

## Reproductive Strategies in a Subtropical Anuran Population in Arid Punjab, Pakistan

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**Abstract :** Records of breeding activity in a sympatric population of 5 species of anuran amphibians, around Rabwah, Distt. Jhang, Punjab, Pakistan, were kept over a 3-year period (1979-81 inclusive), and compared with local temperature variations and sequence of rain fall. Essentially all local amphibians and sporadic breeders with certain preferences which isolate them from their sympatrics specific size of adult, activity time, breeding habits like selections of calling and egg laying site, difference in the frequency and duration of calls, preference to certain temperature or rainfall, larval habitat partitioning etc. Despite close links with environmental factors and co-occupancy of potential breeding sites, hybridization is prevented.

Amphibian fauna of arid Punjab presents beautiful example of coexistence, each species utilizing maximum of pond resources, and at the same time successfully avoiding competition with its sympatrics, at every level of its life cycle.

Amphibian community of the study area comprises of six species: *Bufo stomaticus*, *Microhyla ornata*, *Rana cyanophlyctis*, *R. breviceps*, *R. syhadrensis* and *R. tigerina* (Khan, 1976, 1982). *R. breviceps*, a species of northern highland (Khan, 1979) is rare in the study area and riparian in distribution (Khan, in Mirza and Ali 1972) do not interact with the local amphibian, is not included in present study.

Present work is undertaken to understand how species in a sympatric community in temperate environments, adjust to fluctuations in temperature and rain fall. To understand inter and intraspecific mechanisms helping species to partition common breeding site, studies on reproductive strategies, employed by various amphibian species, may reveal interesting mechanisms of adaptations and selections (Blair, 1964). Each amphibian form represents unique pattern of calling and selection of site for spawning. This pattern has played a key role in the evolution of that species. Such studies help to understand the link between amphibians and their aquatic

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habitats and importance of their terrestrial surroundings. Such adaptations have resulted due to a variety of selection pressures which have acted through ages and now controlled by the genome of species enabling each form to maintain its identity in the ecosystem.

Temperature is seldom a limiting factor in tropics for amphibian reproductive activity, though seasonal rain fall is so (Inger and Greenberg, 1956; Schmidt and Inger, 1968; Inger and Bacon, 1968; Inger, 1973; Dale, 1960; Church, 1960; Zeller, 1960). Berry and Varughese (1968) find that neither temperature nor rainfall effect reproductive activity in throughly aquatic frog *Amolops larutensis*. On the other hand in temperate region both temperature and rainfall are limiting factors (Glass Rugh, 1944; Bragg, 1945; Caruso, 1949; Blair, 1961) curtailing reproductive activity within a short period.

Plains of Pakistan is western part of vast Indo-Gengetic basin (Khan, 1980). Reclamation of land and extensive canalization has changed steppic environs resulting extensive distribution of local amphibians. These amphibians depend on short summer monsoon spells for their reproductive activity. Present study records observations made on the reproductive strategies during three years of study 1979 to 1981.

#### MATERIAL AND METHOD

The study area included part of the city Rabwah and western and northern cultivated areas falling within a radius of 1 km. from Herp Laboratory, 15/6 Darul Saddar North, Rabwah Pakistan (Long 72.085 and Lat. 31.045 N). Sites within city included low lying water catchment areas; lawns of Offices of Majlis Ansar Ullah, Saddar Anjuman Ahmadyah, open spaces near Darul Khalafat and ditches along both sides of Sargodha road. Water is held at these places from 4 to 8 days and is never deeper than 30-40 cm. deep. However low lying areas in front of Railway Station held water from 3 to 4 months, and during 1979 this site was holding water throughout the year. This site has thick grass and stands of *Capparis*, with overhanging *Acacia* and *Ziziphus* trees.

Sites in the cultivated suburbs include fields under regular cultivation. During summer peddy is sown with enough water for breeding amphibians. At places low lying areas exist where water gathers. There is no permanent water body except deep ditches along both sides of the railway tract as it leaves Rabwah on the West. These ditches hold water up to December thus are available for breeding.

Each year, soon after rain began, daily inspections of potential breeding site was made. At a time observations included one complete loop of

the study area, during which all ponds and flooded areas were visited and irrigation channels checked. Location of frogs and toads was noted and their behaviour noted. Night time observations were made between 6 am and 10 am. often this lasted till midnight depending on frog activity. Occasionally 2 or 3 loops were made at different time during a single night.

Following data was collected ;

Daily temperature : morning, noon, evening ;

Record of rainfall : time, duration, quantity ;

Initiation of calling of each species : date, time, location ;

Peak calling spell of each species : date, time, location ;

First amplexic pair observed for each species : date, time, location ;

First appearance of tadpoles of each species : date, location ;

Disappearance of tadpoles from ponds of each species.

