

Oral Disc Morphology of Amphibian Tadpole and Its Functional Correlates*

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Abstract. Oral discs of five sympatric amphibian tadpoles occurring in ponds and puddles of plains of Pakistan, are described in detail. Morphology of circumoral region of each species of tadpole is correlated to its feeding habits.

Key words: Tadpole oral disc, feeding adaptations (Amphibia: Anura).

INTRODUCTION

Five species of sympatric amphibian tadpoles: *Bufo stomaticus*, *Microhyla ornata*, *Rana cyanophlyctis*, *R. syhadrensis* and *R. tigerina*, are most frequent animals encountered in ponds and puddles of plains of Punjab and Sindh, during summer monsoon rains (Khan, 1982; Khan and Tasnim, 1987). These tadpoles share common food base in pond ecosystem, without apparent competition for it among them.

Oral morphology of anuran tadpoles differs specifically reflecting adaptive radiations of each species to exploit different parts of the available food base in the pond ecosystem. These morphological differences have extensively been used by morphologists to establish relationships among genera and families of anuran amphibians (Günther, in Boulenger, 1882; Boulenger and Annandale, 1918; Noble, 1927; Orton, 1953; Lynch, 1973). Recently, different feeding modes of tadpoles have been included in taxonomic considerations (Starrett, 1973; Heron-Royer, 1884; Wassersug, 1980, 1989; Wassersug and Pyburn, 1987). According to Orton's (1953) definitions of major types of amphibian tadpoles, the *Microhyla ornata* tadpole which lacks keratinized hard mouth-parts, is Type II, while ranoid tadpoles of *Bufo* and *Rana*, with keratinized mouth-part, are Type IV.

Basic elements of circum-oral armature constituting the oral disc, are same in tadpoles belonging to different genera and families. However, they are widely modified according to the ecological and dietary specializations of the tadpoles (Altig and Johnson, 1966), reflecting wide array of food preference

and different methodologies employed in feeding (Altig and Johnston, 1989).

Tadpoles are primary consumers. They feed on scraps from the surfaces of submerged plants which are rasped with the help of different elements of oral disc. Tadpoles frequently supplement their carbohydrate rich diet by protein by resorting to carnivory to enhance speed of their development in uncertain temperate aquatic environs. Due to mixed opportunistic dietary habits, tadpoles occupy an important position in lower trophic level, and are main constituents of food chain in pond ecosystem. They fall prey to naids, turtles, fishes and host of other water creatures and their larvae. Tadpoles prey on bacteria, rotifers, crustaceans, larvae of several water arthropods and feed on carcasses of drowned animals etc. (Cooke, 1974; Banks and Beebee, 1987; Caldwell *et al.*, 1980; Formanowicz, 1987; Smilitsch, 1988; Khan, 1991). Thus tadpoles play important role of a scavenger in pond ecosystem and help maintain health of the ecosystem during hot temperate summer.

Khan (1982) devised key for identification of amphibian tadpoles of plains of Punjab, Pakistan, based on oral disc morphology, without giving detailed descriptions of their oral discs. In this paper circum-oral region of Pakistani tadpoles is described in detail and its morphology is correlated to the feeding ecology of each species of tadpole. Moreover, observations on mode of feeding of each species of tadpoles are recorded.

MATERIALS AND METHODS

Material for present study was collected from natural ponds and puddles around Rabwah City, Punjab, Pakistan, with fine mesh hand-net. The tadpoles are killed by putting alive in Chloretone solution, later fixed, hardened and stored in 10% buffered formalin.

For specific identification of tadpoles Khan (1982)

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was used. Tadpoles at Stage 35 (Khan, 1965) were selected for circum-oral studies, since at this stage the tadpole has typical morphology, and the oral disc is fully developed and functional.

To fix a tadpole for detailed study of its oral disc under dissection microscope, a dissection dish was made, by filling a large Petri dish with molten wax. When hardened, an elongated pit, of the size of the tadpole, is excavated in its middle, the tadpole is fixed in the pit belly up, with an entomological needle. Detail of the oral disc is studied under low power dissection binocular microscope, and drawn with the help of a camera-lucida.

