



## Axolotls on the Verge of Extinction: An Alarming Fact

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### Abstract

The axolotls are the neotenic amphibians, closely related to the tiger salamanders. They are of immense zoological importance due to more than one reason. These unique creatures are endemic as they are the native residents of only Lake Xochimilco and Lake Chalco in central Mexico. Nowadays Lake Chalco no longer exists, and Lake Xochimilco remains as a remnant of its former self, mainly existing as canals. In the IUCN Red list, axolotls have been designated as critically endangered in the wild. Unfortunately, these small, attractive creatures are on the verge of extinction in the wild, as revealed by some recent studies. Surveys in past twenty years have recorded gradually declining number of axolotls in their native habitat. In 2014 researchers found less than one axolotl per square kilometer of the lake, which is quite an alarming number. The major causes of such decline have been enlisted as: urbanization, water pollution, and the massive invasion of exotic predator fishes. Though the axolotls are not yet totally extinct from the world, as they have been cultured in several laboratories, but restoring their population in the wild, has now become a major challenge for the conservation biologists. They are trying for it in different ways. Let us hope for a better future, where these wonderful creatures can get back their old status in the wild.

**Keywords:** Axolotl, neoteny, limb regeneration, lake xochimilco, extinction, restoration

### 1. Introduction

The axolotl, also known as the Mexican salamander, is a fascinating living creature in this world, as they show a classical example of neoteny, i.e., attainment of sexual maturity in the larval stage itself. When they complete their metamorphosis, they become the adult urodele Amphibia, *Ambystoma mexicanum* (Shaw, 1789). They are of immense importance due to more than one reason.

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Though the axolotls are not yet totally extinct from the world, as they have been cultured in several laboratories, but restoring their population in the wild, has now become a major challenge for the conservation biologists. They are trying for it in different ways, such as improving the water quality, eliminating the foreign fishes, and re-establishing

Lake Xochimilco as more than just a series of canals. Let us hope for a better future, where these wonderful creatures can get back their old status in the wild.



Fig 1: Image of a captive Axolotl larva



Fig 2: Image of an Axolotl in wild

## 2. Discovery

The adult *Ambystoma* and its larval phase were known since long time. They were earlier erroneously regarded to be the adult of different species of Urodele related to a pennibranchiate form, especially to *Siren*. But Cuvier suspected the biological status of this animal and regarded it as a urodele larva. Dumeril was the first to establish the fact that the axolotl larva can metamorphose into the entirely lung-breathing and land-dwelling adult *Ambystoma*.

Five male and one female axolotl were collected by Jardin des Plantes at Paris in 1863. Two years after, these larvae started breeding. The eggs laid by the female developed into fully grown axolotls within a few months. Attainment of such sexual capability by these animals led many scientists to believe that these are actually the adult forms of some urodeles. But in the next autumn, all were surprised to note that most of the axolotls lost their larval features and metamorphosed into adult *Ambystoma*. The gills were lost, gill-clefts became closed and dorsal and caudal fins disappeared during the metamorphosis. The remaining members of the same brood retained their aquatic larval stage. The transformation of axolotls into adult *Ambystoma* firmly established the larval nature of axolotls.

## 3. Causative Factors for Neoteny

Some external, internal and genetic factors are responsible for inducing neoteny in axolotls.

### External Factors

- According to Gadow (1901), abundance of food and other favourable conditions in water induce the axolotls to continue their aquatic larval life, without metamorphosing into land-dwelling adults.
- Shufeldt suggested that higher depth and lower temperature of water inhibit thyroxine secretion which retards metamorphosis. The role of temperature in metamorphosis was also established by Huxley's (1929) experiments.
- Weissmann claimed that retardation of metamorphosis of axolotls is possibly due to the saline nature of the water.
- Marie Von Chauvin, of University of Freiburg performed some experiments to establish the role of physical factors in neoteny. She kept some axolotls in water-holes with high vertical walls, so that they were not allowed to reach the land above the water-holes. It has been observed that this forced and prolonged use of larval gills and tails cause their further development, whereas the growth of limbs and other structures necessary for terrestrial life remained suspended.

### Internal Factors

- Zondeck & Leiter (1923) established that calcium delays metamorphosis in axolotls.
- Gressner (1928) advocated that insulin hormone inhibits metamorphosis.
- Etkin (1968) and his coworkers established the role of two hormones-namely Thyroxine ( $T_4$ ) and Prolactin, secreted from the thyroid gland and anterior pituitary respectively, in amphibian metamorphosis. They said that during early premetamorphic stage of development, the level of Thyroxine is kept very low, while the level of Prolactin is higher. As the metamorphic changes begin, the situation is reversed, i.e. the level of Thyroxine gradually rises, and the level of Prolactin suddenly falls. Thus these two hormones, exert a positive and negative role respectively.