#### METERIOLOGICAL OBSERVATIONS

Pakistan, except southern coastal strip, fall within subtropical continental low land climatic region (Ahmed, 1951). Its main feature being high summer temperature and late summer (July-August) monsoon rains, low winter temperature and light winter (December-January) mosoon shower. However, uncertainty, when rain will start and stop, prevails each year. Conditions in western and southern Punjab, are most uncertain.

Rainfall fluctuate between 200 mm to 350 mm annually. Summer rains may be heavy (prolonged) or very short and winter spells may altogether be cancelled or may start late extending into (March-April), prolonging winter low temperature. July-August are rainniest, while June driest. General character of meteriological conditions of the study area is evident from record of rain and temperature for three years of present study (Fig. 1, 2, 3).

1979

Total rainfall ; 318 mm ; rainniest month ; July (75 mm), August (110 mm).

Driest month : February (5 mm) ; Hottest evening : 17 June (29°C)  
Fig. 1.

Year 1979 has been rainniest for many preceeding years of general draught, in the sense that rain was evenly distributed over the year. Environmental uniformity influenced amphibian activity both by providing

abundance of water and meeting commulative effect of preceedings two years of deficient rain fall. This year may be characterized as abnormally moist with mild temperature throught. Breedings sites never dried out because of intermittent rain, after every 10 to 15 days.

About 3 mm rain fsll on 7-8 February, preceeding cold winds, heavy overcast, in the general form of drizzling while 2 mm fell on 23, temperature not rising over 8°C. Same conditions continued in March, with the difference that cold wind has stopped, evenings have become warmer with temperature rising to 13°C remaining constant, total rainfall this month was 16 mm. Cold winds prevailed in early April falling temperature to 10°C, continued with slight fluctuations and rise of temperature. Two days of intermittent rain fell 12 mm, from 14 to 16 April. Last half of the month was rainless. After short spell on 14 May, heavy rain fell from 17 to 22 (15 mm) and after a lag of 4 days, rain came on 27 May and continued into June : 15th and 17 to 26 (11 mm) and 29 to 30 (2 mm). Despite extended raining period during May and June, temperature has gradually risen, it was highest 29°C on evening of 17th. July and August, receiving heaviest rain for the year. It continued intermittently through September to 26 October. July-August rains brought down the temperature, until at the end of August it fell to 18°C and by mid September it touched 10°C mark.

#### 1980

Total rain : 280 mm ; rainniest months : March (50 mm), July (70 mm), September (30 mm); Hottest evening : June 26th (28°C); Driest months : April (3 mm), June (4 mm).

This year rain fall is characteristically concentrated early in the year February (48 mm) to Mareh (65 mm) and late July (80 mm) to September (50 mm). A heavy overcast followed by cold wind brought mid February 18 mm rain, and on 21st 3 mm fell, Evening temperature gradually rose above 10°C when mid March rains and subsequent prevalence of cold were brought it down. April, this year recorded 3 mm rain. Temperature rose abruptly with slight fluctuations due to May rains. Prevailing acidity during June raised evening temperature to 29°C, until July and owned heavy showers brought it gradually down.

Year 1980 has been dry with water available in early months when the temperature is low. However, short spells during April-June, initiated calling in local amphibians. Most of the period potential breeding sites remained dry. First week of July saw peak breedings activity, which was abruptly stopped by heavy pour of mid July.

1981

Total rain fall : 249 mm : rainniest months : August (145 mm), September (50 mm) ; driest months : June (0.00 mm), Hottest evening 25th July (30 mm).

1981 was driest and hottest for two preceeding years. Main rain fall concentrated in August and September. From February temperatute rose steadily through May, June and July adding up until maximum was built up in second half of July.

February spell came on 6th in the form of heavy overcast, cold wind and intermittent rain fall. By 9th it cleared off, except slight overcast on 15th evening and drizzling gathering 20 mm. Rain was not comming until mid March (13 mm), followed by April (17 mm) and May (10 mm). June was dry and desolate. July intermittent rain brought relief then began heavy reins of the season during first week of August. Throughout the year temperature has been high.

This year amphibian reproductive activity was of a continuous character throughout summer. Most of the amphibians utilized shallow irrigation channels and newly watered fields for breeding. The potential sites remained dry except for July August rains. Pools of refuse water in the subruhs of the city were seats of great breeding activity during hot evening.

### CALLING PATTERNS

Calling pattern of *Bufo stomaticus* and *Rana tigerina* is strikingly similar, and presents an ideal example of convergent evolution. In these species a chorus is initiated by few individuals available at a potential breeding site. They quickly begin calling, males from surrounding areas gather at the site and soon join the chorus. By dusk maximum number of males have gathered and chorus is at its full swing. Calling males usually occupy marginal water, and are half submerged in shallow water (Fig. 4). As water rises, they move to higher places, so that during calling their limbs and bodies rest on substratum. Calls come in bouts, chorus alternating with the period of silence of 20 seconds to several minutes (Fig. 6). Calling, every time, is started by one or few individuals of the same species or of other sympatric species.

