Chapter 1

Morphological Characters and Annual Cycle
Rana limnocharis Wiegmann, the streaked frog (Plate I) is closely related to the common Indian bullfrog, Rana tigrina Daudin, but is much smaller in size and possesses imperfectly webbed toes. The systematic position of Rana limnocharis is

Phylum - Chordata
Subphylum - Gnathostomata
Class - Amphibia
Order - Anura
Suborder - Diplasiocela
Family - Ranidae
Subfamily - Raninae
Genus - Rana Linnaeus
Species - limnocharis Wiegmann

It is one of the widely distributed frog species in India and has been reported from China, Burma, Ceylon, Malay Peninsula, Borneo and Lombok (Satyamurti, 1967). In Himalayas, it has been reported by Acharji and Kirpalini (1951) from Sikkim (2134 metre above sea level) and Kangra and Kulu Valley. It is also found in Nepal, Kumaon and Simla Hills. Boulenger (1920) recorded it from Khasi and Garo Hills in Meghalaya (formerly part of Assam) and other parts of North-Eastern India. As stated earlier it has been found to be the most common species of frog available at Shillong (90°7' E, 24°0'N) at an altitude of 1515 metres in the Khasi Hills. During the active period of its annual cycle
from April to October, it is found mostly at the edges of
eutrophic ponds, perennial streams and marshy places. It also
occurs in paddy fields in large numbers during paddy season
(May-October). Although not very agile, on alarm it goes deep
into the water and reappears soon on the surface and swims
ashore to seek shelter in the shore vegetation. Many a time
it is seen to keep its snout above the surface of the water
and whole body hanging below in the water. There is, however,
no detailed account of its morphometry and ecology of its high
altitude populations.

This chapter has been devoted to the analysis of
morphological and taxonomical characteristics and the study
of annual cycle of *Rana limnocharis* found at Shillong. While
analysing the taxonomical characteristics, absolute measurements
as well as morphometric ratios of various body parts, the
criteria adopted by Tinsley (1973 and 1975) has been followed.
Investigations on the annual cycle include its breeding
activity and population fluctuation in relation to seasonal
changes such as temperature and rainfall.

**REVIEW OF LITERATURE**

A review of literature reveals that workers have mostly
concentrated on the study of natural history, taxonomy,
distribution, home range movement and population fluctuations
of anurans in relation to environmental changes. Following account deals with a review of contributions on these aspects.

Ever since the publication of the "Biology of Amphibia" by Kingsley Noble (1931) who incorporates early investigations on the systematics and ecology of amphibians, a number of interesting contributions on anuran biology have come up. The more important among these are those of Bragg (1941) on the ecology and natural history of anurans of Canadian river flood plain; Bragg and Smith (1942) on breeding behaviour of Oklahoma anurans; Anon (1953) on the ecology of Rana catesbeiana and Rana arvalis; Zweifel (1955) on the systematics, ecology and distribution of Rana boylei; Savage (1961) on the life history and ecology of Rana temporaria temporaria; Garanin (1961) on the ecology of Rana terrestris in different biotopes; Burkett (1969) on the ecology of cricket frog Acris crepitans; Morris and Tanner (1969) on the ecology of Western spotted frog Rana pretiosa pretiosa; Van Gelder and Oomen (1970) on the ecology of Rana arvalis in The Netherlands and Bloomer-Schlosser (1975) on certain ecological aspects of development of some Malagasy frogs.

There are a large number of reports on the systematics and taxonomy of anurans but there are very few detailed accounts on their biometry. Berger (1966) furnished a detailed study of the biometry of various parts of Rana esculenta, Rana ridibunda and Rana lessonae. He used 14 various morphometric measurements
and 5 index values in his descriptions and discussed their utility. He also referred to Kauri's (1959) indices showing relationship with environmental parameters like temperature and altitude, but felt that their application was difficult. While studying the biology and systematics of *Xenopus* and *Xenopus vestitus* Tinsley (1973 and 1975) has used 9 indices showing ratios between various body parts besides giving 18 absolute measurements. He has compiled data on weight, sex, breeding, gut contents, colour patterns and parasitic infections. Van Dijk (1966) showed the utility of the ratios in the systematic study of anuran larvae.

