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A STUDY ON CERTAIN COMMON POND BREEDING ANURANS AND THEIR TADPOLES IN A POND OF WESTERN ASSAM, INDIA

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ABSTRACT
Breeding activity of Anurans is determined by the prevailing ecological condition of the habitat. They normally select pollution free breeding site that can ensure food material for the metamorphosing tadpoles. Seven species of Anura namely *Duttaphrynus melanostictus* (Schneider, 1799) *Microhyla ornata* (Dumeril and Bibron, 1841), *Uperodon globulosus* (Gunther, 1864), *Euphlyctis hexadactylus*(Lesson, 1834), *Fejervaria teraiensis* (Dubois, 1984), *Hoplobatrachus tigerinus* (Daudin, 1803) and *Polypedates teraiensis* (Dubois, 1987) were monitored in a pond throughout the breeding season till emergence. Ecological parameters were recorded. Gut content of the tadpoles was analyzed to record the preference of plankton in each species. The study revealed the suitable ecological parameters for breeding in these species. Description of stage 38 tadpole of the studied species is included.

KEY WORDS: pond, anurans, tadpoles, breeding, ecology.

INTRODUCTION

Reproduction in Anurans is influenced by abiotic factors. Breeding activity is governed by temperature, rainfall (Roy et. al, 2004) and moisture (Doreas & Foltz, 1991). After breeding, survival of the tadpole is also influenced by abiotic factors such as temperature size of habitat and habitat type (Jennings & Scott, 1993). Biotic factors such as diet (Kupferberg, 1997) and interspecific and intraspecific competition (Travis, 1980) etc. affect behavior and survival of tadpoles. Pond breeding anurans can tolerate variation in pH, dissolved oxygen and free carbon dioxide content in water. Morphological differences in tadpoles are determined by the nature of the habitat. Tadpoles of benthic forms have dorsal eyes, weak tail fins and ventral mouth. On the other hand, surface feeder tadploles have bulging lateral eyes, tail fin is well developed, and ventral fin is broader than dorsal fin and possesses antero-dorsal mouth.

A number of authors studied developmental biology of Amphibia (Ao and Bordoloi, 2001; Ao et al., 2006; Bortamuli et.al, 2010, Saha and Gupta, 2011) in North east India. Literature related to water quality parameters of breeding habitat and breeding ecology of amphibian in North East India is very scanty. Sinha et.al (2000) described qualitative analysis of food spectrum of anuran tadpoles from Arunachal Pradesh, India. Ao and Bordoloi (2003) recorded described the water quality parameters of amphibian breeding habitats of Nagaland. Roy et al. (2004) described the role of weather condition in breeding season for *Polypedates leucomystax*.

The present study deals with monitoring the habitat ecology and food spectrum of tadpoles of seven species of anurans in a pond of Assam, North-East India.

MATERIALS AND METHODS

The study site was a temporary pond in Kokrajhar district, western Assam, India (26°32′N-26°35′N and 90°09′E-90°15′E; altitude 64.5m above the sea level). The study began when egg masses were observed in the pond. Ecological parameters were recorded and tadpoles of each species were monitored. Onset of monsoon was in March (2007) and it continued through September. Sufficient water in the pond during this period allowed the tadpoles to complete their life cycle. A few tadpoles of each species were reared in aquarium till emergence so that identification can be confirmed. Stage 38 tadpoles of each species were preserved in 10%formaldehyde and measurement was taken later on.

Depth of water in the pond was recorded monthly at the deepest point. Water temperature was recorded with a mercury thermometer in morning at 8 AM. Monthly precipitation was obtained from Assam agricultural office located at Kokrajhar. pH, free CO_2 and dissolved oxygen (DO) etc. were recorded monthly as per standard methodology(APHA ,2005). Planktons were collected from the habitat with plankton net (mesh size, 50µm) and were preserved in 4% formaldehyde solution. Tadpoles were collected from habitat and reared in the aquarium till emergence and compared with adults.. Morphological terminology of tadpoles was followed after Altig and McDiarmid (1999) and staging as per Gosner (1960). Tadpoles of Gosner's stage 38 were measured with dial vernier caliper (five tadpoles of each species). For study of food preference tadpoles were collected from habitat and gut content analysis was done. The guts of the tadpole of stage 38 were removed, gut length was recorded and content from10mm of foregut and 10mm from the hind gut were taken for identification of food items of the tadpoles. Planktons were identified with the help of standard literature. Photographs of live tadpoles were taken with a digital camera (Model Sony Cybershot, 6.0m.p.& 3x o.z.).

