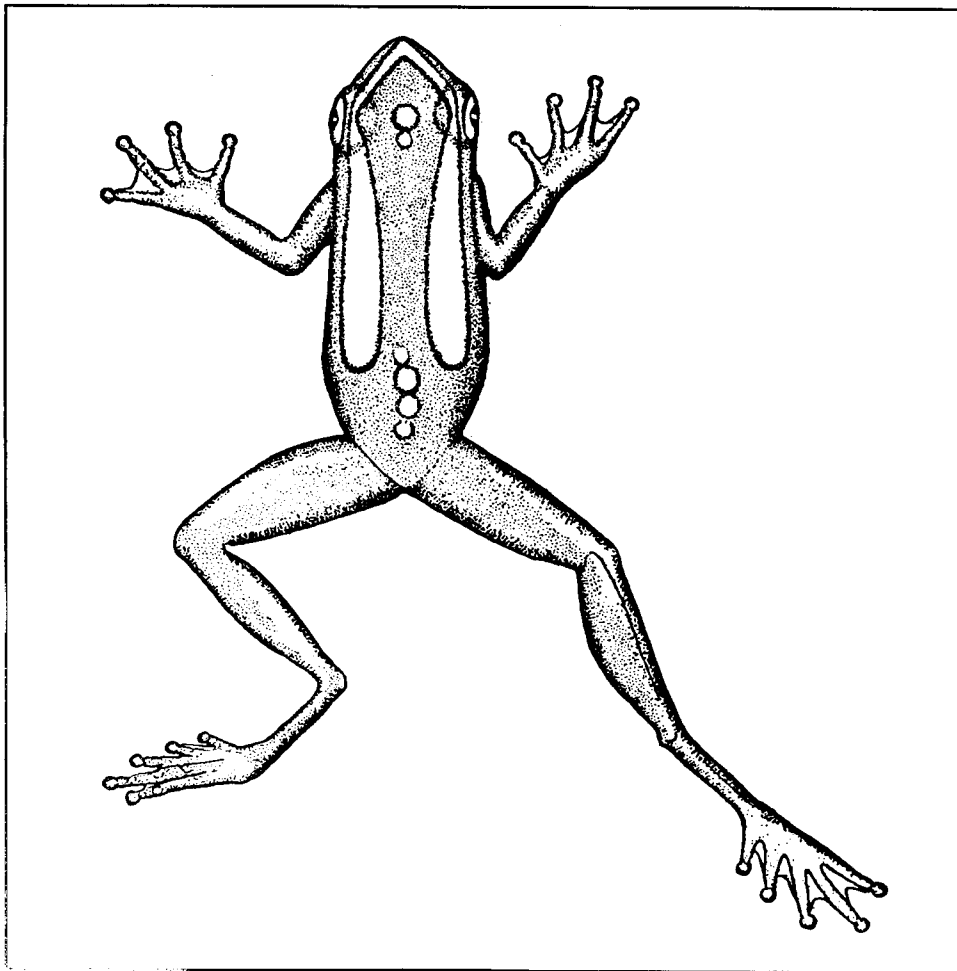

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Riparian Tadpoles: *Hoplobatrachus tigerinus* (Daudin, 1802) with Notes on Breeding Habits and Feeding Ecology

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Introduction

Hoplobatrachus tigerinus, the fairly common Indo-Pakistan "tiger frog" (Figure 1) is the largest, most colorful amphibian in the plains of Punjab. Its blotched green and bright yellow garb and distinct, vividly yellow dorsal streak distinguish it from the rest of the local amphibians. It frequents marshy areas, wetlands, and grasses around ponds and puddles below 1000 m throughout Pakistan, Kashmir and into eastern Afghanistan (Khan, 1976, 1979, 1980). It is diurnal but secretive, spending most of its time in moist environs among the roots of grasses around ponds and puddles. When alarmed it immediately jumps into the water, burying itself in the debris at the bottom. It is voracious feeder on a variety of items, including insects, amphibians, lizards, snakes, small mammals and birds. Odd tidbits like human hairs, cattle dung and grass have also been found in its stomach contents (Khan, 1973).

Breeding is triggered by the first monsoon showers during mid-July and lasts till mid-monsoon (i.e, mid-August) (Khan and Malik, 1987). The male is more active with characteristic bright yellow coloration, while the female is relatively sedentary and modest in color. When rain falls, males gather in low-lying areas, where water is fast accumulating, and croak in chorus, a characteristic, nasal, voluminous "cronk, cronk, cronk" repeated 6–8 times in succession. There is moderate scuffling among males trying to reach females; amplexus is axillary. The pair moves away to lay eggs, which are laid in small, loose, gelatinous patches that float for some time, but soon sink in the deep water, developing into tadpoles within a week (Khan, 1982).

