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THE AMAZING DIVERSITY OF CICHLID FISHES

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AGES: 15–16

Imagine swimming through warm, clear-blue water where, all around you, you see brightly colored fishes of all shapes and sizes. Does this sound like a tropical coral reef? Maybe so, but it could also be a tropical freshwater lake, with hundreds of different types of cichlid fishes. Cichlids live only in freshwater and are found in lots of different lakes and rivers across the world. Their bright colors and interesting behaviors mean that they are popular to keep as pets in fish tanks, but they also are incredibly interesting to scientists and are a valuable food source. Scientists study cichlids because they want to understand how different types of cichlids have evolved to suit their different environments. Cichlids are important for food in many countries, both through fishing of wild populations and fish farming (aquaculture), in specially built ponds or tanks.

CICHLIDS

Freshwater fishes of the family Cichlidae that can be found in warm climates, in many types of water bodies across Africa, Central and South America, and Asia.

WHAT ARE CICHLIDS AND WHERE CAN WE FIND THEM?

Cichlids (pronounced sik-lids) are freshwater fishes that can be found in warm climates, in many types of water bodies such as lakes, ponds,

Figure 1

Cichlid fish species in Lake Malawi exhibit great diversity in shape, size, and color (Image credit: Isabel Magalhaes).

rivers, and streams. There are lots of different species of cichlids. They come in an amazing range of sizes, colors, and patterns (Figure 1). Most cichlid species alive today are found in Africa, with almost 2,000 known species in African lakes alone. In Central and South America there are 560 known species, and 32 in Madagascar (reviewed by Kocher [1] and Turner [2]). Three species can be found in southern Asia and seven in the Middle East. Because cichlids are found in so many countries in the southern hemisphere, some scientists believe that they existed on the ancient southern supercontinent known as Gondwana. Gondwana was a huge land mass which, around 120–160 million years ago, broke up into the pieces that we know today as South America, Africa, Arabia, Madagascar, India, Australia, and Antarctica. However, other scientists have a different idea: they think that cichlid fishes may have moved between continents by swimming across oceans. We may never know for sure which one of these ideas is correct, but what scientist *do* agree on is that cichlids have been around for a long time, with the oldest cichlid fossils being 45 million years old. We also know that cichlids are capable of very rapid **speciation**. This is the evolutionary process by which one species gives rise to a new, closely related species.

SPECIATION

An evolutionary process that leads to the formation of new, distinct species that can no longer breed with the original species.

The cichlid species in the Great Lakes of East Africa have attracted the most attention from researchers [2]. In these lakes, almost 2,000 species of cichlids have evolved over the last 100,000 years, which is considered the very recent evolutionary past. Scientists are interested in understanding exactly how the new species arise, and why speciation occurs more quickly in cichlids than in other types of vertebrates. The three Great Lakes of Africa have the highest number of described species: around 1,000 species in Lake Malawi[1] , 500 in Lake Victoria, and 250 in Lake Tanganyika. In each of these lakes, cichlid

[1] To learn more about Lake Malawi life, see https://www.bbc.co.uk/programmes/p00379zw

species form what is known as an **adaptive radiation**, which is a group of many species that have rapidly evolved from a single species called the common ancestor. These species have lots of variety in their size, shape, and color, as well as in what they eat and where in the lake they live. As such, cichlid fishes are important for understanding how evolution gives rise to biodiversity.

ADAPTIVE RADIATION

Rapid increase in the number of species descended from a common ancestor, characterized diversity in diet and habitat.

There are several theories to explain how so many species of cichlids emerged in the African Great Lakes in a relatively short time. However, in this article, we will focus on two theories: ecological selection and sexual selection.

ECOLOGICAL SELECTION

Ecological selection is the adaptation of species to different food sources or habitat niches. Different species of cichlids have different mouth, tooth, and body shapes that are adapted to different ways of feeding. Some species sift through sediment for food, some feed on zooplankton, and some feed by scraping the algae off rocks. Other species are predators of fish, eggs from other fish, and insects. There are specialized crab-eaters and many snail-eating species. Some cichlid species specialize on very specific types of food, such as sponge-eating species and species that remove parasites from the skin of catfish. One species feeds mainly on flies that rest on rock surfaces near the water.