The distribution of many anuran species of the world has been given in "Amphibians and Reptiles of the World" by Bogert (1954), "Living Amphibians of the World" by Cochran (1967) and Grzimek's Animal Life Encyclopedia by Heusser (1974). The first good description on Reptilia and Batrachia of the Indian subcontinent was given in the Fauna of British India by Boulenger (1890). Other important contributions on the distribution and systematics of Indian anuran have been made by Annandale (1918); Narayan Rao (1923); Smith (1935); Acharji and Kiritpalini (1951); Satyamurti (1967); Moorthy (1968); Roonwal (1963); Mansukhani (1970) and Pillai and Chanda (1976). Satyamurti (1967) made a good compilation of the taxonomy and biology of many Indian anurans. The distribution pattern of the anurans of North-Eastern India, has been recently furnished by Pillai and Chanda (1976).
During the last two and half decades several investigations have been made on population ecology of anurans. In this connection the work of Dole (1947, 1965, 1972); Tracy and Dole (1969); Dole and Durant (1974); Martof (1953); Calef (1973) and Schroeder (1976) are worth mentioning. Dole and his group have investigated the home range movements of Hyla cadaverina, spatial relations and home range of natural populations of Rana pipiens, homing and orientation of Bufo americanus to their home site and movement and seasonal activity of Atelopus oxyrhynchus. Martof studied the dispersal movement for homing response of Rana clamitans. Van Dijk studied the habitat and dispersal of certain South African anura. Most of these workers have used toe clipping method for marking the frogs.

Among the work on fluctuations of anuran populations those of Ashby (1969) on Rana temporaria; Van Gelder and Öomen (1970) on Rana arvalis in The Netherlands; Scott and Stantett (1974) on Alychnia spurrelli in Costa Rica; Heym (1975) on Rana esculenta, Rana ridibunda and Rana lessonae; Zimka (1971) Rana arvalis in Poland; Günther (1974) on Rana ridibunda, Rana lessonae and Rana esculenta in German Democratic Republic and Knoflacher (1975) on a frog population in East Austria deserve mention. They have mostly concentrated on various aspects of population dynamics such as its relation to reproduction, growth and migration, pH, temperature and humidity, rainfall, food and specific biotope. Recently
Plate II A - Area of collection of frogs at Pologround Shillong: A canal.

Plate II B - Area of collection of frogs at Pologround Shillong: Paddy fields.

Plate II C - Area of collection of frogs at Pologround Shillong: A stream.
Koskela (1973) and Koskela and Pasanen (1974) have worked out in great detail the annual cycle and behaviour of *Rana temporaria* in Northern Finland in relation to environmental factors such as temperature, rainfall and diurnal rhythm.

As far as Indian frogs are concerned, a review of literature reveals that although a number of contributions have been made on taxonomy and distribution, very little information is available of their ecology and developmental biology. Although, *Rana limnocharis* is available throughout eastern tropics, little is known about its biology and ecology of this high altitude populations. Its taxonomy and distribution has been described by Boulenger (1920) and Satyamurti (1967).

**MATERIALS AND METHODS**

Live specimens of *Rana limnocharis* were collected from the Polo Ground area in Shillong. Analysis of morphological characteristics was made according to the criteria followed by Tinsley (1973 and 1975) on a sample of 25 males and 25 females collected during their breeding period. During paddy season they were available in large numbers in paddy fields. After collection the specimens were brought to the laboratory and preserved in formalin. The colour pattern was studied in
live specimens. The weight of the frogs was taken after blotting their body surface with blotting paper. For measurements dividers were used and an accuracy of the order of 0.1 mm was strived at. For the study of the changes in the population structure, the specimens were collected at regular intervals throughout the year, taking one hour as a unit for each collection. The number of males, females and juveniles was recorded after each collection. The observations on the annual cycle were based on the breeding behaviour of the frog in relation to temperature and rainfall.