This paper describes the external morphology of the *H.*

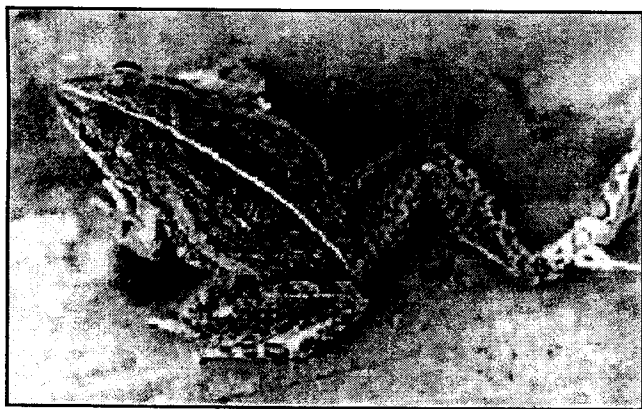


Figure 1. *Hoplobatrachus tigerinus* male.

tigerinus tadpole, with notes on its ecological correlates and habits.

Materials and Methods

The tadpoles for this study were collected from different localities by dredging along the bottom of various ponds and puddles lying along the northwestern border of Rabwah City. Comparative material was available from Ghakhar, District Gujranwala, and Datta and Manshera, N.W.F.P., the tadpoles were preserved in Bouin's Fluid and stored after dilution 1:1 with water (Khan, 1965).

A binocular laboratory microscope was used to study details of external morphology of the tadpole; drawings were made with the help of a camera lucida.

Description

Tadpole (Figure 2): Body and tail are muscular and cylindrical. The oblong body is as broad as high, with parallel lateral walls; its ventrum is flat. An infraocular bulge due to the enormously developed jaws and associated musculature is characteristic of this tadpole (Khan, 1996). The anteriorly located mouth is surrounded by a circular oral disc free of papillae. Eyes are large, dorsal in position, lying in the anterior half of the head. The nares are small, dorsolateral in position, and nearer to eyes than to the tip of snout. The spiracle is round, lies midway up on the left side, and is nearer to body end than to the oral disc. The spiracle tube is small and posteriorly directed at an angle of 45° to the long axis of body. The base of the spiracle is about three times as broad as the diameter of the opening. The anal tube is relatively short, mesial, and collapsed so that its dextral or sinistral position is not clear.

The tail is very muscular, with narrow, weak fins. It is almost round in cross section, and is about 2½ times longer than the body. At its base the tail is as high as the body. It is broadest at the middle, then becomes narrower and tapers even-

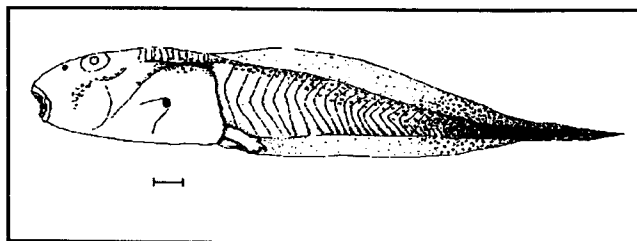


Figure 2. *Hoplobatrachus tigerinus* tadpole at Stage 35 (scale bar = 1 mm).

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ly to an acute tip. The rather narrow fins are a bit broader dorsally, forming a narrow crest along the posterior one-fourth of the tail.

Color: Head and body are gray, with a large patch of melanophores below the eyes and along the dorsum of the body. Tail and fins are darkly speckled, while the posterior one-fourth of the tail is heavily pigmented.

Measurements in mm (data from 10 specimens): Body length 12.5–13; tail length 25.4–25.9; total length 38.9–40; greatest breadth of body (at the level of eyes) 7–7.13; interorbital space 2.2; internarial space 1.6–1.8; tail muscle height (at base) 4.80–4.59; tail height (at mid tail) 6.5; body depth 6.1.

Oral disc (Figure 3): The oral disc is anterior, circular, without papillae, and emarginate. The labia are semicircular. The anterior labium has an outer complete and four inner mesially broadly interrupted rows of keratinized triserial, cylindrical sharp-tipped teeth. The posterior labium has two outer complete tooth rows, second being longest, while the inner three are mesially broadly interrupted. The dental formula for the *Hoplobatrachus tigerinus* tadpole is 5(4+4)/(3+3)5. A typical tooth is a cylindrical dark-brown keratinized structure, 0.4–0.45 mm long, which gradually tapers to a pointed tip. The teeth are triserially arranged in rows.

