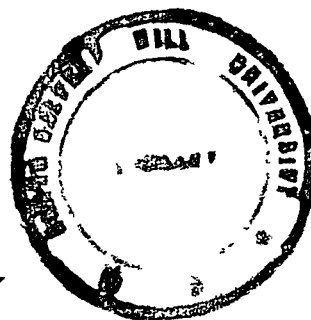


STUDIES ON SURVEY OF FROGS AND TOADS OF
KOHIMA, NAGALAND, AND CERTAIN ASPECTS
OF ECOBIOLOGY AND DEVELOPMENT OF
Rhacophorus leucomystax (KUHL)

Abstract

KIYASETUO

DEPARTMENT OF ZOOLOGY
SCHOOL OF LIFE SCIENCES



THESIS

SUBMITTED IN FULFILMENT OF THE REQUIREMENT OF THE DEGREE OF
DOCTOR OF PHILOSOPHY

To



THE NORTH-EASTERN HILL UNIVERSITY

SHILLONG-793014

MEGHALAYA
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ABSTRACT

The thesis includes a survey and systematics of anuran fauna of Kohima, Nagaland and a detailed study of certain aspects of ecobiology of Rhacophorus leucomystax, a common frog species of this region. The thesis has 7 chapters, first 2 arranged in Part I and the other 5 in Part II.

PART I : SURVEY AND SYSTEMATICS

CHAPTER 1 : STUDY SITE AND SURVEY

A description of the study sites at Kohima and surrounding areas (altitude 183-2440 m a.s.l.) has been provided. The frogs were collected from ^{the} following places: (1) Central Kohima, (2) Phezou, (3) Dzünarü, (4) Science College and neighbouring areas, (5) Jakhama, (6) Rükhroma, (7) Dzüku, (8) Medziphema and (9) Dimapur. The survey was continued from 1981 to 1985. In all, 21 anuran species have been collected.

CHAPTER 2 : SYSTEMATICS

Taxonomic descriptions of the 21 species have been provided with a key for their easy identification and notes on their habit, habitat and their distribution, they include 2 new records, 1 new genus and 3 new species. The species described are listed below.

Suborder : Anomocoela

Family : Pelobatidae

Subfamily : Megophryinae

1. Megophrys monticola Kuhl and Van Hasselt, 1822.
2. Megophrys boettgeri (Boulenger, 1899).
3. Megophrys dzünarü sp. nov.

Suborder : Procoela

Family : Bufonidae

Subfamily : Bufoninae

1. Bufo melanostictus Schneider, 1799

Family : Hylidae

Subfamily : Hylinae

1. Hyla annectens (Jerdon, 1870).

Suborder : Diplasiocoela

Family : Ranidae

Subfamily : Raninae

1. Amolops afghanus (Günther, 1858).
2. Rana mawphlangensis Pillai and Chanda, 1977.
3. Rana nagalandsis sp. nov.
4. Rana liebigii Günther, 1860.
5. Rana verrucosa Günther, 1875.
6. Rana cyanophlyctis Schneider, 1799.
7. Rana limnocharis Wiegmann, 1835.
8. Rana tigrina Daudin, 1803.
9. Pterorana khare gen. and sp. nov.

Family : Rhacophoridae

Subfamily : Rhacophorinae

1. Rhacophorus leucomystax (Kuhl, 1929).
2. Rhacophorus reinwardtii (Schlegel, 1837).
3. Rhacophorus nigropalmatus Boulenger, 1895.
4. Rhacophorus bisacculus Taylor, 1962 (new record).
5. Chirixalus vittatus (Boulenger, 1887) (new record).

Subfamily : Philautinae

1. Philautus annandalei (Boulenger, 1906).

Family : Microhylidae

Subfamily : Microhylinae

1. Microhyla ornata (Dumeril and Bibron, 1841).

PART II : ECOBIOLOGY AND DEVELOPMENT OF RHACOPHORUS LEUCOMYSTAX

CHAPTER 3 : MORPHOMETRIC ANALYSIS AND ANNUAL BREEDING CYCLE.

This chapter deals with morphometric analysis and annual breeding cycle of the population of Rhacophorus leucomystax a common frog of Kohima, Nagaland. The snout-vent length of the males ranges between 38-65 mm and that of females 40-75 mm, the body weight of males 5.0-18.2 gm and that of females 5.5-37.95 gm. There are typical stripes on the dorsal side, spotted with interorbital cross-bars, broken striped and an X-shaped mark behind the eyes. Absolute measurements of 18 body parts and 8 ratios of selected parts have been provided. The annual breeding cycle of this species has 4 periods.

(1) Emerging and pre-breeding period (April-May). During this period, the frogs emerge from hibernation and live in bamboo plantation. (2) Spawning and breeding (June-July). This is the period of chorusing, courtship, amplexus and breeding in the pools. (3) Postbreeding and entering (August-November). During this period the frogs are seen to live on banana plants and trees, and by the end of this period they start undergoing hibernation. (4) Hibernation (December-March). During this period, they undergo hibernation under the forest litters.

CHAPTER 4 : BREEDING BEHAVIOUR AND POPULATION DYNAMICS

This chapter deals with observations on breeding behaviour and population dynamics on Rhacophorus leucomystax at the breeding site. The frogs swarm and go to the pools on early summer evening preferably after rain in early moon phases. They show courtship and amplexus, make foamy nests around and deposit eggs. Embryonic development occurs in the nests and postembryonic development in the pool water. Though, large number of frogs are collected in summer, they can be collected in almost equally good number even in winter during hibernation from below the forest litters. During other periods they remain distributed on trees.

CHAPTER 5 : FOOD AND FEEDING HABITS

This chapter includes an analysis of the diet of Rhacophorus leucomystax. The food intake was highest during breeding period and lowest during hibernation period. The food items were taken out from the stomach and analysed every month. Varieties of items were recorded but arachnids and insects (particularly isopterans, coleopterans and orthopterans) formed high percentage. The frog takes food even during hibernation though the volume of food intake was lowest during this period.

CHAPTER 6 : PITUITARY-GONADAL CYCLE

This chapter includes a study of behaviour of acidophils, basophils and chromophobes of the pars distalis during annual breeding cycle of Rhacophorus leucomystax. The basophils (gonadotrophic cells) were found to be in high numbers during late hibernation and pre-breeding periods whereas, acidophils (somatotrophic

cells) were high during other periods. Thus, a direct relationship was noted between maturity of gonads and the cellular behaviour of pars distalis and the levels of hormones released from these during different periods.

CHAPTER 7 : NORMAL TABLE OF DEVELOPMENT

The seventh and the last chapter includes a normal table of development of Rhacophorus leucomystax. The development has been divided into 46 stages: Fertilization 2, Cleavage and blastulation 9, Gastrulation 5, Neurulation 3, Tail bud and gill formation 8, Operculum fold formation 5, Hindlimb bud 5, Toes indentation 4, and metamorphosis 5. Hatching occurs within 3 to 4 days and larvae metamorphose into young froglet in 57 to 58 days.

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15 April 1986

CERTIFICATE

I certify that this thesis entitled "Studies on Survey of frogs and toads of Kohima, Nagaland, and certain aspects of ecobiology and development of Rhacophorus leucomystax (Kuhl)" submitted by Mr. KIYASETUO for the Ph.D.degree of the North-Eastern Hill University, Shillong, embodies the record of original investigation carried out by him under my supervision. He has been duly registered and the thesis presented is worthy of being considered for the award of the Ph.D. degree. This work has not been submitted for any degree to any other University.


(M.K.KHARE)

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GENERAL INTRODUCTION

GENERAL INTRODUCTION

The group Anura consisting of frogs and toads comprises the largest living Order in Amphibia. More than 2600 anuran species belonging to 250 genera and 17 families have been described from various parts of the world (Gorham, 1974; Heusser, 1974). In all, 94 species classified under 19 genera and 6 families have been described from the Indian subcontinent (Ananthakrishnan, 1980). Among these, 40 species belonging to 11 genera and 6 families have been reported from the north-eastern India (Pillai and Chanda, 1976). It is surprising but true that anuran fauna of Nagaland has never been investigated earlier.

The importance of frogs and toads is known since times immemorial. They form a valuable component of our biosphere. And since the times when foundations of modern science were being laid in 16th century they have been used as common experimental animals for understanding various life processes in vertebrate systems. The conduction of electricity through nerve was first demonstrated by Galvani in 1780 (Ronan, 1983). For more than a century, frogs have been used the world over, in schools, colleges, universities, pharmacological institutes and other research centres for demonstrating vertebrate anatomy, physiology and development (Cochran, 1961; Nace, 1968; Heusser, 1974). Certain vital concepts elucidating the phenomena of development and differentiation have emerged as a result of investigations on frogs and toads. Not long before, when modern biochemical methods were scarce, live frogs were used for detecting earliest stages of pregnancy in human beings (Cochran, 1961). The value of frogs in food and medicine has been known since ages (see Henderson, 1864;

Cochran, 1961). Like other tribes in north-eastern hills of India, Nagas take them as delicious food item. In Nagaland, live frog's skin is used as a cure for burns. The frog's skin is spread and tied over the burnt part. When the wound is healed, the frog's skin is known to be sloughed off. Certain Naga tribes swallow small frogs to get relief from stomach ailments such as in case of food poisoning. Cooked frog's meat is used for injury, fractures and scabies.

The frogs and toads have also been used to control insect pests in agricultural systems (Okada, 1927; Liu and Chen, 1932; Khan, 1973). In recent years, thousands of tons of frozen frog legs worth crores of rupees ~~were~~ exported as gourmet food items from India to various countries of the world in Europe, Japan and America (see reports of Marine Products Export Development Authority, Government of India, Cochin). Thus, frogs are precious animals from an economic point of view also.

For all these purposes, whether academic or economic, millions of frogs are collected every year from nature. This may lead to extinction of certain frog species. Government of India, in recent years, have shown increasing concern over indiscriminate exploitation of the frog fauna (Rao, 1984). It has now become necessary to adopt strict conservation practices. Though Central Inland Fisheries Research Institute, Government of India, has been attempting culture of frogs on an experimental basis, large scale frog culture is the need of the hour.

While taking up programmes for culture and conservation of certain common species it is also necessary for us to have fairly good knowledge of the anuran fauna of our country. Keeping this in view, it was planned to conduct a thorough survey and study of

Systematics of the anuran fauna of Kohima and surrounding areas in the state of Nagaland. The present work was started in 1981. The survey was continued till 1985. During the first six months of the survey work, Rhacophorus leucomystax was found to be a common frog species in the region. Since there is not much work on its biology barring occasional reports (Cochran, 1961; Church, 1963; Ting, 1970), the above species was selected for detailed study including certain aspects of its ecobiology, apart from a general survey and investigations on the Systematics.

The present thesis has been divided into two parts. The first part deals with a description of the study site, and survey and Systematics of the frogs and toads of Kohima and the surrounding areas. In all, 21 species have been described with a taxonomic key provided. This includes description of 1 new genus, 3 new species and 2 new records from this country. The second part deals with the investigation on following ecobiological aspects of Rhacophorus leucomystax: Morphometric analysis of samples from its population at Kohima, annual breeding cycle, breeding behaviour, population dynamics, food and feeding habits, pituitary gonadal cycle and normal table of development. Studies on the annual breeding cycle, breeding behaviour and population dynamics reflect phases of the life history of this frog through different seasons. A normal table is needed for undertaking any experimental study on different stages of development. Food and feeding habits not only reveal its diet, but also the biotope preference with regard to its habitat. The cyclic changes in pars distalis of the pituitary give us an idea of the regulation of somatotrophic and gonadotrophic hormones in relation to gonadal changes, which control the behaviour and breeding activity of the

frog species through the annual breeding cycle. The study is expected not only to be of use in our understanding of the anuran fauna in Nagaland and India but also of anuran ecobiology in other parts of the world as well.

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PART I

SURVEY AND SYSTEMATICS

CHAPTER I

Study Site and Survey

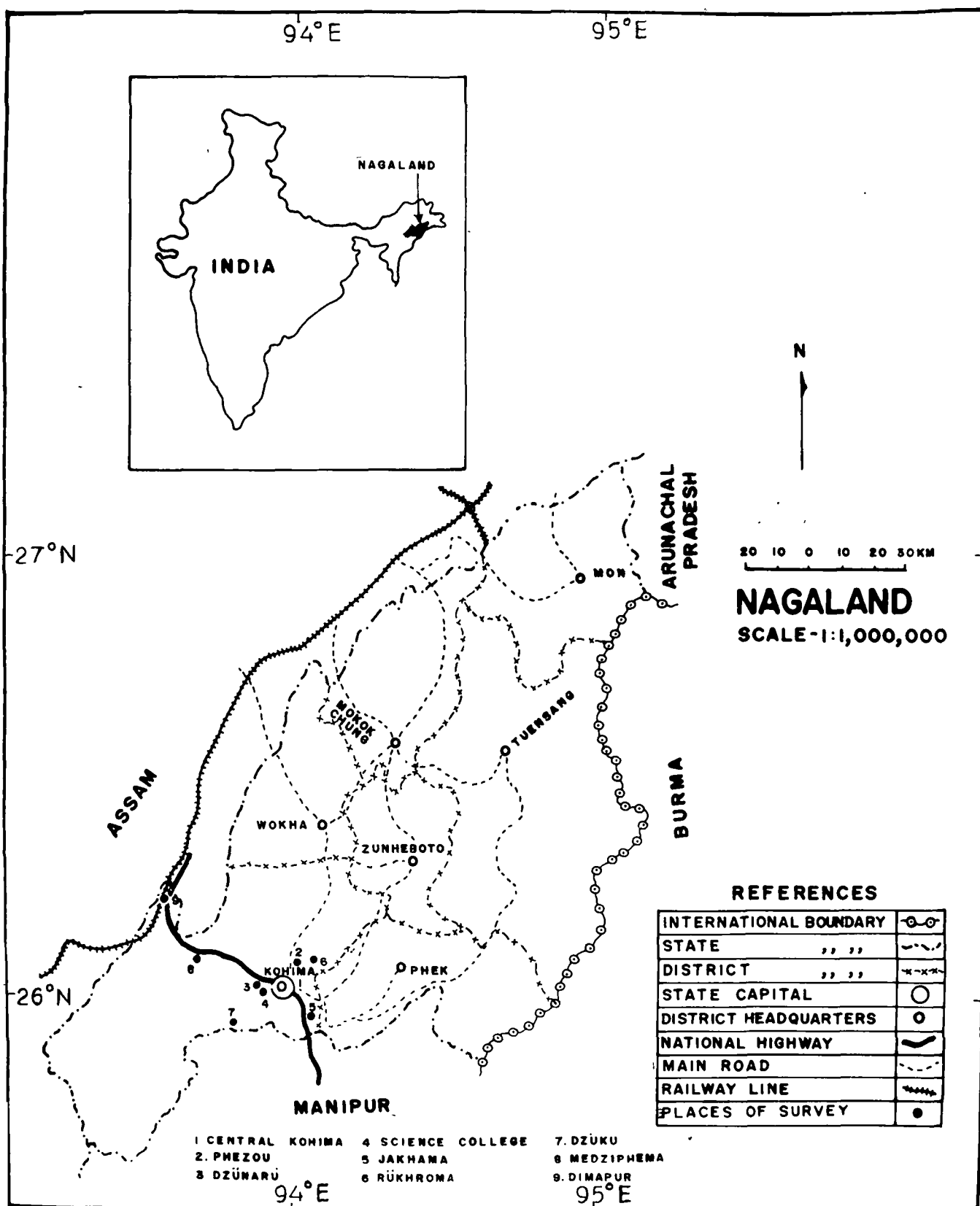


Fig. 1.1

1.1

STUDY SITE AND SURVEY

1.1.1 NAGALAND

The state of Nagaland (Fig. 1.1) is located on the North-Eastern Hills of India ($25^{\circ}6' - 27^{\circ}4'N$ and $93^{\circ}20' - 95^{\circ}15'E$) extending from 183 m a.s.l. to 3840 m a.s.l. On the east of Nagaland is Burma, on the north-west Assam, on the north Arunachal Pradesh and on the south Manipur. The state has an area of 16,579 km² and 7 districts: Kohima, Wokha, Mokokchung, Tuensang, Phek, Zenheboto and Mon.

1.1.2 KOHIMA DISTRICT

Kohima is the Capital of Nagaland. This district has an area of 4,041.00 km² situated at an altitude extending from 183-3,044 m a.s.l. It has 4 seasons: (1) Spring (March-April), (2) Summer and Rainy (May-August), (3) Autumn (September and October) and (4) Winter (November-February). Heavy rains start in summer. They become occasional at the beginning of autumn and rare during winter and spring. The climate over the lower altitude is warm subtropical, and cold temperate at higher altitudes. During winter, at high altitude it is very cold with occasional snowfall and frost. On the western and southern zones of this district, there are temperate evergreen, rain and high forests with strips of thickly growing bamboos; on the eastern and northern zones there are subtropical deciduous forests; and on the central hilly regions there are temperate evergreen rain forests. About 40% of the district is under degraded regrowth forests because of jhumming. There are a number of seasonal and perennial streams and rivers, permanent pools, rain pools and lakes in Kohima. The topographical landscape shows varying degrees of slopes, high hills, mountains and low hills.

Plate 1.1 Site of collection of frogs at Mhasizou
forest in Central Kohima.

Plate 1.2 Site of collection of frogs at Touliezie
pond in Central Kohima.



PLATE 1·1



PLATE 1·2

1.1.3 PLACES OF SURVEY AND COLLECTION

Survey of anurans was conducted during the years 1981-1985 mainly at the following places in the central part of Kohima and neighbouring areas:

- (1) Central Kohima (26°1'N, 93°98'E; 1410-1445 m a.s.l.),
Pls. 1.1 and 1.2)

Central Kohima has temperate evergreen forest, - seasonal and perennial pools and rivers. There is luxuriant growth of aquatic vegetations in the water bodies, and that of herbs and shrubs around these making them ideal habitats for anurans. A large number of specimens were collected from Central Kohima, particularly Zoological Park, Kewhira, Touliezie, Merübotsa, Kelobokha, Chiesierlekha, Sanuorü and Dzülounu belonging to following species.

<u>Species</u>	<u>Period</u>
i) <u>Rana limnocharis</u>	Throughout the year.
ii) <u>Amolops afghanus</u>	Autumn.
iii) <u>Rhacophorus leucomystax</u>	Throughout the year.
iv) <u>Rhacophorus reinwardtii</u>	Summer.
v) <u>Rhacophorus nigropalmatus</u>	Spring and winter.
vi) <u>Rhacophorus bisacculus</u>	Summer, winter as well as spring.
vii) <u>Microhyla ornata</u>	Early summer.
viii) <u>Hyla annectens</u>	Summer, winter as well as spring.
ix) <u>Megophrys boettgeri</u>	Summer.
x) <u>Chirixalus vittatus</u>	Summer.
xi) <u>Philautus annandalei</u>	Summer.
xii) <u>Bufo melanostictus</u>	Summer, autumn as well as winter.
xiii) <u>Pterorana khare</u> (gen. and sp. nov.) (a frog with lateral flaps)	Late autumn.

Plate 1.3 Site of collection of frogs at Jotsoma
fishery pond in Science College area, Kohima.

Plate 1.4 Site of collection of frogs at Science
College area, Kohima.



PLATE 1·3



PLATE 1·4

(2) Phezou (26°15'N, 94°01'E; 1,400 m a.s.l.).

Phezou is situated about 10 km north of Kohima town, and it has evergreen deciduous rain forest, a perennial stream with a deep waterfall. A specimen of Rana mawphlangensis was collected from this waterfall in September.

(3) Dzünarü (26°1'N, 93°94'E; 1,980 m a.s.l.).

Dzünarü is situated about 10 km west of Kohima town. It has a perennial stream flowing down a high hill in the midst of evergreen rain forest. There are thick bushes on both sides of the stream. Following 2 specimens were collected from this stream.

<u>Species</u>	<u>Period</u>
i) <u>Rana nagalandsis</u> (sp. nov.)	Late autumn and early winter.
ii) <u>Megophrys dzünarü</u> (sp. nov.)	Early summer.

(4) Science College and neighbouring areas (26°15'N, 93°95'E; 1,982.5 m a.s.l.), Pls. 1.3 and 1.4.

Science College and its neighbouring areas are situated about 9-11 km west of Kohima town. There are 2 permanent pools and some temporary ditches and streams near an evergreen rain forest on the south-western ward. Thick bushes of shrubs and herbs grow on both the sides in these areas adjoining the water bodies. A number of specimens were collected particularly from the College Campus and Jotsoma, belonging to the following species.

<u>Species</u>	<u>Period</u>
1) <u>Philautus annandalei</u>	Summer.
2) <u>Rhacophorus leucomystax</u>	Summer.
3) <u>Rhacophorus reinwardtii</u>	Summer.
4) <u>Rana limnocharis</u>	Summer.
5) <u>Hyla annectens</u>	Summer.
6) <u>Bufo melanostictus</u>	Summer.

(5) Jakhama (25°92'N, 94°08'E; 1,910 m a.s.l.).

Jakhama is situated about 25 km south of Kohima town. It has a perennial stream with a swift current, surrounded by ever-green rain forest. There are bushes on both sides of this stream. Following 3 species were collected from this stream.

<u>Species</u>	<u>Period</u>
i) <u>Amolops afghanus</u>	Early summer.
ii) <u>Rana liebighii</u>	Early summer.
iii) <u>Rana nagalandsis</u> (sp nov).	Late autumn and warly winter.

(6) Rükhroma (26°25'N, 94°07'E; 1,400 m a.s.l.).

Rükhroma is situated about 15 km north-east of Kohima town. This area has steep hills with a stream and waterfall. A specimen of Pterorana khare with lateral flaps was collected from this stream in May.

(7) Dzüku (25°85'N, 93°83'E; 2,135-2,440 m a.s.l.).

Dzüku is situated about 35 km south of Kohima town. Dzüku is a valley known for its beauty. It spreads over several kms. on top of a plateau. The central valley is dressed with prairies (tall grasses) and there is a stream running in the middle of this valley. Following 2 species were collected from this stream.

<u>Species</u>	<u>Period</u>
i) <u>Megophrys monticola</u> (tadpoles)	Spring.
ii) <u>Rana verrucosa</u>	Spring.

(8) Medziphema (26°25'N, 93°69'E; 305 m a.s.l.).

Medziphema is situated about 57 km west of Kohima town. It is a plain area with mixed bamboo and deciduous forests. There are

a number of ditches, pools, lakes and rivers. Following species were collected from this area.

<u>Species</u>	<u>Period</u>
i) <u>Rana tigrina</u>	Spring.
ii) <u>Rana cyanophlyctis</u>	Spring.

(9) Dimapur (26°38'N, 93°63'E; 183 m a.s.l.).

Dimapur is situated about 72 km west of Kohima town. It is a warm plain area having a number of pools, ditches and lakes. Following species were collected in this area.

<u>Species</u>	<u>Period</u>
i) <u>Rana cyanophlyctis</u>	Summer.
ii) <u>Rana tigrina</u>	Summer.
iii) <u>Rana limnocharis</u>	Summer.
iv) <u>Rhacophorus leucomystax</u>	Summer.
v) <u>Bufo melanostictus</u>	Summer.

While describing study site help has been taken from Jonchay and Rado (1965), Panger (1975) and Zeliang (1979).

- Jonchay, I.D. and S. Rado. 1965. Larouse International Atlas. Librairie Larouse, Paris. 13A.
- Panger, I. 1975. Soil survey Reports, Nagaland. Directorate of Agriculture, Nagaland, Kohima. 158 pp.
- Zeliang, D.K. 1979. Nagaland Forests. Hooghly Printing Co., Ltd. Calcutta. 22 pp.

CHAPTER 2

Systematics

Ever since the publication of "Systema Naturae" by Linnaeus (1758), a large number of anuran species have been described from various parts of the world. Heusser (1974) reported 2600 anuran species belonging to 250 genera under 17 families described by this time. This number is increasing year by year. Though, anuran fauna of India has been investigated since late 19th century (see e.g. Boulenger, 1890 and 1920; Annandale, 1912; Smith, 1924 and 1929; Daniel, 1963 and 1964; Satyamurti, 1963 and 1969; Pillai and Chanda, 1976 and Inger et al, 1984 among others), there is no report on the anuran fauna of Nagaland. The present work has^{been} taken up to fill in the gap and make a headway in this direction.

During the course of the present investigation, the author has been able to collect 21 species. The identification and description of the species is based on the guidelines provided by Boulenger (1890 and 1920), Gadow (1901), Noble (1931), Wright and Wright (1933) and personal communications with Mr. S.K. Chanda, Zoologist, Zoological Survey of India, Calcutta and Dr. M.S. Hoogmoed of Rijksmuseum van Natuurlijke Historie, Leiden, The Netherlands. Descriptions of all species have been checked with original works. In few cases cross references were consulted as originals could not be available. Out of 21 species described, 16 species have already been reported from other parts of north-eastern India (see Pillai and Chanda, 1976). The rest 5 include 2 new records and 3 new species (with 1 new genera) described for the first time not only from the north-eastern hills of India but also the Indian subcontinent. An attempt has been made to prepare the key to all these species.

The new species have been deposited and registered at the Eastern Regional Station, Zoological Survey of India, Shillong.

