

## Intestinal Coiling and organ development during metamorphic process of *Polypedates maculatus*: a gross view studied in North West Odisha

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### Abstract

Two years study was conducted during the year 2018-2020 in the localities of North west Odisha. The aim of this study was to provide the detailed information on the structure of intestinal coiling and development of organs in different stages of *Polypedates maculatus* till the completion of metamorphosis. During the completion of metamorphic process, anuran tadpoles undergo dramatic changes as they pass from aquatic to terrestrial life. The quality and quantity of food and nature of habitat affects the normal configuration of digestive tract in anuran tadpoles of *Polypedates maculatus* as it is completely modified due to the striking transformation in gastric region.

**D**evelopment of the normal pattern of intestinal coiling in anurans depends on vitelline circulation, proper regulated hydrostatic pressure in both coelom and digestive tract and the restricted space present in coelomic cavity. Complete differentiation of digestive tract depends on circulation of blood. Intestine swells and coiling gets reduced when the excessive hydrostatic pressure is formed. When the hydrostatic pressure is reduced, the digestive tract gets flattened. Coiling of guts results from elongation of intestine within a restricted body coelom. The excess reduced coelom causes reduced and abnormal direction of coiling<sup>12</sup>. During metamorphosis, remodelling of intestine occurs in *Xenopus laevis* reported

by Schreiber *et al.*,<sup>26</sup> and in *Microhyla berdmorei* by Lalremsanga<sup>14</sup>. Digestive tracts and feeding behaviour are drastically changed during metamorphosis in anuran tadpole was studied by Houdry *et al.*,<sup>9</sup>. Shortening of alimentary canal occurs in case of larva of *Rana catesbeiana* was reported by Pretty *et al.*,<sup>24</sup>. Numerous workers studied on the alimentary tract of anuran larvae<sup>3,8,6,18,5,25,28,1,20</sup>. Nakajima *et al.*,<sup>20</sup> worked on fine structural changes in the intestinal epithelium during metamorphosis of the bullfrog, Marshall and Dixon<sup>16</sup> studied on the cell specialization in the epithelium of the small intestine of feeding *Xenopus laevis* tadpoles. At macroscopic

level, longer digestive tracts are associated with a herbivorous diet, whereas shorter ones are associated with carnivorous diets was reported by Nobel<sup>21</sup>; Altig and Kelly<sup>2</sup>; Vilee *et al.*,<sup>29</sup> and Martin *et al.*,<sup>17</sup>. Undifferentiated tube with an esophagus, a gastric region, and a long coiled intestine are correlated with general morphological pattern<sup>8</sup>. Metamorphic shortening of the digestive tract was studied on larvae of different anurans, like *Rana pipiens*<sup>11</sup>, *Alytes obstetricians*<sup>5</sup>. Changes in the structure of the alimentary canal at selected stages of development of *Phrynohyas resinifictrix* was reported by Wilczynska<sup>30</sup>. Nodzinski *et al.*,<sup>23</sup> reported the different growth pattern of major organs in larval stages. In stage 25, the gut and pancreas have growth spurts, then grow at a constant rate till stage 39-40 (for pancreas) or stage 42 (for gut). Hourdry and Beaumont<sup>10</sup> studied details on the change at metamorphosis from microphages herbivory to microphagus carnivory and dramatic shortening of intestine and differentiation of stomach. Inter specific variation in shape and size of visceral organ has been established by Nodzinski *et al.*,<sup>22</sup>.

Field survey was conducted in the evenings from 4:00 PM and continued till late at night during the breeding season (April to August in the year 2018 -2020) in the localities of North west Odisha). The surveys were based on extensive search and physical verification. Larvae from different stages Gosner<sup>7</sup> were utilized for establishing the structure of intestinal coiling patterns. The tadpoles of *Polypedates maculatus* were collected from foam and reared in the laboratory. They were sacrificed from time to time from

Gosner stage 22-42 for convenience. 5 tadpoles from each stages were dissected out to record the normal configuration of digestive tracts. Observations were made for specific stages and specific illustrations with variation were retained after comparing the similarities between or among the stages.

The tadpoles develop inside foam nest until external gill stage. However, the stage 22 marks the development of a prototype of the future digestive tract and the process of coiling of alimentary tract continues till stage 42.

*Stage 22 :*

The alimentary canal is tightly packed, the foregut is undeveloped and does not differ from oesophagus or small intestine. Only the position of pancreas distinguish the foregut from the mid gut. The main coil is cylindrical and narrow and the left side curves down to form a “U” shaped coil or loop.

*Stage 25 :*

Ascending and descending spirals comprise two and half coils respectively. In addition both the spiral exhibit gradual increase in the number of coils. Further, there is a decrease in the right half of the main coils.

*Stage 29 :*

During this stage, the main coiling of alimentary tract is slightly displaced from the centre and is seen shifted to the left. Due to various feeding habit of the tadpoles, the alimentary canal become dark coloured.