The dark brown, keratinized beak is a prominent feature of the oral disc. The upper jaw is a strongly arched structure, with a sharp, serrated free edge; it is mesially produced into a large serrated tooth. Flanks of the upper jaw are flat and enclose the lower jaw laterally. The lower jaw is narrower, non-serrated and sharp-edged. It is mesially excavated into a U-shaped concavity into which the median tooth of the upper jaw bites when the mouth is closed.

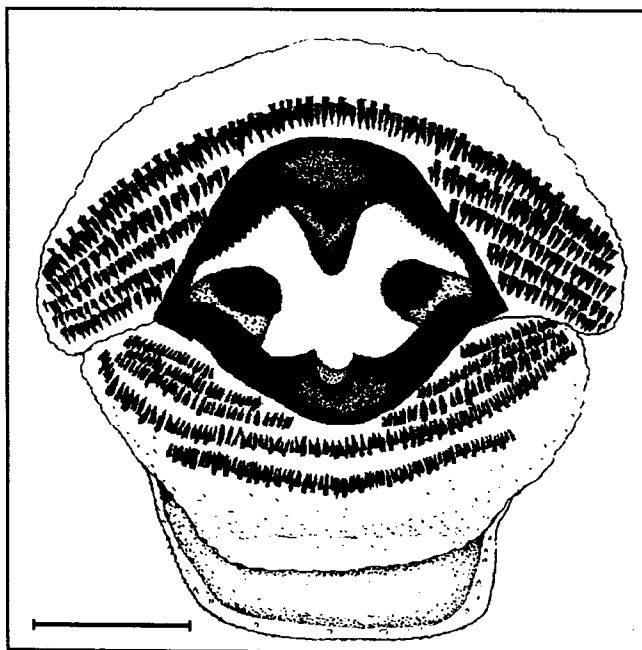


Figure 3. *Hoplobatrachus tigerinus* tadpole oral disc (scale bar = 1 mm).

A long, keratin-tipped, cylindrical papilla is present on each side within the buccal cavity. There are no oral papillae. The posterior labium can be expanded into a broad, wide sucker, when necessitated in lotic environments for attachment to supports against the water current.

There is considerable confusion in the literature regarding the number of tooth rows on the oral disc of the *H. tigerinus* tadpole. Annandale and Rao (1918) recorded five tooth rows on each labium in tadpoles from the eastern Himalayas, while Boulenger (1920) and Boulenger and Annandale (1918) record dental formula 3-4/4-5 and an entirely papillated oral disc; Liu and Hu (1961) record 4(1-4)/4(1-3) dental formula in tadpole from China. The confusion of McCann regarding the dental formula of this species (1932; Figures 1 and 2) is depicted by figuring an oral disc which is neither like that of *Euphlyctis cyanophlyctis* nor *H. tigerinus*. Minton (1966) records a smooth-edged oral disc with three long and two short tooth rows on anterior, two long and one short row on posterior labium of this tadpole.

Ecological correlates

The *H. tigerinus* tadpole remains solitary throughout its life. It is a voracious feeder—an obligate macrophagous, cannibalistic carnivore, mainly larvivorous (Mohanty-Hejmadi and Dutta, 1981; Khan, 1996). It has never been observed feeding on vegetation, nor have gut contents revealed any vegetarian habits. Breeding times of *H. tigerinus* and the common toad *Bufo stomaticus* are synchronized. *Bufo* larvae are the staple food source for *H. tigerinus*, while *Limnonectes syhadrensis*, *E. cyanophlyctis* and *Microhyla ornata* tadpoles are rarer items in its diet. Larger zooplankton like copepods and *Daphnia*, which are filtered from the incoming water current, also form a considerable portion of this tadpole's diet. Other rarely ingested items include water beetles, bugs, naiads and larvae of fishes.

Many local amphibians breed in ephemeral puddles and

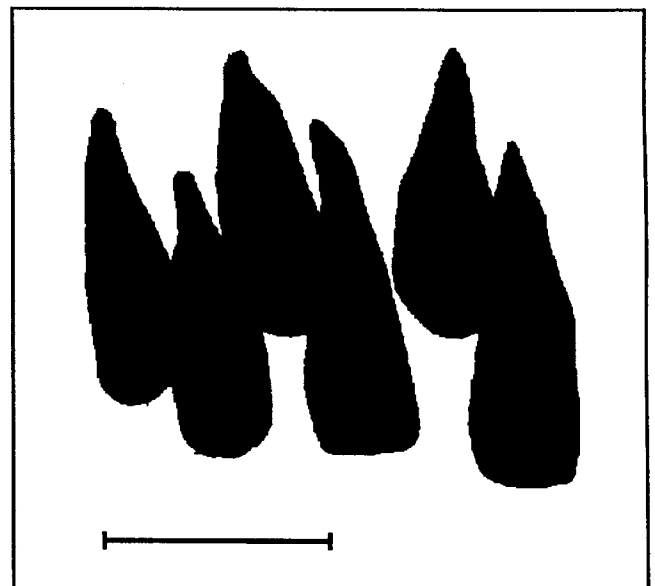


Figure 4. *Hoplobatrachus tigerinus*, a group of labial teeth (scale bar = 0.25 mm).