OBSERVATIONS

1. ANALYSIS OF MORPHOLOGICAL AND TAXONOMICAL CHARACTERISTICS.

Sex and reproductive condition

The 50 specimens studied comprised half males and half females. All the males were mature. Among the 25 females, 5 were spent (20%), 4 did not have ripe ova (16%) and the rest 16 (64%) were mature, containing ripe ova. Many pairs were found in amplexus and spawning was observed during the period of collection.

Size and weight

Body length of males ranged from 3.1 - 4.1 cm, with a mean length of 3.68 cm. In females, it ranged from 3.7 - 5.6 cm, with a mean of 4.53 cm.

The body weight of males ranged from 3.5 - 4.5 gm, with
Fig. 1 - Dorsal view of Rana limnocharis Wiegmann showing vertebral band and longitudinal ridge on the skin.

Fig. 2 - Lateral view of the head region of Rana limnocharis Wiegmann showing skin fold above tympanum.

Fig. 3 - Figure showing tibio-tarsal articulation in relation to the position of the eye and snout.

Abbreviations:

Vtbnd = Vertebral band  Fd = Skin fold
Lnrág = Longitudinal ridge  Ey = Eye
Tym = Tympanum  Snnt = Snout
H,imb = Hind limb  Nst = Nostril
Tbtra = Tibio-tarsal articulation
Fig. 4 - Pattern of fingers in the forelimb of *Rana limnocharis* Wiegmann.

Fig. 5 - Pattern of toes in the hindlimb of *Rana limnocharis* Wiegmann.

Abbreviations:

Wb = Webb
a mean weight of 4.06 gm. The weight of females ranged from 8.1 - 13.8 gm, with a mean of 11.72 gm.

**Morphological characteristics**

1. The skin bears narrow longitudinal ridges on the dorsal side. (Fig. 1).

2. A fold of skin is found above the tympanum and another transverse fold is seen behind each eye. (Fig. 2).

3. Vomerine teeth are arranged in two oblique series between the choane, extending below the level of their posterior border.

4. The head is as long as broad and moderately depressed. (Fig. 2).

5. The snout is pointed or rounded, projecting more or less beyond the mouth. (Fig. 2).

6. The nostrils are situated nearly midway between the eye and tip of the snout, slightly towards the snout. (Fig. 3).

7. The tympanum is distinct and is approximately 1/2 or 2/3 as wide as the eye. (Fig. 2).

8. The fingers and toes are bluntly pointed. (Fig. 4 and 5).

9. The first finger extends beyond the second. The sub-articular tubercles are well developed and prominent. (Fig. 4).
10. The hind limbs are moderately long and the tibiotarsal articulation (heel) reaches the eye or beyond, between the eye and the snout and sometimes even beyond the snout. (Fig. 3).

11. The toes are obtusely pointed and slightly swollen at the end. (Fig. 5).

12. Toes are imperfectly webbed. Fingers are not webbed. (Figs. 4 and 5).

13. There is usually a small outer metatarsal tubercle and a prominent inner metatarsal tubercle.

14. There is a variation in the relative length of the hind limb.

Colour pattern

The dorsal surface is dark brown, or sometimes greyish olive, with large black spots on the back. These black spots are intermingled with yellow and rarely orange markings which are more distinct on the lateral sides of the body. The ventral surface of the body is pale, yellowish white, with dark yellow on the sides bordering the belly wall and the lining of the lower jaw. The lower jaw has narrow black bands on its borders alternating with the yellow colour.

There is a vertebral band on the mid dorsal region varying in colour and thickness, being narrow in some and
broad in others. The colour is yellow, yellowish-orange or creamy white (Plate 1). This band is found to continue on the dorsal aspect of the thigh and inner aspect of the shank up to the foot. Sometimes it is absent in the posterior region of the shank. (Fig. 1).

The limbs have black markings. On the inner surface of the toes and fingers there are black lines with intermediate creamy white spots at the region of the subarticular joints. The web between the toes is grey and the ventral surface of the toes specially the tips is dark grey.