(a) General

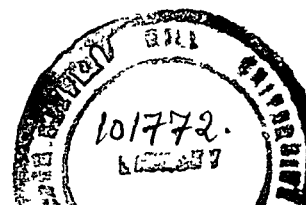
Though Amphibian systematics started as early as in 16th century (Cochran, 1961), the term 'Amphibia' was first used in "Systema Naturae" by Linnaeus in 1758. A number of exhaustive survey reports, monographs and books have been published on the taxonomy of frogs and toads since late 19th century. Worth mentioning among these are, "The Fauna of British India" by Boulenger (1890), the Cambridge Natural History Vol. VIII "Amphibia and Reptiles" by Gadow (1901), "A monograph of the South Asian, Papuan, Melanesian and Australian frogs of the genus, Rana" by Boulenger (1920), "The Biology of the Amphibia" by Noble (1931), "Handbook of frogs and toads of the United States and Canada" by Wright and Wright (1933), "A monograph on the frogs of the family Microhylidae" by Parker (1934), "Amphibians and Reptiles of the World" by Bogert (1954), "The World of Amphibians and Reptiles" by Mertens (1960), "Living Amphibians of the World" by Cochran (1961) and "Grzimek's Animal Life Encyclopedia, Vol. V Fishes and Amphibians" by Heusser (1974). The literature is piling up day by day. We now have a fairly good understanding on anuran fauna of the world, but it is not possible to review all contributions here due to limited nature of the work.

(b) Work done in India

The first 'elaborate' account on the anuran fauna of British India was published by Boulenger in 1890. Among other contributions which appeared since then, more important ones are the following. Annandale (1912) covering Assam; Boulenger (1920) covering the whole of India; Hora and Chopra (1923); Punjab; Smith (1924):

whole of India and Indo-China; Rao (1937): South India; Acharji and Kripalani (1952): Western Himalayas; Behura (1962 and 1965): Orissa; Satyamurti (1963 and 1967): Madras and neighbouring areas; Daniel (1963, 1964 and 1975): Western India; Roonwal (1963): Rajasthan; Grandison and Daniel (1964): Maharashtra; Daniel and Verma (1964) and Daniel and Selukar (1964); Madhya Pradesh; Daniel and Skull (1964): Gujarat; Murthy (1970): Madras and its neighbourhood; Mansukhani and Murthy (1970): Rajasthan; Raja Singh (1970): Tamil Nadu; Weltner (1972, 1975a and 1975b): Himalayas; Venkateswarlu and Murthy (1974) and Murthy (1974): Bihar; Murthy (1974) and Biswas (1975): Whole of India; Mehta, Chandra and Soni (1975): Himachal Pradesh; Mohanty-Hejmadi (1977): Orissa; Mansukhani and Sarkar (1977): West Bengal; Venkateswarlu, Rao and Murthy (1977): Madras; Chopra (1977): Uttar Pradesh; Tilak and Mehta (1977) and Tilak, Sarkar and Mehta (1977): Himachal Pradesh; Pillai (1977): Andamans; Pillai (1978, 1979 and 1981): South India; Paranjape and Mulherkar (1979): Poona; Mansukhani and Sarkar (1980): Andaman and Nicobar; Inger, Shaffer, Sashy and Bakde (1984a and 1984b): South India; Naik (1984): Gujarat; Kemp (1912), Hora (1923), Smith (1929), Roonwal and Kripalani (1961), Yazdani and Chanda (1971), Pillai and Yazdani (1973), Pillai and Chanda (1973, 1976, 1977, 1979 and 1981), Menon (1975) and Mansukhani and Sarkar (1981): North-Eastern India.

In all, 94 species belonging to 19 genera under 6 families have been described from the Indian subcontinent (Ananthakrishnan, 1980). Of these 40 species have been reported from North-Eastern India except states of Nagaland and Mizoram (Pillai and Chanda, 1976).



(c) Criteria for taxonomic description

As to the criteria of taxonomic identification, early workers (see for review Gadow, 1901) prescribed the following features for the identification of anuran families and sub-families: Proportion of tongue, character of shoulder girdle, shape of transverse processes or diapophyses of sacral vertebra, presence or absence of teeth, terminal points or phalanges of digits, shape of the centra of the vertebra. For genera^s and species: Presence or absence of webs, discs, vocal sacs, vomerine teeth, tympanum distinct or indistinct. Boulenger (1920) proposed the use of size, head depression, relationship of head length with width, shape and size of tympanum, vomerine teeth, skin of dorsum, colouration, subarticular tubercles, relationship of interocular distance with inter narial distance, relationship of tibiotarsal articulation with eye or nostril or snout level. This criteria has been followed by workers all over the world, but in recent years they also use webbing formula, shape of the snout, relationship of tympanum diameter with eye diameter, relationship of finger discs with tympanum diameter, distance between eye and tympanum with eye diameter, shape of subarticular tubercles (see for reference Hoogmoed, 1979, Clarke, 1983).

In addition to morphological characters absolute measurements of certain selected characters have also been used in taxonomic descriptions, such as, snout-vent length, head length, head width, snout length, eye diameter, interocular width, tympanum diameter, hindlimb length, tibia length, 3rd, 4th and 5th fingers length, forelimb length, 1st, 2nd, 3rd and 4th fingers length (see Boulenger, 1920). In all 7 to 18 absolute measurements

have been used by workers (Duellman and Klass, 1964; Metter, 1964; Berger, 1966; Tinsley, 1973 and 1975; Pillai and Chanda, 1977; Adnrzejewski, Przystalski and Wilezynska, 1977).

Cochran (1953) suggested that ratios can give better information and compensate the natural variation of sizes. Brown and Alcala (1963) used 3 ratios, namely: (i) Breadth of 3rd finger disc/length of 3rd finger. (ii) Head width/snout-vent length and ^(ili) head width/length of tibia while describing the genus, Cornufer (Ranidae). Duellman and Klass (1964) applied 7 absolute measurements and 6 morphometric ratios for the population of hyliid frog, Triprion petastus. Metter (1964) while comparing 2 populations of tailed frog, Ascaphus truei, used 13 absolute measurements and 4 ratios. Berger (1966) used 14 absolute measurements and 5 index values, while describing the various body parts of Rana esculenta, Rana ridibunda and Rana lessonae. Tinsley (1973 and 1975) while describing the systematics and ecology of the genus, Xenopus used 17 absolute measurements and 9 morphometric ratios of the various body parts, weight of males and females were also taken. Pillai and Chanda (1977) have used 18 absolute measurements while describing 2 new species of frogs, Rana danieli and Rana mawphlangensis. Adnrzejewski, Przystalski and Wilezynska (1977) studied the biometric structure of Pelobates fuscus using 14 features measurements for each individual.

(d) Taxonomic keys

Taxonomic keys are indispensable for easy identification of any species.

Gadow (1901) used following characteristic features to distinguish anuran families:

(i) Teeth: The anurans belonging to families Hylidae, Discoglossidae, Pelobatidae, Cystignathidae-Hemiphractinae, Cystignathinae, Engystomatidae-Dyscophinae, Genyphryninae, Ranidae-Ceratobatrachinae and Raninae have teeth, and those belonging to families Bufonidae, Cystignathidae-Dendrophryniscinae, Engystomatidae-Engystomatinae, Ranidae-Dendrobatinae did not have teeth.

(ii) Shape of sacral diapophyses: The members of families Discoglossidae, Bufonidae, Pelobatidae, Hylidae, Engystomatidae have dilated sacral diapophyses, where as members belonging to Cystignathidae, Ranidae have cylindrical sacral diapophyses.

(iii) Shape of the centra of vertebra: Opisthocoelous vertebrae with ribs are found in Discoglossidae; Procoelous without ribs are found in Bufonidae, Procoelous or opisthocoelous without ribs are found in Ranidae, Hylidae; Procoelous or opisthocoelous with ribs are found in Pelobatidae, Cystignathidae.

(iv) Nature of terminal phalanges: Terminal phalanges may not be claw-shaped e.g. Discoglossidae, Bufonidae, Pelobatidae, Cystignathidae; Terminal phalanges may be claw-shaped as in Hylidae.

Wright and Wright (1933) used mainly the external features for taxonomic key of anurans:

(i) Tail: Male with tail belong to Ascaphidae and male without tail belong to Brevicipitidae, Scaphiopodiidae, Bufonidae, Leptodactylidae, Hylidae, Ranidae.

(ii) Waist, body and hindlimb: The anurans having wide waist, broad and thick body and short hindlimbs belong to Brevicipitidae, Scaphiopodae, Bufonidae, whereas those having narrow waist and

thin body and long hindlimbs belong to Leptodactylidae, Hylidae, Ranidae.

(iii) Parotoid: Parotoids are present in Bufonidae and absent in Brevicipitidae, Scaphiopodidae, Leptodactylidae, Hylidae, Ranidae.

(iv) Colour: Male throat not discoloured are characteristic of Scaphiopodidae, Leptodactylidae, Brevicipitidae, where male throat discoloured is a characteristic of Bufonidae, Hylidae.

(v) Pupil: Pupils are vertical in Scaphiopodidae, Leptodactylidae and pupils are not vertical in Bufonidae, Hylidae, Ranidae, Brevicipitidae.

Noble (1931) and Cochran (1961) classified the salientia, based on the type of the vertebral column as follows :

(i) Amphicoela: Leiopelmidae.

(ii) Opisthocoela: Pipidae, Discoglossidae.

(iii) Anomocoela: Pelobatidae.

(iv) Procoela: Bufonidae, Atelopodidae, Dendrobatidae, Rhinodermatidae, Hylidae, Heleophrynidae, Rhinophrynidae, Pseudidae, Centrolenidae, Leptodactylidae.

(v) Diplasiocoela: Ranidae, Rhacophoridae, Microhylidae, Phrynomeridae.

In recent years (see e.g. Pillai and Chanda, 1979; Clarke, 1983; Hoogmoed and Lescure, 1984 among others) have used size; presence or absence of vomerine teeth, parotoid, disc, intercalary cartilage; shape of snout; vertical or horizontal oval pupil; distinct or indistinct tympanum; smooth or wart dorsum skin; forked or unforked omosternum; dilated or cylindrical sacral diapophyses; and number of subarticular tubercles for genera and species.

An extensive survey of anuran fauna was conducted from 1981 to 1985 in an area of about 4041 km² at Kohima district (Nagaland). The animals were captured by hands or net. They were photographed in the live conditions. The colour patterns were noted. Details of their habit, habitat and altitude where collected were recorded. The animals were then anaesthetized with chloroform; a small cut was made in their abdomen and they were killed and preserved in 7% formalin. The preserved specimens were examined in the laboratory. They were identified with the help of established criteria (see for reference Boulenger, 1890 and 1920; Gadow, 1901; Annandale, 1912; Noble, 1931; Wright and Wright, 1933; Hoogmoed, 1979; Pillai and Chanda, 1979 and Hoogmoed and Lescure, 1984 among others). For morphometric analysis following measurements were taken.

- | | |
|--------------------------|--|
| 1. Snout-vent length | : Measurement between the snout and vent of the animal. |
| 2. Head width minimum | : Measurement at the tip of the snout, parallel to the nostrils. |
| 3. Head width maximum | : Measurement at the widest region of the head. |
| 4. Head length | : Measurement from the anterior length of the animal to occipital condyle. |
| 5. Eye diameter | : Transverse distance across the exposed eye orbit. |
| 6. Inter ocular distance | : Shortest distance between two eyes. |
| 7. Nostril diameter | : Across long axis of nostril including the bordering flap. |
| 8. Inter narial distance | : Across measurement between the two nostrils. |

- | | |
|---|---|
| 9. Distance between eye and nostril | : Measurement of the distance between the eye and nostril. |
| 10. Distance between nostril and tip of snout | : Measurement of the distance between the nostril and tip of snout. |
| 11. Tympanum diameter | : Measurement between annulus tympanicus across tympanic membrane. |
| 12. Hindlimb length | : Total distance from the vent to the tip of 5th toe. |
| 13. Tibia length | : Medial measurement along the dorsal surface of tibia. |
| 14. 5th toe length | : Measurement from the base to the tip of 5th toe. |
| 15. Forelimb length | : Measurement from the origin of forelimb to the tip of 1st finger. |
| 16. Lower forelimb length | : Measurement of the outer angle of elbow to the tip of 1st finger. |
| 17. 1st finger length | : Measurement from the base to the tip of 1st finger. |
| 18. 2nd finger length | : Measurement from the base to the tip of 2nd finger. |

Webbing formula: The general webbing formula has been expressed as follows: $1(1)$, $2i(1)$, $2e(1)$, $3e(1)$, $4i(1\frac{1}{2})$, $4e(2)$, $5(1)$ where, $2i$ etc. stands for inner side of the second finger/toe and $2e$ etc. stands for external side of the second finger/toe.

The numbers in the parenthesis indicate the number of phalanges free of webbing, when counted from the tip of the finger/toe towards the palm/sole. When a disc is present at the tip, it is taken as phalange No. 1.

For confirmation of genera, endoskeleton was dissected and studied, except for those which I also had 1 or 2 specimens. For these X-ray photographs have been provided.

Other features taken into consideration for the identification are : presence or absence of vomerine and maxillary teeth, nature of tongue and eye pupil, presence or absence of discs on tips of digits, presence or absence of subarticular tubercles, shape and number of metacarpal and metatarsal tubercles, relationship of tibia-tarsal articulation with the level of eye or nostril or tip of snout. The characters considered for identification has been illustrated in Figs. 2A, B, C, D, E and F.

2.4 SYSTEMATIC DESCRIPTION AND KEY

The Table 2A illustrates the skeletal features of the 10 genera described and following account deals with the systematic descriptions of the species.

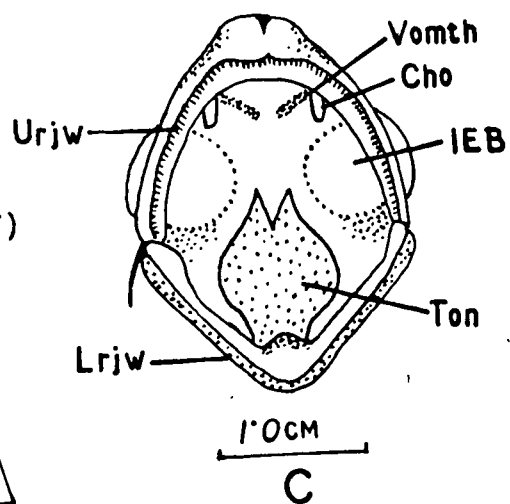
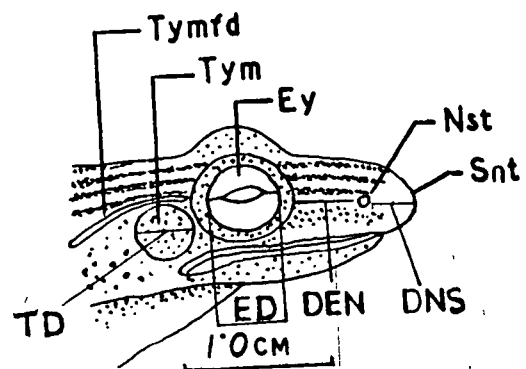
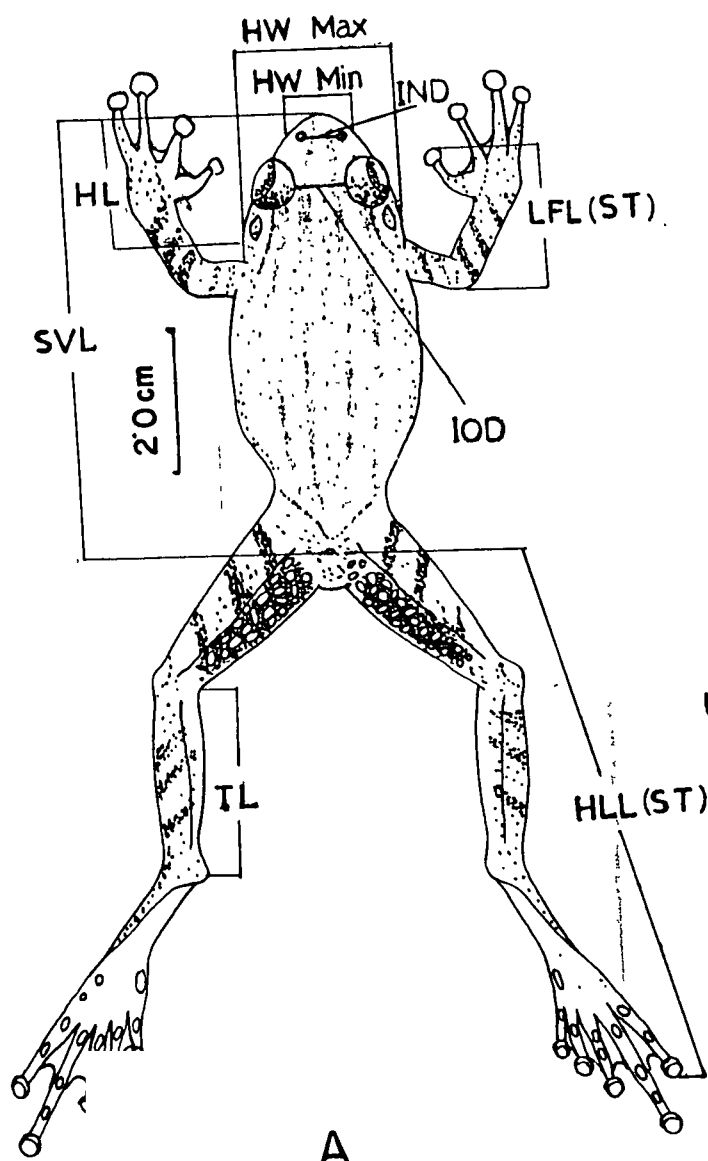
Fig. 2A : Dorsal view of a frog.

Fig. 2B : Lateral view of head.

Fig. 2C : Mouth gape.

Abbreviations:

Cho	: Choanae
DEN	: Distance between eye and nostril
DNS	: Distance between nostril and tip of snout
ED	: Eye diameter
Ey	: Eye
HL	: Head length
HLL (ST)	: Hindlimb length (straightened)
HW Max.	: Head width maximum
HW Min.	: Head width minimum
Ieb	: Inner eye ball
IND	: Internarial distance
IOD	: Interocular distance
LFL (ST)	: Lower forelimb length straightened
Lrjw	: Lower jaw
Nst	: Nostril
Snt	: Snout
SVL	: Snout-vent length
TD	: Tympanum diameter
Ton	: Tongue
Tymp	: Tympanum
Tymfd	: Tympanum fold
Urjw	: Upper jaw
Vomth	: Vomerine teeth



A

B

C

Fig. 2

Fig. 2D : Ventral view of hand.

Fig. 2E : Ventral view of foot.

Fig. 2F : Tibia-tarsal articulation.

Abbreviations:

Dis	: Disc
Hlmb	: Hindlimb
Metcartub	: Metacarpal tubercle
Mettartub	: Metatarsal tubercle
Nst	: Nostril
Sachum	: Sacral hump
Snt	: Snout
Subartub	: Subarticular tubercle
Tbtra	: Tibia-tarsal articulation
1FL	: 1st finger length
2FL	: 2nd finger length
3FL	: 5th toe length

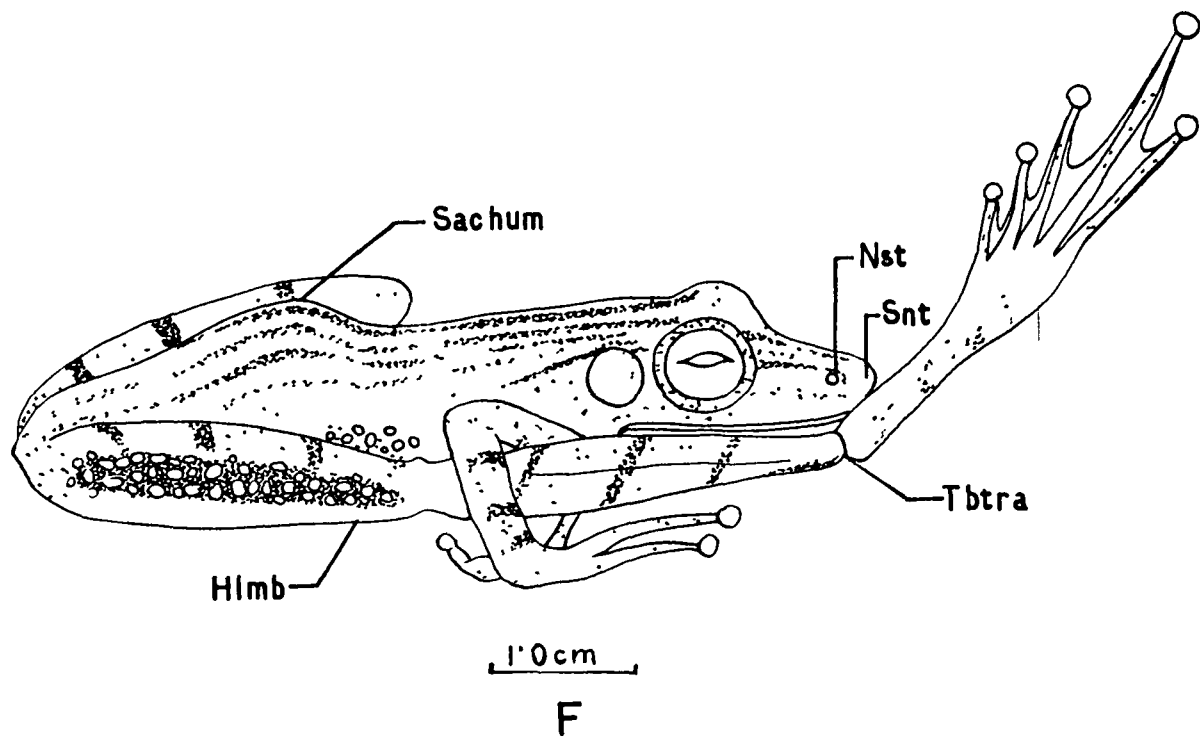
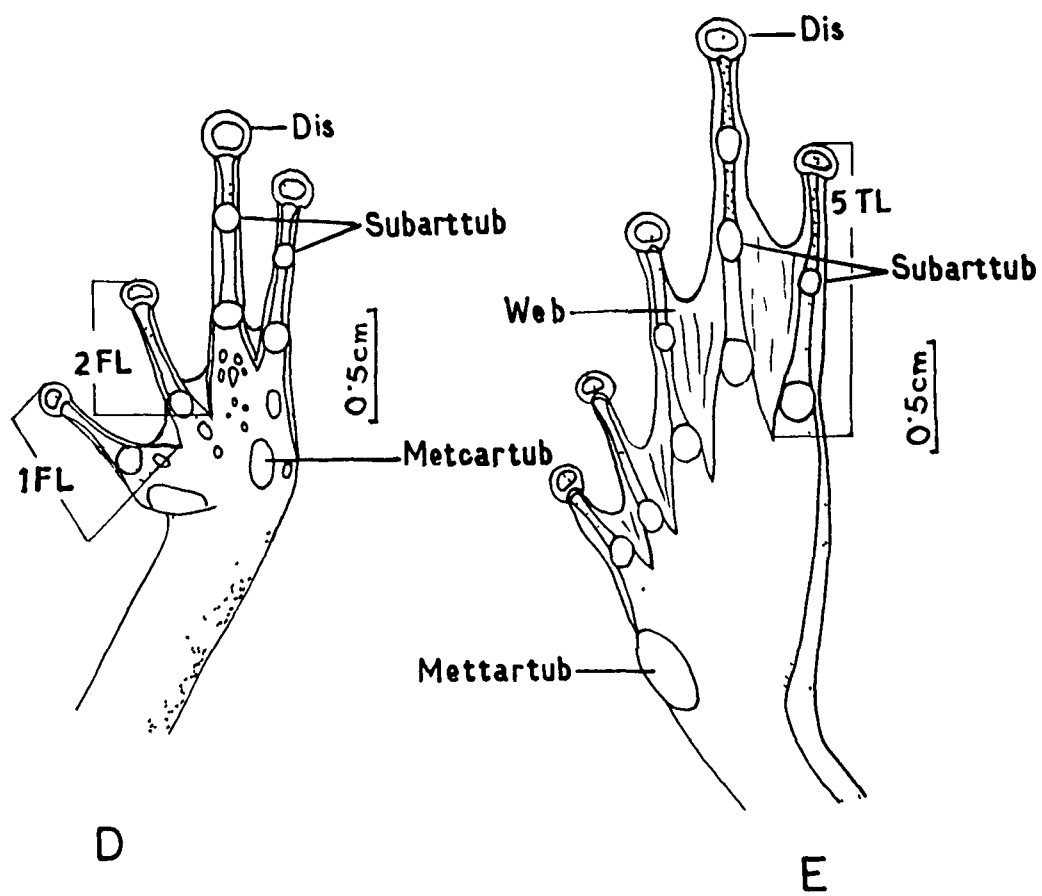


Fig. 2

Table 2 A : Skeletal features of the genera.