DESCRIPTION

Morphology of the oral disc of *Bufo stomaticus* is described here as typical for amphibian tadpoles (Fig. 1A). Mouth (4) of a ranoid tadpole is surrounded by keratinized and papillated structures collectively called-oral disc. Its major parts are anterior (1) and posterior (8) labia, on which rows of keratinized, spiny tiny teeth (2) are arranged. The beak immediately, surrounds mouth, with a preoral (3) and a postoral (5) halves, both edged with sharp serrations.

Delicate flat membraneous labial palps (7) lie on lateral sides of the oral disc, with margins produced into one or two rows of delicate filliform labial papillae (6).

Configuration of labia, beak blades, labial palps, papillae and the morphology, arrangement and number of labial tooth rows, differ inter-specifically in ranoid tadpoles.

Dental formula of a tadpole depicts, number and arrangement of tooth rows on its oral disc. Figure on the left of "/" refer to the preoral labium, while those on right, for posterior labium. Open figures indicate total number of tooth rows, number in parenthesis are the number of interrupted rows in order of arrangement on labium. A dental formula 2(2)/3(1-2), indicates 2 tooth rows on anterior labium, of which second is interrupted, while of the 3 posterior labial rows first and second are interrupted.

Bufo stomaticus Lütken

Dental formula for *Bufo stomaticus* is 2(2)/3 (Fig. 1). The labial palps are flat with numerous short labial papillae.

Dark brown teeth range 0.04-0.06 mm in length, with thick, cylindrical base fixed on a pad of tissue. Crown is flat, orally concave, produced into 5-6 sharp cusps on sides (Fig. 1B).

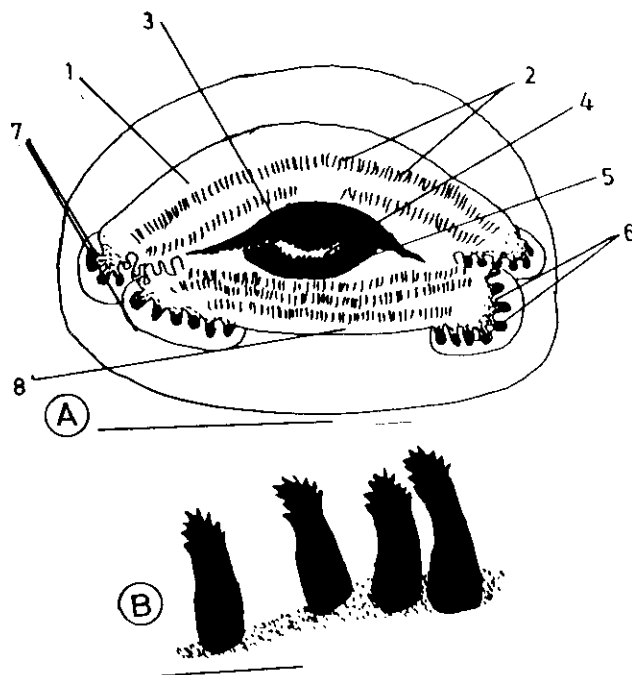


Fig. 1. *Bufo stomaticus* tadpole; A, oral disc; 1, anterior labium; 2, a row of labial teeth; 3, preoral half of the beak; 4, mouth opening; 5, postoral half of the beak; 6, labial papillae; 7, labial palps; 8, posterior labium (scale = 1 mm); B, a part of the tooth row (scale = 0.25 mm).

The beak brown beak has thin, narrow, widely arched preoral blade, while postoral blade is thicker and v-shaped with fine, sharp serrated edges.

Microhyla ornata

A typical oral disc with hard keratinized mouth parts is absent in this tadpole (Fig. 2). The mouth opening is a horizontal slit with a median U-shaped cleft (9) in the lower jaw, which remains open even when mouth is closed.