There are distinct ridges on the back, formed of folds of the skin, which may be black or dark brownish grey. The tympanic region has black round spots surrounded by black ridge on the upper boundary and the lower boundary creamy white.

An analysis of the measurements of the following 15 morphological characters was carried out so as to compare these with the morphometric measurements given by other workers.

1. Body length : Snout to vent.

2. Body width : Measured at the widest point across abdomen.

3. Head width (minimum) : At the tip of the snout, parallel to the nostrils.
4. Head width (maximum) : Measured at the widest point, across the eyes.

5. Snout length : Perpendicular distance from below the nostrils to the tip of the mouth.

6. Eye diameter : Transverse distance across exposed orbits.

7. Inter-ocular distance : Transverse distance between inner bases of circum-orbital plaques.


9. Inter-narial distance : Distance between the inner margins of nostril bordering flaps.

10. Hind limb length : Vent to tip of 5th toe.

11. Tibia length : Medial measurement along the dorsal surface of tibia.

12. 5th toe length : Measurement of outer ventral surface of the digit.

13. Total fore limb length : Origin of limb to the tip of the 1st finger.

14. Lower fore limb length : Outer angle of elbow to the tip of the 1st finger.

15. 1st finger length : Base to the tip of 1st finger.

Measurements of 50 living adult specimens were taken and a summary of data is given in Table I. The relationship
## TABLE I

Analysis of Characters of *Rana limnocharis* Wiegmann: 1. Dimensions

Measurements (cm.)

<table>
<thead>
<tr>
<th>Characters</th>
<th>MALES (25)</th>
<th></th>
<th>FEMALES (25)</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Range</td>
<td>Mean</td>
<td>Range</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Standard deviation</td>
<td></td>
<td>Standard deviation</td>
</tr>
<tr>
<td>Body length</td>
<td>3.62</td>
<td>3.1 - 4.1</td>
<td>4.53</td>
<td>3.7 - 5.6</td>
</tr>
<tr>
<td>Body width</td>
<td>1.31</td>
<td>1.1 - 1.8</td>
<td>1.57</td>
<td>1.1 - 2.1</td>
</tr>
<tr>
<td>Head width (min.)</td>
<td>0.47</td>
<td>0.3 - 0.6</td>
<td>0.58</td>
<td>0.3 - 0.85</td>
</tr>
<tr>
<td>Head width (max.)</td>
<td>1.17</td>
<td>0.8 - 1.35</td>
<td>1.28</td>
<td>1.0 - 1.6</td>
</tr>
<tr>
<td>Snout length</td>
<td>0.44</td>
<td>0.3 - 0.85</td>
<td>0.49</td>
<td>0.3 - 0.8</td>
</tr>
<tr>
<td>Eye diameter</td>
<td>0.57</td>
<td>0.4 - 0.75</td>
<td>0.60</td>
<td>0.5 - 0.85</td>
</tr>
<tr>
<td>Inter-ocular distance</td>
<td>0.40</td>
<td>0.3 - 0.5</td>
<td>0.43</td>
<td>0.3 - 0.6</td>
</tr>
<tr>
<td>Nostril width</td>
<td>0.16</td>
<td>0.1 - 0.3</td>
<td>0.26</td>
<td>0.1 - 0.4</td>
</tr>
<tr>
<td>Inter-narial distance</td>
<td>0.39</td>
<td>0.25 - 0.5</td>
<td>0.51</td>
<td>0.4 - 0.6</td>
</tr>
<tr>
<td>Hind limb length</td>
<td>4.94</td>
<td>4.0 - 5.8</td>
<td>5.61</td>
<td>5.0 - 6.6</td>
</tr>
<tr>
<td>Tibia length</td>
<td>1.83</td>
<td>1.4 - 2.1</td>
<td>2.29</td>
<td>1.65 - 2.7</td>
</tr>
<tr>
<td>5th toe length</td>
<td>0.68</td>
<td>0.5 - 0.9</td>
<td>0.76</td>
<td>0.6 - 0.95</td>
</tr>
<tr>
<td>Total fore limb length</td>
<td>2.04</td>
<td>1.4 - 2.7</td>
<td>2.25</td>
<td>1.9 - 3.1</td>
</tr>
<tr>
<td>Lower fore limb length</td>
<td>0.79</td>
<td>0.55 - 1.0</td>
<td>0.84</td>
<td>0.6 - 1.0</td>
</tr>
<tr>
<td>1st finger length</td>
<td>0.53</td>
<td>0.3 - 0.8</td>
<td>0.66</td>
<td>0.5 - 1.0</td>
</tr>
</tbody>
</table>
TABLE - II
Analysis of Characters of Rana limnocharis Wiegmann: 2. Ratios