Females attracted to the site, apparently calling. show themselves among calling males. Several males jump upon it, after a series of tugging and kicking bouts, strongest males is able to maintain its amplexic hold and soon the pair leave for a calmer corner, with much vegetation, for ovulation.

*Microhyla ornata* and *Rana syhadrensis* are solitary in habits, they do not form choruses like *stomaticus* and *tigerina*. Individuals call from their perch, which they choose along the margin. *Microhyla* like to sit in a slight depression formed by the hooves of some cattle while visiting the pond to nibble at the grass blades or to drink water. Usually this depression is well concealed by over growing grass (Khan, 1974). On the other hand *R. syhadrensis* chooses the roots of long grass or that of small plants growing along the margin. Calling males are well concealed, because of their solitary habits amplexic pairs in these two forms are difficult to locate. During three years of present study 12 amplexic pairs were recorded for *R. syhadrensis* and none of *M. ornata*. Therefore most of the observations, pertaining to the amplexus in these species, are based on number of eggs masses observed at a time on a site.

Rain fall is not a limiting factor for initiation of reproductive activity in *Rana cyanopholyctis*. General drought and pre-rain hot evenings are ideal for breeding activity in this frog. In hot and dry season, water is confined to refuse-water channels and small puddles formed in the outskirts of the city. These sites are often with a thick cover of pond grass, with shallow muddy water. When optimum evening temperature is reached, males gather at these places and begin calling. The sites are in great hustle and bustle due to calling and jumping males over each other to form pairs.

When troubled spot is closely observed, frogs are afloat with their forelimbs resting on the grass blades, and vigorously calling in an uncoherent broken calls, mixed with squeaks and occasional spurts. The water and vegetation are in commotion. Males riding the backs of females make for quieter part of the site for ovulation. Amplexus is rare in the species during heavy rains, July and August (Figs. 1, 2, 3).

### SPECIES ACCOUNT

Following accounts, of reproductive activity of each local amphibian species, are compiled from the field notes. Reproductive activity of each species, is plotted against fluctuations in temperature and rainfall in figures 1, 2, 3.

#### *BUFO STOMATICUS* LUTKEN

It is one of the most familiar, widely distributed and only representative of the genus in the plains of Pakistan (Khan, 1972, 1976, 1979, 1980, 1987). Its low guttural call is one of the most familiar animal calls of early summer rains (Khan, 1982). It is the first amphibian to arrive at the flooded areas and quickly form very noisy choruses.

Calling pattern of *B. stomaticus* is consistent throughout period of present study (Fig. 1, 2, 3). In 1979, early March rains with 13°C evening temperature, initiated calling, however, regular choruses were set up by April and continued through May-June. First male called on 3 March with 20 pairs, heaviest pairing 68 was noted on 4 March (Table 3). During April 25 pairs were noted, second heaviest for the year and so on. Last pair was encountered on 2 August.

During 1980, prevailing cold winds of February-March and unusual hailstorm on the night of 15 March allowed low temperature till the end of March. Optimum temperature for calling activity of toad was reached in the first week of April. Though at this time there was no water available except in the permanent water bodies, the toads invaded recently watered fields. First male this year was heard on 6 April with 29 pairings from 6 sites (Table 1, 2). Heaviest pairing 45 followed mid-April rains. During April a total of 198 pairs were sighted. Heaviest calling was during May. July and August down pours. This year last male was heard on 28 August.

During 1981, optimum temperature was reached, for initiating calling, in first week of March. First male was heard on 4 March with 28 pairings. Heaviest pairing 33, was noted on 5 March. Last call for the year was heard on 3 September while last pair recorded for the year on 15 August.

#### *MICROHYLA ORNATA* (DUMERIAL & BIBRON)

The ant-frog is smallest of the local amphibians (Khan, 1974, 1976, 1979). It has wide distribution throughout southeast Asia. Pakistani population being its western most extent (Khan, 1980). This frog stays close to water in the surrounding moist grass. Its characteristic resping call closely follow first heavy rain of the monsoon season. Males do not gather at a place. They call while well spaced from each other, about half to one meter away from water (Fig. 4). Efforts to find an amplexic pair, during the course of present study, proved fruitless. So the number of egg-rafts at the surface of water, where males have been calling, were taken as number of pairing (Khan, 1982 b).