ECOLOGICAL SELECTION

The process by which populations of organisms adapt to new environments or resources. Their ecology (diet or body shape, for example) changes as a result of this process.

Cichlid species have also adapted to live in different habitats. There are streamlined species that inhabit offshore sandy areas, and rock-dwelling species that live their lives on rocky shores. Some species inhabit empty snail shells and others live up to 100 m below the surface and have evolved huge eyes to enable them to see in the dim light.

These varied behaviors are associated with structural changes to body and head shape, jaw size and shape, and the size, shape, and number of teeth. Cichlids in different lakes have independently evolved the same changes. When species in similar environments adapt to resemble each other, it is called **convergent evolution** (Figure 2). All these differences in diet and niche have led to the hypothesis that there are many cichlid species because they have adapted to different food sources and habitats. If fish only mate with other fish that feed on the same food or live in the same habitat, then these groups can eventually become separate species.

CONVERGENT EVOLUTION

independent evolution of similar characteristics in distantly related organisms.

SEXUAL SELECTION

Another possible theory to explain the diversity of cichlid species is called **sexual selection**, which basically means individuals of one sex

SEXUAL SELECTION

An evolutionary process resulting from a preference by one sex for certain characteristics in individuals of the other sex.

Figure 2

Figure 2

The Convict Julie **(A)** and the Golden Mbuna **(B)** live in similar habitats but in different lakes, and they have evolved similar body size and characteristics, such as a streamlined body shape, golden body colour and dark horizontal stripes. Despite the similar appearance, the Golden Mbuna is not very closely related to the Convict Julie. In fact, it is more closely related to the Blue Moorii cichlid **(C)** which lives in the same lake but has evolved to live in a different habitat. This is an example of convergent evolution, where the evolution of the Convict Julie and the Golden Mbuna have converged on a similar set of evolutionary adaptations, despite not having a recent common ancestor. Individual images compiled to create the panel. **(A)** https://commons.wikimedia.org/wiki/File:Julidochromis_regani.jpg (image copyright Regani; image in public domain); **(B)** https://commons.wikimedia.org/wiki/File:Melanochromis_auratus_(female).jpg (image copyright Vlad Butsky, licensed under CC BY 2.0); **(C)** https://commons.wikimedia.org/wiki/File:Cyrtocara_moorii_male_2.jpg (image copyright Brian Gratwicke, licensed under CC BY 2.0).

show preference for certain characteristics in individuals of the other sex. A striking characteristic of cichlids in the African Great Lakes is that the males of many species are brightly colored. This is similar to bird species like the peacock and pheasant, in which males have extravagant plumage and colouration to attract potential mates. Male cichlids are also thought to display bright colors to attract females. Many cichlid species can be identified by the color of the males' bodies, but females are mostly brownish- or grayish-colored and harder to distinguish. The sexual selection hypothesis states that the preference of females for males with differently colored bodies has led to the emergence of species that have different colors.

Most male cichlids put a lot of effort into trying to attract females. As well as having brightly colored bodies, males from some species have developed interesting strategies. For example, some males build huge and complex sandcastles, called bowers (Figure 3). They build and maintain these bowers for several weeks and females have been shown to prefer males with bowers of certain sizes and shapes. Because female cichlids often choose males to mate with based on their appearance (body colouration) or behavior (bower-building), these choices lead to evolution of different species of cichlids based on the characteristics that females prefer.

WHY STUDY CICHLIDS?

Cichlids are useful for studying the process of how new species evolve, because 2,000 unique species have evolved in the last 10 million years. Few other animals offer the opportunity for scientists to study speciation in this way. But cichlids are not only important for understanding how species emerge. Many cichlid species live in areas that are poor in food resources, and they provide an important food source for local communities. For example, tilapia cichlids are one of the most important freshwater food resources in tropical regions, and they are even farmed extensively in other parts of the world for human consumption.