<table>
<thead>
<tr>
<th></th>
<th>MALES (25)</th>
<th></th>
<th>FEMALES (25)</th>
<th></th>
<th>OVERALL (25+25)= 50</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Range</td>
<td>Mean</td>
<td>Range</td>
<td>Mean</td>
<td>Standard deviation</td>
</tr>
<tr>
<td>Head width (min.)</td>
<td>0.40</td>
<td>0.27 - 0.50</td>
<td>0.45</td>
<td>0.3 - 0.6</td>
<td>0.425</td>
<td>0.44</td>
</tr>
<tr>
<td>Head width (max.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snout length</td>
<td>0.94</td>
<td>0.72 - 1.54</td>
<td>0.84</td>
<td>0.6 - 1.0</td>
<td>0.89</td>
<td>0.93</td>
</tr>
<tr>
<td>Head width (min.)</td>
<td>0.41</td>
<td>0.22 - 1.2</td>
<td>0.51</td>
<td>0.25 - 0.89</td>
<td>0.46</td>
<td>0.51</td>
</tr>
<tr>
<td>Eye diameter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inter-ocular distance</td>
<td>1.42</td>
<td>1.0 - 2.17</td>
<td>1.39</td>
<td>0.92 - 1.75</td>
<td>1.40</td>
<td>1.45</td>
</tr>
<tr>
<td>Nostril diameter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inter-narial distance</td>
<td>0.38</td>
<td>0.22 - 0.38</td>
<td>0.36</td>
<td>0.20 - 0.40</td>
<td>0.34</td>
<td>0.32</td>
</tr>
<tr>
<td>Tibia length</td>
<td>2.69</td>
<td>2.22 - 3.6</td>
<td>3.01</td>
<td>1.94 - 4.17</td>
<td>2.85</td>
<td>2.92</td>
</tr>
<tr>
<td>5th toe length</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st finger length</td>
<td>0.67</td>
<td>0.33 - 0.89</td>
<td>0.78</td>
<td>0.56 - 1.17</td>
<td>0.72</td>
<td>0.75</td>
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<tr>
<td>Lower fore limb length</td>
<td>0.55</td>
<td>0.38 - 0.74</td>
<td>0.50</td>
<td>0.40 - 0.70</td>
<td>0.525</td>
<td>0.54</td>
</tr>
<tr>
<td>Total fore limb length</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body length</td>
<td>0.74</td>
<td>0.62 - 0.90</td>
<td>0.81</td>
<td>0.72 - 0.96</td>
<td>0.775</td>
<td>0.79</td>
</tr>
<tr>
<td>Body length</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hind limb length</td>
<td>0.74</td>
<td>0.62 - 0.90</td>
<td>0.81</td>
<td>0.72 - 0.96</td>
<td>0.775</td>
<td>0.79</td>
</tr>
</tbody>
</table>
Plate III A - Ventral view of *Rana limnocharis* Wiegmann (Male)

Plate III B - Ventral view of *Rana limnocharis* Wiegmann (Female)

Abbreviations:

Vs = Vocal sac  
Tp = Thumb pad  
Ab = Abdomen
between 8 of the above features was evaluated to define the distinguishing characters of this species. These ratios are presented in Table II.