The abbreviations used in the description of tadpoles of Gosner's stage. 38 were as follows:

N= total number of specimens studied; BH, maximum body height; BL, body length; BW, maximum body width; TAL, tail length.

RESULT

Early monsoon starts in March. At the onset of monsoon pond starts getting filled up with rain water. Breeding activity of seven species of anurans- *Duttaphrynus melanostictus* (Schneider, 1799) *Microhyla ornata* (Dumeril and Bibron, 1841), *Uperodon globulosus* (Gunther, 1864), *Euphlyctis hexadactylus*(Lesson, 1834), *Fejervaria teraiensis* (Dubois, 1984), *Hoplobatrachus tigerinus* (Daudin, 1803) and *Polypedates teraiensis* (Dubois, 1987) were studied in the habitat (Fig 1)

Data related to abiotic factors recorded are presented in Table.1 and Table.2; average rainfall in fig.2 and biotic factors in Table.3. Table.4 shows the planktons recorded in the gut of the tadpoles. Measurement and description of general morphology of tadpoles are based on stage 38(Gosner). Live photographs of tadpoles are presented in Fig.1.

FIGURE 1: A- Tadpole of *F. teraeinsis,* B- Tadpole of *M. ornata,* C-Tadpole of *P. teraeinsis,* D- Tadpole of *H. tigerinus,* E- Tadpole of *U. globulosus,* F-Tadpole of *E. hexadactylus,* G-Tadpole of *Duttaphrynus Melanostictus,* H-Study site (Pond).

Family: Bufonidae

Duttaphrynus *melanostictus* (Schneider, 1799)

Tadpoles found in the habitat: March to end of April

General morphology of the tadpoles

(N=5; BL, 6.9-7.0mm; BW, 4.16-4.2mm; BH, 3.12-3.18mm; TAL, 8.9-9.0mm; gut length, 40-43mm)

The body is black in color, roughly oval in shaped, snout rounded. Eyes placed dorsally but directed laterally. Tail musculature dark coloured with transparent weak fins. Ventrally body is pinkish, intestinal coils are visible through transparent skin. Mouth is antero-ventral.

Ecology of the tadpole

Ecological data was recorded during the presence of the tadpoles. water temperature, 23-26°c; water pH, 5-6; free carbon dioxide, 2.0-3.0mg/L and dissolved oxygen, 6.0-8.26mg/L. Tadpoles are bottom feeders. In natural habitat they are always found in group.

Gut content

Phytoplanktons: *Volvox sp., Oscillatoria sp., Nostoc sp., Gloeocapsa sp., Ulothrix sp., Cladophora sp., Oedogonium sp., Cosmarium sp., Diatom sp.*

Zooplanktons: *Lecane sp., Lepadella sp., Eucyclops sp., Diaphnosoma sp.*

Family: Microhylidae

***Microhyla ornata* (Dumeril and Bibron, 1841):**

Tadpoles found in the habitat: March to June

General morphology of the tadpoles

(N=5; BL, 9.63-9.78mm; TAL, 15.0-15.6mm; BH, 4.32-4.5mm; BW, 6.2-6.4mm; gut length, 46.0-48.0mm)

Body dorsally creamy white with dark diamond shaped marking on between inter ocular space. Body ventrally transparent, all the anatomical organs are visible. Tail musculature is without spots. Body oval in shape, snout rounded. Body laterally depressed. Eyes are comparatively large, bulging and placed laterally. The spiracle is medial, situated on the posterior ventral body. Tail fins are transparent, lower fin is broader than upper one. No keratodont and hard parts in the oral disc.

Ecology of the tadpole

Tadpoles are found in temperature ranging from , 23-27°c; water pH, 5.0-7.0; free carbon dioxide, 2.0-6.0mg/L and dissolved oxygen, 4.13-8.26mg/L. Tadpoles are surface feeders. They have pumping type feeding in natural habitat and they are phytoplanktons feeder.