Unfortunately, many cichlid species have recently become endangered, often by over-fishing. Another problem for cichlids comes from habitat changes caused by humans, including the building of dams or the development of lake shores. Because many cichlid species are only

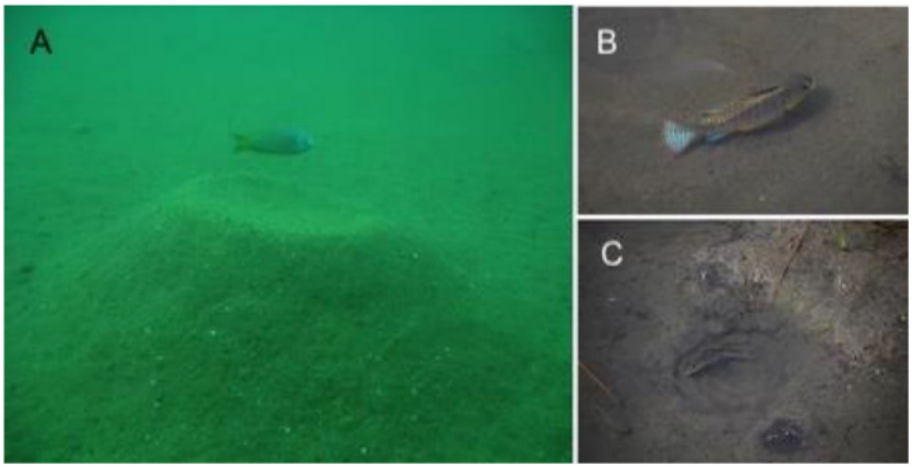

Figure 3

(A) A male of a bower-building cichlid species from Lake Malawi defending their territory around a bower built to attract potential mates (Photograph credit: Isabel Magalhaes) **(B,C)** Soda cichlids on bowers (Photograph credits: Antonia Ford).

found in one lake or a small geographical area, even small areas of development can negatively impact some species. Also, introduction of **invasive species** to some African lakes has threatened many native cichlid species, some to the point of extinction. In Lake Victoria, once called "Darwin's dream pond" for the number of cichlid species it contained, the introduction of the Nile perch in the 1970s caused a drastic reduction in the number of cichlid species. Nile perch are predatory fish that can grow up to 2 meters long. They are extremely voracious and grow very quickly. Unfortunately, Nile perch feed mostly on cichlids, and some cichlid species have been drastically reduced. Another problem for cichlids comes from chemicals entering the water through runoff from farm fields. These chemicals fuel the growth of algae, which make the water murky, and in some locations females cannot see the colors of males. Since they can not distinguish males based on color, females may mate with males from a different species, a process called **hybridization**. Hybridization can lead to species losing their unique characteristics and becoming less well-adapted to their environments.

INVASIVE SPECIES

A species that finds a new place to live, away from its native area, and increases in number, sometimes causing negative impacts on native species and the ecosystem.

HYBRIDIZATION

Interbreeding between animals or plants of different species.

Some cichlid species, such as the Nile tilapia (*Orechromis niloticus*), are also invasive species themselves! Nile tilapia, native to North, East, and West Africa, have been widely introduced and farmed in Africa and many countries in Asia, Europe, and North and South America. In these new places, Nile tilapia often threaten the native ecosystems and species.

PROTECTING CICHLIDS

Several conservation projects aim at protecting the amazing biodiversity of cichlid species across the world. These include policies to reduce the impact of overfishing and breeding programmes to ensure that the rarest of species do not become extinct. For

example, the Pangani tilapia is an important species found only in the Pangani River basin in East Africa. A combination of factors, including habitat degradation, heavy fishing pressure, and competition from the invasive Nile tilapia, have led to the Pangani tilapia becoming critically endangered. A conservation project led by Sokoine University in Tanzania aims to restore degraded habitat and map the habitat of the species to protect it[2]. Other conservation projects may use breeding programmes to try to rebuild species numbers. In 2013, the Zoological Society of London asked people to help find any remaining Mangarahara cichlids, of which only 3 individuals were known, all in captivity. Thanks to their request, a wild population of the species was found in Madagascar, thought to include only 18 individuals, and a breeding programme was started at a local aquaculture facility to try to restore their numbers[3]. Hopefully, future conservation projects will continue to help preserve these important species, so that scientists can continue to learn about the fascinating evolutionary process of adaptive radiation and future generations can enjoy them.

[2] https://www.speciesconservation.org/case-studies-projects/pangani-tilapia/5314

[3] https://blogs.scientificamerican.com/extinction-countdown/fish-found-the-greatest-conservation-success-story-of-2013/

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We are the MYP5 class: a bunch of energetic and engaged teens. We already knew about conservation and climate change issues. We are a diverse group coming from all over the world!

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