**Distinguishing characters of male and female of *Rana limnocharis***.

Besides dimensions and ratios shown in Table I and II, the sexes can be distinguished by the following diagnostic characters:

**MALE** (Plate III-A)

1. Mature male frogs are smaller and lighter in comparison to female frogs.

2. It has a relatively slender and streamlined body.

3. It has a prominent thumb-pad which become darker and thicker in the breeding season.

4. It has black markings on the vocal sacs below the throat.

5. In the breeding season, the lateral vocal sacs are swollen and produce a distinct, low to high guttural croaking sound.

**FEMALE** (Plate III-B)

1. Mature female frogs are larger and much heavier in comparison to the males.
2. Their abdomen is much swollen, depending upon the maturity of the ovaries.

3. The skin of the abdomen in the region of groins is thinner and translucent so that the ripe ova in the abdomen can be seen through it.

4. Females can be identified at any time by the absence of the thumb-pad, absence of lateral cheek pouches and inability to croak.

2. ANNUAL CYCLE.

The annual cycle of *Rana limnocharis* can be divided into four phases (1) Emerging and 'Pre-breeding period', (2) Spawning and 'Breeding period' (3) Entering and 'Post-breeding period' and (4) 'Hibernation period'. (Fig. 6). The emergence of frogs from the hibernation period is observed in late March when average minimum and maximum temperatures are recorded to be 11.5°C and 22.4°C. This is usually associated with the first showers of rains. The period since the emergence of frogs to the start of amplexus and spawning constitutes the Pre-breeding Period. From the first or second week of April when the minimum and maximum temperatures are recorded to be 13.8°C and 24.6°C and rainfall increases (average 214.05 mm), the frogs show intensive feeding, active movements, amplexing behaviour and start spawning. From this
Fig. 6 - Diagramatic representation of the annual cycle of *Rana limnocharis* Wiegmann.
Total monthly rainfall (mm)

Average minimum and maximum temperature

ANNUAL CYCLE OF RANA LIMNOCHARIS WIEGMANN

AT SHILLONG

FIG. 6
time to August the frogs lead active life and breed. This period is called the Breeding Period. During breeding period the spawns are seen in temporary ponds, ditches and very slow moving streams often attached to submerged vegetation. Early larval stages are seen from the middle of May when the temperature fluctuates between 14.6°C (min.) and 22.7°C (max.) with an average monthly rainfall of 443.85 mm. The temperature during June is recorded to be 16.7°C (min.) and 22.9°C (max.); during July 17.4°C (min.) and 24.3°C (max.); and during August 17.7°C (min.) and 23.8°C (max.). The rainfall during these months is recorded to be 556.76 mm, 387.45 mm and 355.35 mm respectively. The metamorphosed froglets are observed from early June. Larvae hatched from spawns laid during May and June start metamorphosing by July or August. From June onwards and specially after August large number of young froglets are observed. During middle of October when temperature is reduced to 15.0°C (min.) and 20.7°C (max.) and average monthly rainfall becomes 140.15 mm, the number decreases indicating that they start entering hibernation. The period from September to late October can be designated as Post-breeding Period. The frogs remain in hibernation from November to middle or late March. The average atmospheric temperature during November is noted to be 6.5°C (min.) and 15.5°C (max.); during December 5.7°C (min.) and 18.3°C (max.); during January 4.9°C (min.) and 14.0°C (max.); and during February 9.5°C (min.) and 19.4°C (max.).
Fig. 7 - Number of frogs collected per unit time during different months of the year in 1976 and 1977.
rainfall during these months is recorded to be 70.7 mm, 37.5 mm, 0.4 mm and 45.2 mm respectively. During hibernation the frogs are found in burrows, sometimes below stones and rarely outside in the vicinity of ponds.

The population structure was analysed from the samples collected at two regular intervals each month for one hour every time during 1976 and 1977. The data for each month has been illustrated in Fig. 7. The frogs were easily collected from April to October. Minimum number was caught in March and November. It was very difficult to find them during December, January and February. During both the years the number of frogs collected went on increasing from April to July/August and then showed a gradual decline. From June onwards until the start of hibernation, the number of juveniles collected were much more every month. The sex ratio during 1976 was found to be approximately 9 females for 7 males. In 1977 it was found to be approximately 7 females for 5 males. The females were always more than the males, in each collection.