Gut contents

Phytoplanktons: *Volvox sp., Oscillatoria sp., Spirogyra sp., Diatom sp.*

***Uperodon globulosus* (Gunther, 1864):**

Tadpole's available habitat: April to June

General morphology of the tadpole

(N=5; BL, 9.63-9.8mm; TAL, 15.0-15.3mm; BH, 4.32-4.45mm; BW, 6.2-6.5mm; gut length, 43.0-45.0mm)

Body dorsally spotted dark brown, ventrally light brown or pinkish. Tail musculature is striped. Tail fins are transparent, light brown with dark dots. Tip of tail is black. Body dorsally oval shaped, snout rounded. Body laterally depressed. Eyes are moderate in size, bulging, and placed laterally. Spiracle is medial in ventral body just above the anal tube. Upper fin of tail is slightly broader than lower one. No keratodont and hard parts in oral disc.

Ecology of the tadpole:

Tadpoles are found in water temperature, 24-27°c; pH, 5-7; free carbon dioxide, 2.0-6.0mg/L and dissolved oxygen, 4.13-8.26mg/L. Tadpoles are surface feeder. They have pumping type feeding in natural habitat and are phytoplankton feeders. They are found in group on surface water.

Gut contents

Phytoplanktons: *Gloeocapsa sp., Oscillatoria sp., Volvox sp., spirogyra sp., Diatom sp.*

Family: Dicroglossidae

***Euphlyctis hexadactylus* (Lesson, 1834)**

Tadpoles found in the habitat: April to August

General morphology of the tadpole

(N=5; BL, 18.7-18.82mm; TAL, 25.3-25.5mm; BH, 8.9-9.0mm; BW, 11.28-11.42mm; gut length, 220.0-225.0mm)

The body is dorsally brown with dark pigmentation on the posterior side. Body ovoid in shape, snout is rounded. Eyes are placed dorsally but directed laterally. The spiracle is sinistral. The tail is comparatively short. Tail musculature is saddled, light brown spotted. Tail fins are light brown transparent. Mouth is on the ventral side.

Ecology of the tadpole

Tadpoles are bottom feeders and feed on both phyto- and zoo-planktons. They are found as solitary in natural habitat. They are found in water temperature, 24-27°c; water pH, 5-7; free carbon dioxide, 2.0-6.0mg/L and dissolved oxygen, 4.13-8.7mg/L.

Gut contents

Phytoplanktons: *Oscillatoria sp., Nostoc sp., Gloeocapsa sp., Ulothrix sp., Cladophora sp., Oedogonium sp., Cosmarium sp., Diatom sp.*

Zooplanktons: *Lecane sp., Lepadella sp., Eucyclops sp., Diaphnosoma sp., Daphnia sp., Heliodiaptomus sp.*

***Fejervaria teraiensis* (Dubois, 1984)**

Tadpoles found in the habitat: March to June

General morphology of the tadpole

(N=5; BL, 11.65-11.76mm; TAL, 26.05-26.25mm; BH, 5.7-5.84mm; BW, 7.1-7.3mm; gut length, 130-135mm)

The body is dorsally dark brown, pigmented. Tail musculature is mottled. Tail fins are light brown with dark pigmentation. Body roughly oval in shaped, snout rounded. Eyes are moderate, placed dorsally but directed laterally. Spiracle sinistral. The upper tail fin is slightly broader than lower one. Tip of tail pointed and directed slightly upward. Oral disc is ventral in position.

Ecology of the tadpole

Tadpoles are bottom feeders. They are found in groups in natural habitat. They are found in water temperature, 23-27°c; water pH, 5-7; free carbon dioxide, 2.0-6.0mg/L and dissolved oxygen, 4.13-8.26mg/L.

Gut contents

Phytoplanktons: *Volvox sp., Oscillatoria sp., Nostoc sp., Gloeocapsa sp., Ulothrix sp., Cladophora sp., Oedogonium sp., Cosmarium sp., Diatom sp.*

Zooplanktons: *Lecane sp., Lepadella sp., Eucyclops sp., Diaphnosoma sp., Daphnia sp.*

***Hoplobatrachus tigerinus* (Daudin, 1803)**

Tadpoles found in the habitat: April to August

General morphology of the tadpole

(N=5; BL, 17.65-17.74mm; TAL, 34.4-34.6mm; BH, 8.45-8.52mm; BW, 10.4-10.6mm; gut length, 130-135mm)

The body is large. The body is dorsally yellow brown, posterior side is greenish, Y-shaped marking posterior to intraocular space. Tail musculature is brown, unicolored with dark dots. Tail fins are transparent with black dots. The body is dorsally roughly oval in shape, slightly broader in posterior side. The snout is roughly pointed. Eyes are large, placed dorsally. Spiracle is single and sinistral. Upper tail fin is slightly broader than lower one. Tip of tail is pointed. Oral disc is antero-ventral.