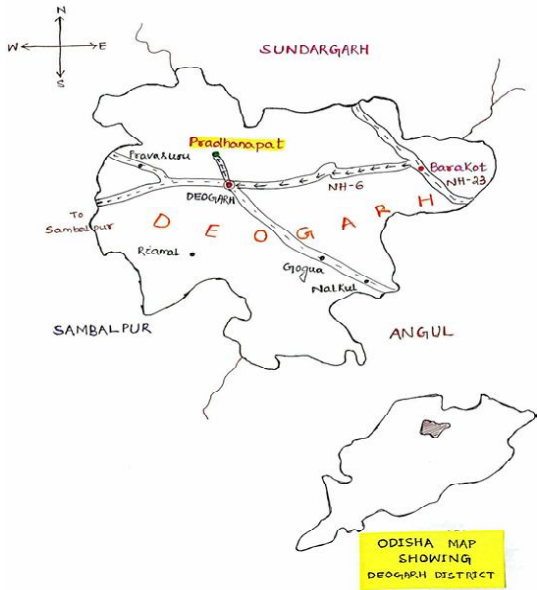


Fig. 1. Map showing Sampling area of North West Odisha denoted by arrow mark.

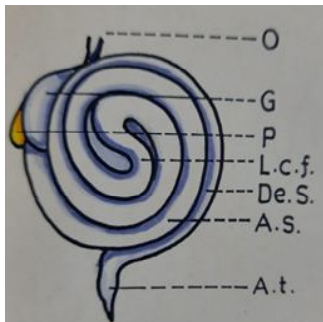


Fig-2 Intestinal coiling of stage 22 showing "U" shaped main coil and undifferentiated mid gut and hind gut.

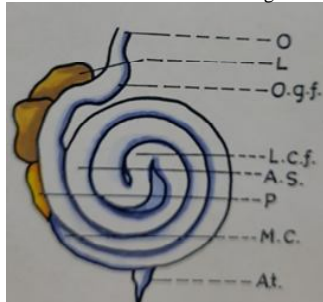


Fig-3 Intestinal coiling of stage 25 showing gradual increase in number of coils and formation of oesophago-gastric flexion.

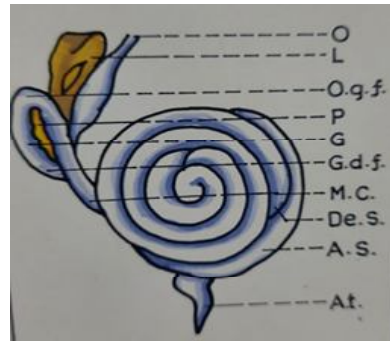


Fig-4 Intestinal coiling of stage 29 showing pancreas in oesophago-gastric flexion and gastro-duodenal flexion.

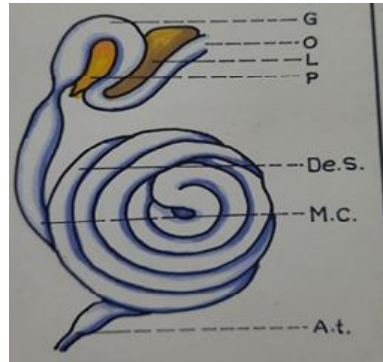


Fig-5 Intestinal coiling of stage 31 showing irregular coiling pattern and flattening of gastric region (stomach)

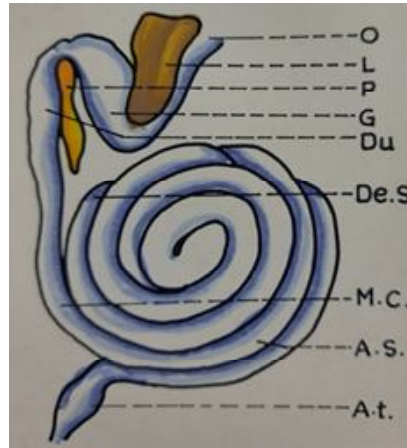


Fig-6 Intestinal coiling of stage 33 showing distinct duodenum, elongated gastric region and overlapping of two coils.

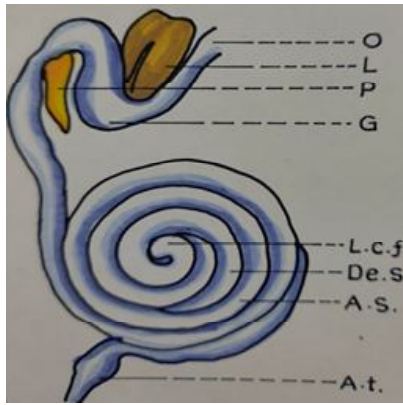


Fig-7 Intestinal coiling of stage 35 showing superimposition of two coils like a cone with the loop of coil formation at the top.

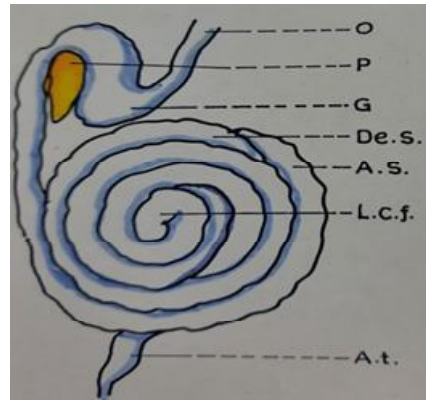


Fig-9 Intestinal coiling of stage 39 showing lateral displacement of pancreas and narrow alimentary canal with increased number of coiling than stage 37.

