Metamorphic Events in Frogs Life cycle

Meaning of Metamorphosis:

Metamorphosis may be defined as “a rapid differentiation of adult characters after a rela-tively prolonged period of slow or arrested differentiation in a larva”.

According to Duellman and Trueb (1986) Metamorphosis can be defined as “a radical transformation from larval life to the adult stage involving structural, physiological, bio-chemical and behavioural changes”.

Types of Amphibian Metamorphosis:

1. Progressive metamorphosis: During metamorphosis if the animal pro-gresses in the evolutionary grades, the meta-morphosis is considered as a progressive meta-morphosis; e.g., in most anurans of Amphibia.

2. Retrogressive metamorphosis: When metamorphosis takes place in lower direction, i.e., by metamorphosis the animal retrogresses or shows indication of degeneration in the scale of evolution, called retrogressive metamorphosis; e.g., Ascidia of urochordates or in neotenic forms like salamanders.

Metamorphic changes of amphibians:

Etkin (1968) have divided three stages:

a. Premetamorphic stage: The stage is characterized by the consi-derable growth and development of larval structures but metamorphosis does not occur.

b. Prometamorphosis: The stage is characterised by the conti-nuous growth specially the development of limbs and initiation of metamorphic changes.

c. Metamorphic climax: The stage is characterised by the radical changes in the features of the larva, and climax is considered by the loss of most larval features.

Structure of Metamorphosis:

Structure of a freshly hatched tadpole larva:

1. A freshly hatched tadpole larva has a limbless body.

2. The body is divided into an ovoid head, a short trunk and a slender tail.

3. A small opening situated ventrally at the root of the tail is known as anus.

4. An adhesive sucker is present on the ven-tral side of the head by which the tadpole larva attaches itself to the aquatic weeds.

5. The mouth is lacking and as a result it cannot take anything from outside.

6. The yolk material provides the nutrition.

7. The respiratory organs comprise of three pairs of highly vascular and branched feathery external gills.

8. After a few days the mouth is formed near the sucker.

9. A pair of horny jaws surrounds the mouth.

10. The tail becomes more elongated and develops a dorsal and a ventral fin.

11. V-shaped myotomes develop on both the sides of the tail.

12. At this time this free-swimming tadpole larva ingests aquatic weeds, as a result of which the alimentary canal becomes extremely elongated.

13. To accommodate such a long alimentary canal inside the cavity of the short trunk, it becomes spirally coiled like the spring of a watch.

Structure of an advanced tadpole larva:

1. In the advanced stage, the pharynx of the tadpole larva becomes perforated by gill- slits.

2. External gills disappear and the internal gills are formed between the gill slits.

3. The gills and the gill-slits are covered by the operculum (or gill-cover).

4. Thus the tadpole larva has three pairs of external gills at the start which are subsequently replaced by three pairs of internal gills.

5. In the larval stages, the arterial arches also show modifications in terms of both external and internal gills (Fig. 7.28).

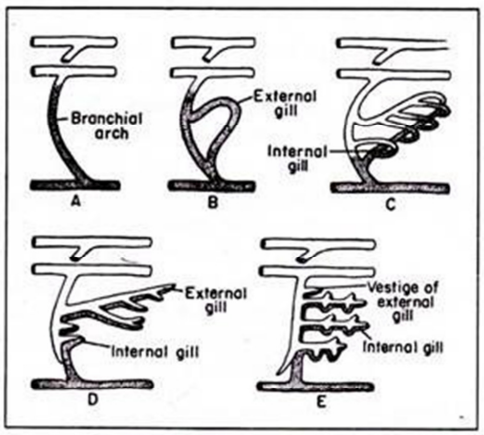


Fig. 7.28: Showing the stages (A–E) of development of an aortic arch in relation to external and internal gills in larval phase of *Bufo*.

6. The operculum fuses with the trunk on all sides except a small opening, called spiracle on the left side.

7. Water enters into the pharynx through the mouth and goes out through the spiracle.

8. During this transit of water the internal gills are bathed with water containing oxygen dissolved in it.

9. While the internal gills are functioning, a pair of lungs develops as outgrowths from the pharynx on the ventral surface.

10. The hind limbs appear prior to the forelimbs.

11. The forelimbs remain first hidden under the operculum and subsequently emerge through it.

12. At this stage both the internal gills as well as the newly formed lungs are functional.

13. When the lungs become fully developed, the internal gills become degenerated.

14. At this stage it looks like a miniature toad except having a tail.

15. As the limbs are developing, the animal enters into a period of starvation.

16. The material of the tail becomes eventually absorbed into the body.

Structure of a freshly formed toad:

1. After the absorption of tail, the young toad leaves the primal aquatic home and comes to the land and hops.

2. The mouth becomes wider and a pair of true bony jaws replaces the horny jaws.

3. It now changes its food habit to become carnivorous type, as a result the alimentary canal becomes short and less coiled.

The changes that take place in the tadpole can be divided into four groups.

They are:

1. Changes of tadpole in habit and habitat:

(i) With the metamorphosis, the metamorphosed larva leaves aquatic medium and frequently visits the land.

(ii) The herbivorous tadpole larva changes into carnivorous specially consume the insects (insectivorous).

(iii) The praying habits develop by the adults and the adult animals become more active and swift moving.