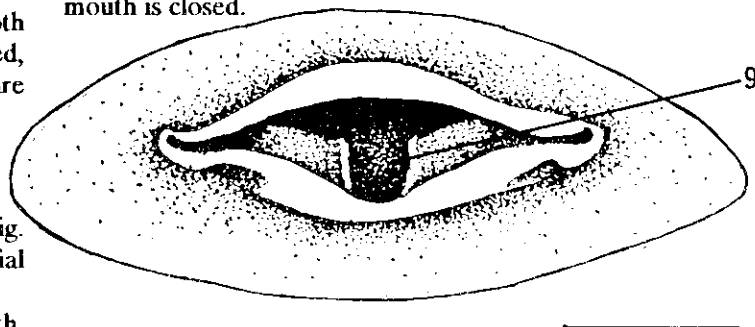


Fig. 2. Oral disc of *Microhyla ornata* tadpole; 9, U-shaped mouth opening in the lower jaw (scale = 1 mm).

Oral papillae described by Khan (1982) at Stage 25, in *M. ornata* are lost at Stage 35.

Rana cyanophlyctis

The oral disc, is ventral, round with broad, strongly arched, anterior labium and a narrower, arched, posterior labium (Fig. 3A). A single uninterrupted row of dark brown teeth line outer border of anterior labium, while a pair of uninterrupted rows lie on the posterior labium. Dental formula is 1/2.

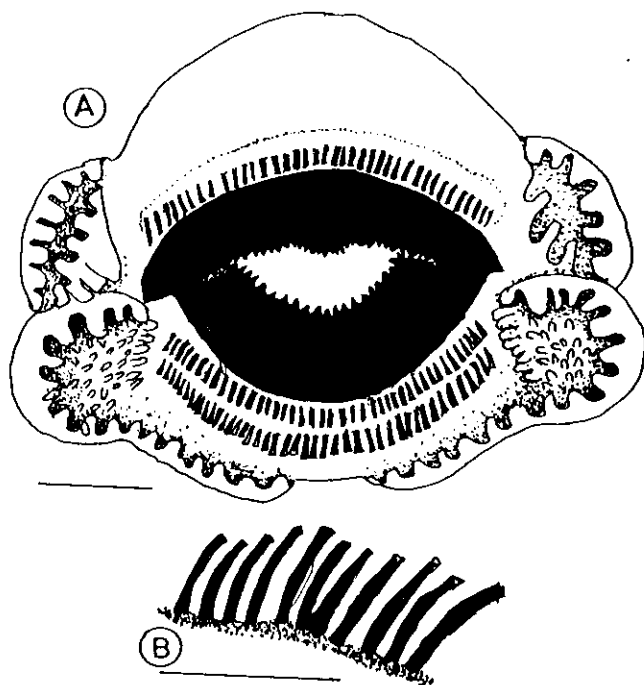


Fig. 3. *Rana cyanophlyctis* tadpole; A, oral disc (scale = 1 mm); B, a part of labial tooth row (scale = 0.5 mm).

A tooth of *R. cyanophlyctis* is long, orally curved rod, almost squarish in transverse section, with blunt tip. The teeth are arranged in a single row, like teeth of a rake. The size of teeth varies from 0.13 to 0.34 mm (Fig. 3B).

Beak is thick and broad, its anterior half is a broadly arched, dark brown keratinized plate, with sharp fine serrated cutting edge, mesially produced in a serrated low tooth. The postoral half is broad, V-shaped finely serrated broader plate.

Broad labial palps are produced into low lobulated papillae arising from their incurved edges. Anterior half of the palp is smaller while posterior is broader, extends

along posterior labium, narrowly separated mesially from that of the other side. It laterally encloses a patch of tuberculated small papillae, on each side.

Rana syhadrensis

The ventroanterior flexor of the buccal floor of *R. syhadrensis* tadpole has pushed the oral disc upward and forward, so that it is more anterior than anteroventral. Anterior labium is narrower than the posterior. The oral palps are thick, with thick, cylindrical, filiform blunt tipped labial papillae (Fig. 4A). The papillae are arranged in a double row along posterior half of the palp which extends along posterior labium, narrowly interrupted mesially from that of the other side.