During 1979, mid-May evening temperature of 20°C and heavy rains triggered this species to call on 14 May. Calling continued intermittently to mid-June. Twelve egg-rafts were recorded from 7 to 15 June. (Table 1, 2, 3), while 8 during July. This year last male was heard on 18 July. and last egg-raft was noted on 15 July.

Optimum temperature for reproduction was reached by mid-May 1980 and showers in this month induced calling on 13 May. By last week of May maximum 10 spawns were noted while 9 during June. Second spell of calling came during early July with one spawn. Last male called on first August. Late rains during 1981 delayed reproductive activities in *M. ornata*. First male was heard calling on 5 May, while first spawn was noted on 8th. This month a total of 12 spawns were recorded and same number was recorded during July. Last male called on 10 August.

### *RANA CYANOPHLYCTIS* SCHNEIDER

Common skittering frog is a regular feature of water bodies in the study area. It is most widely distributed amphibian throughout Saharo-Sindhian and Indo-Oriental region (Khan, 1976, 1980). This frog is highly aquatic and littoral, its population remains permanently resident in and around the pools in which its breeding takes place. Its call usually continues through most of the hot summer evenings and herald summer season. Its peculiar habit of skittering over the surface of pond water for some distance, was first noticed by Emperor Babar in this autobiography (translated by Beveridge, 1979 : 503).

This frog is remarkably capable of adjusting itself to uncertain aquatic conditions in the temperate, arid parts of Punjab plains. During drought, except permanent water bodies, all other potential breeding sites are dried up, it migrates to permanent water bodies in the area, pools of water formed along the courses of rivers, or into shallow pools of polluted refuse water formed in the suburbs of the city and villages in the area. Despite prevailing dry and desolate conditions these sites have thick growth of pond-grass and other water-weeds, providing an excellent hiding place to *R. cyanophlyctis*. During hot and dry summer nights, these sites are seat of great hustle and bustle. Male *R. cyanophlyctis* are very active and vocal, setting whole place in commotion; Males utter a variety of calls from low grunts to fine squeaks. Pairing takes place as soon as evening temperature reaches 12°C, irrespective of the initiation of rains.

Calling season, in all 3 years of study started with few of stray individuals calling in the afternoons. It followed eventually by evening callings as evening temperature reaches optimum. In this species calling is started where temperature reaches a range of 12-15°C rather than rain fall. In 1979 first calls was heard on 26 February, 1980 on 2 April (cold wind and heavy rain fall did not allow the temperature to rise to optimum earlier), and in 1981 first male called on 25 February. Amplexic pairs are not easily detectable, when the animals are breeding in the



refuse water pools due to thick vegetation at the site. In open water bodies first pair for 1979 was recorded on 15 March, 1980 on 5 April and for 1981 on 5 March, after 18, 3 and 9 days respectively of first call. Similarly the end of calling period also varies considerably, from year to year, it always comes with the drop of temperature below optimum, in 1979 it ended on 15 September, 1980 on 22 September and in 1981 on 8 October, due to prologation of hot season,

It is difficult to determine peak calling period in this frog, since it calls continuously throughout summer season. Marked decline in calling was observed during heavy rains in this species. Perhaps it might not be so, since at this time other sympatric amphibians are calling. Their loud calls subdue the low and weak call of *R. cyanophlyctis*, who may be as vocal as ever.

Amplectic pairs are difficult to locate in this littoral and highly aquatic species. Breeding sites are with thick vegetation and pairs keep to the most obscure part of their habitat for ovulation. Moreover, for most of the calling season males are solitary. In early breeding season when *R. cyanophlyctis* breeds in small pools of refuse water, a female generally may stay in a group of calling and reproductively active males and pairs with several males at a time, since each suitor is displaced in the amplectic hold by others. In this struggle few eggs are laid and fertilized by sperms released in the water. Most probably these sperms are from the male involved in pairing, or by other males struggling for the female. During rains, all the potential-breeding sites have swollen in size. Males are spaced widely. Rare solitary pairs are noted. However, still tendency is towards forming small groups of calling males.

#### *RANA TIGERINA* DAUDIN

Common tiger frog joins *Bufo stomaticus* to invade lowlying water catchment areas during first monsoon rain. Its grunty voluminous call is easily distinguishable from those of rest of the local amphibians. While calling heavy males jump over each other in amplectic assaults, until one finds a mate. The pair moves away to a solitary place, where ovulation takes place.

*Rana tigertna* is best characterized as apportunistic breeder, with limitations to an appropriate temperature, heavy downpour and flowing gathring water in lowlying area. In 1979, early March rains and rise in evening temperature to 14°C, triggered vocalization, followed by mid-April, May and June calling spells, closely following the rain fall pattern. Every peak calling was followed by heavy pairing. This year by July.