(iv) In the first stage of adult toad, they jump into nearby pond and in other aquatic medium, and then jump on the land by their elongated hind limbs.

2. Morphological metamorphic changes:

a. Regressive changes:

(i) The tissues of tail and tailfin are completely absorbed into the body.

(ii) The horny jaws with teeth are shed and mouth becomes a large transverse slit.

(iii) The external gills disappear and the gill slits communicate to the pharyngeal cavity.

(iv) The length of the alimentary canal much reduces.

(v) The changes of the blood vascular system take place and ultimately some blood vessels are reduced.

(vi) The lateral line sense organ disappears.

(vii) Operculum and spiracle disappear.

b. Progressive changes:
(i) The fore and hind limbs increase in size.

(ii) The tongue becomes long and more elastic which is free and bifid posteriorly.

(iii) The eyes become large and prominent and develop eye-lids and nictitating membrane.

(iv) External nostrils communicate with buccal cavity through internal nostrils.

(v) Tympanum and middle ear develop.

(vi) Liver becomes more enlarged.

(vii) Three chambered heart develops from two-chambered heart.

(viii) Pronephros is replaced by mesonephros.

3. Biochemical changes during metamorphosis:
(i) The concentration of serum protein becomes about double during metamorphosis.

(ii) Biosynthesis and concentration of haemoglobin are greater in adult than in larvae.

(iii) In the liver, DNA synthesis, lipid synthesis, enzymes for ornithine urea cycle increase during adult stage.

iv) Alkaline phosphatase and hydrolase decrease in adult stage of the anurans.

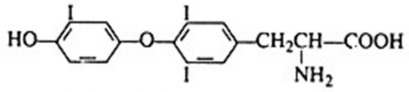
4. Changes in Physiology:
(i) At the beginning of metamorphosis, the pancreas starts to secret insulin and glucagon hormones. This is related to the increased role of the liver.

(ii) During the larval stage, the end product of nitrogen metabolism is ammonia. But after metamorphosis, the toads and frogs excrete most of their nitrogen in the form of urea. This is a shift from ammonotelism to ureotelism with the change of environment from aquatic medium to land.

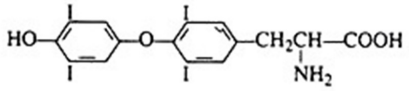
Hormonal Control for Metamorphosis:

Two hormones such as Triiodothyronine (T_3) and Tetraiodothyronine (T_4) or thyroxine are necessary for biochemical and morphological changes during anuran metamorphosis. These thyroid hormones are produced by the induction of anterior pituitary lobe or pars distalis when it reaches certain degree of differentiation.

Then it is capable to synthesize a hormone, thyrotropin (Thyroid Stimulating Hormone, TSH) which acts on the thyroid, stimulating the production and secretion of triiodothyronine (T_3) and thyroxine.



3, 5, 3'–Triiodothyronine (T_3)



3, 5, 3'5'–Tetraiodothyronine (Thyroxine)(T_4)

In pre-metamorphic stage the prolactin level is high but levels of thyroid stimulating hormone (TSH) and thyroid hormone (T_3, T_4) are low. The hypothalamus – pituitary link is poorly developed. In pro-metamorphosis, the hypothalamus and pituitary link develops.

The prolactin level is low but the levels of thyroid stimulating hormone (TSH) and thyroid hormones (T_3, T_4) are high. In metamorphic climax, the prolactin level increases suddenly, then maintains steady low level. The TSH is high until end of climax and the thyroid hormone (T_4) level becomes low.

Metamorphosis of Toad:

The young tadpole larva resembles a fish. It leads an independent and self-supporting life. This fish like tadpole larva completely metamorphoses into toad, is exclusively a progressive process. According to Mohanty-Hejmadi and Dutta (1978) – development is rapid being completed in 34-52 days. Daniel (1963) reports the hatching in about 4 days after laying.

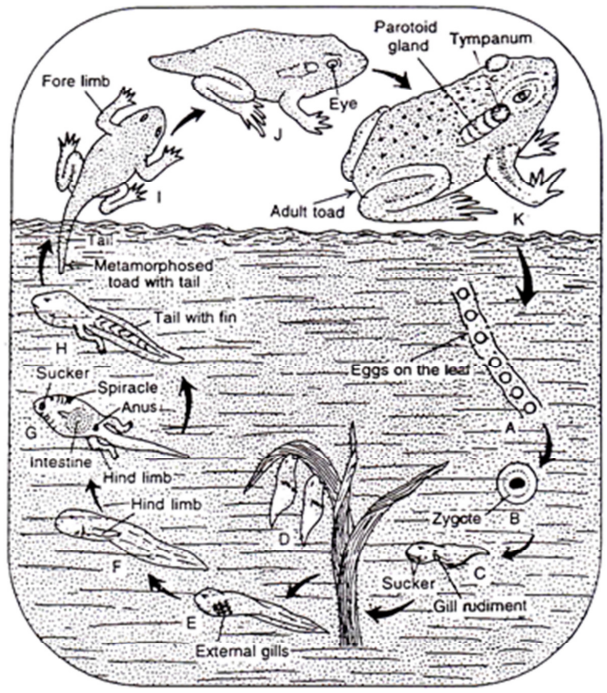


Fig. 7.27: Schematic representation of the larval development and metamorphosis of *Bufo*.