Dental formula is 2(2)/3, but unlike *Bufo stomaticus* the second row of teeth on the anterior labium is very broadly interrupted mesially, and it is represented by few teeth on sides of the labium. The third outermost row on posterior labium is smaller, about one third of the size of the first two.

Teeth are uniserial in arrangement. Each tooth consists of three tiers of similar pieces, lying on each other. Each piece is less than 0.5 mm in length, with free flattened orally curved crown, produced laterally into three sharp cusps (Fig. 4B). Base of the tooth is cylindrical and hollow, fitted on the lower piece.

The beak blades are narrow, thin and delicate, the preoral half is broadly arched with fine serrated edge, while postoral half is V-shaped, and sharply serrated.

Labial palps are not distinct, however, labial papillae are present in two rows, the outer row is longer, its papillae are longer, thick, filiform and blunt tipped. The inner shorter row is confined along the posterior labium with relatively is with smaller blunt tipped papillae.

Rana tigrina Daudin

Unlike other tadpoles the oral disc of *Rana tigrina* lies at the anterior end of the body. It is round, with non-papillated rim, without oral palps and papillae (Fig. 5A).

Teeth of *R. tigrina* are arranged in biserial rows, its dental formula is 5(4-4)/(3-3)5. The anterior labium is broadly arched with 5 dental rows. The outer most row is complete while four inner are broadly interrupted mesially, progressively decreasing in length from 2nd to 5th, which is about one fourth of the size of the first row. Of the five rows on the posterior labium, the outer two are complete, while three inner are interrupted mesially. The second outer row is longest, extends to the full length of the posterior labium.

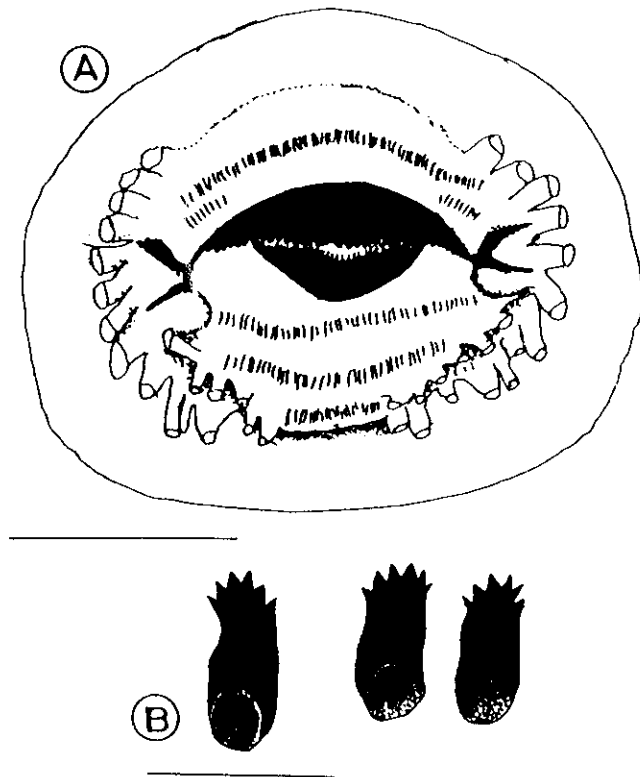


Fig. 4. *Rana syhadrensis* tadpole; A, oral disc (scale = 1 mm); B, teeth (scale = 1 mm).

A tooth is a cylindrical keratinized structure, its crown gradually attenuates to its pointed tip. Teeth vary from 0.34-0.4 mm in length (Fig. 5B).

Dark brown beak is thick and broadest of all the tadpoles studied. Its anterior strongly arched half is thick, finely serrated and mesially produced into a large serrated tooth. The posterior half is thicker, with sharp non-cerrated edges, it is mesially excavated into a U-shaped concavity into which median tooth of the anterior half fits on closure of the beak.

Extra keratinized surfaces are present in the buccal cavity of *Rana tigerina* tadpole. A pair of long cylindrical thick papillae, tipped with keratinized plates, lie at the angles of the mouth opening (Fig. 5A: 10) and a median-buccal keratinized shield is observable through opened mouth, at the dorsum of interior of buccal cavity (12).