Ecology of the tadpole

Tadpoles are bottom feeders. Ecological parameters recorded are water temperature, 24-27°c; water pH, 5-7; free carbon dioxide, 2.0-6.0mg/L and dissolved oxygen, 4.13-8.7mg/L. In captivity, tadpoles show cannibalistic character. Tadpoles are not gregarious.

Gut contents

Phytoplanktons: *Oscillatoria sp., Nostoc sp., Gloeocapsa sp., Ulothrix sp., Cladophora sp., Oedogonium sp., Cosmarium sp., Diatom sp.*

Zooplanktons: *Lecane sp., Lepadella sp., Eucyclops sp., Diaphnosoma sp., Daphnia sp., Rhinediaptomus sp., Heliodiaptomus sp.*

Family: Rhacophoridae

***Polypedates teraiensis* (Dubois, 1987):**

Present in habitat: Foam nest recorded from April.

General morphology of the tadpole

(N=5; BL, 14.6-14.7mm; TAL, 31.5-31.62mm; BH, 7.6-7.8mm; BW, 8.2-8.6mm; gut length, 120-125mm)

The body is dorsally brown with dark pigmentation. The body is elliptical in shape, snout blunt, rounded. Eyes are bulging, placed laterally. The spiracle is sinistral. Mouth is anteroventral. Tail musculature is brown with dark dots. Tail fins transparent.

Ecology of the tadpole:

They are found in water temperature between 24-26°C; water pH 5-6, free CO_2 2.0-3.0 mg/L and dissolved oxygen, 6.33-8.26mg/L. They are observed as both bottom and surface feeders in the aquarium.

Gut contents:

Phytoplanktons: *Oscillatoria sp., Nostoc sp., Gloeocapsa sp., Ulothrix sp., Cladophora sp., Oedogonium sp., Cosmarium sp., Diatom sp.*

Zooplanktons: *Lecane sp., Lepadella sp., Eucyclops sp., Diaphnosoma sp.*

DISCUSSION

Differences in reproductive phenology of Anuran species already been attributed to their reproductive modes and to specific physiological characters, such as levels of tolerance to temperature and precipitation. A stable hydro period at the reproductive site in temporary ponds, especially after the first rains, is one of the factors responsible for the aggregation of species that spawn directly in water (Arzabe *et al*., 1998). The present study has shown that breeding activity of pond breeding seven species of Anurans is influenced by rainfall, temperature and depth of water. Though only one pond was monitored for completion of life cycle of the tadpoles a number of temporary pools in the neighborhood were studied. It was observed that some ponds were not selected by the gravid female for egg laying though all the parameters recorded were more or less similar. Similar phenomenon was observed in the study of *Hyla annectans* (Ao and Bordoloi, 2000). Normally tadpoles were found to occupy the periphery of the pond rather than deeper waters in the centre of the pond.

Temperature tolerance and relative humidity during onset of breeding differed from species to species. *Duttaphrynus melanostictus* eggs were recorded in low temperature and when the depth of water was low in March (temperature, 23-26◦c; depth of water, 6-12cm).

TABLE 1: Monthly water temperature (in ◦C) and depth of water (in cm) of the pond.

Month	Water Temperature in ◦c	Depth of water in cm	Tadpoles found in habitat
March	23-25	6-15	A, B & E
April	24-26	15-30	A, B, C, E, F & G
May	26-27	30-80	B, C, D, E & F
June	26-27	80-100	B, C, D, E & F
July	26-27	100-120	D & F
August	25-27	120-150	D & F
September	26-27	150-200	F

A- *Duttaphrynus Bufo melanostictus*, B- *Microhyla ornata*, C- *Uperodon globulosus*, D- *Euphlyctis hexadactylus*, E- *Fejervaria teraiensis*, F- *Hoplobatrachus tigerinus*, G- *Polypedates teraiensis.*

TABLE 2. Monthly water quality parameter of the pond.

