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Biology Article Assignment #3 – Fish Evolution (10 pts)

Answer the following questions after reading the article: Fish Evolution Takes a Wild Ride

1. What is unique about the Lower Congo River concerning the fish species found in the river? What does the term endemic mean?

2. What are the names of the two scientists leading the Congo Project and where are they from?

3. How do new species typically form?

4. What role did the Congo River play in the evolution of the chimpanzee and the bonobo? What must happen to a population for speciation to occur?

5. What measurements did the scientists take and what instruments did they use? What did they discover about the underwater geography of the Lower Congo River?

6. Explain how the geography and hydrology of the Lower Congo River is likely driving the speciation of different fish species within the river?

7. How do the characteristics of the fish species *Lamprologus lethops*, also called *mondele bureau* by the locals, support the researcher's hypotheses for fish evolution occurring in the Lower Congo River?

Article: Fish Evolution Takes a Wild Ride



The Lower Congo River boasts the highest-volume whitewater rapids in the world. National Geographic

The Congo River is an enormous waterway with a split personality. For most of its length it is slow and lazy, descending gently through Central Africa's tropical forests. Near the city of Kinshasa, the water puddles against a natural rock barrier, creating an expansion called Pool Malebo. Then, the river literally goes off the deep end and turns torrential. The water spills at 50,000 cubic meters per second down a steep gorge at Pool Malebo's west side, churning the world's most extreme rapids. Large whirlpools spin and parcels of water rise from the river depths, easily capsizing small boats. The Lower Congo River continues much like this—unruly and unpredictable—for about 350 kilometers before it flows into the Atlantic Ocean.

This river is exceptional not only because of its whitewater. It is also known for its incredible assortment of fish. So far, scientists have discovered 320 fish species living in the Lower Congo River's 350 kilometers of water. (For comparison, the entire Upper Nile River, a stretch well over 1,400 km long, supports only about 115 fish species.) Furthermore, 90 of the Lower Congo River's fish species are endemic, or found nowhere else. Some of its denizens are particularly bizarre, sporting features like long snouts, eel-like bodies, tiny eyes, and colorless skin. The sheer number and variety of fishes suggest that they're evolving quickly. "I call it evolution on steroids," says Dr. Melanie Stiassny, a curator of ichthyology at the American Museum of Natural History (AMNH). "It's extraordinary."

What's driving the rapid fish evolution in Lower Congo? That's the question behind the Congo Project, an ongoing research study led by Stiassny and AMNH ichthyologist Bob Schelly. So far, the evidence points to a powerful, obvious presence: the character of the river itself.

Dividing Lines

How do new species typically form? For most organisms, speciation starts when two groups belonging to a single species become separated geographically and then evolve in different directions. Many kinds of landscape features can separate populations of the same species, such as a mountain range or ocean water surrounding a chain of islands.

Take, for example, the Congo River. The common chimpanzee (*Pan troglodytes*) lives only north of the river, and the pygmy chimpanzee (*Pan paniscus*), or bonobo, lives only south of it. Evolutionary biologists suspect that at least 800,000 years ago, two populations of a single ancestral ape species somehow found themselves on opposite sides of the Congo River. (One scenario is that a small group managed to cross its expanse and couldn't return.) The two groups of ancient apes were therefore unable to mate with one another. Over generations, mutations built up in their DNA and were passed to offspring. Eventually, the two populations grew so different that they speciated—they became two different species that could no longer interbreed, even if their ranges overlapped.



The two species of chimpanzees diverged from a common ancestor at least 800,000 years ago.
Kabir Bakie/Thomas Lersch

River fishes have long been thought to follow different rules. Since they live in water, there are no obvious barriers to their movement—they can swim anywhere they want. Presumably, “there should be no difference in what species live on one side of the river versus the other side of the river,” says Stiassny. In other words, one would not expect there to be anything *inside* the Congo River that could separate fish populations like the river itself separated chimpanzees. But something obviously is steering the evolution of fish in the Lower Congo. After several field seasons collecting and identifying new species, Stiassny realized her team was only scratching the surface, literally and figuratively. “We hadn’t been looking at the river the way a fish would look at the river,” she says. “We didn’t really know anything about what was below the surface.” In the summer of 2008, the ichthyologists teamed up with hydrologists to search the Lower Congo River’s mysterious depths for an evolutionary driver.

Kayaking for Science

Before the Congo Project’s 2008 field season, nobody had mapped the Lower Congo’s riverbed or measured its currents in any more than a cursory way. So ecologist and geographer Ned Gardiner, a research associate at AMNH, and John Shelton, a hydrologist with the U.S. Geological Survey (USGS), worked with a team of world-class kayakers to make a historic riverbed survey. The scientists rigged one of the kayaks with a GPS logger and an echo sounder, a device that directs pulses of sound waves toward the river bottom to measure its depth.

The kayakers slid their boats into the river’s first series of rapids below Kinshasa’s Pool Malebo. They battled whitewater for 130 kilometers over 5 days, taking depth readings of the river bottom all the while. “We’d really never experienced a river of this size and depth,” says lead kayaker Tripp Jennings. Often, he says, it was like riding “a firehose entering a swimming pool.” At one point, a whirlpool tipped Jennings’ craft skyward and then completely submerged its 2.7-meter length. The vortex released him just in time for him to take his next breath.

The kayak data was astounding. “We couldn’t believe it,” says Stiassny. “It’s almost like you’re boating over a mountain range. There are huge peaks and enormous troughs. This is the deepest river in the world, there’s no question about it.” In one stretch, the echo sounder registered depths of 220 meters—much deeper than the previous record-holder, the Yangtze.