It is also to be noted that Thyroxine secretion is under the control of two other hormones, along the hypothalamo-hypophyseal-thyroidal axis; TSH from anterior pituitary and TRH from hypothalamus.

This view of Etkin *et al* was further supported by several other scientists, such as Kuhn, Bytenski, Saez etc. who performed thyroidectomy experiments on amphibian larvae, to understand the importance of thyroid gland and its secretions.

### Genetic Factors

- From the genetic point of view, it can be mentioned that both Thyroxine and prolactin are protein hormones by nature. So, these must be encoded by their respective genes. Thus, it can be easily understood that these genes get 'switched on' or 'switched off,' to be expressed or not, as per the situational requirement. Before metamorphosis, the gene for thyroxine remains switched off, while the gene for Prolactin remains switched on. During metamorphosis, the case is just reversed.

## 4. Significance of Neoteny

- Many scientists hold the view that axolotls and other animals who remain neotenic, do so to live in a better environment that is water, where food and other resources are more available. Thus, it can be considered to have some adaptive significance.
- According to some, neoteny seems to be a survival mechanism. By being neotenic, salamanders can reproduce and survive in the form of a smaller larval stage, and require a lower quality and quantity of food compared to the big, adult forms which are terrestrial.
- Garstang and others suggest that neoteny in axolotl can be considered as a case of atavism, i.e., reverting back to ancestral characters.

## 5. Importance of Axolotl Larva

They are of immense zoological importance due to more than one reason:

- Firstly, from the evolutionary perspective, as they show a classical example of neoteny.
- Secondly, axolotls are extensively used in scientific researches due to their ability to regenerate lost appendages within a period of months, and in certain cases, even more vital organs. They can also readily accept transplants from other individuals, including eyes and parts of the brain, restoring these organs to full functionality.
- In some cases, axolotls are even known to repair a damaged limb, as well as regenerating an additional one, thus ending up with an extra appendage that makes them more lucrative to the pet owners.
- It is also to be mentioned that these larvae were initially noticed by the natives of Mexico, who used to take these larvae as a part of their staple diet, and they called them as Axolotl, meaning 'play in the water'.

## 6. Present Status

In the IUCN Red list, axolotls have been designated as critically endangered in the wild. Unfortunately, these small, attractive creatures are on the verge of extinction in the wild, as revealed by some recent studies. The Mexican axolotl was once world famous for its abundance but now has become the most threatened specimen among the amphibians in North

America. The vast wetlands upon which Mexico City had developed which once provided a productive habitat of axolotl, has now been reduced to some isolated patches of wetlands only, surrounded by development. Nowadays Lake Chalco no longer exists, as it was artificially drained to avoid periodic flooding, and Lake Xochimilco remains as a remnant of its former self, mainly existing as canals. A recent study from the Mexican authority showed that in 1998 there were about 6000 axolotls per square kilometer in Lake Xochimilco, the original native habitat of axolotls. By 2008, the figure decreased into 100; and in 2014, researchers found less than one per square kilometer. These studies clearly indicate the alarming fact, that these wonderful tiny creatures have become almost extinct in the wild. The major causes of such decline have been enlisted as: urbanization, water pollution, and the massive invasion of exotic predator fishes such as carp and tilapia, introduced by the Mexican government in the 1980's to help feed local communities.

According to Smith, 1989, descents of the originally collected specimens of axolotl by Jardin Des Plantis in 1863 are still being maintained and cultured in the laboratories, throughout the world, and many of today's captive axolotls probably came from this original stock. Thus, there are some rays of hope that axolotls, though almost in the verge of extinction in the wild, do still exist in this world in captive, laboratory conditions, mainly due to their immense regeneration power.

### 7. Conservation Efforts

The major challenge for conservation biologists is the restoration of axolotls in their wild, native habitat. According to the 2010 joint study by the University of Wisconsin-Madison and the national Autonomous University of Mexico, the best options for saving the axolotls in the wild is to restore their habitat as far as possible. This includes improving the quality of water, eliminating foreign fish, and re-establishing Lake Xochimilco as more than just a series of canals. Current efforts revolve around building axolotl sanctuaries in Lake Xochimilco, in which the axolotls are separated from the invasive fishes by wooden gates. Other option like reintroducing lab-raised axolotl populations in the wild is also being attempted. Though the perfect goal has not yet been reached, but, with the positive efforts going on, it can be hoped that very soon, these wonderful little creatures will get back their original status in the wild.

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