Broad posterior labium of *R. tigerina* tadpole can be widened into a sucker, when necessary, for attachment to rocks and other supports in strong current of water. In preserved material sucker is not distinctly observable.

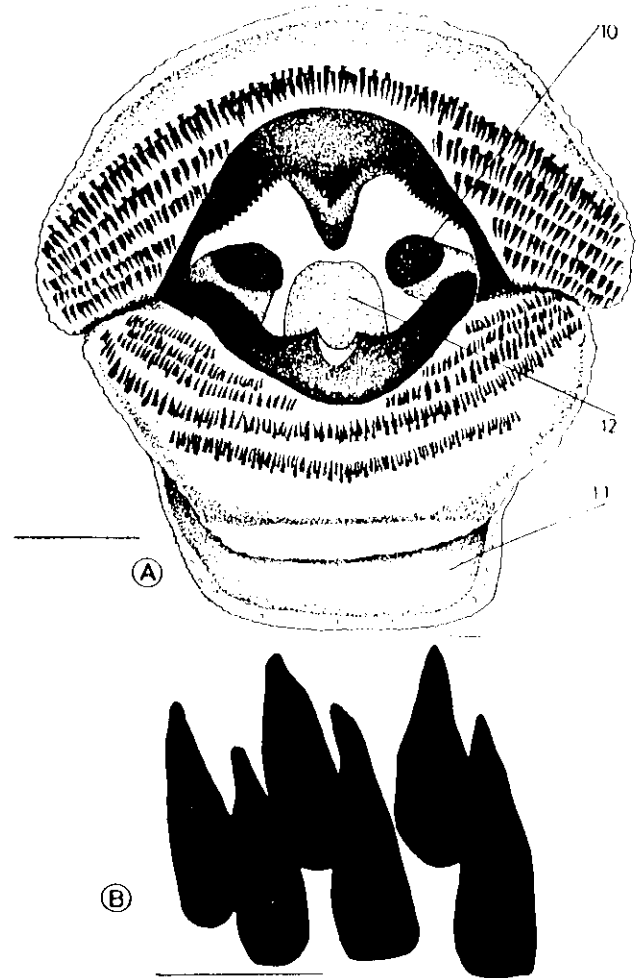


Fig. 5. *Rana tigerina* tadpole; A, oral disc (scale = 1 mm); 10, lateral buccal keratinized tipped papilla; 11, postoral sucker; 12, buccal keratinized plate; B, a part of tooth row (scale = 0.25 mm).

DISCUSSION

Elements of circum-oral food gathering gear: labia, tooth rows, beaks and papilla are universal among anuran tadpoles. Variation in number of tooth rows, morphology of teeth, papillae and beak, differ specifically. Each species uses elements of its oral disc for the same purpose of gathering of food in different ways, reflecting morphological constraints imposed by its phylogeny and its morphological specializations to exploit a particular part of the common food base, with minimum competition with its sympatrics (Lynch, 1973). Each circum-oral morphotype represents a particular niche to which a tadpole is adapted (Khan, 1982; Thibaudeau and Altig, 1988).

Table I.- Comparison of oral disc elements of amphibians tadpoles inhabiting ponds and puddles of Punjab and Sindh, Pakistan.

Oral disc elements	<i>Bufo stomaticus</i>	<i>Microhyla ornata</i>	<i>Rana cyanophlyctis</i>	<i>Rana syhadrensis</i>	<i>Rana tigerina</i>
Anterior labium					
Number of tooth rows	1 (2)	0	1	1 (2)	1 (4)
Mode of arrangement of teeth in a row	uni	-	uni	uni	bi
Tooth elements	1	-	1	3	1
No. of cusps on a tooth	5-9	-	0	5-6	1
Labial palp	+	-	+	ind	-
Labial papillae	small	-	lobu	thick	-
Beak	+	-	+	+	+
Posterior labium					
No. of tooth rows	3	0	2	3	5(4)
Extra oral structures	-	-	-	-	+
Mode of feeding	rasp	micro	detri	micro and rasp	carni

+, present; - absent.

bi, biserial; ind, indistinct; lobu, lobulated; carn, carnivorous; detri, detritivorous; mic, microphagus; rasp, rasper of vegetative matter.