August rains, few stray individuals called, last vocalizing on 3 August. During 1980 cold atmospheric conditions delayed initiation of breeding in the local amphibians. Mid-April showers quickly developed vigorous choruses with heavy amplexus, second vocalization spell was not coming until May rains (Fig. 2). A pause through dry June was followed by third spell during July, till last male called on 15 August. No pairing was observed after mid-July. Dry conditions and high temperature during 1981 were adopted by this amphibian by lengthening its reproductive period. Mid-March rains, this year, initiated first spell of calling and amplexus. Calling continued from April to early June, Heavy amplexus taking place only after heavy downpour. Second breeding spell followed April rains, third early May and fourth late May rains, while fifth came in July and sixth early August rains. This year last Individual called on 28 August (Fig. 3).

During three years of present study it is observed that in *Rana tigerina* vocalization is initiated by first monsoon rains, no matter it comes during day time. Quickly males gather and form choruses in broad daylight, followed by amplexus. In such conditions night are comparatively silent.

#### *RANA SYHADRENSIS* ANNANDALE

The common cricket frog characteristically calls from the thick grass growing along sides of water channels with flowing water. Its call is monosyllable, repeated continuously, with short breaks. Males are solitary, each selecting roots of grass or some nearby bush, often 2 to 4 feet away from water (Fig 4).

Males follow each other in calling, starting and stopping together. Minimum temperature on which this amphibian calls ranges from 22 to 25°C.

During 1979, first male was heard on 24 May following mid-May rains. First pair was not observed until 28 May. Calling continued intermittently to mid-July and was later resumed by August rains. This year last male called on 18 August and last pair was noted on 13 August (Fig. 1). Minimum temperature required to initiate call was reached by mid-April in 1980. This year first male called on 15 April. Then calls were heard continuously from water channels in the agricultural area. However, first pair was observed on 12 May. Calling continued through June-July-August, until last male called on 25 August (Fig. 2). During 1981, May rains triggered calling, however main calling spell was not coming

until mid-May to mid-June, mostly from irrigation channels because of absence of heavy rains during this period. However, July-August heavy rains caused a continuous calling spell from potential breeding sites. Last individual called on 13 September (Fig. 3 ; Table 1).

#### DISCUSSION

On the advent of summer season, local sympatric anuran amphibians appear at potential breeding sites in a specific hierarchical order. First to appear is *R. cyanophlyctis*, followed by *B. stomaticus* and *R. tigerina* activated by first monsoon fall. Then by mid-monsoons appear *R. syhadrensis* *Microhyla ornata* at the potential breeding sites. Succession in appearance reduces the chances of hybridization and competition to large extent. Vocalization by males advertizes not only the presence of a male at the same time, but also presence of water in potential breeding locality. Each species has its own distinct call, which can be easily recognized in a chorus. All the local amphibians fall within species of rice fields (Dubois, 1976). Calling is a premating isolation mechanism strongly reducing probability of mismatching. A study of sonograph of the calls, reveal that, in general character, calls are louder (except that of *R. cyanophlyctis*), with frequency between 200 to 1300 Hz. A characteristic pause around each note is well marked. Variations in the duration of notes is from 0.01 to 0.46s (Fig. 5, 6). Similarly choice of calling sites by each species (Fig. 4) is also characteristic and reduces chances of hybridization and competition among adults. *R. cyanophlyctis* calls while afloat among vegetation, *B. stomaticus* loves to call from shallow marginal water, with lower half of the calling animal covered with water, while *R. syhadrensis* calls 2 to 4 feet away from water, from under a shelter, which might be a clump of grass, a small stone or roots of a thorny bush and *Microhyla ornata* generally prefers a shallow depression in moist earth formed by hooves of a goat or eroded by rain water, covered with grass (Khan, 1974). Marten and Marler (1977) have shown that perch height and sound frequency are more important than habitat in determining how long the sound will be carried. Selection of calling site performs an important function in the breeding ecology of the sympatric anurans. Crump (1977) has found that 74 species of amphibians, in a tropical habitat, utilize same site for breeding food and shelter by successful habitat partitioning, by selecting call sites, egg laying sites etc., Extent of territory of calling male vary from species to species. Actively breeding *R. cyanophlyctis*, *R. tigerina* *B. stomaticus*, tend to form thick calling aggregations, in which every individual is from half to one foot apart or even closer. However, these aggregations are observed in early breeding season for short durations,

following first seasonal rain. Later males of these species are quite distantly spaced from each other, rarely two individuals coming together. Such calling aggregation are never observed in *R. syhadrensis* and *M. ornata*, calling in these species remaining to large extent individual affair.