Locals call this blind, colorless fish *mondèle bureau*. It’s helping scientists understand how the Lower Congo River’s geological features foster the evolution of unique fishes.
National Geographic

A Clue Rises to the Surface

Meanwhile, Gardiner and Shelton boarded a pirogue—a dugout canoe with an outboard motor—to map more accessible parts of the river in detail. They chose sites that were particularly interesting for both their fish and water features. One such site is called Bulu. In this series of bends, Stiassny and her colleagues had collected one of the Lower Congo River's strangest species, *Lamprologus lethops*, during the 2007 field season. Local people, who have found this fish only in Bulu, call it *mondele bureau*, or “white man's office.” These fish are both blind and colorless—characteristics commonly found in cave-dwelling creatures. Animals that live in perpetual darkness have little need for sharp vision to find food or body pigments for camouflage.

Another clue made this case all the more curious. *Mondele bureau* has never been seen alive; it is always found dead, floating on the water's surface. One day in 2007, a villager handed Stiassny a freshly caught *mondele bureau* that was still alive, but barely. It died in her palm, but not before she noticed something bizarre. “It was something we would never anticipate,” she says. “Its skin and gills were full of air bubbles.”

Stiassny and her team speculated that the blind fish live at extraordinary depths of water. Some mechanism in the water might be popping the fish up to the surface like champagne corks, accelerating them so quickly that the gases would bubble out of their blood from the rapid loss of pressure. This is very much like “the bends,” an affliction that deep-sea divers experience if they surface too quickly from deep water.

Gardiner and Shelton visited Bulu with a battery of high-tech equipment to measure the river depth and complexity of water currents. They equipped a small trimaran—a three-pontoon boat—with a GPS logger, an echo sounder, and an oceanographic device called an acoustic Doppler current profiler. “The river is so deep that we have to use instruments that were designed for the ocean,” says Gardiner. Acoustic Doppler current profilers measure the speed and direction of currents in a 3-D column of water. “By mapping velocity in three dimensions,” says Gardiner, “we can understand what the fishes might be experiencing as they move around the river.”

The hydrologists hit the jackpot at Bulu, finding a jagged canyon 160 meters deep with complex, turbulent currents. “The water accelerates going over this cliff beneath the surface,” says Gardiner. “The acceleration in flow generates whirlpools. If *mondele bureau* lives in a protected place down deep and gets pulled by a whirlpool, perhaps this fish gets pulled upward faster than it can swim.” The data immediately told Gardiner and Shelton that a jet of water from this circulation pattern could easily launch *mondele bureau* toward the river's surface—and to its demise.

The turbulent canyon has probably isolated *mondele bureau* from other fish. Over time, it developed its unique features as adaptations to its unique environment. “We see from the hydrologic measurements that there are very powerful movements of water throughout the Lower Congo River that are separating different sampling locations of fishes,” says Gardiner. “If the water is more powerful than a fish's ability to swim, it's a barrier just like a brick wall.”



With every new expedition to the Lower Congo River, Stiassny and colleagues catch fishes that were unknown to science. The current tally exceeds 320 species. “I’d be willing to bet we’re missing hundreds more,” she says. National Geographic

Fishing for Evidence

Other sampling sites tell the same story: that the Lower Congo River’s fish are evolving quickly because the river’s wild water is separating them geographically. At a particularly high-speed spot just downstream from Pool Malebo where the kayakers had paddled mightily, Stiassny and her team took advantage of the calmer currents at the river’s edges to collect more fish. The slender fish netted there, *Teleogramma brichardi*, show rapid evolution in progress. Back at the laboratory at AMNH, Stiassny and Schelly scrutinized two groups of *T. brichardi*, each caught on opposite sides of the river. First, they studied the fishes’ morphology, or their appearance inside and out. Computer analysis of the morphology allows scientists to recognize patterns in body shape and other physical features like color. This can suggest how closely the two populations of *T. brichardi* are related to one another. The researchers didn’t find much—the two groups looked nearly identical to each other.

So Schelly analyzed the fish at the genetic level by sequencing a short section of their DNA. Using similarities and differences in the DNA, he constructed tree diagrams to depict the genetic relationships of the two populations of *T. brichardi*. Five percent of their DNA differed—a high amount. (The DNA of humans and chimpanzees differs by only 1.2 percent.) “This is extremely surprising for two populations of a single species that look exactly the same,” says Schelly. This degree of genetic separation indicates that mutations occurring in fish on one riverbank are not being passed to fish on the other bank, and vice versa. That’s a strong clue that the two populations aren’t interbreeding.

The powerful current in the channel between the two populations of fish likely keeps them apart from each other so that they are evolving in different directions. It’s almost as though they were living in entirely separate bodies of water. *T. brichardi* is well on its way to splitting into two species of fish.

Using the evidence collected from mondele bureau, *T. brichardi*, and other diverse fishes in the Lower Congo River, the Congo Project is overturning the idea that fish use different rules than land animals to play the evolution game. That geographic barriers—their “brick walls”—are simply made of water, and thus are a lot less conspicuous than those on land. “Studying fish,” says Stiassny, “gives you a very different perspective on evolution, ecology, the whole world.” Presumably, the Lower Congo River’s wild water has powerfully influenced the evolution of its fishes for tens of thousands of years, ever since the river first eroded through the rock at Pool Malebo and tumbled on its maiden voyage downstream. It’s left a legacy of biodiversity that continues to yield surprises—a wild evolutionary ride that shows no signs of slowing.