DISCUSSION

MORPHOMETRIC AND ECOLOGICAL CONSIDERATIONS.

*Rana limnocharis* is a widely distributed species throughout the eastern tropics; it is found in warmer plains as well as subtropical high altitudes (Satyamurti, 1967). Studies on the systematics of anurans are based mostly on...
on specific morphological characters. Tinsley (1973 and 1975), while studying the systematics of *Xenopus* and *Xenopus vestitus*, reported that there may be intraspecific variations depending upon the ecology of a species and described many such variations. There are no such studies available on the frog species found in India and neighbouring countries. It was with this aim that besides the description of the specific morphological characters, fifteen absolute measurements, viz., body length (snout vent length or SVL), body width, head width (min.), head width (max.), snout length, eye diameter, interocular distance, nostril width, internarial distance, hind limb distance, tibia length, 5th toe length, total fore limb length, lower fore limb length, first finger length and eight ratios, viz., Head width (min.)/Head width (max.), Snout length/Head width (min.), Eye diameter/Interocular distance, Nostril diameter/Internarial distance, Tibia length/5th toe length, 1st finger length/Lower fore limb length, Total fore limb length/Body length, Body length/Hind limb length, have been analysed in the present investigation (Tables I and II) as per the criteria followed by Tinsley. The general morphological character of *Rana limnocharis* available at Shillong do not show any important variation in comparison to the descriptions available in the literature (Boulenger, 1920). The vertebral band is said to be absent in some cases (personal
communication, Zoological Survey of India, Eastern Regional Station, Shillong) but none of the specimens were observed in the present investigation without such bands.

Satyamurti (1967) has given body length, lengths of fore limb and hind limb of *Rana limnocharis* collected from seven different localities in the South India. Most of them were young ones. The SVL of full grown specimen from Yercaud was 53 mm. Boulenger (1920) gave SVL of full grown specimens from various places in South-East Asia. They were: Japan: males 40 mm; Loo Choolds: males 48/49 mm and females 50 mm; Sanghai: females 39-46 mm; Formosa: females 46 mm; Hongkong: females 40-45 mm; Sikkin: males 43 mm, females 45-64 mm; Darjeeling: female 39 mm; Nilgiri: males 43 mm, females 45-64 mm; Malabar: females 45-47 mm; Trivandrum: females 33 mm; Madras: females 35-37 mm; Ceylon: females 52 mm; Bangkok: males 44/45 mm and females 51 mm; Siam: females 46 mm; Malacca: females 57-67 mm; Singapore: males 38 mm and females 57-60 mm; Java: males 46 mm and females 42-50 mm; Lombok: females 42-50 mm; and Borneo: females 56-62 mm. In the present investigation on *Rana limnocharis* the SVL of males was found to be 36 mm and of the females 45 mm. The weight of males ranged from 3.5 to 4.5 gm and that of females from 8.1 to 13.8 gm during breeding season. This supports that there may be intraspecific variations. The utility of ratios of various body parts has been increasingly felt in the systematic analysis by recent workers (Berger, 1966;
Van Dijk, 1966 and 1977; Tinsley, 1973 and 1975). Berger (1966) quotes Terentiev (1950) who while arguing on the utility of the ratios said, "as far as a definition of differences between various forms is concerned various well chosen ratios of different body parts provide much greater informative value". The utility of these ratios has further been elaborated by Van Dijk (1966) in the systematic studies of anuran larvae. Absolute measurements may vary but ratios between various body parts remain almost constant. This has been tested in different anuran tadpoles in our laboratory also (Mr. A.K. Sahu, personal communication). Tinsley (1975) has also taken into consideration the weight, sex, breeding behaviour, gut contents, colour pattern and parasitic infections in his systematic analysis of *Xenopus*. It is felt that these informations may be relevant to ecological interactions and may account for adaptation and distribution of different species. Investigations on all aspects except parasitic infections of *Rana limnocharis* have included in the present thesis, but a detailed study of all these aspects and morphometric ratios of various populations of this species from different localities would be required to understand the ecological interactions in its adaptation and distribution.