After first monsoon rain there is hustle and bustle at an undisturbed breeding site. Every species of anurans is calling by its characteristic call. Silence in call of one species is occupied by the call of other. A sudden silence ensues due to a disturbance, and soon calling is resumed by the call of a "leader" followed by the call of its own species, and later by the other sympatric. There is hierarchial resumption of call, often the "leader" is either *B. stomaticus* or *R. tigerina*. Hierarchial arrangement may altogether be changed according to reproductive state of the species. Reproductively most active species takes up the role of the "leader", and its call dominate the locality (Dubois, 1976).

All five species of amphibians studied, deposit their eggs in ditches, puddles and ponds, developing into free swimming aquatic larva (r-strategists Pianka, 1970). Such anurans have been regarded by Crump (1974) as most advanced. With possible exception of *R. cyanophlyctis* who behaves as a littoral species, travelling to long distance in search of pools with water (Khan, 1979; Mohanty-Hejmadi and Dutta, 1979), rest of the local amphibians spend most of their time outside water except for short period for breeding and escape from enemies. These species put all their reproductive energy into vocalization and egg and sperm production. Vocalization starts when potentially needed water is available, following closely with heavy pairing. No time and energy is lost, every species tries to utilize environmental favourableness for which it has waited so long, as quickly as possible, temperature and rainfall being limiting factors. Heyer et al (1975) have shown that total environment for which the tadpole stage is adopted is marked by extreme environmental variability and unpredictability. Biological environments vary in the same pond from one year to the next (Wiest, 1974; Collins, 1975; Heyer, 1973). In subtropical environments an amphibian is in stress throughout its life, in water or out of it.

Of all the local amphibians *R. cyanophlyctis* has most extended breeding season. During 1979 it called for 202 days, amplexic pairs were noted for 140 days and larvae were collected for 206 days; in 1980 these figures were 173, 160 and 139 respectively; in 1981; 225, 140 and 184. *B. stomaticus* stand second in this order. Its values were for 1979; 132,

104, 139; 1980 : 132, 125, 126 and for 1981 : 183, 164 and 136. Third best being *R. tigerina* 1979 : 128, 127, 110; 1980 : 127, 96, 110 and for 1988; 165, 144 and 115 days.

*R. syhadrensis* rank fourth in the breeding hierachical order. In 1979 it called for 95 days, pairs were noted for 81 days and 1st period extended for 72 days, in 1980 these values were 132, 107, 121. While in 1981 : 136, 99, 92 days *M. ornata* ranks as having shortest breeding period. During 1979 : 60, 62, 80 ; 1980 ; 64, 56, 48 ; 1981 ; 97, 71 and 37 days. Heyer (1973) also records short breeding period for *M. ornata*, in Thailand.

The redroductive activity and seasonal pattern described in the present study are important as temporal isolation mechanisms and in inter and intraspecific competition among sympatric amphibians.

#### TEMPORAL ISOLATION

In five species of local amphibians 3 congeneres are present. They utalize sympatrically potential breeding sites. However, present study has revealed isolation among them to avoid competition, and hibridization, *R. cyanophlyctic* has most extended breeding period. It is sexually activated at relatively lower temperature. Except for 1980 when cold wave delayed its breeding activicty up to 2 April, in 1979 it was active by 26 February and in 1981 by 25. This frog has first spell in early season and second spell, though much weaker, late in the season. On the other hand *R. tigerina* is activated by first monsoon rains, except for 1980 when activated on 10 April, in 1979 on 8th and during 1981 on 16 March. While *R. syhadrensis* prefers to utalize second monsoonal spell, except for 1980 when it called earlier 15 April, in 1979 it called on 24 May and in 1981 on 1 May. Thus in local ranid congenres hibridization is minimized by spacing breeding activity at different time, and overlapping in the breeding activity is minimized. Their calls differ from each other more markedly (Fig. 5), thus acting as important isolating factor. Littlejohn and Michaud (1959) have shown that females of congeneric frogs recognize the call of of their males. Moreover, there is great difference in size, coloration and habits of the three frogs. The isolation is further strengthend dy difference in the preference of choice of calling site, *R. cyanophlyctis* prefere to call from among emergent vegetation while afloat ; *R. tigerina* prefers marginal water and *R. syhadrensis* selects a perch 2 to 4 feet away from water. They also differ in selection of egg laying sites, *R. cyanophlyctis* prefers to lay its egg among floating vegetation, eggs are covered over by

mud particles and adhere to the leaves of vegetation (Khan, 1982). *R. tigerina* prefers a quiet corner, with vegetation, where eggs are laid in batches floating over the surface of water. Eggs of *R. syhadrensis* are laid in relatively small batches over the surface of water. Ranid congeners are isolated throughout their lives in the arid subtropical environment.

*Bufo stomaticus* and *Microhyla ornata*, both with no near relative in the local breeding complex, are well isolated from each other and ranid congeners. *B. stomaticus* is early breeder with breeding overlap with *R. cyanophlyctis* and *R. tigerina*. However, due to its characteristic call breeding habits and morphology hybridization do not take place.

