cardboard mats, apparently uninterested in the movement around them.

About an hour after the bell rang, the volume of small fish started to peter out, and the carriers started to bring tambaqui, the large fruit-eating relatives of the piranhas that are much appreciated because of their large size, juicy flesh and, most importantly, large bones that do not have to be *ticado*. As soon as the tambaqui started to be brought in, most of the large men lying on the mats got



up and started work. They were specialist tambaqui cleaners and had waited for the higher value fish that merited their services. They expertly prepared the fish, which were more than an arm-length long. Most were cut down the middle with a machete so that they could be baked on an open fire.

More than an hour later, as the flow of tambaqui reduced, the arapaimas were brought in. Arapaima can reach lengths of over two meters and are the most expensive fish. Only then did the largest, fattest men on the cardboard mats rise to start their night's work as Arapaima cleaners. The chaos of the market had a tight social hierarchy that was reflected in the size of waistlines, but that could only be understood by careful observation. The gross categories we could discern certainly contained other, more subtle, relationships and Lyn planned to study them for a popular article.

Unfortunately, other things came up, and neither Lyn nor I ever got around to studying the market society in detail. Later, the government constructed floating pontoons that allowed push carts to reach the boats and the Manaus midnight market disappeared into history with its complex social interaction and feats of great physical strength.



Although the market was interesting, it was not a relaxing place for someone with an aversion to crowds and noisy places and the following weekend Lyn suggested that we go to the Hotel Tropical to swim at night. The hotel overlooks the Rio Negro and, as it was upstream of the city, the water was unpolluted. We parked the car in front of the hotel and walked through the gardens. The understory had been planted with exotic species, but most of the trees had been there when the hotel was built.

The track led to a pontoon anchored in front of a vertical stone wall. A light

illuminated the pontoon and a few meters in front of it, but the black water stretched into the darkness in the direction of the far bank, about 5 km away. Lyn walked to the edge of the pontoon and dived gracefully into the water, leaving hardly a ripple. I looked at the deep dark water and the demons came. I knew that there were no sharks there, but knowledge doesn't help if you have been conditioned since childhood to fear deep dark water. I thought of staying on the pontoon, but that also wasn't an option. Young men do not admit to young females that they are scared whitless!



**Photo 10.3** Amazonian pink dolphins are generally friendly, but can be intimidating when they appear out of the black water at night. Photo by Bill Magnusson.

I dived into the water and swam out to where Lyn was practicing her freestyle. The warm water was relaxing and having someone beside you reduces your fear much more than the 50% it reduces the chance that you will be taken by a predator. I relaxed, dived a short distance and came back to the surface to look

around. The shore was about 8 m away and the water calm. The reflection of the light on the shore made zig-zag shapes across the smooth surface.