Month	pH	Free CO_2 in mg/L	Dissolved oxygen in mg/L
March	5.0-5.5	2.0-3.0	6.0-6.5
April	5.0-6.0	2.0-3.0	6.33-8.26
May	6.0-6.5	3.0-5.0	4.13-8.0
June	6.5-7.0	5.0-6.0	6.33-7.44
July	6.5-7.0	4.0-6.0	7.44-8.26
August	6.0-7.0	3.0-4.0	8.5-8.7
September	6.0-7.0	3.0-4.0	8.0-8.54

TABLE 3. Planktons found in the habitat.

Planktons	March to Early May (Pre monsoon)	Late May to Early July (Monsoon)	Late July to September (Post monsoon)
Phytoplanktons :			
Chlorophyceae:			
Volvox sp.	+	-	-
Spirogyra sp.	+	+	+
Ulothrix sp.	+	+	+
Cladophora sp.	+	+	+
Oedogonium sp.	+	+	+
Voucheria sp.	+	+	+
Scenedesmus sp.	-	+	+
Cosmarium sp.	+	+	+
Cyanophyceae:			
Gloeocapsa sp.	+	+	+
Nostoc sp.	+	+	+
Oscillatoria sp.	+	+	+
Chlamydomonas sp.	+	+	-
Anabaena sp.	+	+	+
Microcistis sp.	+	+	+
Basillariophyceae:			
Diatom sp.	+	+	+
Zooplanktons:			
Rotifera:			
Lepadella sp.	+	+	+
Lecane sp.	+	+	+
Platyias sp.	+	+	+
Cladocera:			
Diaphnosoma sp.	+	+	+
Daphnia sp.	+	+	+
Copepoda:			
Eucyclops sp.	+	+	+
Rhinediaptomus sp.	+	+	+
Heliodiaptomus sp.	+	+	+

+= present, -= absent

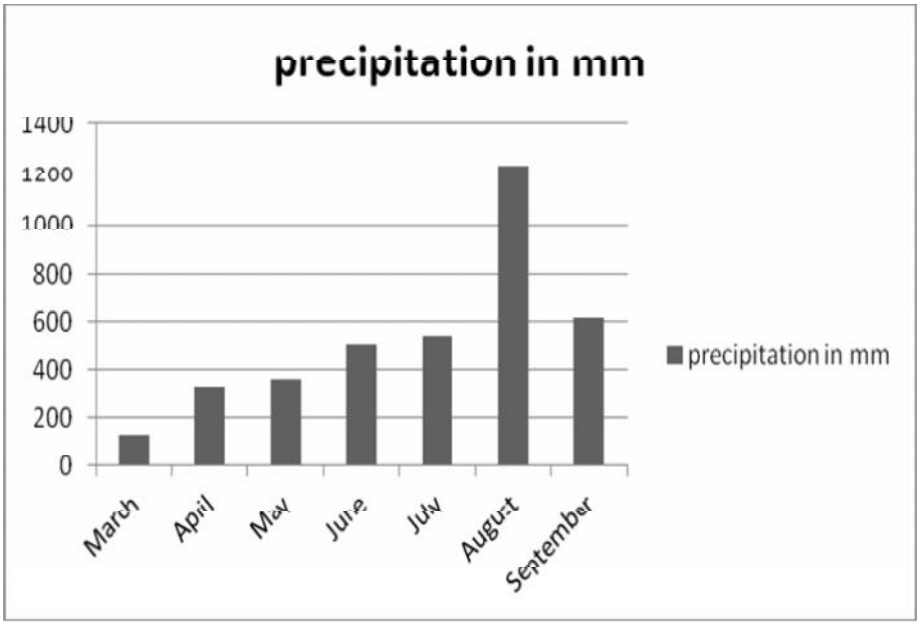

FIGURE 2: Average rainfall of study area from March to September, 2007 (in mm).

TABLE.4: Planktons found in the gut of the tadpoles.