### COMPETITIVE RELATIONS

Difference in the initiation, peak and ending of reproductive activity in local population of amphibians, minimize, to large extent but does not completely prevent, co-occupancy of the local ponds at adult and larval stage. Interaction among local amphibians more acutely may occur in larval stage. Khan (1982 a) has shown that larvae of each species can easily be distinguished on the basis of their morphology and adaptations. *Bufo* larvae prefer to form schools, feeding along marginal water, characteristic of bufonid larvae (Biswenger and Test, 1966). *Microhyla ornata* larvae, on the other hand, are filter feeders, forming midstream feeding schools. Tadpoles of ranid congeners are not known precisely for their habits. *R. cyanophlyctis* tadpoles are first to appear in ponds, and mainly caught from among marginal aquatic vegetation. While those of *R. tigerina* are collected from more deeper water. *R. syhadrensis* tadpoles are best collected from water channels, with little standing water. Thus there is evidence to believe habitat partitioning exists among tadpoles of local ranid congeners. Due to sympatry habitat overlap cannot be ruled out. Despite exposure of local amphibians to one another and interaction in their demand on the pool environments throughout developing season, tadpole of each ranid species appear to have strong preferences minimizing interaction among themselves.

Neither at adult stage nor at larval stage, local amphibians come in direct confrontation, in a sympatric habitat. Each species has evolved specific strategy to coexist through out its ontogeny to ensure its phylogenetic existence in the ecosystem. Local pond and puddles are supporting amphibian fauna not on knockout basis but due to peaceful coexistence.

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Table 1  
Record of observations on reproductive activity of sympatric amphibian in arid Punjab, Pakistan, during 1979 - 1981.

Species	First call	First call temperature	1st Amp. pair	1st tadpole	Last call	Last tadpole	Last amp. pair
<b>1979</b>							
<i>Bufo stomaticus</i>	3 March	13°C	3 March	8 March	13 July	25 July	12 July
<i>Mitrokhyla ornata</i>	14 May	20°C	8 June	25 May	18 July	13 August	13 July
<i>Rana cyanophlyctis</i>	26 February	10°C	15 March	26 February	15 September	19 September	15 August
<i>Rana tigerina</i>	8 March	12°C	8 March	27 March	3 August	15 August	13 July
<i>Rana syhadrensis</i>	24 May	20°C	28 May	23 May	18 August	3 August	13 August
<b>1980</b>							
<i>Bufo stomaticus</i>	6 April	12°C	6 April	12 April	28 August	16 August	9 August
<i>Mitrokhyla ornata</i>	13 May	23°C	22 May	29 May	30 July	16 July	8 July
<i>Rana cyanophlyctis</i>	2 April	11°C	5 April	8 April	22 September	25 August	6 August
<i>Rana tigerina</i>	10 April	12°C	10 April	22 April	15 August	5 September	4 July
<i>Rana syhadrensis</i>	15 April	21°C	12 May	18 May	25 August	16 September	5 August
<b>1981</b>							
<i>Bufo stomaticus</i>	4 March	13°C	4 March	12 March	3 September	25 August	15 August
<i>Mitrokhyla ornata</i>	5 May	20°C	8 May	26 July	10 August	2 August	15 August
<i>Rana cyanophlyctis</i>	25 February	10°C	5 March	2 March	8 October	2 September	2 August
<i>Rana tigerina</i>	16 March	13°C	16 March	28 March	28 August	20 August	4 August
<i>Rana syhadrensis</i>	1 May	20°C	18 May	26 May	13 September	26 August	7 August

Table 2  
 Frequency of monthly sighting of amplexic pairs in a sympatrically reproducing population of amphibians in arid Punjab, Pakistan.

Species	Year	Months												Total pairs observed	
		F	M	A	M	J	J	A	S	O					
<i>Bufo stomaticus</i>	1979		134	25	18	8	12	1							198
	1980			198	29	14	21	2							264
	1981		133	41	10	3	24	2							213
<i>Microhyla ornata</i>	1979				1	12	8								21
	1980				10	9	1								20
	1981				12	1	12								25
<i>Rana cyanophlyctis</i>	1979		25	22	13	3		3							66
	1980			32	26	2		2							62
	1981		16	14		2		2							34
<i>Rana tigerina</i>	1979		21	20	14	6	3	6							68
	1980			45	27	9	10	2							93
	1981		27	38	18	4	3	1							91
<i>Rana sylvadrensis</i>	1979				13	8	15								36
	1980				12	10	4	2							28
	1981				7	0	6	12							25

Legend to figures

Fig. 1. Relation between evening temperatures (curves), rain fall (bar graph), and reproductive activity of 5 species of anurans in arid Punjab during 1979. For each species, rectangles above line indicate period of calling, Brackets above delimit period of peak vocalization, rectangles below the lines represent the amplexic pairs (granules ovulation). 1. *Bufo stomaticus*. 2. *Microhyla ornata*. 3. *Rana cyanophlyctis*. 4. *Rana tigerina*. 5. *Rana syhadrensis*.