Genus	Maxillary and vomerine teeth	Vertebral column	Sacral diapophyses	Omosternum	Coracoid	Intercalary cartilage
<u>Megophrys</u>	Present	Anomocoelous	Dilated	Unforked	Medially overlapped	Absent
<u>Bufo</u>	Absent	Procoelous	Dilated	Absent	Medially overlapped	Absent
<u>Hyla</u>	Present	Procoelous	Dilated	Unforked	Medially overlapped	Present
<u>Amolops</u>	Present	Diplasiocoelous	Cylindrical	Unforked	No medial overlap	Absent
<u>Rana</u>	Present	Diplasiocoelous	Cylindrical	Forked	No medial overlap	Absent
<u>Pterorana</u> (<i>gen. nov.</i>)	Present	Diplasiocoelous	Cylindrical	Forked	No medial overlap	Absent
<u>Rhacophorus</u>	Present	Diplasiocoelous	Cylindrical	Forked	No medial overlap	Present
<u>Philautus</u> and <u>Chirixalus</u>	Maxillary teeth present, vomerine teeth absent	Diplasiocoelous	Slightly dilated	Forked	No medial overlap	Present
<u>Microhyla</u>	Absent	Diplasiocoelous	Slightly dilated.	Absent	No medial overlap	Absent

2.4.1 Megophrys monticola Kuhl and Van Hasselt, 1822
(Anomocoela: Pelobatidae: Megophryinae).
Plate 2.1A, B, C, D, E and F.

Megophrys monticola Kuhl and Van Hasselt, Algemeene
Konst-en Letter-Bode, 1822(7): 99-104.

Megophrys montana, Boulenger, Cat. Batr. Sal., Ecaud. Brit.
Mus., 1882: 442.

Megophrys montana, Van Kampen, Amph. Indo-Austr. Arch.,
1923: 8.

Megophrys monticola, Pillai and Chanda, Rec. Zool. Surv.
India, 1979: 386.

Diagnosis: A small frog, SVL of young adult males 14-17 mm. Skin of dorsum warty, belly granular. Vomerine and maxillary teeth present. Pupil vertically oval. Tympanum indistinct, as large as eye diameter. Fingers free, toes webbed. Fingers and toes with swollen tips. 1st finger *as long as* 2nd finger. No sub-articular tubercles. Tibio-tarsal articulation reaching eye level. Colour of dorsum greyish dark, brown. Belly dark with minute white patches.

Description: Only young adults were examined. Snout-vent length of young males measured 14-17 mm.

Head as broad as long, slightly depressed. Snout round in dorsal, slightly acuminate in lateral profile, projecting over the mouth. Distance between eye and nostril shorter than the horizontal diameter of the eye, 1.5 times the distance between nostril and tip of snout. Internarial distance equidistant with the interocular distance. Eyes moderately large, bulging, pupil vertically elliptical. Tympanum indistinct, oval, as large as horizontal diameter of the eye, separated from the eye by a distance 1/3rd its distance.

Plate 2.1A Megophrys monticola male.

Plate 2.1B Ventral view of head.

Plate 2.1C Lateral view of left side of head.

Plate 2.1D Ventral view of right hand.

Plate 2.1E Ventral view of right foot.

Plate 2.1F Range and distribution.

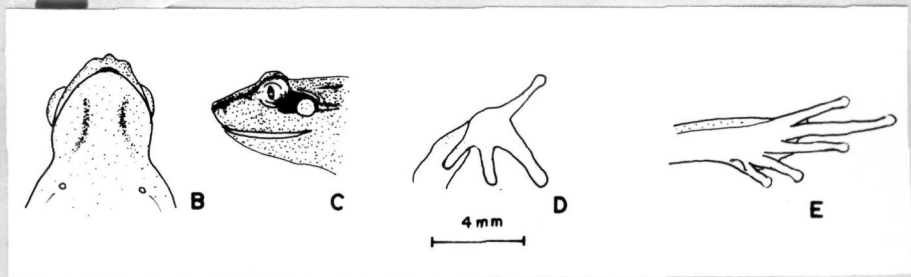


PLATE 2.1

Vomerine teeth small, strong, in oblique series, innerly posterior to the choanae. Upper jaw toothed. Lower jaw without teeth. Tongue large, oval, bifid.

Forelimbs long. Fingers without web. Fingers are with swollen tips. There is no metacarpal tubercle. No subarticular tubercles. Length of fingers: $1 \approx 2 < 4 < 3$.

Hindlimbs short. Tibio-tarsal articulation reaching at the eye level when passed forward along the body. Toes rudimentary webbed, webbing formula: $1(2), 2i(2), 2e(2), 3i(3), 3e(2), 4i(3), 4e(3), 5(2)$. Toes with swollen tips. There is no metatarsal tubercle. No subarticular tubercles. Length of toes: $1 < 2 < 3 < 5 < 4$.

Skin of dorsum coarsely granular. Belly smooth. A V-shaped fold connecting the eye orbits. Tympanic fold present.

Colour of dorsum brown, grey, dark. A black triangular marked connects the eyeorbit, on the dorsum. There are patches of white spots on both lateral sides of the body. Belly dark with minute dispersed white spots.

Measurements: Table 2.1.

Habit and habitat: They are mostly nocturnal frogs, found in cool streams. Live among the tick herbs and bushes near the streams.

Breeding: Probably, they breed in February and March in cool stream. Since, their tadpoles bearing lozenge-shaped (funnel) structure around their mouths were collected in early part of April. Completed metamorphosis by May in the laboratory.

Economic use: It is not known.

Table 2.1: $\bar{X}$ Measurements of Megophrys monticola.

Characters	Male (mm) N = 2
Snout-vent length	15.5
Head width minimum	1.5
Head width maximum	5.5
Head length	5.5
Eye diameter	2.0
Inter-ocular distance	2.25
Nostril diameter	0.5
Inter-narial distance	3.0
Distance between eye and nostril	1.5
Distance between nostril and tip of snout	1.0
Tympanum diameter	2.0
Hindlimb length	20.0
Tibia length	7.0
5th toe length	2.25
Forelimb length	7.5
Lower forelimb length	3.0
1st finger length	1.5
2nd finger length	1.5

Range and distribution: Collected from Dzöku valley at an altitude between 2135-2440 m a.s.l. Its distribution extends in Thailand, Sumatra, Java, Borneo and Philippines (Heusser, 1974). Pillai and Chanda (1979 and 1981) also reported it from Meghalaya in north-eastern India.

2.4.2 Megophrys boettgeri (Boulenger, 1899)

(Anomocoela: Pelobatidae: Megophryinae).
Plate 2.2A, B, C, D, E and F

Leptobrachium boettgeri Boulenger, Proc. Zool. Soc. Lond., 1899:171.

Diagnosis: A small frog, SVL of males 30-35 mm and of females 43 mm.

Skin of dorsum rough, belly granular. Vomerine and maxillary teeth present. Pupil vertically oval. Tympanum indistinct, $1/2$ the horizontal eye diameter. Fingers free, toes webbed. Fingers and toes with swollen tips. 1st finger shorter than 2nd finger. No subarticular tubercles. Tibio-tarsal articulation reaching eye level. Colour of dorsum greyish brown, pink. A line interconnecting the eye orbits. Belly dark with minute white spots. 2 large white spots on the chest.

Description: Moderately small species. Snout-vent length of males 30-33 mm and of females 43 mm.

Head as broad as long, slightly depressed. Snout pointed in dorsal, acuminate in lateral profile, projecting over the mouth. Distance between eye and nostril half the horizontal diameter of the eye, 1.4 times the diameter of the eye, 1.4 times the distance between nostril and tip of snout. Internarial distance $4/5$ th the interocular distance. Eyes moderate, bulging, pupil vertically oval. Tympanum indistinct, oval, $1/2$ the horizontal diameter of the eye, separated from the eye by a distance of its diameter.

Vomerine teeth small, oval, innerly posterior to the choanae. Upper jaw toothed. Lower jaw without teeth. Tongue oval, monofid.

Forelimbs long. Fingers free. Fingers have swollen tips. Metacarpal tubercle absent. No subarticular tubercles. Length of fingers: $1 < 2 < 4 < 3$.

Plate 2.2A Megophrys boettgeri female.

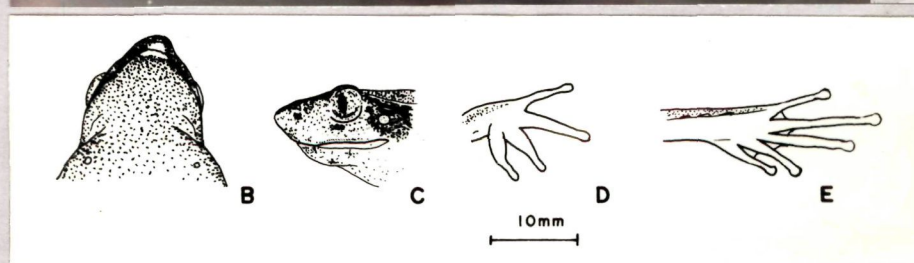
Plate 2.2B Ventral view of head.

Plate 2.2C Lateral view of left side of head.

Plate 2.2D Ventral view of right hand.

Plate 2.2E Ventral view of right foot.

Plate 2.2F Range and distribution.



Hindlimbs short. Tibio-tarsal articulation reaching at the eye level when passed forward along the body. Toes are rudimentary webbed, webbing formula: 1(2), 2i(2½), 2e(2), 3i(2½), 3e(2), 4i(3), 4e(3), 5(2). Toes ended with swollen tips. Metatarsal tubercle absent. No subarticular tubercles. Length of toes: 1<2<3<5<4.

Skin of dorsum rough with broken ridges. Belly granular. A glandular tubercle at the joint of jaws. Tympanum fold visible.

Colour of dorsum greyish pink, brown. A brown line interconnecting the eye-orbits. An irregular brown V-shaped mark on the dorsum. Dark cross-bars on limbs. Belly dark with minute white spots. 2 large white spots on the ches.

Measurements: Table 2.2

Habit and habitat: Diurnal as well as nocturnal frogs. In summer, they live in damp places near streams which are covered by vegetation.

Breeding: They breed in streams from May till July. During this period, males sit on shady damp places and croak.

Economic use: They are not edible.

Range and distribution: Pillai and Chanda (1976) mentioned that it has been reported from Arunachal Pradesh also. No record has since then been made from north-east India except the present collection from Zoological park Kohima at an altitude of 1,444 m a.s.l.

Table 2.2: $\bar{X}$ Measurements of Megophrys boettgeri.

Characters	Male (mm) N = 2	Female (mm) N = 1
Snout-vent length	31.5	43.0
Head width minimum	4.4	5.3
Head width maximum	10.5	14.0
Head length	10.5	14.0
Eye diameter	4.0	6.0
Inter-ocular distance	3.75	4.0
Nostril diameter	0.6	0.8
Inter-narial distance	3.0	4.0
Distance between eye and nostril	2.5	2.4
Distance between nostril and tip of snout	1.8	1.8
Tympanum diameter	2.25	3.0
Hindlimb length	49.0	65.0
Tibia length	17.5	23.0
5th toe length	6.0	6.0
Forelimb length	15.0	23.0
Lower forelimb length	11.9	15.7
1st finger length	2.5	4.0
2nd finger length	3.0	4.5

2.4.3

Megophrys dzûnarü sp. nov.

(Anomocoela: Pelobatidae: Megophryinae).

Plate 2.3A, B, C, D, E, F and G

Diagnosis: A large pelobatid frog, SVL of male 93 mm. Skin of dorsum minutely granular. Belly smooth. Small dorso-lateral folds present. Vomerine and maxillary teeth present. Pupil vertically oval. Tympanum indistinct, $1/2$ the horizontal eye diameter. Fingers free, toes webbed. Fingers and toes with swollen tips. 1st finger longer than 2nd finger. Subarticular tubercles not visible. Tibio-tarsal articulation reaching eye level. Colour of dorsum dark grey, a dark triangular shaped interconnecting the eye orbits, V-shaped behind the head on the dorsum. Belly yellow pinkish with 2 white spots on the chest.

Description: A large pelobatid. Snout-vent length of male measured 93 mm. No female in the collection.

Head broader than long, greatly depressed. Snout round in dorsal, acuminate in lateral profiles, projecting over the mouth. Distance between eye and nostril shorter than the horizontal diameter of the eye, almost equidistant with the distance between nostril and tip of snout. Internarial distance 1.5 times the interocular distance. Eyes large, bulging, pupil vertically oval. Tympanum indistinct, oval, $1/2$ th the horizontal diameter of the eye, separated from the eye by a distance double its diameter.

Vomerine teeth small, strong, ~~innerly~~ parallel from anterior to hinder border of the choanae. Upper jaw toothed. Lower jaw without teeth. Tongue oval, slightly bifid.

Forelimbs long, slender. Fingers free, ended with swollen

Paper on this species communicated

Plate 2.3A Megophrys dzūnarū male.

Plate 2.3B Ventral view of head.

Plate 2.3C Lateral view of left side of head.

Plate 2.3D Ventral view of right hand.

Plate 2.3E Ventral view of right foot.

Plate 2.3F Range and distribution.

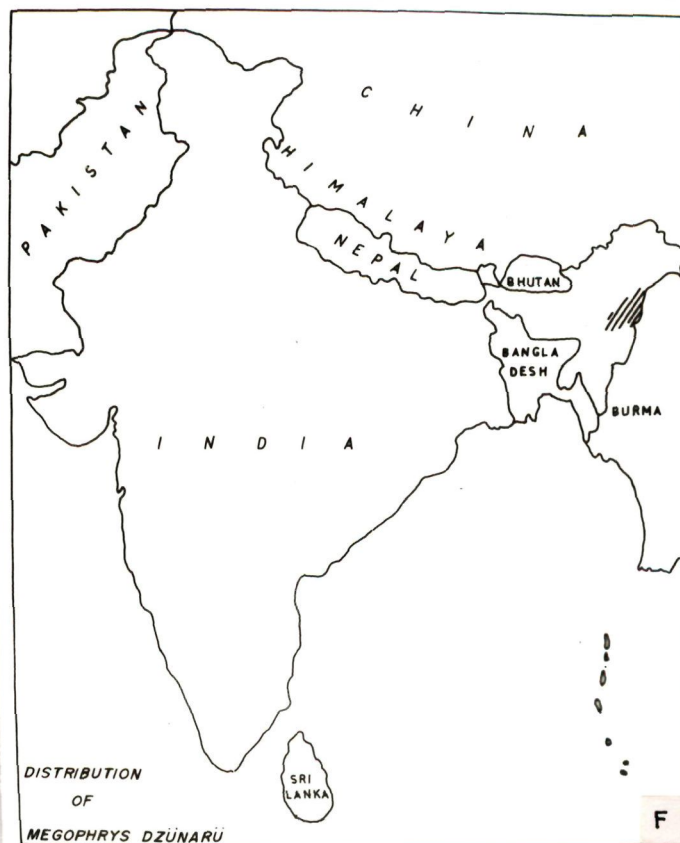
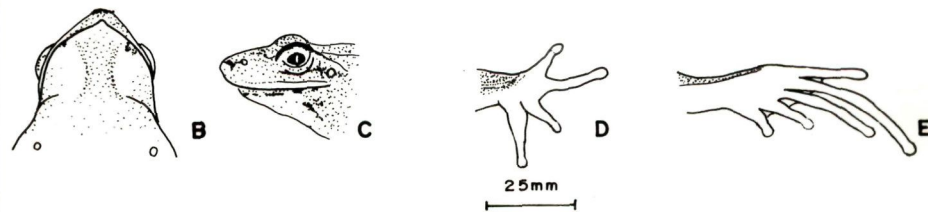


PLATE 2.3

Plate 2.3G : X-ray photograph of Megophrys dzūnarū.



PLATE 2.3

tips. There is 1 indistinct oblong inner metacarpal tubercle. Subarticular tubercles not visible. Length of fingers: $4 < 2 < 1 < 3$.

Hindlimb moderately short, muscular. Tibio-tarsal articulation reaching at the eye when passed forward along the body. Toes are webbed rudimentary, webbing formula: $1(2)$, $2i(2\frac{1}{2})$, $2e(2)$, $3i(3)$, $3e(2\frac{3}{4})$, $4i(3\frac{3}{4})$, $4e(3\frac{3}{4})$, $5(2\frac{1}{2})$. Toes with swollen tips. There is 1 indistinct oblong inner metatarsal tubercle. Subarticular tubercles are not visible. Length of toes: $1 < 2 < 5 < 3 < 4$.

Skin of dorsum minutely granular. Belly almost smooth. Tympanic fold present. Small distinct dorso-lateral folds, extending from tympanum fold to the waist.

Colour of dorsum dark-grey. A dark triangular shaped inter-connecting the eye orbits. V-shaped mark behind the head on body dorsum. Lateral slate grey with yellow and black spots. Dark cross-bars on limbs. Belly yellow with diffused dark patches, chest reddish pink intermingled with minute dark spots. A white distinct spot on each side of the chest.

Measurements: Table 2.3.

Habits and habitat: Nocturnal in habit. Live near the edge of a cool stream.

Breeding: Their breeding period is not known.

Economic use: Not known.

Range and distribution: This specimen was collected from Dzünarú at an altitude of 1980 m a.s.l.

Table 2.3: Measurements of Megophrys dzünarü

Characters	Male (mm) N = 1
Snout-vent length	93.0
Head width minimum	7.0
Head width maximum	34.0
Head length	26.0
Eye diameter	8.0
Inter-ocular distance	8.0
Nostril diameter	1.75
Inter-narial distance	11.0
Distance between eye and nostril	5.0
Distance between nostril and tip of snout	5.7
Tympanum diameter	4.0
Hindlimb length	120.0
Tibia length	56.0
5th toe length	19.0
Forelimb length	40.0
Lower forelimb length	36.0
1st finger length	12.5
2nd finger length	12.0

Holotype: Male frog, ⁷⁵¹Reg. No. V/ERS.8219 in formalin. loc. Dzūnarū, Kohima (alt. 1980 m a.s.l.), coll. Kiyasetuo, 20.5.1985.

Relationship: This specimen shows following pelobatid characters resembling those of Megophrys.

- i) Morphology: Vertical pupil, maxillary teeth well developed, tympanum indistinct, fingers free, no subarticular tubercles.
- ii) Skeleton: Vertebral column procoelous (anomocoela), no ribs, sacral diapophyses greatly dilated, no intercalary cartilage, omosternum unforked, coracoid medially overlapped.

Closer examination reveals its similarity with Megophrys major Boulenger (Taylor, 1962). They are: Large body size, head broader than long; nostril almost equidistant between eye and tip of snout; small dorso-lateral folds present; toes webbed rudimentary; a triangular dark mark between the eyelids.

Though it is similar to Megophrys major, the two show following differences.

<u>Megophrys major</u> (male)	<u>Megophrys dzūnarū</u> (male)
1. Tympanum distinct;	Tympanum indistinct.
2. 1st finger as long as 2nd;	1st finger longer than 2nd.
3. Tibia-tarsal articulation reaching the tip of snout;	Tibia-tarsal articulation reaching at the eye level.
4. Skin of dorsum smooth;	Skin of dorsum minutely granular.

Not only the above differences attribute it to be designated as sp. nov., but also as a species it is quite distinct from Megophrys major.

The specimen has been assigned a new species, Megophrys dzūnarū to commemorate the place of collection.

2.4.4.

Bufo melanostictus Schneider, 1799

(Procoela: Bufonidae: Bufoninae).

Plate 2.4A, B, C, D, E and F.

Bufo melanostictus Schneider, Hist. Amph., 1799: 216Bufo melanostictus Boulenger, Cat. Batr. Sal. Ecaud.
Brit. Mus., 1882: 306.Bufo melanostictus Van Kampen, Amph. Indo-Austr. Arch.,
1923: 80.

Diagnosis: A large toad, SVL of males 52-89 mm and of female 103 mm. Skin of dorsum warty and tuberculated, belly rough. Vomerine and maxillary teeth lacking. Pupil horizontally oval. Parotoid glands present. Tympanum distinct, $\frac{2}{3}$ rd the horizontal eye diameter. Fingers free, toes webbed. Fingers and toes with slightly dilated tips. 1st finger longer than 2nd finger. Tibio-tarsal articulation not reaching eye level. Colour of dorsum grey, dark. Belly grey.

Description: Bufo melanostictus is a large toad. Snout-vent length of males 52-89 mm and of females 103 mm.

Head small, broader than long, slightly depressed. Snout pointed in dorsal, truncate in lateral profile, slightly projecting over the mouth. Distance between eye and nostril shorter than the horizontal diameter of the eye, 1.3 times the distance between nostril and tip of snout. Internarial distance $\frac{5}{6}$ th the interocular distance. Eyes moderately large, bulging, pupil horizontally oval. Tympanum distinct, oval $\frac{2}{3}$ rd the horizontal diameter of the eyes, separated from the eye by a distance of its diameter. Behind each tympanum a prominent paratoid gland is present.

Vomerine teeth wanting. Upper and lower jaws without teeth. Tongue oblong unforked.

Plate 2.4A Bufo melanostictus male.

Plate 2.4B Ventral view of head.

Plate 2.4C Lateral view of left side of head.

Plate 2.4D Ventral view of right hand.

Plate 2.4E Ventral view of right foot.

Plate 2.4F Range and distribution.

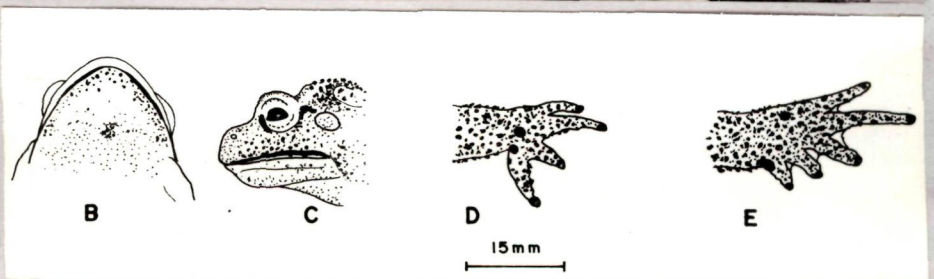
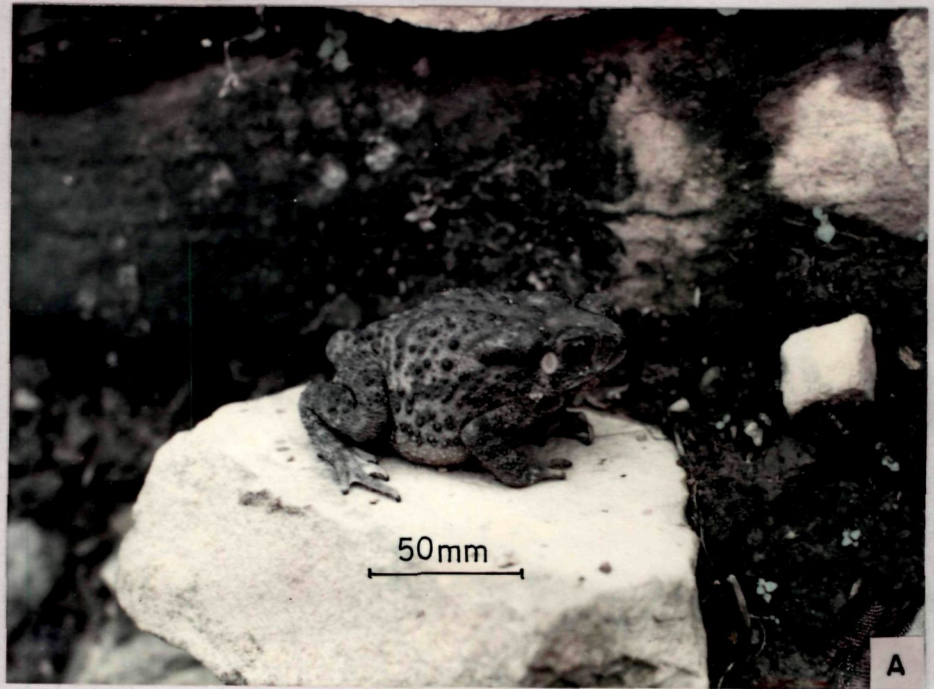


PLATE 2·4

Forelimbs short. Fingers are free. Fingers ended with slightly dilated tips. There are 2 oval metacarpal tubercles (outer tubercle large, inner tubercle small). Subarticular tubercles tuberculated, irregularly arranged. Length of fingers: $2 < 4 < 1 < 3$.

Hindlimbs short. Tibio-tarsal articulation not reaching at the eye level when passed forward along the body. Toes are webbed, webbing formula: $1(1\frac{1}{2})$, $2i(1\frac{3}{4})$, $2e(1\frac{1}{2})$, $3i(3)$, $3e(2)$, $4i(3)$, $4e(3)$, $5(1\frac{1}{2})$. Toes are ended with slightly dilated tips. There are 2 oval metatarsal tubercles (outer tubercle small and inner tubercle large). Subarticular tubercles tuberculated, numerous, irregularly arranged. Length of toes: $1 < 2 < 5 < 3 < 4$.

Skin of dorsum warty, tuberculated. Belly rough. Vocal sacs and thumb pads are present in male during breeding season.

Colour of dorsum grey, dark. Warts are tipped with black. Jaws are edged with black striped cross-bars on limbs. Belly grey.

Measurements: Table 2.4.

Habit and habitat: A nocturnal toad. They are found in varied habitats such as in inhabiting areas, forests, dry places, fields etc. They hide in crevices, under litters during day time and come out for foraging at night. During winter, they hibernate in crevices.

Breeding: Their breeding season begins from April till June in pools and paddy fields. Toadlets were collected in last part of June.

Economic use: Bufo melanostictus is not edible. They have been used for poisoning food. Angamis observe every year one day in the name of toad (Thegou khupfhü), merry making for children.