shallow margins of large water bodies in low-lying areas (Khan and Malik, 1987). Later, tadpoles of the various species migrate to different niches in relatively deeper water. The *H. tigrinus* tadpole lolls at the bottom; its dorsally located eyes enable it to observe activity taking place above in the water column. As a prey item comes within striking range, it darts, grabbing the prey in its powerful jaws, then settles at the bottom, subduing the prey by cutting large chunks from its body. Its powerful, muscular tail with low fins is a tool for quick and agile movements in the water column. The tadpole periodically rises to the water surface to fill its lungs, quickly ascending and descending in the water column, since at middle depths it is highly exposed to attacks from its enemies. In ephemeral shallow pools it scurries to the margin of the pond for this purpose. It avoids predatory fishes, naiads, turtles etc., by confining itself to deep water among the roots of submerged grasses.

Each species of riparian tadpole represents a morphotype, and occupies a particular ecological niche in the shared habitat (Thibaudeau and Altig, 1988; Altig and Johnston, 1989; Khan, 1991). The riparian amphibians differ in their breeding times, calling sites, egg-laying sites, larval habits, larval developing sites, and larval feeding habits (Khan and Malik, 1987). The predaceous *H. tigrinus* tadpole is a free-lancer; it invades the niches of sympatric tadpoles to prey on them. Tadpoles in such situations usually take refuge under debris at the bottom to avoid it.

The cylindrical body, dorsal eyes, anterior disposition of mouth, oral disc without papillae, hypertrophied jaws and associated musculature, peculiar multiserial teeth, suctorial post-oral labium are characteristics of carnivorous *H. tigrinus* tadpole. Altig and Brodie (1972) and Wassersug and Heyer (1983) have shown the drag force of the water current depends on the tadpole's body profile; the cylindrical body of the *H. tigrinus* tadpole flexes with the currents and eddies, reducing the chance of the tadpole being swept downstream. Unlike the similarly lentic/benthic *Bufo* and *E. cyanophlyctis* tadpoles, its

body is cylindrical, reducing drag force as it darts after its prey. The dorsal disposition of the eyes reflects on its natural resting position (Löschenkohl, 1986), and enables it to survey all the activity taking place in the water column. The circum-oral chemosensitive papillae and palps, which help a tadpole in handling food (Altig and Brodie, 1972), are lacking in *H. tigrinus*. The eyes appear to be the main prey-detecting and food-monitoring organ. The anteriorly disposed mouth quickly dismembers the struggling prey (Lynch, 1973), while fine-tipped, cylindrical, triserial teeth hold the prey item by piercing into its body. Cuspless teeth have also been reported in larvivorous leptoactylids (Starrett, 1973), *Scaphiopus holbrookii*, *S. hurterii*, *Spea hammondi* and *Ascaphus* tadpoles (Gosner, 1959).

During summer when most of the temporary breeding sites in Punjab are teeming with different species of tadpoles, these sites, if not replenished by subsequent rains, tend to dry out quickly due to high temperatures. As water level falls, tadpoles and potential predatory aquatic animals are concentrated in the fast-drying pool, and interact with each other. Except *Microhyla ornata* (which rarely breeds in temporary sites), tadpoles resort to carnivory, because protein rich diet hastens the metamorphic process. However, herons and other predatory birds take their toll of struggling tadpoles. A few tadpoles, having burrowed in mud, survive if rain comes soon. The ultimate surviving tadpoles in such concentrated situations are mostly *H. tigrinus*, if not picked up by predators.

Lactate and pyruvate level in tadpole's tail vary little during intense swimming (Gatten et al., 1984), so that energy deficit is an important constraint on swimming ability of the tadpole; they cannot outswim their predators as fishes do. The tadpoles living in open ponds with little or no vegetation mostly reduced their conspicuousness by being drab in color, while those in ponds with much vegetation are camouflaged by being spotted. The dark tail of *H. tigrinus* may serve to deflect attack from vitally important body to a relatively less important part (Caldwell et al., 1981; Kehr and Basso, 1990).

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