Planktons found in the gut of the tadpoles	*B. melanostictus*	*M. ornata*	*U. globulosus*	*E. hexadactylus*	*F. taraiensis*	*H. tigerinus*	*P. taraiensis*
Phytoplanktons :							
Chlorophyceae:							
Volvox sp.	+	+	+	-	+	-	-
Spirogyra sp.	-	+	+	-	-	-	+
Ulothrix sp.	+	-	-	+	+	+	+
Cladophora sp.	+	-	-	+	+	+	+
Oedogonium sp.	+	-	-	+	+	+	+
Voucheria sp.	-	-	-	-	-	-	-
Scenedesmus sp.	-	-	-	-	-	-	-
Cosmarium sp.	+	-	-	+	+	+	+
Cyanophyceae:							
Gloeocapsa sp.	+	-	+	+	+	+	+
Nostoc sp.	+	-	-	+	+	+	+
Oscillatoria sp.	+	+	+	+	+	+	+
Chlamydomonas sp.	-	-	-	-	-	-	-
Anabaena sp.	-	-	-	-	+	+	+
Microcistis sp.	-	-	-	-	-	-	+
Basillariophyceae:							
Diatom sp.	+	+	+	+	+	+	+
Zooplanktons:							
Rotifera:							
Lepadella sp.	-	-	-	+	+	+	+
Lecane sp.	-	-	-	+	+	+	+
Platyias sp.	-	-	-	-	-	-	-
Cladocera:							
Diaphnosoma sp.	-	-	-	+	+	+	+
Daphnia sp.	-	-	-	+	+	+	-
Copepoda:							
Eucyclops sp.	-	-	-	+	+	+	+
Rhinediaptomus sp.	-	-	-	-	-	+	-
Heliodiaptomus sp.	-	-	-	+	-	+	-

+= present, -= absent

Species of the family Microhylidae were found to be an early monsoon breeder. In *M. ornata* and *U. globulosus*, breeding period lasted from March to June. Microhylid tadpoles are surface feeder; they spend maximum time in surface water indicating that their tadpoles require sufficient light and temperature. Tadpoles of these species were not found in the deeper region (depth of water, 15-100cm) of the water body.Generally they prefer rain pool. Among those frogs like *H. tigerinus* and *E. hexadactylus* that prefer aquatic life in adulthood, depth of water is not found as an important factor (they are found in both high and low depths of water). The tree frog, *P. teraeinsis* (family:Rhacophoridae) and *F. teraeinsis* (family: Dicroglossidae) have a true terrestrial life in adulthood and are found as pre-monsoon breeder. pH of water is also an important factor for breeding activity of aquatic animals and is species specific. Amphibians are generally more sensitive to low pH during the embryonic stage of development (Gosner and Black, 1957). On the other hand, free carbon dioxide of water affects water pH. High concentration of dissolved oxygen(DO) in water indicates rich aquatic flora, which are diet of many aquatic animals. In the present study tadpoles were found to tolerate slightly acidic water with high concentration of dissolved oxygen and free carbon dioxide. Rich phytoplankton growth was an indicator of pure and high mineral contents in the water of the habitat.

Tadpoles occur in countless aquatic habitats, feeding at many sites (benthic, midwater, surface) throughout the water column and have characteristic morphologies and behavior (McDiarmid & Altig, 1999). The tadpoles of benthic forms, typically have a dorsoventrally flattened body, dorsal eyes and low fins (Saidapur, 2001). Tadpoles of *H. tigerinus, F. taraeinsis, E. hexadactylus* show characteristics of benthic water adaptation viz., dorsal eyes, week tail fins and ventral mouth. On the other hand, Microhylid tadpoles show characteristics of surface feeder with bulging lateral eyes, tail fin well developed, lower fin broader than upper one and antero-dorsal mouth. Bufonid tadpoles adopted to survive in shallow water have thick black body, lack of well developed tail for swimming and week tail musculature.

Analysis of food contents of guts shows that Microhylid tadpoles are phytoplankton feeders, but all the Dicroglossid tadpoles are both zoo and phyto- plankton feeders. Herbivore tadpoles have shorter alimentary canals than the omnivore tadpoles.

Social aggregation is common in some Anurans (Saidapur, 2001). Advantage of social aggregation among animals is benefit of feeding or benefit from predators. Water temperature is often the dominant factor in the tadpole aggregation (Beiswenger, 1975). Tadpoles aggregate, in part, because they absorb more solar radiation than the surrounding water which results in more heat being absorbed in water containing aggregations. Tadpoles which are surface dweller are mostly found in group (Microhylid tadpoles) due to absorption of more solar energy.

From the above study we can conclude that the breeding activity of the species studied is directly co-related to both abiotic and biotic factors. Rainfall, water depth, temperature and physico-chemical parameters of water of the habitat are related to spawning behavior of frogs.

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