Table 2.4: $\bar{X}$ Measurements of Bufo melanostictus

Characters	Male (mm) N = 2	Female (mm) N = 1
Snout-vent length	70.5	103.0
Head width minimum	3.75	4.0
Head width maximum	23.5	38.0
Head length	20.5	34.0
Eye diameter	6.5	8.0
Inter-ocular distance	7.0	6.0
Nostril diameter	1.2	1.2
Inter-narial distance	5.25	5.5
Distance between eye and nostril	3.6	4.0
Distance between nostril and tip of snout	2.8	3.0
Tympanum diameter	5.0	5.0
Hindlimb length	58.0	70.0
Tibia length	29.0	33.0
5th toe length	8.25	10.0
Forelimb length	32.5	35.0
Lower forelimb length	28.7	28.5
1st finger length	7.5	8.0
2nd finger length	6.0	6.0

Range and distribution: Collected from Dimapur, Medziphema, Science College Campus, Touliezie, Kewhira, Sanuorü and Merübotsa at an altitude between 183-1982.5 m a.s.l. Its distribution extends in India, Malaya Archipelago (Gadow, 1901), all over Oriental region (Annandale and Rao, 1918), Southern Asia (Cochran, 1961), Burma, Nepal, Ceylon, China, Malaya, Phillipine islands (Taylor, 1962), Southern-eastern Asia, whole of India from northern India to southern China, Indonesian islands, Thailand, Java, Borneo (Heusser, 1974) and Pakistan (Khan, 1979). Pillai and Chanda (1976) reported it from Meghalaya, Assam, Arunachal Pradesh and Mansukhani and Sarkar (1981) also reported it from Tripura of north-eastern India.

2.4.5

Hyla annectans (Jerdon, 1870)
 (Procoela: Hylidae: Hylinae).
 Plate 2.5A, B, C, D, E and F

Polypedates annectans Jerdon, Proc. Asiat. Soc. Bengal,
 1870: 84.

Hyla annectans, Boulenger, Cat. Batr. Sal. Ecaud. Brit.
 Mus., 1882: 382.

Hyla annectans, Boulenger, Fauna Brit. India, 1890: 509.

Diagnosis: A small leafy green frog, SVL of males 31-41 mm and of females 41-49 mm. Skin of dorsum smooth and belly coarsely granular. Tongue nicked at the hinder margin. Vomerine and maxillary teeth present. Pupil horizontally oval. Tympanum distinct, 2/3rd the horizontal eye diameter. Fingers and toes webbed. Fingers and toes with large discs (3rd and 4th finger discs larger than tympanum). 1st finger shorter than 2nd finger. Tibio-tarsal articulation not reaching eye level. Carpal and tarsal folds present. Colour of dorsum leafy green. On the axilla 2-3 interconnecting black spots present. Belly white or yellow.

Description: A moderately small frog. Snout-vent length of males 31-41 mm and of females 41-49 mm.

Head broader than long, slightly depressed. Snout round in dorsal, truncate in lateral profile, projecting over the mouth. Nostrils elevated. Distance between eye and nostril approximately as long as the horizontal diameter of the eye, slightly more than 2 times longer than the distance between nostril and tip of snout. Internarial distance is half the interocular distance. Eyes are large, bulging, pupil horizontally oval. Tympanum distinct, round, 2/3rd the horizontal diameter of the eye, separated from the eye by a distance half its diameter.

Plate 2.5A Hyla annectens female.

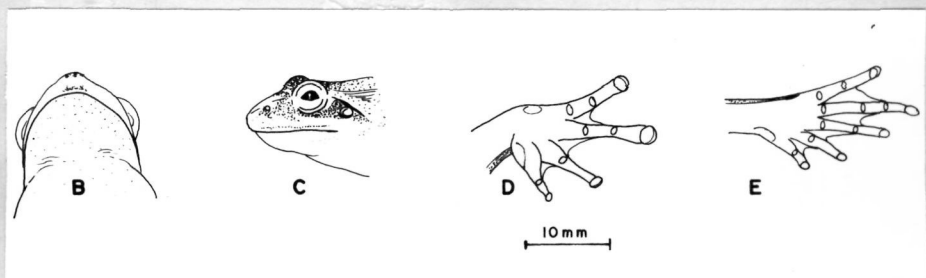
Plate 2.5B Ventral view of head.

Plate 2.5C Lateral view of left side of head.

Plate 2.5D Ventral view of right hand.

Plate 2.5E Ventral view of right foot.

Plate 2.5F Range and distribution.



PI

2.5

Vomerine teeth small, round, strong, innerly anterior to the choanae. Upper jaw toothed. Lower jaw without teeth. Tongue moderately large, oval, monofid, nicked at hinder margin.

Forelimbs long. Fingers are webbed rudimentary, webbing formula: $1(2)$, $2i(2\frac{1}{2})$, $2e(2)$, $3i(2\frac{3}{4})$, $3e(2\frac{1}{2})$, $4(2)$. Fingers have large oval discs at their tips, the 3rd and 4th finger discs larger than the tympanum. There are 2 oval metacarpal tubercles, (outer tubercle small and inner tubercle large). Subarticular tubercles distinct, round, single in 1st and 2nd fingers, bifid in 3rd and 4th fingers. Length of fingers: $1 < 2 < 4 < 3$.

Hindlimbs short, slender. Tibio-tarsal articulation not reaching at the eye level when passed forward along the body. Toes are webbed, webbing formula: $1(2)$, $2i(2)$, $2e(1\frac{3}{4})$, $2i(2\frac{1}{2})$, $3e(2)$, $4i(3)$, $4e(2\frac{1}{2})$, $5(1\frac{3}{4})$. Toes are with oval discs at their tips. There is 1 oval inner metatarsal tubercle. Subarticular tubercles distinct, round, single. Length of toes: $1 < 2 < 5 < 3 < 4$.

Skin of dorsum smooth. Belly coarsely granular. Tympanic fold present. Vocal sacs and thumb pads are visible in male during breeding season.

Colour of dorsum leafy green. Belly yellowish white. There are 2-3 black interconnecting spots on both the lateral sides behind the arms, also on arms and thighs. A state-dark plate on both the lateral sides of the body.

Measurements: Table 2.5.

Habit and habitat: They are nocturnal, arboreal frogs. They live in hollow stems of trees during winter. They visit temporary water bodies in spring and summer.

Table 2.5:X Measurements of Hyla annectans

Characters	Male (mm) N = 3	Female (mm) N = 2
Snout-vent length	37.0	45.0
Head width minimum	2.0	3.0
Head width maximum	11.3	15.0
Head length	10.3	13.0
Eye diameter	3.66	4.75
Inter-ocular distance	5.0	5.0
Nostril diameter	0.56	0.65
Inter-narial distance	3.2	4.0
Distance between eye and nostril	4.5	4.10
Distance between nostril and tip of snout	2.25	2.10
Tympanum diameter	3.2	3.5
Hindlimb length	51.33	60.0
Tibia length	18.6	21.0
5th toe length	7.6	8.5
Forelimb length	18.0	19.0
Lower forelimb length	12.8	16.5
1st finger length	3.0	4.5
2nd finger length	4.6	6.5

Breeding: They breed from April to June in pools, ditches and paddy fields. During this period, males sit near the water and croak. The females lay the eggs in water. They usually swarm to breed at rainy night, where males outnumbered the females at the breeding sites.

Economic use: They are edible frogs. The skin secretion causes eye irritation.

Range and distribution: Collected from Science College Campus, Touliezie, Jotsoma and Mhasizou at an altitude between 1444-1982.5 m a.s.l. Its distribution extends in Western China (Cochran, 1961), Thailand and Burma (Taylor, 1962), North-eastern India, Bangla Desh, Burma, South-western China (Heusser, 1974), Pillai and Chanda (1979) has described it from Khasi hills of north-eastern India.

2.4.6

Amolops afghanus (Günther, 1858)
(Diplasiocoela: Ranidae: Raninae).

Plate 2.6A, B, C, D, E and F.

Amolops afghana Günther, Cat. Batr. Sal. Brit. Mus. London,
1858(16): 81.

Rana afghana Boulenger, Cat. Batr. Sal. Ecaud. Brit. Mus.,
1882: 60.

Ixalus argus Annandale, Rec. Indian Mus., 1912(8): 16.

Rana latopalmata Boulenger, Rec. Indian Mus., 1920(20):217.

Amolops afghanus, Kripalani, Rec. Indian Mus., 1961(50):241.

Diagnosis: Moderately large frog, SVL of male 73-77 mm and of females 94-107 mm. Skin of dorsum coarsely granular, belly rough. Vomerine and maxillary teeth present. Pupil horizontally oval. Tympanum indistinct, $1/3$ rd the horizontal eye diameter. Fingers free, toes webbed. Fingers and toes with large discs (finger discs larger than tympanum). 1st finger shorter than 2nd finger. Tibio-tarsal articulation reaching snout level. Colour of dorsum slate grey, pale green or dark. Belly dark-brown.

Description: Amolops afghanus is a large frog. Snout-vent length of male 73-77 mm and of females 94-107 mm.

Head broader than long, greatly depressed. Snout round in dorsal, truncate in lateral profile, projecting over the mouth. Distance between eye and nostril half the horizontal diameter of the eye, $3/4$ th the distance between nostril and tip of snout. Internarial distance 1.3 times the interocular distance. Eyes moderate, bulging, pupil horizontally oval. Tympanum indistinct, oval, $1/3$ rd the horizontal diameter of the eye, separated by a distance of its diameter.

Vomerine teeth strong, in oblique series, innerly posterior to the choanae. Upper jaw toothed. Lower jaw without teeth. Tongue large, oval bifid.

Plate 2.6A Amolops afghanus male.

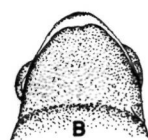
Plate 2.6B Ventral view of head.

Plate 2.6C Lateral view of left side of head.

Plate 2.6D Ventral view of right hand.

Plate 2.6E Ventral view of right foot.

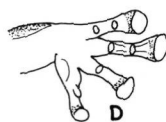
Plate 2.6F Range and distribution.



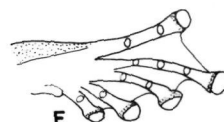
B



C



D



E

20mm

Forelimbs short. Fingers free. Fingers have large oval discs at the tips, size of discs: $1 < 2 < 4 < 3$, all finger discs are larger than tympanum. There is 1 oblong inner metacarpal tubercle. Sub-articular tubercles distinct, round, single. Length of fingers: $1 < 2 < 3 < 4$.

Hindlimbs long, muscular. Tibio-tarsal articulation reaching at the snout level when passed forward along the body. Toes are webbed, webbing formula: $1(\frac{1}{2})$, $2i(1)$, $2e(\frac{1}{2})$, $3i(1)$, $3e(\frac{1}{2})$, $4i(1\frac{1}{2})$, $4e(1)$, $5(\frac{1}{2})$. Toes with oval discs, size of discs: $1 < 5 < 2 < 4 < 3$. There is 1 oblong inner metatarsal tubercle. Subarticular tubercles distinct, round, single. Length of toes: $1 < 2 < 3 < 5 < 4$.

Skin of dorsum coarsely granular. Belly rough. Tympanic fold and sacral hump visible. Upper surface of discs separated from the lower by a groove.

Colour of dorsum slate grey, pale green, dark. Lateral sides darker. Belly dark-brown with patches of white spots. Webs are white with black spots.

Measurements: Table 2.6.

Habit and habitat: A nocturnal frog. This frog species live in cool streams near water falls and hide in crevices.

Breeding: They breed in June to August in a cool stream.

Economic use: An edible frog species.

Range and distribution: Collected from Jakhama and Kelobokha streams at an altitude between 1430-1910 m a.s.l. Its distribution extends from eastern Himalayas to western Himalayas (Gadow, 1901 and Kripalani, 1961) and Upper Renging (Annandale, 1912). It is distributed in Meghalaya, Assam and Arunachal Pradesh in north-eastern India also (Pillai and Chanda, 1976).

Table 2.6: $\bar{X}$ Measurements of Amolops afghanus.

Characters	Male (mm) N = 2	Female (mm) N = 2
Snout-vent length	75.0	98.5
Head width minimum	8.25	9.75
Head width maximum	26.0	32.0
Head length	25.0	27.5
Eye diameter	9.0	10.0
Inter-ocular distance	7.5	7.5
Nostril diameter	1.75	2.0
Inter-narial distance	9.25	9.0
Distance between eye and nostril	5.0	7.05
Distance between nostril and tip of snout	6.5	8.55
Tympanum diameter	3.5	4.0
Hindlimb length	137.0	155.5
Tibia length	50.0	58.5
5th toe length	25.5	29.0
Forelimb length	36.5	43.0
Lower forelimb length	25.5	36.0
1st finger length	11.0	12.0
2nd finger length	11.5	13.25

2.4.7 Rana mawphlangensis Pillai and Chanda, 1977.

(Diplasiocoela: Ranidae: Raninae),

Plate 2.7A, B, C, D, E and F.

Rana mawphlangensis Pillai and Chanda, Bombay Nat. Hist. Soc., 1977(74): 138.

Rana mawphlangensis Pillai and Chanda, Rec. Zool. Surv. India, 1979(75): 3889.

Diagnosis: Moderate large frog, SVL of male 110 mm. Skin of dorsum and belly smooth. Vomerine and maxillary teeth present. Pupil horizontally oval. Tympanum distinct, 1/3rd the horizontal eye diameter. Fingers free, toes webbed. Fingers and toes with large discs (3rd and 4th finger discs larger than tympanum). 1st finger shorter than 2nd finger. Tibio-tarsal articulation reaching beyond the tip of snout by 15 mm. Colour of dorsum deep green. Belly white.

Description: A large frog. Snout-vent length of a male measured 110 mm. No female in the collection.

Head broader than long, slightly depressed. Snout round in dorsal, truncate in lateral profile, slightly projecting over the mouth. Distance between eye and nostril shorter than the horizontal diameter of the eye almost equidistant with the distance between nostril and tip of snout. Internarial distance 1.5 times the interocular distance. Eyes are very large, bulging, pupil horizontally oval. Tympanum distinct, small, oval, 1/3rd the horizontal diameter of the eye, separated from the eye by a distance of its diameter.

Vomerine teeth strong, in oblique series, innerly posterior to the choanae. Upper jaw toothed. Lower jaw without teeth. Tongue broad, **bifid**.

Forelimbs short. Fingers without web. Fingers have large oval discs at the tips, size of discs: 2<1<4<3, 3rd and 4th finger

Plate 2.7A Rana mawphlangensis male.

Plate 2.7B Ventral view of head.

Plate 2.7C Lateral view of left side of head.

Plate 2.7D Ventral view of right hand.

Plate 2.7E Ventral view of right foot.

Plate 2.7F Range and distribution.

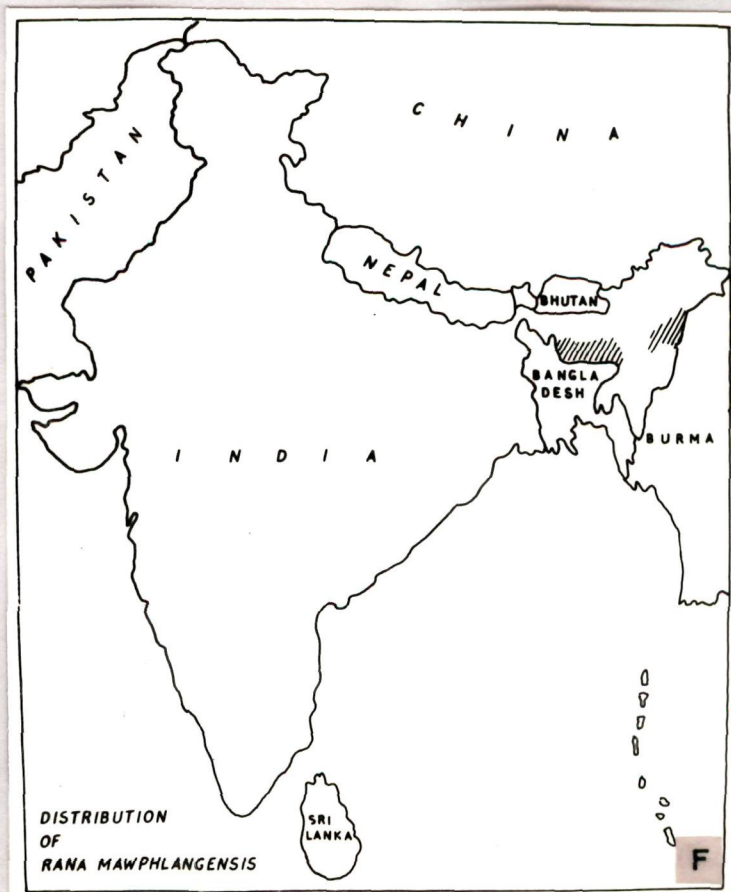
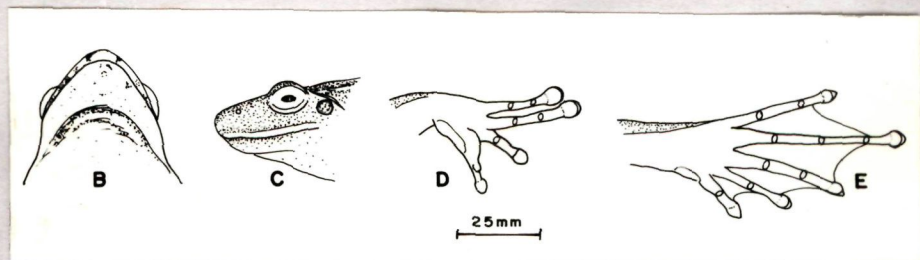


PLATE 2.7

discs are larger than tympanum. There is 1 oblong inner metacarpal tubercle. Subarticular tubercles distinct, round, single, Length of fingers: $1 < 2 < 4 < 3$ (according to Pillai and Chanda, 1977 original description 1st finger is longer than 2nd).

Hindlimbs very long, muscular. Tibio-tarsal articulation reaching beyond the tip of snout by 15 mm when passed forward along the body. Toes are webbed, webbing formula: $1(1), 2i(1), 2e(\frac{1}{2}), 3i(1), 3e(\frac{1}{2}), 4i(2), 4e(2), 5(1)$. Toes are with oblong discs at the tips, size of discs: $1 < 5 < 2 < 3 < 4$. There is 1 oblong inner metatarsal tubercle. Subarticular tubercle distinct, oval, single. Length of toes: $1 < 2 < 3 < 5 < 4$.

Skin of dorsum and belly smooth. Lateral sides of the body and lower part of thighs warty. Tympanic fold and sacral hump visible.

Skin of dorsum deep green with 3 black spots in the mid-axis of the body. Belly white. Lateral sides of the body dark-brown. Upper part of arms and thighs brown with dark cross-bars.

Measurements: Table 2.7.

Habit and habitat: They live in swift stream waterfall. They creep on rocks and hide in crevices.

Breeding: Breeding period is not known.

Economic use: An edible frog species.

Range and distribution: It was collected from Phezou at an altitude of 1400 m a.s.l. Pillai and Chanda (1977) recorded this species from Mawphlang (Meghalaya) and erected a new species, Rana mawphlangensis.

Table 2.7: Measurements of Rana mawphlangensis.

Characters	Male (mm) N = 1
Snout-vent length	110.0
Head width minimum	12.0
Head width maximum	40.0
Head length	33.0
Eye diameter	14.0
Inter-ocular distance	11.0
Nostril diameter	2.5
Inter-narial distance	11.0
Distance between eye and nostril	7.5
Distance between nostril and tip of snout	6.5
Tympanum diameter	5.0
Hindlimb length	160.0
Tibia length	68.0
5th toe length	38.0
Forelimb length	60.0
Lower forelimb length	41.5
1st finger length	14.0
2nd finger length	16.0

2.4.8

Rana nagalandsis sp. nov.

(Diplasiocoela: Ranidae: Raninae)

Plate 2.8A, B, C, D, E and F

Diagnosis: A moderate frog, SVL of males 49-52 mm and that of females 66-68 mm. Skin of dorsum smooth, belly rough. Dorso-lateral folds very distinct. Vomerine and maxillary teeth present. Pupil horizontally oval. Tympanum distinct, $1/2$ the horizontal eye diameter. Fingers free, toes webbed. Fingers and toes with discs. 1st finger shorter than 2nd finger. Tibio-tarsal articulation reaching eye level. Colour of dorsum pinkish grey, brown and belly white.

Description: A moderate frog. Snout-vent length of males 49-52 mm and that of females 66-68 mm.

Head broader than long, slightly depressed. Snout round in dorsal, truncate in lateral profile, projecting over the mouth. Distance between eye and nostril shorter than the horizontal diameter of the eye, $3/4$ th the distance between nostril and tip of snout. Internarial distance almost equidistant with the interocular distance. Eyes very large, bulging, pupil horizontally oval. Tympanum distinct, round, $1/2$ the horizontal diameter of the eye, separated from the eye by a distance of its diameter.

Vomerine teeth small, soft, innerly posterior to the choanae. Upper jaw toothed. Lower jaw without teeth. Tongue oval, bifid.

Forelimbs short, muscular. Fingers are free. Fingers with oval discs at the tips, size of discs: $1 < 2 < 4 < 3$. There are 3 oblong metacarpal tubercles (outer tubercle smallest, innermost largest

* Paper on this species communicated

Plate 2.8A Rana nagalandsis female.

Plate 2.8B Ventral view of head.

Plate 2.8C Lateral view of left side of head.

Plate 2.8D Ventral view of right hand.

Plate 2.8E Ventral view of right foot.

Plate 2.8F Range and distribution.

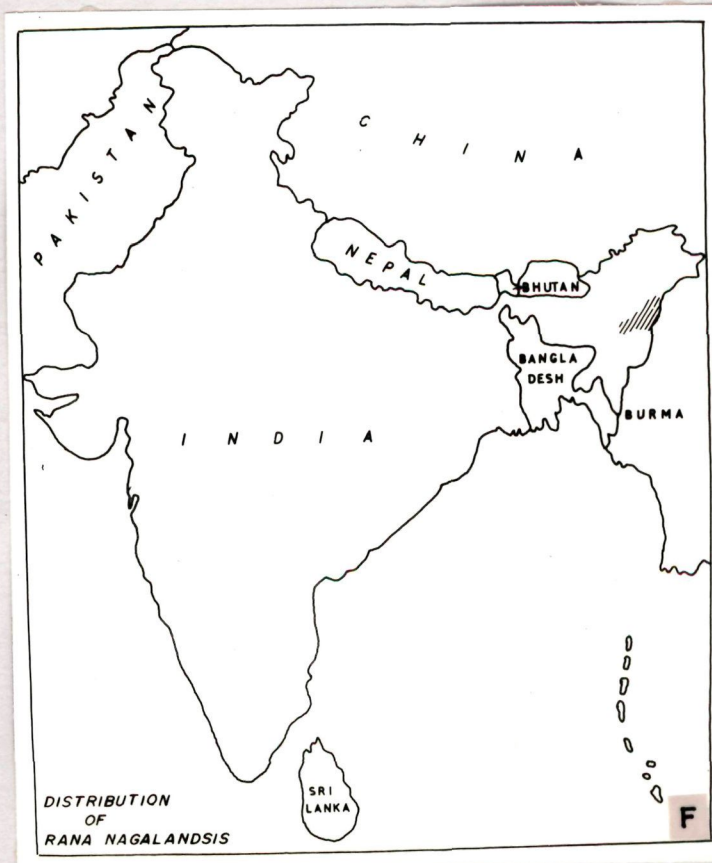
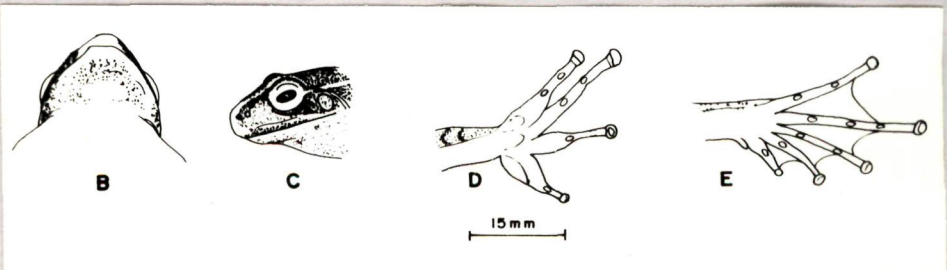


PLATE 2.8

and middle one medium sized). Subarticular tubercles distinct, round, single. Length of fingers: $1 < 2 < 4 < 3$.

Hindlimbs moderately long, muscular. Tibio-tarsal articulation not reaching the snout level when passed forward along the body. Toes are webbed, webbing formula: $1(1\frac{1}{4})$, $2i(1\frac{1}{2})$, $2e(1\frac{1}{4})$, $3i(2)$, $3e(1\frac{1}{2})$, $4i(2\frac{3}{4})$, $4e(2\frac{3}{4})$, $5(1\frac{3}{4})$. Toes are with oval discs at the tips, size of discs: $1 < 5 < 2 < 3 < 4$. There is 1 oblong inner metatarsal tubercle. Subarticular tubercles distinct, oval, single. Length of toes: $1 < 2 < 5 < 3 < 4$.

Skin of dorsum smooth. A large, distinct dorso-lateral fold runs from snout to hinder part on each side of the body. Lateral and belly rough. Tympanic fold and sacral hump visible. Carpal and tarsal folds present.

Colour of dorsum pinkish-grey and brown, lateral slate dark. White tipped tubercles around the vent and hind part of thighs. Belly white and black spots under the throat and chest. Dark cross-bars on limbs.