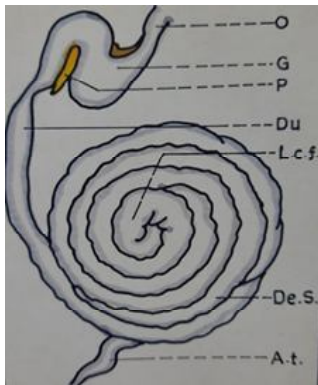


Fig- 8 Intestinal coiling of stage 37 showing lateral displacement of pancreas and narrow alimentary canal with increased number of coiling.

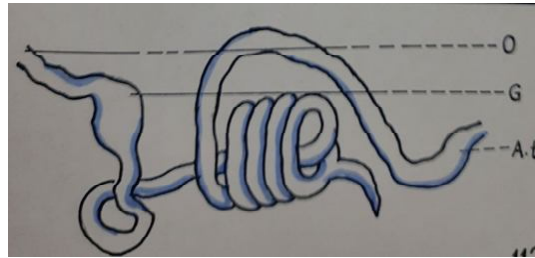


Fig-10 Intestinal coiling of stage 42 marking the initiation of metamorphosis and differentiation in to adult digestive tract.

*Stage 31 :*

The course of coils is irregular. As the coil is drawn towards posterior end, the stomach finds space to flatten.

*Stage 33 :*

At this stage, overlapping of two coils is marked. Ascending and descending spirals enwind anticlockwise and clockwise.

*Stage 35 :*

Gradual increase in number of layers

in the intestine coils. The first coil of the descending spiral is the largest and the rest of the coils lie upon one another decreasing gradually in size, like a coil.

*Stage 37 :*

Gastric loop is observed. Due to rapid and voluminous increase of the alimentary canal, the coil is more or less occupies a central position and pushes liver and pancreas away from the median line.

*Stage 39 :*

Size and number of coils are inversely

proportional to the diameter of the intestine. Gastro- Duodenal loop are seen to be prominent and marked by a “U” shaped Structure.

*Stage 42 :*

This stage makes the initiation of metamorphosis and differentiation of coils into adult digestive tracts. This process is so sudden that, it is difficult to observe further modification. The intestinal spiral is dragged posteriorly by the process of shortening of main coils. In metamorphosed froglet, the observed loops are Duodeno-iliac loop (after Duodenum), in the middle of the intestine and the caudal loop, at the posterior most part of the ilium. As the duodeno-iliac loop is pushed forward, the gastro- duodenal loop in the shape of “U” becomes prominent. It is observed that the intestinal mass changes remarkably during early and late larval development. Ultimately, there is abrupt decrease in length of gastro-intestinal tract during metamorphosis.

In *Rana pipiens* the total gut length of tadpoles shortens to 25% in stage 42 and to 17.8% by the end of metamorphosis<sup>19</sup>. Mc Govern and Charipper<sup>19</sup> observed that shortening of gut to 50% in stage 42 and to 16.3% by the end of metamorphosis. For microhylid, *Kalovla borealis*, the corresponding numbers are 52.3% and 14.7% and for *Rana nigromaculata* the corresponding numbers are 35.9% and 13.3 %<sup>15</sup>. Wilczynska<sup>30</sup> observed gut length is 24% maximum in *Bombina bombina*, and 20% in *Pelobates fuscus* and 24% in *Rana temporaria* at stage 42. Gut length is reduced to 32% (Stage-42) and 10% (Stage 45) in *Rana finchi* and 29% (Stage 42) and 18% (stage 44) in *Bufo divergens*<sup>23</sup>. The present study has been illustrated that the loop of coil

formation is a stationary point, not changing its position along the coils and persists even after metamorphosis which is similar to the conclusion drawn by Khan<sup>13</sup> in *Bufo melanostictus*. Khan<sup>13</sup> observed the S shaped tubular configuration of gastro duodenal groove and dorso ventral groove in stage 22 and 23 in *Bufo melanostictus*. The tadpole of *Polypedates maculatus* shows blending of anterior bend to form the first coil of ascending spiral in stage 24 as observed in other cases. At stage 41 the metamorphosis of digestive tract starts and completed in stage 43. Khan 13 also reported the shortening of alimentary tract and tail in stage 38 of *Bufo melanostictus*. However in case of *polypedates maculatus* the shortening of alimentary tract is so sudden that the tail shortening is least observed. Quality and quantity of food also affect the development of larval digestive tract. In the present study, the feeding of tadpole starts at stage 25 which is the initial point of rapid growth of digestive tract. The tadpole of *polypedates maculatus* stops its feeding at stage 42, which is the main cause of arresting the growth of digestive tract and prepare it for metamorphosis. Tadpoles collected from nature, slightly differ in the development of digestive tract.

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