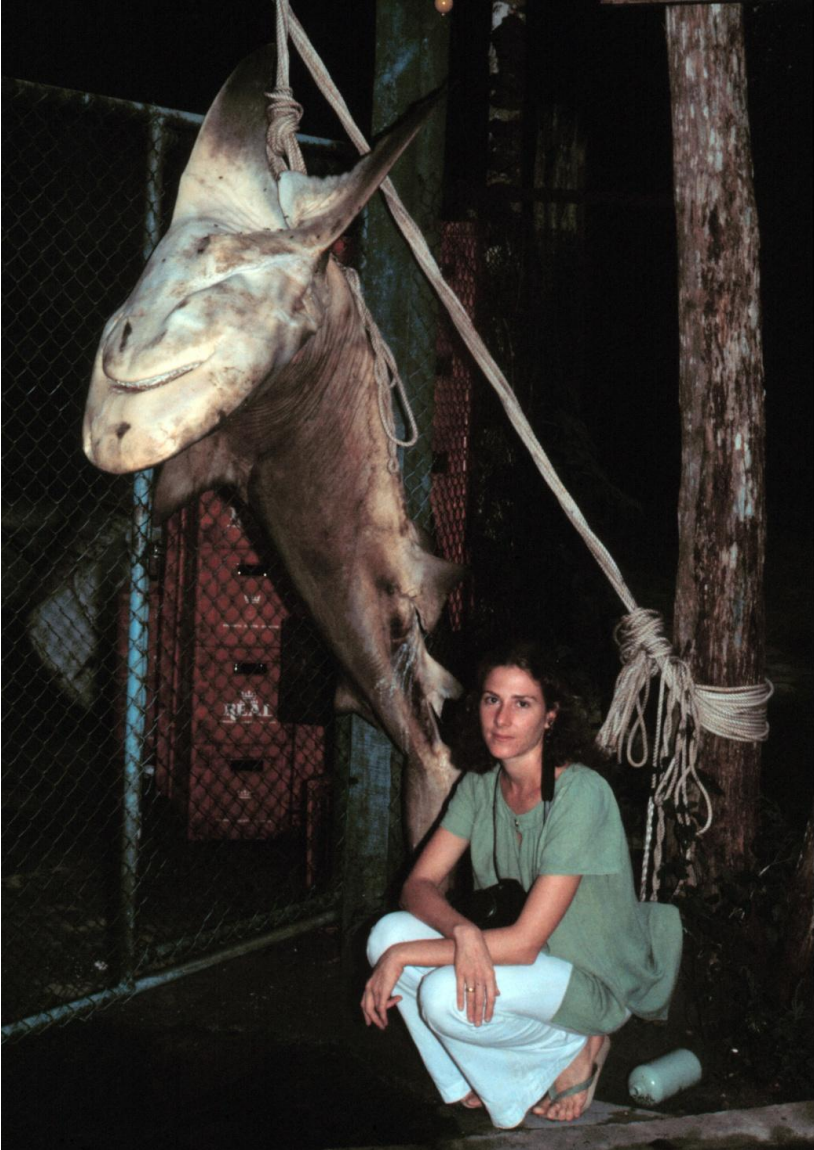
I was suspended vertically when I felt a strong eddy near my feet, as though something big had swum very close. The fear returned and I my heart raced before I regained control and convinced myself that it was just an illusion. I was ready to start swimming again when I felt an eddy against my back and the water exploded beside me, leaving brilliant white bubbles reflected in the light from shore. Before I could react, the water boiled beside me again and I swam madly for shore. By the time I had pulled myself up onto the pontoon my conscious mind had taken control again and I thought “river dolphins!”

Trying not to let Lyn see how nervous I was, I lowered myself back into the water and swam slowly through the black water. I slowed my breathing and carefully controlled my arm strokes and kicking so as to swim smoothly, but I could not control my racing heart. The relaxing night swim had not turned out as I had hoped.



A few days later, fishermen brought the remains of a baby manatee to the office. It would have been about a meter long when alive, but it had been cut in half and only the head and chest remained. The men said that it had been bitten in half by a giant catfish, but I was sure that the blunt teeth of a catfish could not cut through the tough manatee hide so cleanly. The wound was so smooth that it looked as though it could have been made with a butcher's band saw.





**Photo 10.4** Lyn Branch and a bullshark caught in the Amazon River thousands of kilometers from the sea. Photo by Bill Magnusson.

I found a possible culprit for the manatee death about a week later. Fishermen brought in the body of bull shark a bit over two meters long that had been entangled in a gill net. It was a rare occurrence. Bull sharks, *Carcharhinus*

*leucas*, go under various other names within their worldwide distribution. I had known them as whaler sharks in Australia and they are called *cabeça chata*, or flat-head sharks, in Brazil. They are known to penetrate far into freshwater, and have been recorded from Peru, over 3000 km from the mouth of the Amazon. However, they are rarely seen because of the opaque white water of the Amazon and because most of the fishermen's nets are not strong enough to hold them.

Bull sharks are very adaptable and although they are not as streamlined as the more famous white and tiger sharks, they can live in estuaries and rivers which would be too small for most of the larger sharks, and they are thought to be responsible for most shark attacks close to the coast in most places in the world. Their generalized diet apparently even includes baby manatees.

The researchers at INPA thought that the shark would offer an opportunity to determine whether the species could reproduce in freshwater and they carried out an autopsy as soon as it was brought in. Unfortunately, there were no gonads to examine. Shortly after the shark died in the net, the candiru catfish had entered its mouth and eaten all of the organs in the body cavity.