Measurements: Table 2.8.

Habit and habitat: A cold stream nocturnal frog. They ~~move~~ along with water current in autumn.

Breeding: They breed from October till November in cool streams.

Economic use: This is an edible frog species, local people find it tastiest but it is very expensive.

Range and distribution: Collected from cool streams of Dzünarü and Jakhama at an altitude between 1910-1980 m a.s.l.

Table 2.8: $\bar{x}$ Measurements of Rana nagalandensis.

Characters	Male (mm) N = 2		Female (mm) N = 2	
Snout-vent length	50.2		67.0	
Head width minimum	6.0		8.5	
Head width maximum	16.0		19.0	
Head length	14.0		17.5	
Eye diameter	5.0		6.5	
Inter-ocular distance	5.0		7.0	
Nostril diameter	0.9		1.0	
Inter-narial distance	6.0		7.0	
Distance between eye and nostril	2.5		4.0	
Distance between nostril and tip of snout	4.0		5.5	
Tympanum diameter	3.5		3.75	
Hindlimb length	77.5		94.0	
Tibia length	32.0		42.0	
5th toe length	15.0		19.0	
Forelimb length	24.5		31.0	
Lower forelimb length	17.0		25.0	
1st finger length	6.5		9.25	
2nd finger length	6.75		9.5	

Holotype: An adult female frog, ^{ZSI}Reg. No. V/ERS.8216 in formalin, loc. Dzūnarū, Kohima (alt. 1980 m a.s.l.), coll. Kiyasetuo, 20.10.84.

Paratype: An adult female frog, ^{ZSI}Reg. No. V/ERS.8218 in formalin, loc. Jakhama, Kohima (alt. 1910 m a.s.l.), coll. Kiyasetuo, 18.11.84. and adult male frog, ^{ZSI}Reg. No. V/ERS.8217 in formalin, loc. Dzūnarū, Kohima (alt. 1980 m a.s.l.), coll. Kiyasetuo, 20.10.1984.

Relationship: This species shows following ranids characteristics.

- i) Morphology: Pupil horizontal, vomerine and maxillary teeth present, tongue free, fingers free.
- ii) Skeleton: Vertebrae diplasiocoela (procoelous), sacral diapophyses cylindrical, no ribs, no intercalary cartilage.

Closer examination reveals its similarity with Rana assamensis Sclater (Boulenger, 1920) and Rana lateralis Boulenger (Taylor, 1962) in following features: Moderate body size, distinct tympanum and 1/2 the eye diameter, distinct subarticular tubercles; carpal and tarsal folds present, large prominent dorso-lateral folds present, but there are differences which do not allow placing it with anyone of these species. Certain characteristic features of Rana assamensis such as nostril equidistant from the eye and tip of snout; vomerine teeth extend not beyond the posterior borders of choanae; dark cross-band between the eyes; digits ended obtusely; toes entirely webbed; tibio-tarsal articulation reaching beyond tip of snout are not found in this species. Similarly certain characters reported in Rana lateralis such as males with prominent vocal sacs, head longer than broad, snout acuminate, nostril more toward tip of snout, 1st finger longer than 2nd, colour of dorsum greenish or olive are not found in the present species.

Based on these differences this specimen has been assigned a new species, Rana nagalandsis to commemorate the state, Nagaland from where it has been collected.

2.4.9

Rana liebighi Günther, 1860

(Diplasiocoela: Ranidae: Raninae)

Plate 2.9A, B, C, D, E and F

Rana liebighi Günther, Proc. Zool. Soc. London, 1860: 157.

Rana liebighi Boulenger, Cat. Batr. Sal. Ecaud. Brit. Mus., 1882: 21.

Rana liebighi Boulenger, Fauna Brit. India. 1890: 445.

Rana liebighi Annandale, Rec. India Mus., 1912(8): 21.

Rana liebighi Boulenger, Rec. India Mus., 1920(20): 78.

Diagnosis: A very large frog, SVL of male 109 mm. Skin of dorsum warty, belly smooth. A distinct fold across the head behind the eyes is visible. Large dorso-lateral glandular folds broken up into chain of warts present. Vomerine and maxillary teeth present. Pupil horizontally oval. Tympanum hidden. Fingers free, toes webbed. Fingers and toes with obtuse tips. 1st, 2nd and 3rd fingers with conical black horny spines. 1st finger *as long as* 2nd finger. Tibio-tarsal articulation reaching snout level. Colour of dorsum darkish brown. Belly light dark gray.

Description: A very large frog. Snout-vent length of a male measured 109 mm. No female in the collection.

Head broader than long, greatly depressed. Snout round in dorsal, truncate in lateral profile projecting over the mouth. Distance between eye and nostril shorter than the horizontal diameter of the eye, $\frac{3}{5}$ th the distance between nostril and tip of snout. Internarial distance 1.6 time the interocular distance. Eyes large, bulging, pupil horizontally oval. Tympanum hidden.

Vomerine teeth strong, in oblique series, innerly anterior to the choanae. Upper jaw toothed. Lower jaw without teeth. Tongue large, oval, bifid.

Plate 2.9A Rana liebigii male.

Plate 2.9B Ventral view of head.

Plate 2.9C Lateral view of left side of head.

Plate 2.9D Ventral view of right hand.

Plate 2.9E Ventral view of right foot.

Plate 2.9F Range and distribution.

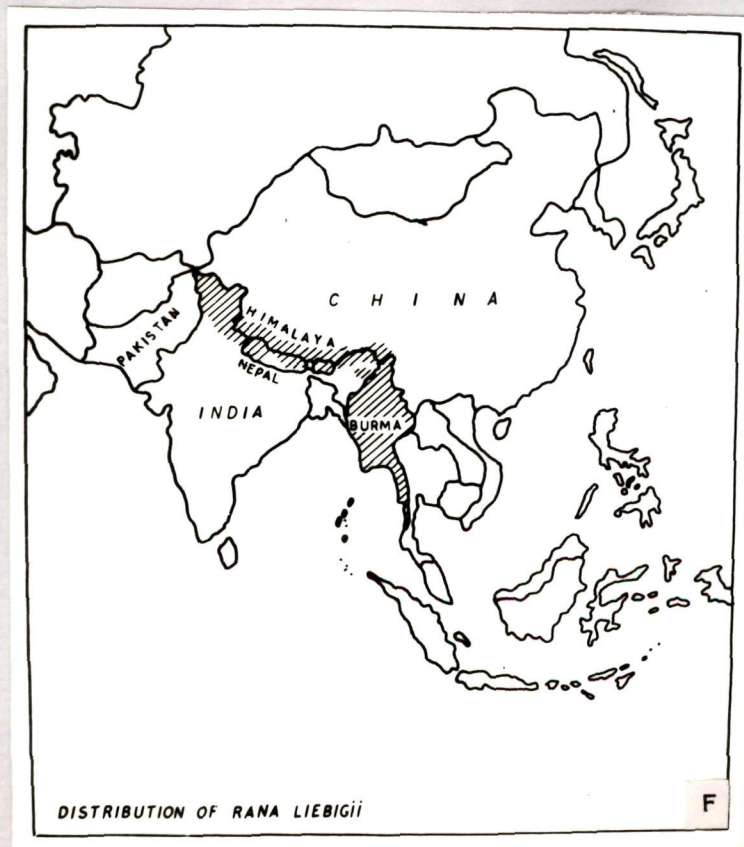


PLATE 2.9

Forelimbs very short, muscular. Fingers free, ended obtusely. There are 3 oblong metacarpal tubercles (outer tubercle smallest, innermost largest and middle one medium sized). Subarticular tubercles distinct, oval, single. Length of finger: $1 \approx 2 < 4 < 3$.

Hindlimbs long, muscular. Tibio-tarsal articulation reaching at the snout level when passed forward along the body. Toes are webbed, webbing formula: $1(\frac{1}{4})$, $2i(\frac{1}{2})$, $2e(\frac{1}{4})$, $3i(\frac{1}{2})$, $3e(\frac{1}{4})$, $4i(\frac{1}{4})$, $4e(\frac{3}{4})$, $5(\frac{1}{2})$. Toes are obtuse at the tips. There is 1 oblong inner metatarsal tubercle. Subarticular tubercles distinct, oval, single. Length of toes: $1 < 2 < 3 < 5 < 4$.

Skin of dorsum warty. A distinct fold across the head behind the eyes. Large dorso-lateral glandular folds broken up into chain of warts are prominent. Belly smooth. Black horny spines on each side of the chest. Inner metacarpal tubercle, upper side of 1st, 2nd and 3rd fingers are with conical black horny spines. Tympanic fold and sacral hump visible.

Colour of dorsum darkish brown. Belly light dark grey.

Measurements: Table 2.9.

Habit and habitat: Nocturnal frog species. They live in forests near a cool stream.

Breeding: Tadpoles with well developed hindlimbs were collected in cool stream in early April. So, probably they breed in January-March.

Economic use: They are edible frogs.

Range and distribution: This frog species was collected from Jakhama river at an altitude of 1910 m a.s.l. Gadow (1901) reported it from Himalayas. Annandale (1912) reported it from Darjeeling, Himalayas, Simla, Kashmir and Burma. Boulenger (1920) reported it from snow-line in Sikkim of Himalayas at 4000-10,000 feet. It is found in Arunachal Pradesh of North-East India also (Pillai and Chanda, 1976).

Table 2.9.: Measurements of Rana liebigii

Characters	Male (mm) N = 1
Snout-vent length	109.0
Head width minimum	7.0
Head width maximum	39.5
Head length	30.5
Eye diameter	9.5
Inter-ocular distance	6.0
Nostril diameter	1.0
Inter-narial distance	10.0
Distance between eye and nostril	5.0
Distance between nostril and tip of snout	8.5
Tympanum diameter	-
Hindlimb length	166.0
Tibia length	62.0
5th toe length	28.0
Forelimb length	35.0
Lower forelimb length	28.0
1st finger length	11.0
2nd finger length	11.0

2.4.10

Rana verrucosa Günther, 1875

(Diplasiocoela: Ranidae, Raninae)

Plate 2.10A, B, C, D, E and F

Rana verrucosa Günther, Proc. Zool. Soc. London, 1875: 567.Rana verrucosa Boulenger, Cat. Batr. Sal. Ecaud. Brit. Mus., 1882: 29.Rana verrucosa Boulenger, Rec. Indian Mus., 1920(20): 26.

Diagnosis: A moderate frog, SVL of ♀ female 55 mm. Skin of dorsum granular, belly smooth. Vomerine and maxillary teeth present. Pupil horizontally oval. Tympanum distinct, 1/2 the horizontal eye diameter. Fingers free, toes webbed. Fingers and toes with swollen tips. 1st finger ~~shorter~~ than 2nd finger. Tibio-tarsal articulation reaching nostril level. Colour of dorsum greyish dark. Belly dirty white.

Description: A moderate frog. Snout-vent length of a female measured 55 mm. No male in the collection.

Head broader than long, slightly depressed. Snout round in dorsal, truncate in lateral profile, projecting over the mouth. Distance between eye and nostril shorter than the horizontal diameter of the eye, equidistant with the distance between nostril and tip of snout. Internarial distance 1.3 times the interocular distance. Eyes large, bulging, pupil horizontally oval. Tympanum distinct, oval, 1/2th the horizontal diameter of the eye, separated from the eye by a distance of its diameter.

Vomerine teeth strong, in oblique series, innerly anterior to the choanae. Upper jaw toothed. Lower jaw without teeth. Tongue broad, bifid.

Forelimbs short, stout. Fingers are without web. Fingers

Plate 2.10A Rana verrucosa female.

Plate 2.10B Ventral view of head.

Plate 2.10C Lateral view of left side of head.

Plate 2.10D Ventral view of right hand.

Plate 2.10E Ventral view of right foot.

Plate 2.10F Range and distribution.

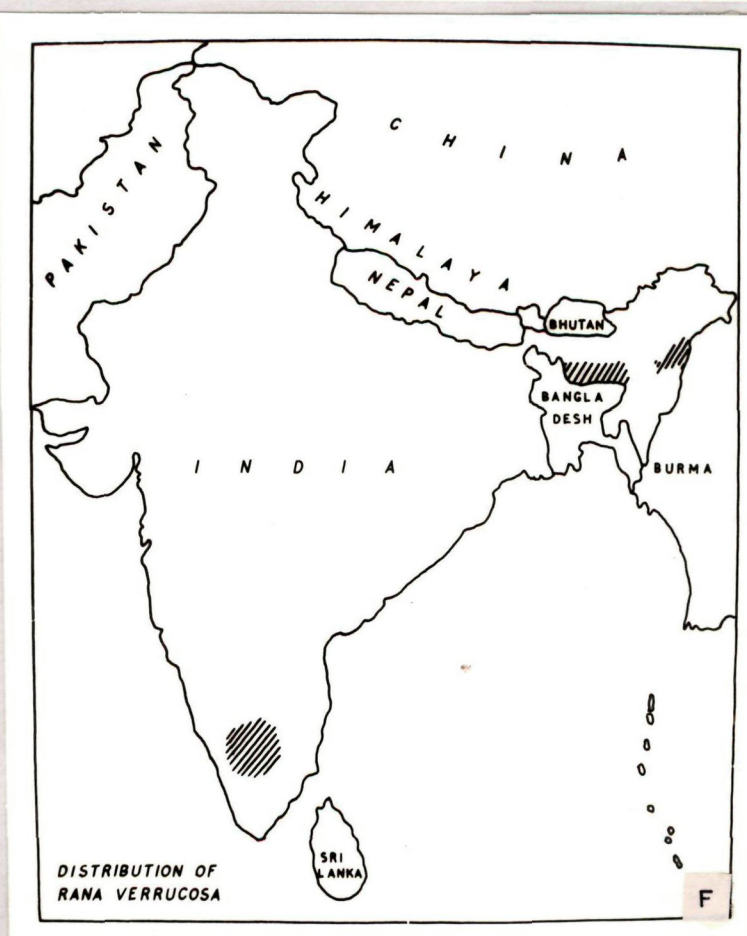
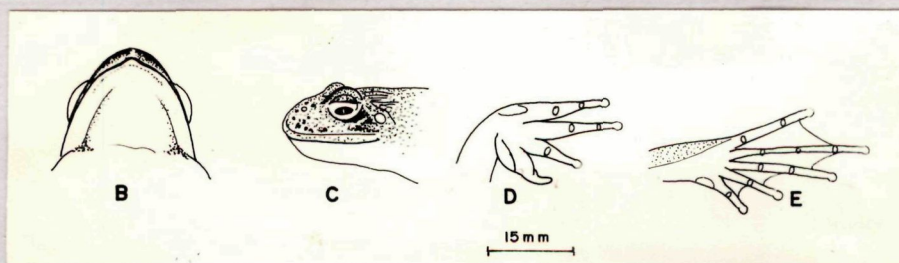


PLATE 2.10

are swollen at the tips. There are 2 oblong metacarpal tubercles (outer tubercle small and inner tubercle large). Subarticular tubercles distinct, oval, single. Length of fingers: $2 < 1 < 4 < 3$.

Hindlimbs long. Tibio-tarsal articulation reaching at the nostril level when passed forward along the body. Toes are webbed, webbing formula: $1(\frac{1}{2})$, $2i(1)$, $2e(\frac{1}{2})$, $3i(1\frac{1}{2})$, $3e(\frac{1}{2})$, $4i(1)$, $4e(1)$, $5(\frac{1}{2})$. Toes are with swollen tips. There is 1 oblong inner metatarsal tubercle. Subarticular tubercles distinct, oval, single. Length of toes: $1 < 2 < 3 < 5 < 4$.

Skin of dorsum coarsely granular. Belly smooth. Tympanic fold and sacral hump visible.

Colour of dorsum greyish dark. Belly dirty white with dispersed dark spots.

Measurements: Table 2.10.

Habit and habitat: Diurnal as well as nocturnal frog species. They are cool stream frogs. They perch at the edges of the streams in the morning.

Breeding: Probably, they breed in winter and early spring in cool stream, since, their tadpoles were collected in a swift stream in April and completed metamorphosis by late May.

Economic use: An edible frog species.

Range and distribution: Collected from Dzūku valley at an altitude between 2135-2440 m a.s.l. Its distribution extends in Malabar hills, Nilgiris (7000 ft.) and Travancore (4000 ft.) (Boulenger, 1920 and Satyamurti, 1967). It is distributed in Meghalaya (Pillai and Chanda, 1976) of north-eastern India.

Table 2.10. ? Measurements of Rana verrucosa.

Characters	Female N = 1
Snout-vent length	55.0
Head width minimum	4.5
Head width maximum	23.0
Head length	21.0
Eye diameter	7.0
Inter-ocular distance	4.5
Nostril diameter	1.0
Inter-narial distance	6.0
Distance between eye and nostril	3.2
Distance between nostril and tip of snout	3.25
Tympanum diameter	3.5
Hindlimb length	90.0
Tibia length	33.0
5th toe length	18.0
Forelimb length	30.0
Lower forelimb length	16.3
1st finger length	7.0
2nd finger length	7.5

2.4.11

Rana cyanophlyctis Schneider, 1799

(Diplasiocoela: Ranidae: Raninae).

Plate 2.11A, B, C, D, E and F.

Rana cyanophlyctis Schneider, Hist. Amph. I, 1799: 137.Rana cyanophlyctis Boulenger, Cat. Batr. Sal. Ecaud. Brit. Mus., 1882: 17.Rana cyanophlyctis Annandale, Rec. Indian Mus., 1912(8): 7.Rana cyanophlyctis Boulenger, Rec. Indian Mus., 1920(20):12.

Diagnosis: A moderately small frog, SVL of males 33-37 mm and of females 55-58 mm. Skin of dorsum coarsely granular, belly smooth. A rear of casque outline of head present. Vomerine and maxillary teeth present. Pupil horizontally oval. Tympanum distinct, $\frac{3}{4}$ th the horizontal eye diameter. Fingers free, toes webbed. Fingers and toes with swollen tips. 1st finger equal or longer than 2nd finger. Tibio-tarsal articulation reaching eye level. Colour of dorsum slate grey, pale. Belly white.

Description: Moderately small frogs. Snout-vent length of males 33-37 mm and of females 55-58 mm.

Head broader than long, slightly depressed. Snout pointed in dorsal, acuminate in lateral profile, projecting over the mouth. Distance between eye and nostril half the horizontal diameter of the eye, $\frac{3}{4}$ th the distance between nostril and tip of snout. Internarial distance $\frac{3}{4}$ th the interocular distance. Nostril elevated. Eyes large, bulging, pupil horizontally oval. Tympanum distinct, oval, $\frac{3}{4}$ th the horizontal diameter of the eye, separated from the eye by a distance $\frac{1}{4}$ th its diameter.

Vomerine teeth small, strong, in oblique series, innerly posterior to the choanae. Upper jaw toothed. Lower jaw without teeth. Tongue large, triangular, bifid.

Plate 2.11A Rana cyanophlyctis female.

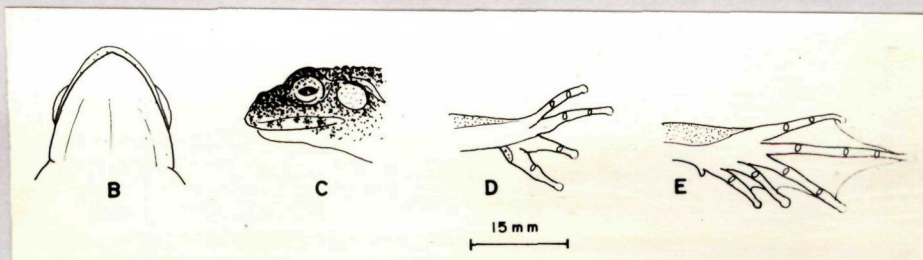
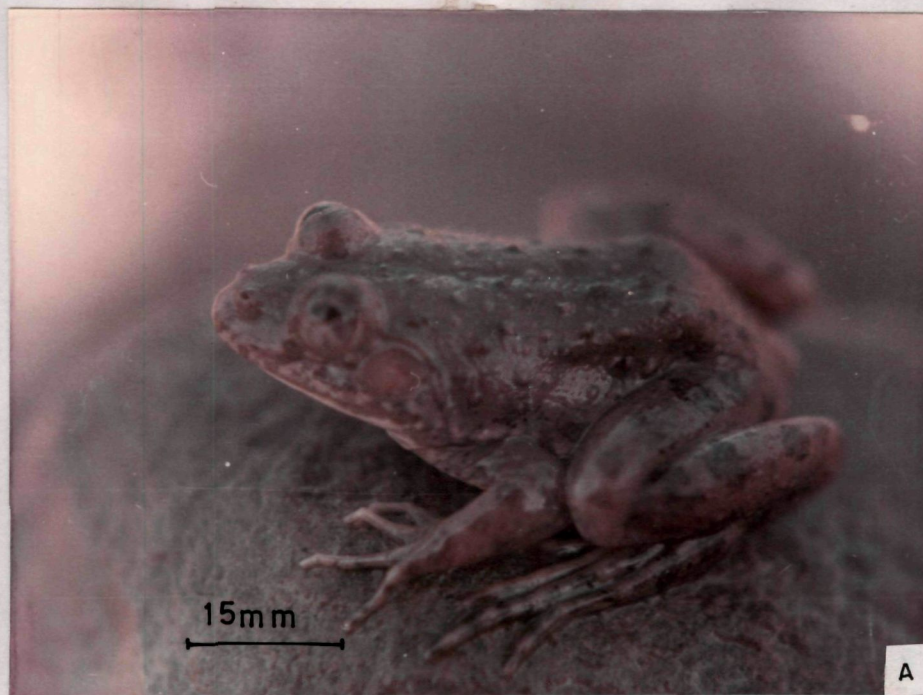
Plate 2.11B Ventral view of head.

Plate 2.11C Lateral view of left side of head.

Plate 2.11D Ventral view of right hand.

Plate 2.11E Ventral view of right foot.

Plate 2.11F Range and distribution.



Forelimbs short, muscular. Fingers are free. Fingers are swollen at the tips. There is 1 oblong inner metacarpal tubercle. Subarticular tubercles indistinct, round, single. Length of fingers: $4 < 2 < 1 < 3$.

Hindlimbs short, muscular. Tibio-tarsal articulation reaching at the eye level when passed forward along the body. Toes are webbed, webbing formula: $1(\frac{1}{2})$, $2i(\frac{1}{2})$, $2e(\frac{3}{4})$, $3i(\frac{3}{4})$, $3e(\frac{1}{2})$, $4i(\frac{1}{2})$, $4e(\frac{1}{2})$, $5(\frac{1}{2})$. Toes are ended with swollen tips. There is 1 oblong inner metatarsal tubercle. Subarticular tubercles indistinct, round, single. Length of toes: $1 < 2 < 3 < 5 < 4$.

Skin of dorsum coarsely granular and tuberculated. Belly smooth. Tympanic fold visible. A rear of casque outline of head present. Vocal sacs in males during breeding period.

Colour of dorsum slate-grey, pale with dispersed black patches. Belly white with diffused black pigment under the throat and chest.

Measurements: Table 2.11.

Habit and habitat: This frog lives in warmer places. Their dwelling extends from deep forests to inhabited areas mainly in ditches, paddy fields and pools. They perch at the edge of the water day and night. They are water frogs and do not hibernate.

Breeding: They breed almost throughout the year except in cold winters. During breeding period, males croak while floating keeping their heads above water surface.

Economic use: They are used as a good item for food.

Table 2.11 $\bar{X}$ Measurements of Rana cyanophlyctis.

Characters	Male (mm) N = 2	Female (mm) N = 2
Snout-vent length	35.0	56.5
Head width minimum	1.75	2.0
Head width maximum	11.0	18.5
Head length	13.0	17.5
Eye diameter	5.5	8.0
Inter-ocular distance	3.75	4.0
Nostril diameter	0.8	1.0
Inter-narial distance	3.0	3.5
Distance between eye and nostril	3.5	2.9
Distance between nostril and tip of snout	5.1	3.6
Tympanum diameter	4.5	5.0
Hindlimb length	46.5	55.5
Tibia length	16.5	21.0
5th toe length	13.0	14.5
Forelimb length	19.5	29.0
Lower forelimb length	12.0	17.0
1st finger length	7.0	8.0
2nd finger length	6.5	7.5

Range and distribution: An abundant^t frog species of Dimapur, Medziphema and its neighbouring areas at an altitude between 183-305 m a.s.l. Its distribution extends in South Arabia, Baluchistan, Afghanistan, India, Ceylon, Northern Malaya Peninsula (Boulenger, 1920 and Satyamurti, 1967), Thailand (Taylor, 1962), Pakistan (Minton, 1966 and Khan, 1976). It is distributed in Meghalaya, Assam, Arunachal Pradesh, Manipur (Pillai and Chanda, 1976) and Tripura (Mansukhani and Sarkar, 1981) in north-eastern India.

2.4.12

Rana limnocharis Wiegmann, 1835.

(Diplasiocoela: Ranidae: Raninae).

Plate 2.12A, B, C, D, E and F.

Rana limnocharis Wiegmann, N. Acta. Ac. Leop-Carol. 1835
(17): 255.Rana gracilia, Boulenger, Cat. Batr. Sal. Ecaud. Brit.
Mus., 1882: 28.Rana limnocharis, Boulenger, Fauna Brit. India, 1890: 450.Rana limnocharis, Annandale, Rec. Indian Mus., 1912(8): 8.Rana limnocharis, Boulenger, Rec. Indian Mus., 1920(20):28.Rana limnocharis, Van Kampen, Amph. Indo-Austr., 1923: 167.