**ANNUAL CYCLE**

Systematic records of the annual cycles of many frog species found in India are still not available. A detailed
account of the life history and developmental table of *Rana tigrina* from North India has been recently given by Agarwal and Niazi (1977). Fragmentary information is available on the life cycles of *Rana crassa*, *Rana hexadactyla* and *Rana cyanophlyctis*. Life cycles of many anurans found in North America has been compiled by Rugh (1962). A detailed representation of the annual cycle of *Rana temporaria* has been recently given by Koskela (1975).

There are few reports available on *Rana limnocharis*. Boulenger (1920) reported that they undergo prolonged hibernation in mountainous districts. Satyamurti (1967) described that populations of *Rana limnocharis* in South India spawn at the onset of monsoon and aestivate during dry season under stones or damp places. The present investigation is the first 'complete' record of the annual cycle of high altitude population of *Rana limnocharis*. It has been divided in four distinct periods: (1) 'Emerging' and 'Prebreeding' (2) 'Spawning and Breeding' (3) 'Entering and Postbreeding' and (4) 'Hibernation periods'. Prebreeding period is a very short period, since emergence from the hibernation in late March and the breeding period starts in April.

Emergence of the frogs from hibernation is usually associated with the first shower of rain. By the first week of April the frogs enter the breeding period. Mating cells are heard, they go into amplexus and spawn. Breeding period continues till August. The postbreeding period lasts during September.
and October when the frogs do not spawn, juvenile stages are seen in large numbers. From November to late March the frogs live in hibernation. The emergence of frogs from hibernation and start of breeding period is clearly associated with increased temperature and first shower of rains. The onset of hibernation is associated clearly with low temperature and reduced rainfall. Increase in the number of the frog population during active period is associated with the increase in temperature and high rainfall.
SUMMARY

This chapter deals with an analysis of morphological characters and morphometric ratios and study of the annual breeding cycle of the streaked frog, *Rana limnocharis* Wiegmann found in Shillong and the neighbouring areas. The size (snout-vent length) of the males ranged from 3.1 to 4.1 cm and that of females from 3.7 to 5.6 cm. The body weight of the males ranged from 3.5 to 4.5 gm and that of the females from 8.1 to 13.8 gm. While analysing the morphological characteristics, 15 absolute measurements along with 8 morphometric ratios of various body parts were taken into consideration, since morphometric ratios are known to be constant for a given species. The males were identified by small slender body, presence of vocal sacs and thumb pads during the breeding season; whereas females lacked these characteristics and had larger bodies with swollen abdomen.

The annual cycle has been divided in four periods: Pre-breeding, Breeding, Post-breeding and Hibernation periods. With the atmospheric temperature ranging from 11.3 C to 22.2 C with an average rainfall of about 80.8 mm during the second fortnight in March, the frogs come out of hibernation and entered the pre-breeding period. By the middle of April with temperature ranging from 13.8 C to 24.6 C and the average monthly rainfall being 214.05 mm, the frogs entered into a period of peak breeding activity. The spawning commenced with
the first shower of rains in April and the young metamorphosed froglet stages were commonly seen by June. By the middle of October when the temperature fluctuated between 15°C and 20.7°C with a rainfall of 140.1 mm, the frogs once again entered into hibernation. As a result of it during December and January which are the coldest months in Shillong, not even a single specimen could be seen in the open natural habitat.

The regular monthly sample collections from the field showed that the population was maximum during breeding period; and the number of the females was more than the males in most of the collections. Juveniles were more from June onwards, often much higher in number than the adults.
REFERENCES


* Anon. 1953. The ecology of *Rana catesbiana* and *Rana erythraea*. Carolina Tips. 16.


* Not consulted in original.