Orientation of oral disc

Position of oral disc on the body of tadpole reflects its feeding ecology, food preferences and methodology employed by it for food acquisition (Altig and Johnston, 1986, 1989; Khan and Malik, 1987; Khan, 1991).

Absence of a typical oral disc in *Microhyla ornata* is indicative that this tadpole does not feed on scraps of pond vegetation. Its anterodorsal permanently open mouth and continuous gulping-in of plankton rich water, reflects its filter feeding microphagus habits. To get necessary amount of food, the tadpole cycles enormous amount of water, through its buccopharyngeal system (Khan, 1991).

Oral discs of *Bufo* and *Rana* tadpoles differ specifically in orientation, it is anteroventral in *Bufo stomaticus* and *R. cyanophlyctis*. The material on which these tadpoles feed, is not visible to them. Labial palps and labial papillae act as sensory and manipulatory organs during feeding. *Rana tigerina* tadpole is unique in having anterior disc. The food on which tadpole feeds is visible to it, thus it lacks oral palps and papillae. It is larvaevorous. During feeding it remains vigilant to subdue the struggling prey. Its sharp spiny teeth pin the prey in desired position helping the tadpole to orientate properly its oral armature which cuts large chunks from the body of the prey.

Ventral disposition of oral discs of *B. stomaticus* and *R. cyanophlyctis* tadpoles also indicates their mainly detritus feeding habits. However, ventro-anterior oral disc of *R. syhadrensis* is unique among these tadpoles. It grazes on algal vegetation as well as it filter feeds the planktonic bloom of the pond.

Functional morphology of keratinized mouth parts

Teeth are arranged in rows on anterior and posterior labia. Species of tadpoles differs in their dental morphologies, number and arrangement of tooth rows on labia.

Crown of *Bufo stomaticus* and *R. syhadrensis* teeth is laterally cuspid. The beak blades are thin, broadly arched with fine serrated sharp edges (Fig. 1B; Fig. 3B). The keratinized gear of these tadpoles is adapted to scratch and rasp surfaces of the submerged vegetation breaking its cells loose. The scratched material by *R. syhadrensis* tadpole is much finer than that scratched by *B. stomaticus* tadpole, since the teeth of *R. syhadrensis* are in three tiers with finner serrations.

While non-cuspidated teeth of both *R. tigerina* and *R. cyanophlyctis* are entirely different from the rest of the tadpoles. The carnivorous tadpole of *R. tigerina* has highest number of tooth rows on both labia, 5/5, and the teeth are arranged in double series in a row (Fig.

5B). The cylindrical sharp-tipped teeth of this tadpole are adapted to pierce into the flesh of the prey and hold it in position, while strong, sharply serrated beak of the tadpole cuts large chunks from its body. The extra keratinized structures in the buccal cavity (10,12) help in stuffing large pieces of food into oro-pharyngeal passage of the tadpole.

Cuspled teeth have been reported in several other larvacvorous tadpoles of genus *Leptodactylus* (Starrett, 1973), *Scaphiopus* (*halbrookii*, *hammodi*, *hateri*) and *Ascaphus* (Gosner, 1959).

Apart from blunt tipped peculiar teeth of *R. cyanophlyctis* this species has smallest number of tooth rows on its labia, one on the anterior labium, two on posterior labium, moreover its beak is thickest, and broadest of all the tadpoles considered. These specializations reflect the detritus feeding habits of this tadpole. The long orally curved teeth rake the detritus mucilage towards mouth, which is cut in large chunks by strong broad beak.

Present study establishes that every species of sympatric tadpoles differ not only in its oral disc morphology, but also in utilization of a particular part of the common food base available in pond ecosystem. The oral armature is occasionally put to carnivory with the same efficiency as in herbivory, to supplement carbohydrate rich diet with protein. It is an inherent necessity of each type of tadpole to complete developmental process as rapidly as possible in uncertain aquatic environs and fast evaporating pond water in hot temperate Pakistani plains.

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