Diagnosis: A moderately small frog, SVL of males 31-33 mm and of females 43-65 mm. Skin of dorsum coarsely granular with broken ridges, belly smooth. Vomerine and maxillary teeth present. Pupil horizontally oval. Tympanum distinct, 5/6th the horizontal eye diameter. Fingers free, toes webbed. Fingers and toes with bluntly pointed tips. 1st finger longer than 2nd finger. Tibio-tarsal articulation reaching eye or nostril level. Colour of dorsum slate grey, brown with mid-dorsal white line or 2-3 reddish spots or without any line or red spots. Belly white.

Description: Rana limnocharis is a moderately small frog. Snout-vent length of males 31-33 mm and of females 43-45 mm. It is very similar to Rana tigrina, the bull frog of India.

Head broader than long, slightly depressed. Snout pointed in dorsal, acuminate in lateral profile, projecting over the mouth. Distance between eye and nostril shorter than the horizontal diameter of the eye, 1.2 times the distance between nostril and tip of snout. Internarial distance equidistant with the interocular distance. Eyes moderately small, bulging, pupil horizontally oval.

Plate 2.12A Rana limnocharis female.

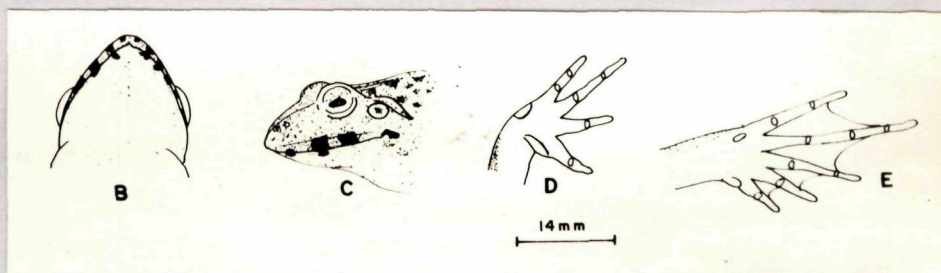
Plate 2.12B Ventral view of head.

Plate 2.12C Lateral view of left side of head.

Plate 2.12D Ventral view of right hand.

Plate 2.12E Ventral view of right foot.

Plate 2.12F Range and distribution.



Tympanum distinct, round, 5/6th the horizontal diameter of the eye, separated from the eye by a distance almost its diameter.

Vomerine teeth strong, in oblique series, innerly extending from anterior to posterior border of the choanae. Upper jaw toothed. Lower jaw without teeth. Tongue oval, bifid.

Forelimbs short, muscular. Fingers are free. Fingers with bluntly pointed tips. There are 2 oblong metacarpal tubercles (outer tubercle small and inner tubercle large). Subarticular tubercles distinct, oval, single. Length of fingers: $4 < 2 < 1 < 3$.

Hindlimbs long, muscular. Tibio-tarsal articulation at the eye level, nostril level when passed forward along the body. Toes are webbed, webbing formula: $1(\frac{1}{2})$, $2i(1)$, $2e(\frac{1}{2})$, $3i(1)$, $3e(1)$, $4i(1\frac{1}{2})$, $4e(1\frac{1}{2})$, $5(\frac{1}{2})$. Toes with bluntly pointed tips. There are 2 oblong metatarsal tubercles (outer tubercle small and inner tubercle large). Subarticular tubercles distinct, oval, single. Length of fingers: $1 < 2 < 5 < 3 < 4$.

Skin of dorsum coarsely granular with longitudinal broken ridges. A glandular tubercle at the jaws angle. Belly smooth. Tympanic fold and sacral hump prominent. Thumb pads and vocal sacs in male during breeding season.

Colour of dorsum slate-grey, brown with dispersed black patches. In certain specimens there is mid-dorsal white line from snout to vent, in some 2-3 reddish spots on mid-dorsum, still in some 2-3 reddish spots with mid-dorsal white line, whereas, in some without mid-dorsal line and reddish spot. Belly white. Dark cross bars on arms and thighs.

Measurements: Table 2.12.

Habit and habitat: They are nocturnal as well as diurnal frogs. They inhabit in paddy fields, forests, rivers and pools. They hibernate under the soil in paddy fields during winter.

Breeding: Their breeding season starts from May till July. They breed in paddy fields, ditches and pools.

Economic use: They are edible frogs, also used for curing burn and wound. In case of food poisoning, small size frogs of this species are swallowed *à live* as an indigenous medicine system in Nagaland.

Range and distribution: Collected from Science College Campus, Touliezie, Sanuorü, Merübotsa, Mhasizou, Jotsoma, Medziphema and Dimapur at an altitude between 183-1982.5 m a.s.l. Its distribution extends in Eastern Asia, from Japan and China to India, Ceylon, Malaya Peninsula, Philippines, Borneo, Lombok, Sikkim (Boulenger, 1920), Nepal (Kripalani, 1961), Thailand and Formosa (Taylor, 1962), Korea, Southern China, Burma, Thailand, Kampuchea, Laos, Vietnam (Heusser, 1974) and from Pakistan (Khan, 1976). Pillai and Chanda (1976) compiled information that it is distributed in Assam, Meghalaya, Arunachal Pradesh and Manipur and Mansukhani and Sarkar (1981) reported it from Tripura also in north-eastern India.

Table 2.12 $\bar{x}$ Measurements of Rana limnocharis.

Characters	Male (mm) N = 3	Female (mm) N = 3
Snout-vent length	32.3	54.0
Head width minimum	2.5	3.2
Head width maximum	12.0	18.6
Head length	9.6	16.6
Eye diameter	3.0	5.6
Inter-ocular distance	2.5	4.3
Nostril diameter	1.2	1.5
Inter-narial distance	2.6	4.3
Distance between eye and nostril	2.75	3.4
Distance between nostril and tip of snout	2.25	2.95
Tympanum diameter	2.6	4.5
Hindlimb length	50.3	65.6
Tibia length	16.6	24.0
5th toe length	10.6	13.6
Forelimb length	14.0	22.3
Lower forelimb length	12.0	14.0
1st finger length	4.5	7.3
2nd finger length	4.0	6.0

2.4.13

Rana tigrina Daudin, 1803

(Diplasiocoela: Ranidae: Raninae).

Plate 2.13A, B, C, D, E and F.

Rana tigrina Daudin, Hist. Rain. Gren. Crap., 1803: 64.Rana tigrina, Boulenger, Cat. Batr. Sal. Ecaud. Brit. Mus., 1882: 26.Rana tigrina, Annandale, Rec. Indian Mus., 1912(8): 8Rana tigrina, Boulenger, Rec. Indian Mus., 1920(20): 17.

Diagnosis: A large frog, SVL of males 93-103 mm and of females 130-132 mm. Skin of dorsum coarsely granular with broken ridges, belly smooth. Vomerine and maxillary teeth present. Pupil horizontally oval. Tympanum distinct, as large as eye diameter. Fingers free, toes webbed. Fingers and toes with swollen tips. 1st finger longer than 2nd finger. Tibio-tarsal articulation reaching snout level. Colour of dorsum yellowish green, grey with a white mid-dorsal stripe. Belly white.

Description: They are very large size frogs. Snout-vent length of males 93-105 mm and of females 130-132 mm.

Head broader than long, slightly depressed. Snout pointed in dorsal, acuminate in lateral profile, projecting over the mouth. Distance between eye and nostril as long as the horizontal diameter of the eye, 1.3 times the distance between nostril and tip of snout. Internarial distance is equidistant with interocular distance. Eyes moderately large, bulging, pupil horizontally oval. Tympanum distinct, oval, as big as eye, separated from the eye by a distance half its diameter.

Vomerine teeth strong, in oblique series, innerly anterior

Plate 2.13A Rana tigrina female.

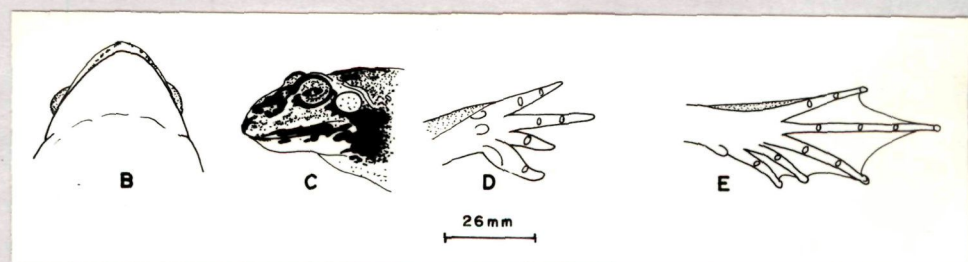
Plate 2.13B Ventral view of head.

Plate 2.13C Lateral view of left side of head.

Plate 2.13D Ventral view of right hand.

Plate 2.13E Ventral view of right foot.

Plate 2.13F Range and distribution.



to the choanae. Upper jaw toothed. Lower jaw without teeth. Tongue large, oblong, bifid.

Forelimbs short, muscular. Fingers are free. Fingers are swollen at the tips. There are 3 oblong metacarpal tubercles (outer tubercle smallest, innermost largest and middle one medium sized). Subarticular tubercles distinct, round, single. Length of fingers: $2 < 4 < 1 < 3$.

Hindlimbs long, muscular. Tibio-tarsal articulation reaching at the snout level when passed forward along the body. Toes are webbed, webbing formula: $1(\frac{1}{2})$, $2i(\frac{1}{2})$, $2e(\frac{1}{2})$, $3i(\frac{3}{4})$, $3e(\frac{1}{2})$, $4i(\frac{3}{4})$, $4e(\frac{3}{4})$, $5(\frac{1}{2})$. Toes are swollen at the tips. There is 1 oblong inner metatarsal tubercle. Subarticular tubercles are distinct, round, single. Length of toes: $1 < 2 < 3 < 5 < 4$.

Skin of dorsum coarsely granular with longitudinal broken ridges. Belly smooth. Tympanic fold and sacral hump are prominent. Thumb pads and vocal sacs in male during breeding season.

Colour of dorsum yellowish grey, green with black marbled all over. A mid-dorsal white line extending from snout to vent. Belly white. Females more greyish as compared to greenish yellow males.

Measurements: Table 2.13.

Habit and habitat: Nocturnal frog species. They live in warmer places near the grassy edges of pools. Hibernate under loose soil in paddy fields or forests in winter.

Breeding: They breed during rainy season from June to September in pools.

Table 2.13: $\bar{x}$ Measurements of Rana tigrina.

Characters	Male (mm) N = 2	Female (mm) N = 2
Snout-vent length	99.0	131.0
Head width minimum	4.5	7.5
Head width maximum	35.0	43.5
Head length	30.5	38.5
Eye diameter	9.5	10.25
Inter-ocular distance	5.5	7.0
Nostril diameter	1.5	2.0
Inter-narial distance	5.5	7.0
Distance between eye and nostril	8.25	10.0
Distance between nostril and tip of snout	7.4	7.5
Tympanum diameter	8.25	9.5
Hindlimb length	142.0	182.5
Tibia length	57.0	70.5
5th toe length	24.0	28.0
Forelimb length	42.0	64.0
Lower forelimb length	26.5	46.2
1st finger length	9.0	13.0
2nd finger length	7.75	10.0

Economic use: They are used as delicious food item. They are also used for curing wounds.

Range and distribution: Collected from Dimapur and Medziphema at an altitude between 183-305 m a.s.l. Its distribution extends in India, Ceylon, Nepal, Burma, China and Southern Yunnan (Boulenger, 1920), South-eastern China, Kampuchea, Laos, Vietnam, Malaysia, Borneo, Sumatra, Java (Heusser, 1974) and Pakistan (Khan, 1976). Pillai and Chanda (1976) have compiled information that it is distributed in Assam and Mansukhani and Sarkar (1981) described it from Tripura also in north-eastern India.

2.4.14

Pterorana gen. nov.Pterorana khare sp. nov.

(Diplasiocoela: Ranidae: Raninae)

Plate 2.14A, B, C, D, E, F and G.

Diagnosis: A moderate frog, SVL of males 53-62 mm. Skin of dorsum coarsely granular, belly smooth. Dorso-lateral ridge distinct. Large flaps of skin on each lateral side and thigh. Vomerine and maxillary teeth present. Pupil horizontally oval. Tympanum indistinct, $1/2$ the horizontal eye diameter. Fingers free, toes webbed. Fingers and toes with discs. 1st finger longer than 2nd finger. Tibio-tarsal articulation reaching snout level. Colour of dorsum slate dark, brown. Belly white.

Description: A moderate frog. Snout-vent length of males measured 53-62 mm. No female in the collection.

Head longer than broad, greatly depressed. Snout round in dorsal, truncate in lateral profile, projecting over the mouth. Distance between eye and nostril shorter than the horizontal diameter of the eye, 1.2 times the distance between nostril and tip of snout. Internarial distance is 1.2 times the interocular distance. Eyes are moderately large, bulging, pupil horizontally oval. Tympanum indistinct, round, $1/2$ th the horizontal diameter of the eye, separated from the eye by a distance of its diameter.

Vomerine teeth soft, small, in oblique series, innerly run from anterior to hinder border of the choanae. Upper jaw toothed. Lower jaw without teeth. Tongue large, oval, bifid.

Forelimbs short. Fingers free. Fingers with an oblong discs, discs are of almost equal size. There are 3 oval metacarpal tubercles.

* Paper on this genus and species communicated

Plate 2.14A Pterorana khare male.

Plate 2.14B Ventral view of head.

Plate 2.14C Lateral view of left side of head.

Plate 2.14D Ventral view of right hand.

Plate 2.14E Ventral view of right foot.

Plate 2.14F Range and distribution.

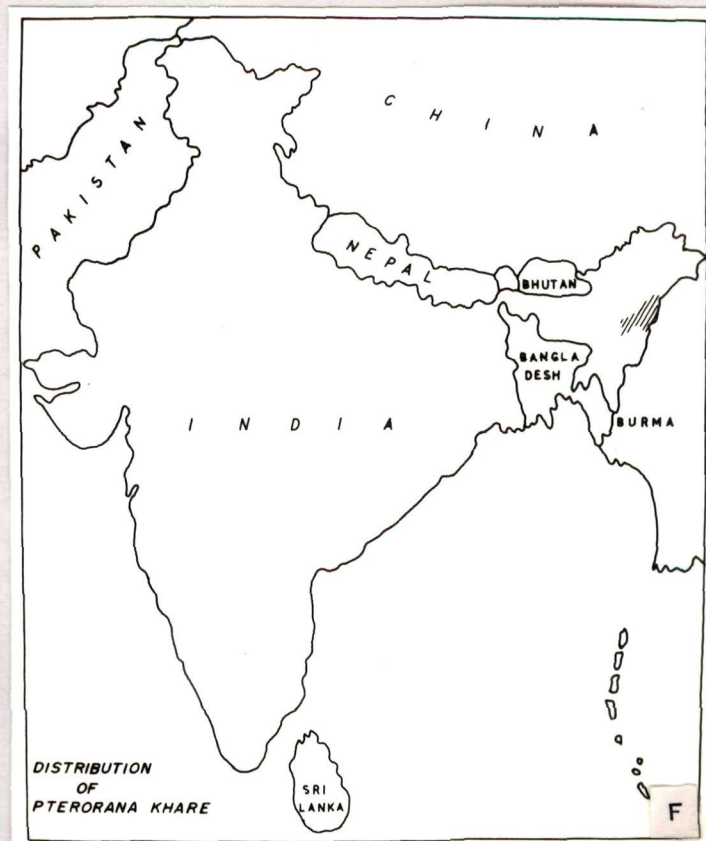
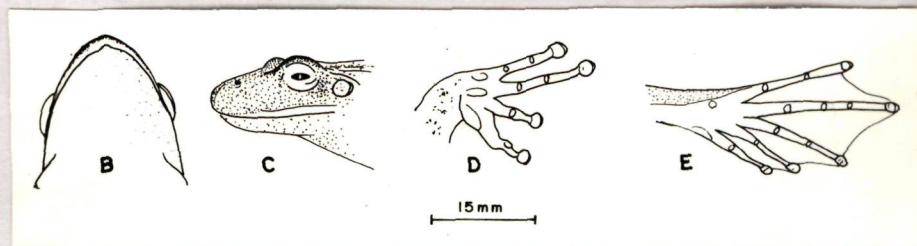


PLATE 2:14

Plate 2.14G : X-ray photograph of Pterorana khare.

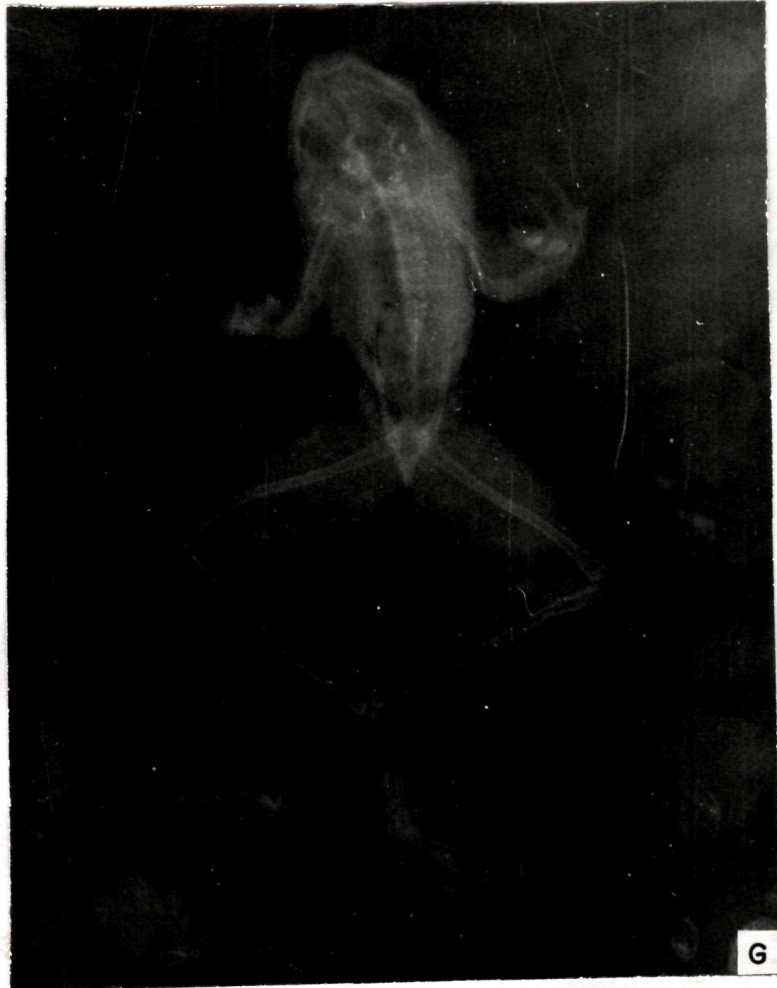


PLATE 214

(outer tubercle smallest, innermost largest and middle one medium sized). Subarticular tubercles distinct, round, single. Length of fingers: $2 < 4 < 1 < 3$.

Hindlimbs long, muscular. Tibio-tarsal articulation reaching at snout level when passed forward along the body. Toes are webbed, webbing formula: $1(\frac{1}{2})$, $2i(\frac{3}{4})$, $2e(\frac{1}{2})$, $3i(\frac{3}{4})$, $3e(\frac{1}{2})$, $4i(\frac{1}{2})$, $4e(\frac{1}{2})$, $5(\frac{1}{2})$. Toes are with oblong discs at the tips, size of discs: $1 < 5 < 2 < 3 < 4$. There are 2 metatarsal tubercles (outer tubercle circular, small and inner tubercle oblong and large). Subarticular tubercles distinct, oval, single. Length of toes: $1 < 2 < 3 < 5 < 4$.

Skin of dorsum coarsely granular. Belly smooth. A large glandular tubercle at the angle of jaws. A dorso-lateral ridge runs distinctly from eye orbit to hinder part of the body. The 1st finger with horny spines. There is flap of skin on each lateral side of the body. This flap measures about 13 mm wide when spread. Each thigh also have a flap of skin, measures about 5 mm when spread. A cap of skin over the vent.

Colour of dorsum slate dark, brown. Belly white with minute black spots under the throat and chest. Dark cross-bars on limbs.

Contents: One species, viz. Pterorana khare spec. nov.

Measurements: Table 2.14.

Habit and habitat: They are nocturnal frogs, found in swift stream waterfalls. They live in among the rocks. They can glide for a considerable distance, so now known as 'Gliding frog'.

Breeding: Breeding period is not known.

Economic use: They are edible frogs.

Table 2.14: $\bar{X}$ Measurements of Pterorana khars.

Characters	Male (mm) N = 2
Snout-vent length	57.5
Head width minimum	6.0
Head width maximum	19.5
Head length	20.5
Eye diameter	6.0
Inter-ocular distance	5.5
Nostril diameter	1.0
Inter-narial distance	8.0
Distance between eye and nostril	4.0
Distance between nostril and tip of snout	3.5
Tympanum diameter	3.0
Hindlimb length	99.0
Tibia length	36.5
5th toe length	18.0
Forelimb length	25.5
Lower forelimb length	21.0
1st finger length	9.0
2nd finger length	7.5

Range and distribution: This frog species was collected from Sanuorü river and Rùkhroma river at an altitude between 1400-1440 m a.s.l. at Kohima. This is the first record of this species as there is no such description in the literature.

Holotype: An adult male frog, ^{ZSI}Reg. No. V/ERS.82/4 in formalin.loc. Sanuorü river, Kohima (alt. 1440 m a.s.l.), coll. Kiyasetuo, 1.10.83.

Paratype: An adult male frog, ^{ZSI}Reg. No. V/ERS.82/5 in formalin. loc. Rukhroma river, Kohima (alt. 1400 m a.s.l.), coll. Kiyasetuo, 15.5.84.

Relationship: The lateral flaps possessed by this frog make it very distinct from other anurans. I have been able to collect 2 specimens- the first one in October, 1983 from Sanuorü river and the second specimen in May, 1984 from Rùkhroma river. The frog extends the lateral flaps as soon as it is placed in water but they become folded outside the water. The structure of vertebral column as seen in X-ray photograph reveals that they belong to the sub-order Diplasiocoela. On closer examination it was found that they are very similar to ranids (horizontal pupil, presence of vomerine teeth, upper jaw toothed, oval and bifid tongue, free fingers, webbed toes, subarticular tubercles distinct, no ribs, digits without intercalary cartilage, slender clavicle, bony cylindrical slender sacral diapophyses).

The points that differ from ranids are large flaps of skin on each lateral side of the body and thighs, toes extensively webbed upto the tips, head longer than broad and head and body greatly depressed.

In view of these differences and its gliding ability it has been proposed to erect for it a new genus. As it is very close to Rana, it has been named as Pterorana (Ptero=wings). The name of the species khare has been proposed in honour of Prof. M.K. Khare, who has been supervising this work.

2.4.15

Rhacophorus leucomystax (Kuhl, 1829)

(Diplasiocoela: Rhacophoridae: Rhacophorinae).

Plate 2.15A, B, C, D, E and F.

Hyla leucomystax Kuhl, In Gravenhorst, Deliciae Musei
Zool. Vratislaviensis fasc. 1, 1829: 26.

Rhacophorus maculatus, Boulenger, Cat. Batr. Sal. Ecaud.
Brit. Mus., 1882: 83.

Rhacophorus maculatus himalayensis Annandale, Rec. Indian
Mus., 1912(8): 14.

Rhacophorus leucomystax, Van Kampen, Amph. Indo-Austr.
Arch., 1923: 246.

Diagnosis: A moderate frog, SVL of males 38-65 mm and of females 40-75 mm. Skin of dorsum, belly coarsely granular. Vomerine and maxillary teeth present. Pupil horizontally oval. Tympanum distinct, 2/3rd the horizontal eye diameter. Fingers and toes webbed. Fingers and toes with large discs. 1st finger shorter than 2nd finger. Tibio-tarsal articulation reaching nostril level. Colour of dorsum grey, brown with spotted or striped or broken striped or an X-shaped mark behind the eye on the dorsum. Belly white.

Description: A moderate frog. Snout-vent length of males ~~38-65~~ mm and of females ~~40-75~~ mm.

Head broader than long, greatly depressed. Snout almost pointed in dorsal, truncate in lateral profile, projecting over the mouth. Distance between eye and nostril shorter than the horizontal diameter of the eye, 1.5 times the distance between nostril and tip of snout. Internarial distance almost equidistant with the interocular distance. Eyes large, bulging, pupil horizontally oval. Tympanum distinct, oval, 2/3th the horizontal diameter of the eye, separated from the eye by a distance 1/3 of its diameter.

Plate 2.15A Rhacophorus leucomystax female.