F. February, M. March, A. April, M. May, J. June, J. July, A. August, S. September, O. October, N. November.

Fig. 2. Relation between evening temperatures (curves), rain fall (bar graph), and reproductive activity of 5 species of anurans in Arid Punjab during 1980. Explanation as for Fig. 1.

Fig. 3. Relation between evening temperatures (curves), rain fall (bar graph), and reproductive activity of 5 species of anurans in arid Punjab during 1981. Explanation as for Fig. 1.

Fig. 4. Typical pond habitat in arid Punjab, during mid-monsoon season. Number indicate species and their usual calling site : 1. *Bufo stomaticus*, 2. *Microhyla ornata*, 3. *Rana cyanophlyctis*, 4. *Rana tigerina*, 5. *Rana syhadrensis*,

Fig. 5. Frequency of calls of anuran amphibians of arid Punjab, Pakistan (modified from Dubois, 1976).

Fig. 6. Duration of notes and intrasequential pause of calls of anuran amphibians of arid Punjab, Pakistan (modified from Dubois, 1976). — = notes, —+—

= intrasequential pause.

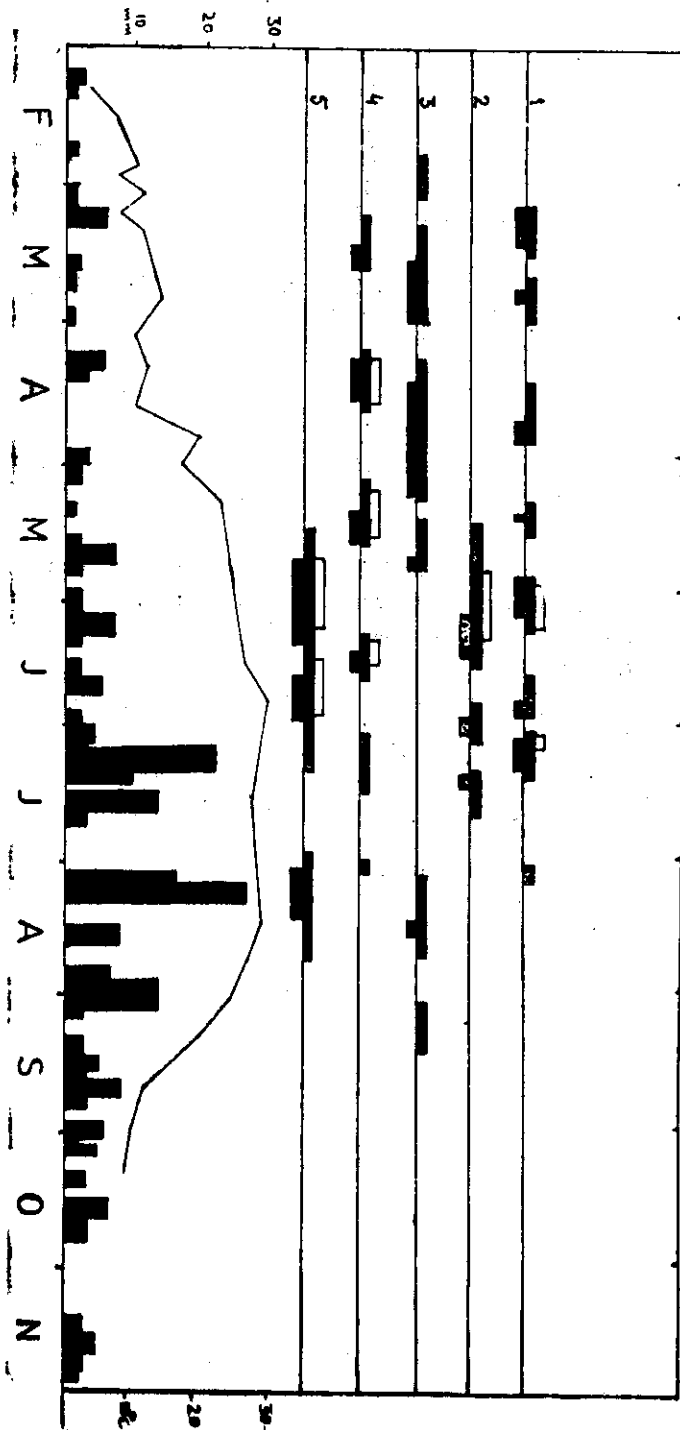


Fig. 1