I was thrilled to see the large predator and to confirm that it did occur in the Amazon thousands of km from the sea. However, I was glad that I had not seen it before Lyn took me swimming at night at the Tropical Hotel. I am fairly sure that bull sharks do not penetrate far into the acid waters of the Rio Negro. If they did, someone would have seen them in the relatively transparent water. However, that is just speculation. If I had seen it before diving in, I am sure that my imagination would have populated the Rio Negro with large man-eating bull sharks.

Lyn invited me to participate in the survey of the Amazon National Park that she was coordinating and I accepted. She needed someone to survey the crocodilians, but I was eager to see the fish and frogs around the mighty Tapajos River upstream of Itaituba where it was dominated by rapids. Her

major research on the Tapajós was in relation to monkeys, but she had worked with the famous herpetologist Ronn Altig and she knew much more about amphibians than I did.

Lyn led me down a forest track that connected the Park headquarters to the river and we came to a shallow pool in a tiny stream. The pool was a couple of meters in diameter and two hand spans deep in the middle. The crystal clear water running into and out of the pool through the stream channel was moving fairly fast, but when it spread out into the pool the current became almost imperceptible. Leaf litter from the forest canopy covered the bottom of the pool and the deep shade did not promote the growth of algae.



**Photo 10.5** *Phyllomedusa vaillanti* tadpoles. Lyn Branch gridded the pond with twine so that she could record the tadpole's movements. Photo by Bill Magnusson.

In the center of the pool was a school of what looked like bright orange fish. The orange animals were about the length of my thumb and swimming parallel,

about a centimeter from each other. Lyn scooped one out and I could see that it was a tadpole. From above it appeared uniform orange with a small black stripe on the head, but from the side I could see that its belly was brilliant silver, making it appear even more like a colorful aquarium fish. The dorsal and ventral fins on the tail were broad near the body, but tapered to a tiny filament on the end.

These were tadpoles of *Phyllomedusa vaillanti*, a green-colored tree frog that looked like a badly nourished Australian green tree frog. Lyn explained that the frogs wrap their eggs in leaves overhanging the pond and the tadpoles fall into the pond after hatching. She was interested in the tadpoles because they belonged to one of the few species of frogs that have tadpoles that school in parallel as do most fish. Social behavior by most species of tadpoles just consists of forming aggregations lying on the bottom or balls of individuals trying to swim towards the center of the mass. This is technically shoaling and tadpoles shoaling generally seem to be either very relaxed or extremely agitated. The tadpoles we were watching were neither relaxed nor agitated, but swam in synchrony, parallel, with extreme precision, which is the definition of schooling.

When we returned to the pond at night, the tadpoles were no longer schooling, but were dispersed throughout the pond, suspended vertically in the water column and maintaining position only through vibrations of the tiny filament on the end of their tails. I had seen only a few small fish during the day, but at night there were large cichlids and characins lying on the leaf litter that I was sure would have eaten the tadpoles if they were palatable.

Lyn wanted to know whether the tadpoles schooled as a result of the amount of light or due to an internal daily rhythm, so I suggested an experiment. I carried the heavy 12 volt battery and spotlight I used for catching crocodiles down to the pool and dragged them up a ladder that an assistant had constructed in a nearby tree. From there I could illuminate the pool as though with daylight

and Lyn registered the behavior of the tadpoles when I turned on the light. They immediately aggregated into a school, showing that the behavior was directly determined by light, and Lyn published the result in *Copeia*<sup>39</sup>.

Accompanying Lyn's study caused a fundamental change in the way I regarded tadpoles. Before, they had just been amorphous larvae that somehow represented the idea that frogs are half formed vertebrates trying to be like mammals, but that are constrained to have larvae because they can't make waterproof eggs or bear live young. The *Phyllomedusa vaillanti* tadpoles were social animals with complex behavior and morphology that lived in close association with large predators. I don't remember having much conscious recognition of the change, but the facts were starting to gnaw away subliminally at my unstated prejudices.



**Photo 10.6** *Phyllomedusa vaillanti* tadpoles. Photo by Bill Magnusson.