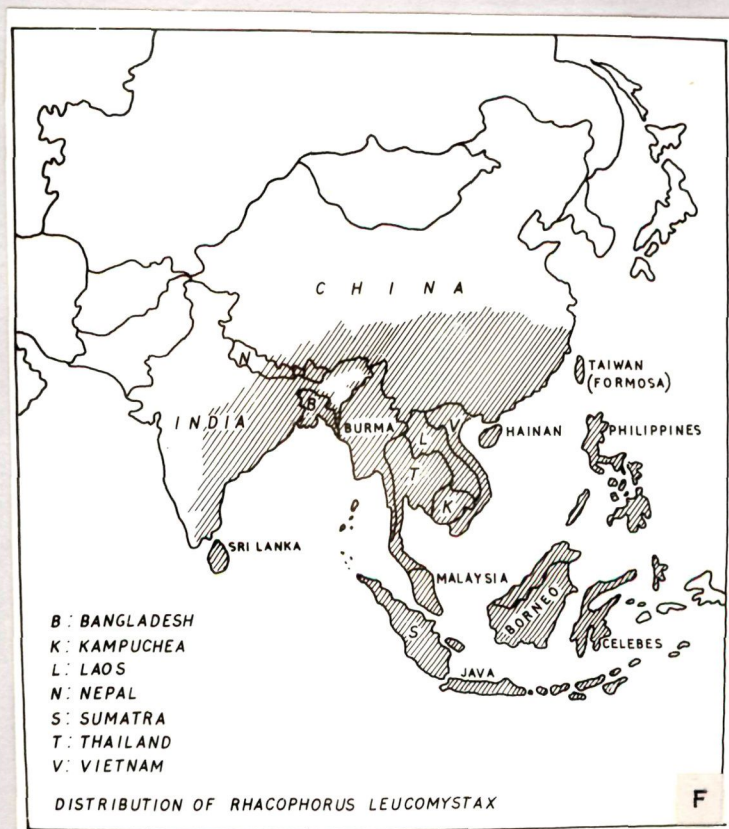
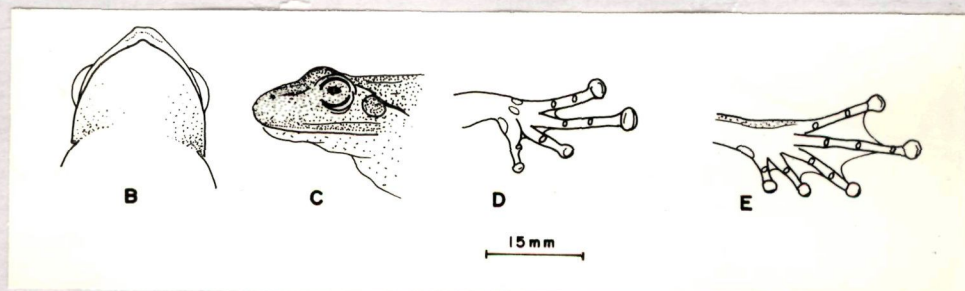
Plate 2.15B Ventral view of head.

Plate 2.15C Lateral view of left side of head.

Plate 2.15D Ventral view of right hand.

Plate 2.15E Ventral view of right foot.

Plate 2.15F Range and distribution.



Vomerine teeth strong, in oblique series, innerly anterior to the choanae. Upper jaw toothed. Lower jaw without teeth. Tongue moderate, oval, bifid.

Forelimbs short. Fingers are rudimentary, webbing formula: $1(2\frac{3}{4})$, $2i(2\frac{3}{4})$, $2e(2\frac{1}{2})$, $3i(3)$, $3e(3)$, $4(3)$. Fingers have an oval discs at the tips, size of discs: $1<2<4<3$. There are 3 oval metacarpal tubercles (outer tubercle smallest, innermost largest and middle one medium sized). Subarticular tubercles distinct, round, single. Length of fingers: $1<2<4<3$.

Hindlimbs long. Tibio-tarsal articulation reaching at the nostril level when passed forward along the body. Toes are webbed, webbing formula: $1(1\frac{1}{2})$, $2i(2)$, $2e(1\frac{1}{2})$, $3i(2)$, $3e(1\frac{1}{2})$, $4i(2\frac{1}{2})$, $4e(2\frac{1}{2})$, $5(1)$. Toes are ended with oval discs, size of discs: $1<2<3<5<4$. There is 1 oval inner metatarsal tubercle. Subarticular tubercles distinct, round, single. Length of toes: $1<2<3<5<4$.

Skin of dorsum, lateral and belly coarsely granular. Tympanic fold and sacral hump prominent.

Colour of dorsum grey, brown with 4 dark longitudinal stripes running parallel to each other from head to hinder part of the body. Dark cross-bar on limbs. Lateral and hinder part of thighs are marbled white on grey background. Belly white with dark patches under the throat.

Measurements: Table 2.15.

Habit and habitat: They are nocturnal arboreal frogs. In summer they visit pools for breeding, in autumn they are found on trees, in winter they hibernate under forest litters and in spring they live in bamboo internodes during day time.

Table 2.15:X Measurements of Rhacophorus leucomystax.

Characters	Male (mm) N = 40	Female (mm) N = 40
Snout-vent length	49.2	56.7
Head width minimum	6.2	6.9
Head width maximum	16.4	18.2
Head length	15.6	17.2
Eye diameter	5.2	5.6
Inter-ocular distance	5.9	6.4
Nostril diameter	1.2	1.1
Inter-narial distance	4.7	5.2
Distance between eye and nostril	4.5	4.85
Distance between nostril and tip of snout	3.0	3.47
Tympanum diameter	3.8	4.2
Hindlimb length	72.5	82.4
Tibia length	26.7	29.0
5th toe length	11.9	13.8
Forelimb length	23.3	27.0
Lower forelimb length	16.8	19.3
1st finger length	5.5	6.4
2nd finger length	6.2	7.1

Breeding: They start breeding by late May till July in pools, paddy fields. They exhibit amplexus and prepare foamy nests on twigs and leaves at the edges about 2-33 cm above the water.

Economic use: Edible frog species. A favourite food item.

Range and distribution: Common frog species of Kohima. Collected from Dimapur, Science College Campus, Jotsoma, Sanuorü, Touliezie, Mhasizou, Tekhuletsa and Phegei at an altitude between 183-1982.5 m a.s.l. Its distribution extends in India, Malay Peninsula, Java (Annandale, 1912; Cochran, 1961 and Church, 1963), Thailand and through south-east Asia (Taylor, 1962) and Borneo (Taylor, 1966). It is distributed in Meghalaya, Arunachal Pradesh (Pillai and Chanda, 1976) and Tripura (Mansukhani and Sarkar, 1981) also in the north-eastern India.

2.4.16

Rhacophorus reinwardtii (Schlegel, 1837).

(Diplasiocoela: Rhacophoridae: Rhacophorinae)

Plate 2.16A, B, C, D, E and F.

Hyla reinwardtii Schlegel, Arnz and Comp., 1837: 31.

Rhacophorus bimaculatus Boulenger, Cat. Batr. Sal. Ecaud. Brit. Mus., 1882: 90.

Rhacophorus bimaculatus Boulenger, Fauna Brit. India, 1890: 472.

Rhacophorus reinwardtii Pillai and Chanda, Rec. Zool. Surv. India, 1979(75): 392.

Diagnosis: A moderate frog, SVL of males 46-48 mm and of female 63 mm. Skin of dorsum smooth, belly rough. Vomerine and maxillary teeth present. Pupil horizontally oval. Tympanum indistinct, 4/5th the horizontal eye diameter. Fingers and toes webbed. Fingers and toes with large discs (2nd, 3rd and 4th finger discs larger than tympanum). 1st finger shorter than 2nd finger. Flaps on heel and cup-shaped above the vent present. Tibio-tarsal articulation reaching beyond eye level. Colour of dorsum leafy green, slate green. Axilla with 2 black spots. Belly yellowish white.

Description: Rhacophorus reinwardtii is a moderate frog. Snout-vent length of males 46-48 mm and of females 63 mm.

Head slightly broader than long, greatly depressed. Snout pointed in dorsal, acuminate in lateral profile, projecting over the mouth. Distance between eye and nostril shorter than the horizontal diameter of the eye, equidistant with the distance between nostril and tip of snout. Internarial distance 5/6th the interocular distance. Eyes very large, bulging, pupil horizontally oval. Tympanum indistinct, oval, 4/5th the horizontal diameter of the eye, separated from the eye by a distance 1/3th its diameter.

Plate 2.16A Rhacophorus reinwardtii female.

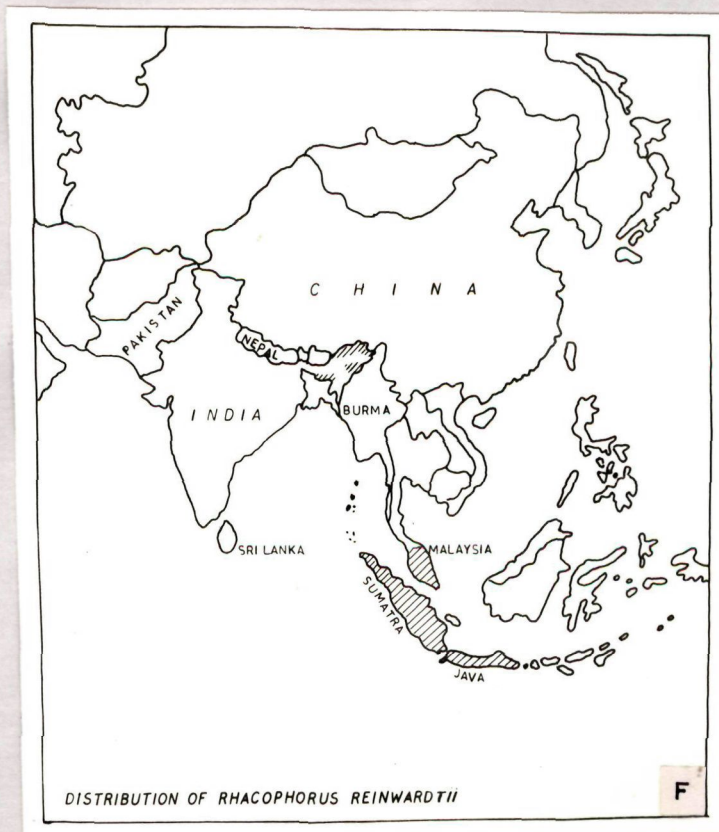
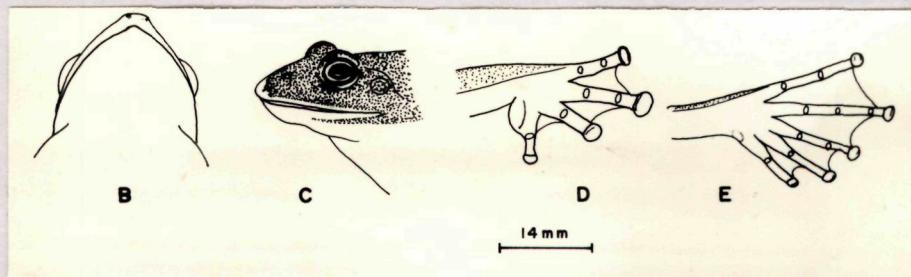
Plate 2.16B Ventral view of head.

Plate 2.16C Lateral view of left side of head.

Plate 2.16D Ventral view of right hand.

Plate 2.16E Ventral view of right foot.

Plate 2.16F Range and distribution.



Vomerine teeth strong, in oblique series, innerly anterior to the choanae. Upper jaw toothed. Lower jaw without teeth. Tongue small, oblong, bifid.

Forelimbs long. Fingers webbed, webbing formula: 1(2), 2i(2), 2e(1), 3i($1\frac{3}{4}$), 3e($1\frac{1}{2}$), 4(1). Fingers have large rectangular discs at the tips, size of discs: $1 < 2 < 4 < 3$, the 2nd and 3rd and 4th finger discs larger than tympanum. There is 1 oval inner metacarpal tubercle. Subarticular tubercles distinct, oval, single. Length of fingers: $1 < 2 < 4 < 3$.

Hindlimbs moderately long, slender. Tibio-tarsal articulation reaching beyond the eye level when passed forward along the body. Toes are webbed, webbing formula: 1(1), 2i($1\frac{1}{2}$), 2e(1), 3i($1\frac{1}{2}$), 3e(1), 4i($1\frac{1}{2}$), 4e($1\frac{1}{2}$), 5(1). Toes are with large rectangular discs at the tips, size of discs: $1 < 2 < 3 < 5 < 4$. There is 1 oval inner metatarsal tubercle. Subarticular tubercles distinct, oval, single. Length of toes: $1 < 2 < 3 < 5 < 4$.

Skin of dorsum smooth. Lateral side and belly rough. Tympanic fold present. Carpal and tarsal folds present. Flap on heel and cup-shaped flap above the vent prominent.

Colour of dorsum leafy green, slate green with white dots embedding in the skin. Lateral and belly yellowish white. There are 2 black spots on each lateral side, anterior spot larger than the posterior spot. Webs are reddish in colour.

Measurements: Table 2.16.

Habit and habitat: An arboreal, nocturnal frogs. Live on trees. Hide in hollow trees in winter.

Table 2.16: $\bar{X}$ Measurements of Rhacophorus reinwardtii.

Characters	Male (mm) N = 2	Female (mm) N = 1
Snout-vent length	47.0	63.0
Head width minimum	3.9	4.5
Head width maximum	18.0	21.0
Head length	16.0	21.0
Eye diameter	5.5	5.5
Inter-ocular distance	6.0	6.5
Nostril diameter	1.0	1.0
Inter-narial distance	5.25	6.0
Distance between eye and nostril	4.0	5.5
Distance between nostril and tip of snout	4.0	5.4
Tympanum diameter	3.75	4.0
Hindlimb length	68.0	85.0
Tibia length	24.5	35.0
5th toe length	13.5	17.0
Forelimb length	21.75	26.0
Lower forelimb length	15.7	17.0
1st finger length	6.0	7.0
2nd finger length	7.0	9.0

Breeding: They breed from May to June in ditches and pools.

Females deposit eggs in a foamy nest, 60-90 cm above water level at the edges. During breeding period, males croak loudly on trees.

Economic use: This frog species is edible.

Range and distribution: Collected from Science College Campus, Jotsoma, Touliezie and Dzölunu at an altitude between 1440-1982.5 m a.s.l. Its distribution extends in Java, Sumatra (Gadow, 1901), Malaysia Peninsula (Cochran, 1961) and Meghalaya and Arunachal Pradesh in north-eastern India (Pillai and Chanda, 1976).

2.4.17

Rhacophorus nigropalmatus Boulenger, 1895
(Diplasiocoela: Rhacophoridae: Rhacophorinae).
Plate 2.17A, B, C, D, E and F

Rhacophorus nigropalmatus Boulenger, Ann. Mag. Nat. Hist., Ser.
6(16), 1895: 170

Diagnosis: A large frog, SVL of males 65-80 mm and of females 92-95 mm. Skin of dorsum smooth, belly rough. Vomerine and maxillary teeth present. Pupil horizontally oval. Tympanum indistinct, $\frac{2}{3}$ rd the horizontal eye diameter. Fingers and toes webbed. Fingers and toes with large discs (2nd, 3rd and 4th finger larger than tympanum). 1st finger shorter than 2nd finger. Tibio-tarsal articulation not reaching eye level. Colour of dorsum leafy green, dark green. Belly white.

Description: Rhacophorus nigropalmatus is a large frog. Snout-vent length of males 65-80 mm and of females 92-95 mm.

Head as broad as long, slightly depressed. Snout round in dorsal, acuminate in lateral profile, projecting over the mouth. Distance between eye and nostril shorter than the horizontal diameter of the eye, $\frac{5}{6}$ th the distance between nostril and tip of snout. Internarial distance almost equidistant with the interocular distance. Eyes large, bulging, pupil horizontally oval. Tympanum indistinct, round, $\frac{2}{3}$ th the horizontal diameter of the eye, separated from the eye by a distance half of its diameter.

Vomerine teeth strong in oblique series, innerly anterior to the choanae. Upper jaw toothed. Lower jaw without teeth. Tongue small, oval, bifid.

Plate 2.17A Rhacophorus nigropalmatus female.

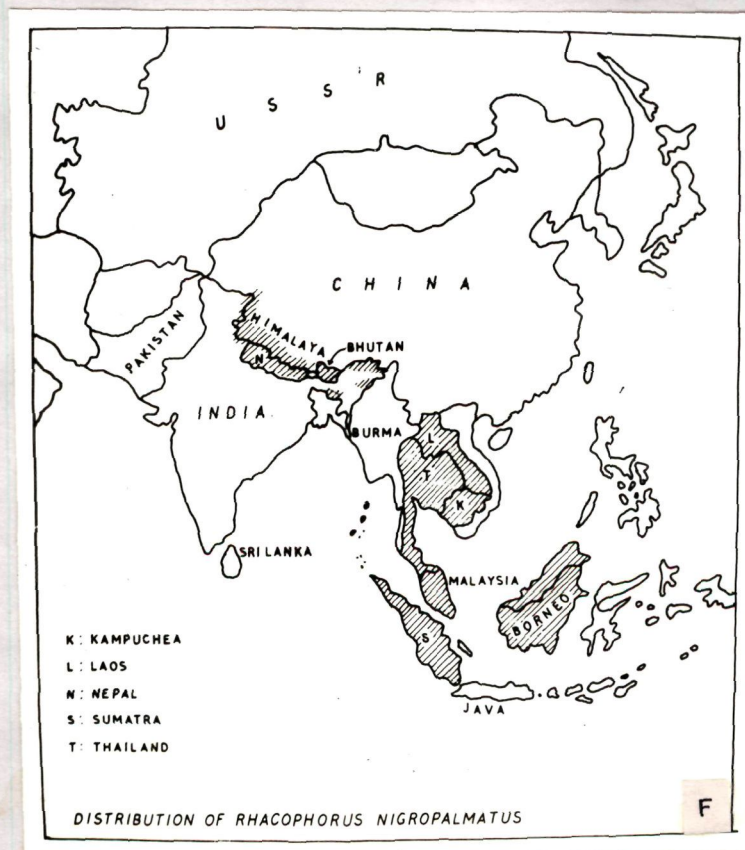
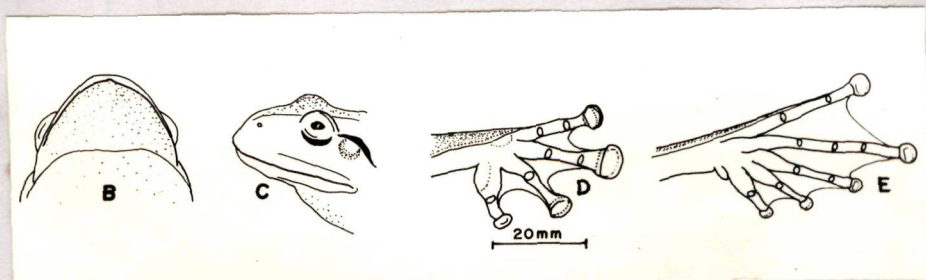
Plate 2.17B Ventral view of head.

Plate 2.17C Lateral view of left side of head.

Plate 2.17D Ventral view of right hand.

Plate 2.17E Ventral view of right foot.

Plate 2.17F Range and distribution.



Forelimbs short. Fingers are webbed, webbing formula: 1(2), 2i(2), 2e($1\frac{1}{2}$), 3i(2), 3e($1\frac{1}{2}$), 4($1\frac{1}{2}$). Fingers are ended with large rectangular discs, size of discs: 1<2<4<3, the 2nd, 3rd and 4th finger discs are larger than tympanum. There are 2 indistinct oblong metacarpal tubercles. Subarticular tubercles distinct, round, single. Length of fingers: 1<2<4<3.

Hindlimbs short, muscular. Tibio-tarsal articulation not reaching at the eye level when passed forward along the body. Toes are webbed, webbing formula: 1(1), 2i($1\frac{3}{4}$), 2e(1), 3i($1\frac{3}{4}$), 3e(1), 4i($1\frac{1}{2}$), 4e($1\frac{1}{2}$), 5(1). Toes are ended with rectangular discs, size of discs: 1<2<3<5<4. There is 1 oblong inner metatarsal tubercle. Subarticular tubercles distinct, round, single. Length of toes: 1<2<3<5<4.

Skin of dorsum smooth. Belly rough. Tympanic fold and sacral hump prominent.

Colour of dorsum leafy green, dark green. Belly yellowish white with dispersed dark spots under the throat.

Measurements: Table 2.17.

Habit and habitat: A nocturnal frog. They hibernate under forest litters in winter. They visit pools in spring.

Breeding: They breed from March to April in pools. Females deposit eggs in a foamy nest on the side of the pools 10-30 cm above the water.

Economic use: This species is edible. Use for curing blisters.

Table 2.17: X Measurements of Rhacophorus nigropalmatus.

Characters	Male (mm) N = 2	Female (mm) N = 2
Snout-vent length	74.5	93.5
Head width minimum	7.5	9.0
Head width maximum	23.75	30.0
Head length	22.0	30.0
Eye diameter	7.0	8.75
Inter-ocular distance	9.0	12.0
Nostril diameter	1.2	1.4
Inter-narial distance	8.0	9.5
Distance between eye and nostril	5.5	5.56
Distance between nostril and tip of snout	6.2	6.3
Tympanum diameter	4.5	6.0
Hindlimb length	95.0	128.5
Tibia length	36.5	47.0
5th toe length	21.5	29.0
Forelimb length	30.0	43.5
Lower forelimb length	19.25	31.5
1st finger length	10.0	14.0
2nd finger length	13.5	18.5

Range and distribution: Collected from Touliezie, Mhasizou and Chiesierlekha at an altitude between 1420-1445 m a.s.l. Its distribution extends in Himalayan forests (Gadow, 1901), North of Siam, Sumatra and Malaya (Taylor, 1962), Thailand, Malaysia, Kampuchea, Laos, Borneo, Sumatra (Heusser, 1974) and Meghalaya and Arunachal Pradesh in north-eastern India (Pillai and Chanda, 1976).

2.4.18

Rhacophorus bisacculus Taylor, 1962.
(Diplasiocoela: Rhacophoridae: Rhacophorinae)
Plate 2.18A, B, C, D, E and F.

Diagnosis: A small cadeverous frog, SVL of males 30-35 mm and of females 38-46 mm. Skin of dorsum and belly coarsely granular. Vomerine and maxillary teeth present. Pupil horizontally oval. Tympanum distinct, $\frac{2}{3}$ rd the horizontal eye diameter. Fingers and toes webbed. Fingers and toes with large discs (3rd and 4th finger discs larger than tympanum). 1st finger shorter than 2nd finger. Tibio-tarsal articulation not reaching nostril level. A row of tubercles on underside of carpal and tarsal. Colour of dorsum grey, green with a green star-shaped in the mid-dorsum and belly white.

Description: A moderate small, ugly looking frog. Snout-vent length of males 30-35 mm and of females 38-46 mm.

Head as broad as long, greatly depressed. Snout pointed in dorsal and lateral profile, projecting over the mouth. Nostrils elevated. Distance between eye and nostril shorter than the horizontal diameter of the eye, 1.6 times the distance between nostril and tip of snout. Inter-narial distance $\frac{3}{4}$ th the inter-ocular distance. Eyes large, bulging, pupil horizontally oval. Tympanum distinct, round, $\frac{2}{3}$ rd the horizontal diameter of the eye, separated from the eye by a distance $\frac{2}{3}$ rd its diameter.

Vomerine teeth small, soft, oblique, innerly anterior to the choanae. Upper jaw toothed, Lower jaw without teeth. Tongue small, oblong, slightly nicked, bifid.

Forelimbs are short. Fingers are rudimentary webbed, webbing formula: 1(2), 2i($2\frac{1}{2}$), 2e(2), 3i(3), 3e($2\frac{3}{4}$), 4(2). Fingers with

* Paper on this species communicated

Plate 2.18A Rhacophorus bisacculus female.

Plate 2.18B Ventral view of head.

Plate 2.18C Lateral view of left side of head.

Plate 2.18D Ventral view of right hand.

Plate 2.18E Ventral view of right foot.

Plate 2.18F Range and distribution.

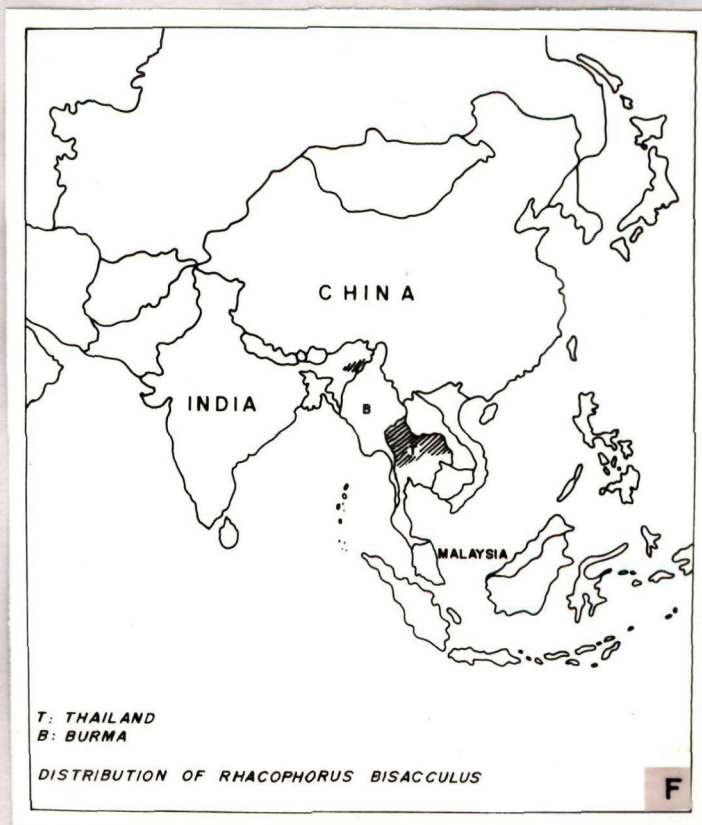
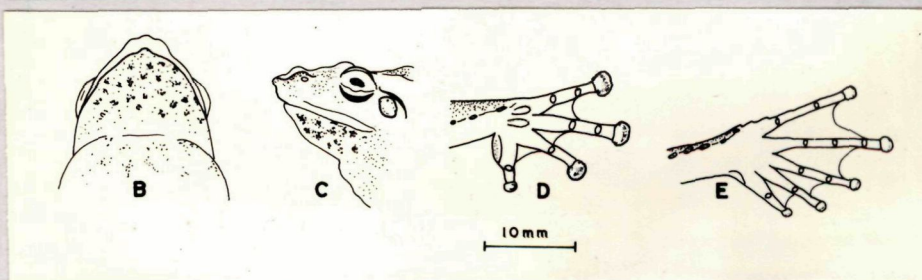


PLATE 2:18

large oval discs, 3rd, and 4th finger discs larger than the tympanum. There are 3 oblong metacarpal tubercles (outer tubercle smallest, innermost largest and middle one medium sized). Subarticular tubercles distinct, oval, single. Length of fingers: $1 < 2 < 4 < 3$.

Hindlimbs long, slender. Tibio-tarsal articulation not reaching at the nostril level when passed forward along the body. Toes are webbed, webbing formula: $1(1)$, $2i(2)$, $2e(1\frac{1}{2})$, $3i(2)$, $3e(1\frac{1}{2})$, $4i(2\frac{1}{4})$, $4e(2)$, $5(1\frac{1}{2})$. Toes with oval discs. There is 1 oblong inner metatarsal tubercle. Subarticular tubercles distinct, round, single. Length of toes: $1 < 2 < 3 < 5 < 4$.

Skin of dorsum and belly coarsely granular. Tympanic fold present. A row of tubercles on underside of metacarpal and metatarsal. Sacral hump visible. A paired of lateral vocal sacs in male.

Colour of dorsum greyish green, grey, with a green star-shaped in the mid-dorsum. Belly white, throat with dispersed black spots. Arms and legs with dark cross bars. Web on toes with bright red pigment.

Measurements: Table 2.18.

Habit and habitat: A nocturnal frog species. This species is an arboreal frog, found mostly in bushes, cling on tree barks near pools and rivers. In winter they hide in bamboo internodes with a hole.

Breeding: They breed in pools from April to early part^{of} July.

During breeding season, males sit in bushes near pools and croak. Chorus increases with evening down pour.

Table 2.18: Measurements of *Rhacophorus bisacculus*.

Characters	Male (mm) N = 2	Female (mm) N = 3
Snout-vent length	32.5	43.16
Head width minimum	2.8	3.3
Head width maximum	12.2	15.0
Head length	12.0	15.0
Eye diameter	4.0	4.75
Inter-ocular distance	3.75	5.0
Nostril diameter	0.7	0.73
Inter-narial distance	3.2	5.0
Distance between eye and nostril	3.9	4.2
Distance between nostril and tip of snout	1.8	2.5
Tympanum diameter	2.75	3.0
Hindlimb length	46.5	59.3
Tibia length	17.5	22.0
5th toe length	8.5	11.3
Forelimb length	15.5	19.83
Lower forelimb length	10.0	15.8
1st finger length	3.5	4.6
2nd finger length	4.75	7.0

Economic use: This frog is not edible. Body secretion is eye irritating.

Range and distribution: Found at an altitude of 1444 m a.s.l. in Touliezie and Mhasizou in Nagaland. Its distribution has also been reported from Thailand (Taylor, 1962).

2.4.19

Chirixalus vittatus (Boulenger, 1887).

(Diplasiocoela: Rhacophoridae: Rhacophorinae).

Plate 2.19A, B, C, D, E and F.

Ixalus vittatus Boulenger, Ann. Mus. Civ. Genova (2)5, 1887: 421.

Diagnosis: A small frog, SVL of males 23-24 mm and of females 24-27 mm. Skin of dorsum coarsely granular, belly smooth. Vomerine teeth wanting, maxillary teeth present. Pupil horizontally oval. Tympanum indistinct, $1/2$ the horizontal eye diameter. Fingers and toes webbed. Fingers and toes with large discs (2nd, 3rd and 4th finger discs larger than tympanum). 1st finger shorter than 2nd finger. Tibio-tarsal articulation reaching eye level. Colour of dorsum yellow, green or grey with 2 white stripes on each dorso-lateral side. Belly white or yellow.

Description: Chirixalus vittatus is a small frog. Snout-vent length of males 23-24 mm and of females 24-27 mm.

Head as broad as long, moderately depressed. Snout almost pointed in dorsal and lateral profile, projecting over the mouth. Nostril elevated. Distance between eye and nostril shorter than the horizontal diameter of the eye, almost equidistant with the distance between nostril and tip of snout. Internarial distance $4/5$ th the interocular distance. Eyes moderate, bulging, pupil horizontally oval. Tympanum indistinct, round, $1/2$ th the horizontal diameter of the eye, separated by a distance $1/3$ th its diameter.

Vomerine teeth wanting. Upper jaw toothed. Lower jaw without teeth. Tongue triangular, moderate, bifid.

Forelimbs short. Fingers webbed rudimentary, webbing formula: $1(2\frac{1}{2})$, $2i(2\frac{1}{2})$, $2e(2\frac{1}{2})$, $3i(2\frac{1}{2})$, $3e(2\frac{3}{4})$, $4(2\frac{1}{2})$. Fingers have large

* Paper on this species communicated

Plate 2.19A Chirixalus vittatus female.

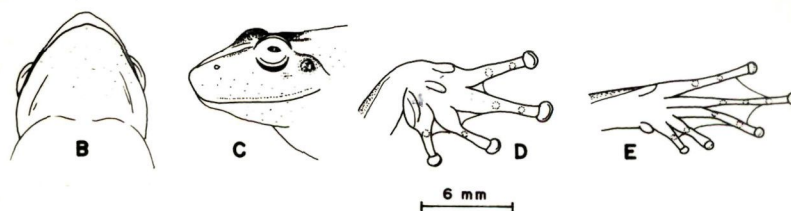
Plate 2.19B Ventral view of head.

Plate 2.19C Lateral view of left side of head.

Plate 2.19D Ventral view of right hand.

Plate 2.19E Ventral view of right foot.

Plate 2.19F Range and distribution.



oval discs at the tips, size of discs: $1 < 2 < 4 < 3$, the 2nd, 3rd and 4th finger discs are larger than tympanum. There are 3 oblong metacarpal tubercles (outer tubercle smallest, innermost largest and middle one medium in sized). Subarticular tubercles indistinct, oval, single, Length of fingers: $1 < 2 < 4 < 3$. The inner two fingers are separated from the other two and tend to be opposite.

Hindlimbs moderately long. Tibio-tarsal articulation reaching at the eye level when passed forward along the body. Toes are webbed, webbing formula: $1(1\frac{3}{4})$, $2i(2)$, $2e(1\frac{1}{4})$, $3i(2)$, $3e(1\frac{1}{2})$, $4i(2\frac{1}{4})$, $4e(2)$, $5(1\frac{1}{2})$. Toes are ended with oval discs, size of discs: $1 < 2 < 3 < 5 < 4$. There are 2 oblong metatarsal tubercles (outer tubercle small and inner tubercle large). Subarticular tubercles indistinct, oval, single. Length of toes: $1 < 2 < 3 < 5 < 4$.

Skin of dorsum coarsely granular. Belly smooth. Tympanic fold visible.

Colour of dorsum yellow, green, grey. There are 2 white stripes on each dorso-lateral side extending from eye orbit to groin. Dorsum with dispersed minute black dots, concentrated on mid-dorsal. Belly white, yellow.

Measurements: Table 2.19.

Habit and habitat: An arboreal and diurnal as well as nocturnal frogs. They hide in bamboo internodes and hollow trees during winter and spring. Live in bushes, on leaves during autumn and summer.

Breeding: They breed by late May till July in pools, paddy fields. Females lay a cluster of eggs on leave and hatch it till the eggs hatched out to external gill stage.

Table 2.19: $\bar{X}$ Measurements of Chirixalus vittatus.

Characters	Male (mm) N = 3	Female (mm) N = 3
Snout-vent length	23.3	26.0
Head width minimum	1.9	2.3
Head width maximum	7.8	8.6
Head length	7.6	9.0
Eye diameter	3.0	3.2
Inter-ocular distance	3.8	3.6
Nostril diameter	0.5	0.5
Inter-narial distance	3.2	3.0
Distance between eye and nostril	1.8	2.1
Distance between nostril and tip of snout	2.0	2.15
Tympanum diameter	1.6	1.7
Hindlimb length	35.6	38.6
Tibia length	12.0	13.6
5th toe length	4.2	5.2
Forelimb length	11.2	12.8
Lower forelimb length	6.1	7.1
1st finger length	2.0	3.0
2nd finger length	2.8	4.0

Economic use: This frog species is not edible.

Range and distribution: It was collected from Touliezie, Sanuorü
 and Merübotsa at an altitude between 1400-1440 m a.s.l. ^{in Nagaland.} Its
 distribution ^{also} extends in Burma (Boulenger, 1887) and Thailand
 (Taylor, 1962 and Heyer, 1971).

2.4.20

Genus: Philautus Gistel(Syn. Ixalus Dum. and Bibr.).Philautus annandalei (Boulenger, 1906).

(Diplasiocoela: Rhacophoridae: Philautinae).

Plate 2.20A, B, C, D, E and F

Philautus annandalei Boulenger, Journ. As. Soc. Bengal, 1906: 385.Ixalus annandalei Boulenger, Journ. As. Soc. Bengal, 1906: 385.Ixalus annandalei, Annandale, Rec. Indian Mus., 1912(8): 16.

Diagnosis: One of the smallest frogs, SVL of males 17-19 mm. Skin of dorsum and belly warty. Vomerine teeth wanting, maxillary teeth present. Pupil horizontally oval. Tympanum indistinct, $\frac{1}{3}$ rd the horizontal eye diameter. Fingers free, toes webbed. Fingers and toes with small oval discs. 1st finger shorter than 2nd finger. Tibio-tarsal articulation reaching eye level. Colour of dorsum greyish dark. Belly dark.

Description: The smallest adult frogs collected. Snout-vent length of males measured 17-19 mm. No female in the collection.

Head broader than long, slightly depressed. Snout round in dorsal, truncate in lateral profile, projecting over the mouth. Distance between eye and nostril shorter than the horizontal diameter of the eye, 1.2 times the distance between nostril and tip of snout. Eyes are small, bulging, pupil horizontally oval. Tympanum indistinct, round, $\frac{1}{3}$ rd the horizontal diameter of the eye, separated from the eye by a distance $\frac{1}{3}$ rd its diameter.

Vomerine teeth lacking. Upper jaw toothed. Lower jaw without teeth. Tongue oblong, small, bifid.

Forelimbs short. Fingers webbed rudimentary. Fingers with small oval discs at the tips, size of discs: $1 < 2 < 4 < 3$. There is 1

Plate 2.20A Philautus annandalei male.

Plate 2.20B Ventral view of head.

Plate 2.20C Lateral view of left side of head.

Plate 2.20D Ventral view of right hand.

Plate 2.20E Ventral view of right foot.

Plate 2.20F Range and distribution.

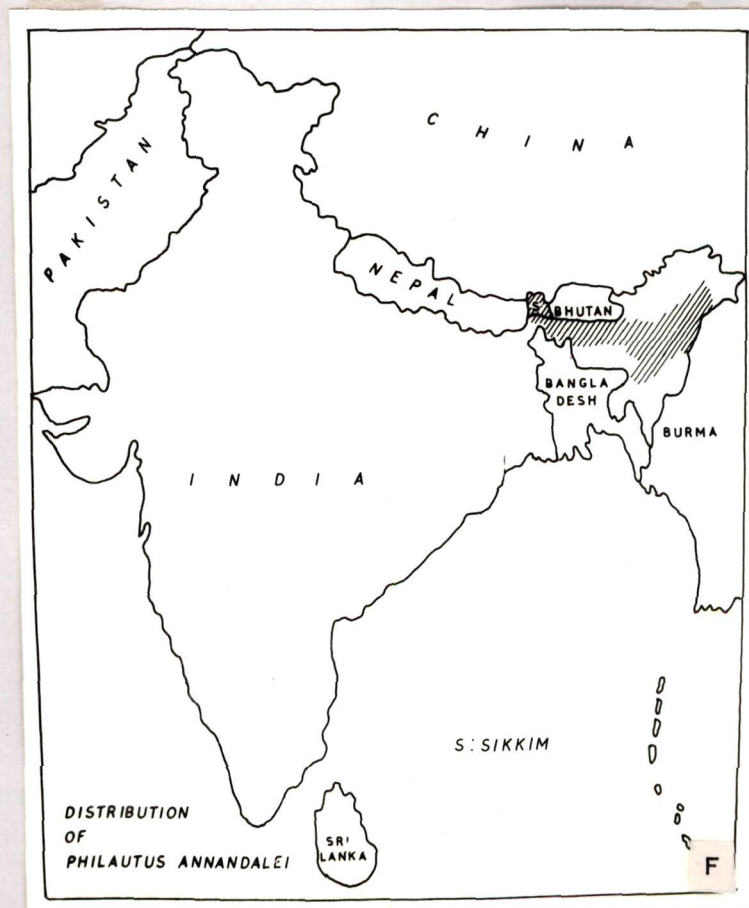
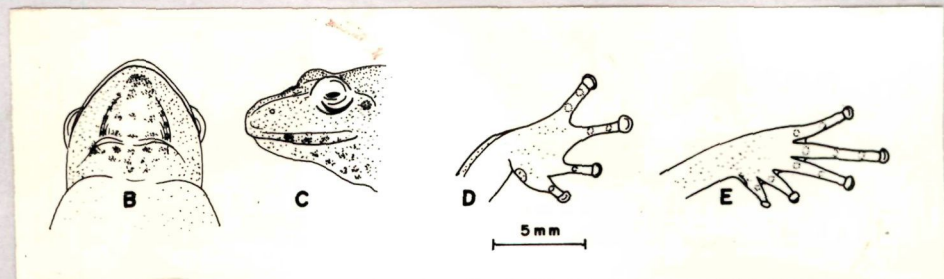


PLATE 2.20

oval inner metacarpal tubercle. Subarticular tubercles indistinct, round, single. Length of fingers: $1 < 2 < 4 < 3$.

Hindlimbs short. Tibio-tarsal articulation reaching at the eye level when passed forward along the body. Toes are webbed rudimentary, web present between 3rd and 4th toes and 4th and 5th toes. Toes with oval discs, size of discs: $1 < 2 < 3 < 5 < 4$. There is 1 oval inner metatarsal tubercle. Subarticular tubercles indistinct, round, single. Length of toes: $1 < 2 < 3 < 5 < 4$.

Skin of dorsum and belly coarsely granular. Vocal sacs present in the male during breeding period. Tympanic fold and sacral hump visible.

Colour of dorsum greyish dark. A dark V-shaped marked inter-connecting the eye orbits. An indistinct H-shaped dark mark on the dorsum. Tympanal fold is tint orange-red. Belly dark with dispersed white patches.

Measurements: Table 2.20.

Habit and habitat: A nocturnal as well as diurnal arboreal frogs, found mostly on leaves and in bushes during summer. Occur in cool and hilly places.

Breeding: They breed by May till July. During this period, males sit on leaves and croak frequently.

Economic use: It is not edible frog species.

Range and distribution: Collected from Science College Campus, at an altitude of 1982.5 m a.s.l. Annandale (1912) reported it from Assam, Sikkim at an altitude between 4000-5000 ft. and Pillai and Chanda (1976) also reported it from Assam.

Table 2.20: $\bar{X}$ Measurements of Phyllautus annandalei.

Characters	Male (mm) N = 2
Snout-vent length	18.0
Head width minimum	1.9
Head width maximum	9.0
Head length	7.5
Eye diameter	2.75
Inter-ocular distance	2.5
Nostril diameter	0.5
Inter-narial distance	1.75
Distance between eye and nostril	1.83
Distance between nostril and tip of snout	1.45
Tympanum diameter	1.0
Hindlimb length	26.0
Tibia length	9.25
5th toe length	3.5
Forelimb length	9.0
Lower forelimb length	5.0
1st finger length	1.5
2nd finger length	2.0

2.4.21 Microhyla ornata (Dumeril and Bibron, 1841).

(Diplasiocoela: Microhylidae: Microhylinae).

Plate 2.21A, B, C, D, E and F

Engystoma ornatum Dumeril and Bibron, Erpetologie Generale, 1841
(8): 745.

Microhyla ornata, Parker, Mon. Micro., 1934: 139.

Diagnosis: A small frog, SVL of males 21-22 mm and of females 23-24 mm. Skin of dorsum coarsely granular, belly smooth. Rear of casque outline of head present. Vomerine and maxillary teeth lacking. Pupil circularly oval. Tympanum hidden. Fingers free, toes webbed. Fingers and toes with swollen tips. First finger shorter than 2nd finger. Tibio-tarsal articulation not reaching eye level. Colour of dorsum slate grey, pink or red. A black branch spreading on the dorsum. Belly white.

Description: A very small frog. Snout-vent length of males 21-22 mm and of females 23-24 mm.

Head small, broader than long, slightly depressed. Snout round in dorsal, acuminate in lateral profile, projecting over the mouth. Distance between eye and nostril as long as the horizontal diameter of the eye, 1.3 times the distance between nostril and tip of snout. Eyes are small, bulging, pupil circular. Tympanum hidden.

Vomerine teeth wanting. Upper and lower jaws without teeth. Tongue oval, unforked.

Forelimbs very short, small. Fingers are free. Fingers ended with swollen tips. There are 3 oval metacarpal tubercles. (outer tubercle largest and innermost smallest and middle one medium

Plate 2.21A Microhyla ornata female.

Plate 2.21B Ventral view of head.

Plate 2.21C Lateral view of left side of head.

Plate 2.21D Ventral view of right hand.

Plate 2.21E Ventral view of right foot.

Plate 2.21F Range and distribution.

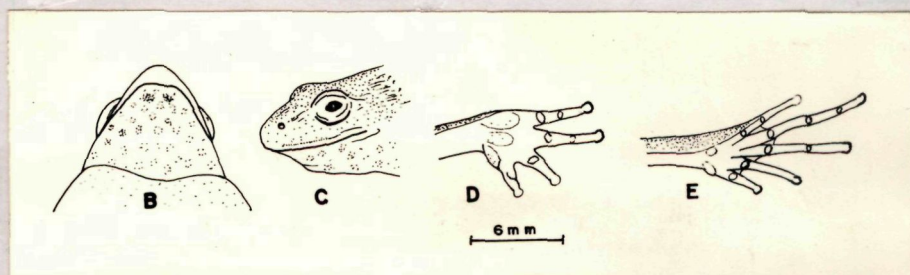


PLATE 2.21

sized). Subarticular tubercles distinct, round, single. Length of fingers: $1 < 2 < 4 < 3$.

Hindlimbs short, muscular. Tibio-tarsal articulation not reaching at the eye level when passed forward along the body. Toes are webbed rudimentary, webbing formula: $1(2)$, $2i(2)$, $2e(2)$, $3i(2\frac{1}{2})$, $3e(2)$, $4i(3)$, $4e(3)$, $5(1\frac{1}{4})$. Toes with swollen tips. There are 2 metatarsal tubercles, outer tubercle round, small and inner oblong, large. Subarticular tubercles distinct, oval, single. Length of toes: $1 < 2 < 5 < 3 < 4$.

Skin of dorsum coarsely granular. Rear of casque outline demarcates the small head. A warty line extends from the head to the pelvic region dorsally. Belly smooth. Vocal sacs present in male during breeding season. Tympanic fold present. Pectoral fold across the chest is prominent.

Colour of dorsum slate grey, pink, red. Black branches spreading out from mid-dorsum dark line to both lateral sides. A black plate on each lateral side from snout to waist. Belly white with patches of black spots under the chest and throat. Dark cross-bars on limbs.

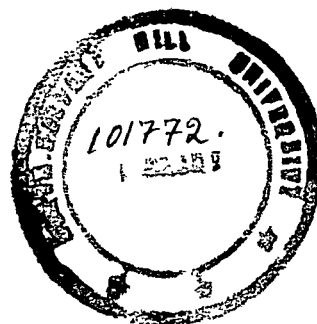
Measurements: Table 2.21.

Habit and habitat: A nocturnal frog. They hide inside crevices in paddy fields during winter and become active during summer.

Breeding: They breed from June to July in paddy fields and pools. During this period, males sit in shallow depressions 2-3 feet away from water body and croak at night. Females deposit small eggs in the water.

Table 2.21: Measurements of Microhyla ornata.

Characters	Male (mm) N = 2	Female (mm) N = 2
Snout-vent length	21.5	23.5
Head width minimum	1.5	1.6
Head width maximum	7.0	7.5
Head length	5.25	7.0
Eye diameter	2.0	2.5
Inter-ocular distance	3.25	3.75
Nostril diameter	0.5	0.5
Inter-narial distance	2.5	2.75
Distance between eye and nostril	2.0	1.9
Distance between nostril and tip of snout	1.5	1.6
Tympanum diameter	-	-
Hindlimb length	33.5	34.5
Tibia length	12.0	13.0
5th toe length	3.5	4.75
Forelimb length	7.0	7.75
1st finger length	1.5	1.5
2nd finger length	1.8	2.0
Lower forelimb length	5.0	6.0



Economic use: This frog species is not edible.

Range and distribution: This species was collected from Touliezie, and Merübotsa at an altitude between 1410-1440 m a.s.l. Its distribution also extends in Thailand, India, Ceylon, Southern China, Indo-China, Formosa and Malaya (Taylor, 1962), India, Burma, Ceylon, Southern China (Satyamurti, 1967) and Pakistan (Khan, 1974 and 1979). Pillai and Chanda (1981) reported it also from Garo Hills of Meghalaya in north-eastern India.

2.4.22 Key.

Key to the Genera of Anurans of Kohima, based on morphology

(Those with single species are indicated in parenthesis).

- | | | |
|---|-----|--|
| 1. Maxillary teeth present | - - | 2 |
| Maxillary teeth absent | - - | 9 |
| 2. Fingers free | - - | 3 |
| Fingers webbed | - - | 6 |
| 3. Pupil horizontally oval | - - | 4 |
| Pupil vertically oval | - - | <u>Megophrys</u> |
| 4. Fingers without discs, if discs present small, no groove separating upper and lower surfaces of discs | - - | 5 |
| Fingers with large discs, upper surface of discs separated from lower by a groove | - - | <u>Amolops</u> (<u>afghanus</u>) |
| 5. Large flaps of skin on each lateral side of the body and thighs | - - | <u>Pterorana</u> (<u>khare</u>) |
| No flaps of skin on the lateral side of the body and thighs | - - | <u>Rana</u> |
| 6. Vomerine teeth present | - - | 7 |
| Vomerine teeth absent | - - | 8 |
| 7. Tongue monofid, nicked behind | - - | <u>Hyla</u> (<u>annectens</u>) |
| Tongue bifid, not nicked behind | - - | <u>Rhacophorus</u> |
| 8. Finger discs large, two dorsolateral stripes present, inner two fingers separated and opposite to the outer two fingers. | - - | <u>Chirixalus</u> (<u>vittatus</u>) |
| Finger discs small, no dorsolateral stripes, inner fingers not separated and opposite to the outer fingers | - - | <u>Philautus</u> (<u>annandalei</u>) |
| 9. Tympanum distinct, parotoid glands present | - - | <u>Bufo</u> (<u>melanostictus</u>) |
| Tympanum hidden, parotoid glands absent | - - | <u>Microhyla</u> (<u>ornata</u>) |

Key to the Species of Anurans of Kohima
(Those genera with more than 1 species).

Genus : Megophrys

1. Head as broad as long, 1st finger shorter or equal with 2nd finger - - 2
 Head broader than long, 1st finger longer than 2nd finger - - dzünarü
2. Skin of dorsum rough, tympanum 1/2th the eye diameter, 1st finger shorter than 2nd finger. - - boettgeri
 Skin of dorsum warty, tympanum as large as eye diameter, 1st finger equal with 2nd finger. - - monticola

Genus : Rhacophorus

1. Colour of dorsum leafy green, fingers webbed almost upto the discs. - - 2
 Colour of dorsum greyish brown or green, finger webbed at the base. - - 3
2. Two black spots on the axilla, tibio-tarsal articulation reaching beyond eye level. - - reinwardtii
 No black spots on the axilla, tibio-tarsal articulation not reaching eye level - - nigropalmatus
3. Colour of dorsum greyish green, a row of tubercles on underside of carpal and tarsal. - - bisacculus
 Colour of dorsum greyish brown, no tubercles on underside of carpal and tarsal. - - leucomystax

Genus : Rana

- | | |
|--|---------------------------|
| 1. Digits are with discs at the tips | - - 2 |
| Digits are without discs at the tips | - - 3 |
| 2. Large dorso-lateral folds present, colour dorsum pinkish grey and brown, tibio-tarsal articulation reaching eye level | - - <u>nagalandsis</u> |
| No dorso-lateral folds, colour of dorsum deep green, tibio-tarsal articulation reaching beyond the tip of snout. | - - <u>mawphlangensis</u> |
| 3. Tympanum distinct | - - 4 |
| Tympanum hidden | - - <u>liebigii</u> |
| 4. Tympanum 3/4th or as large as eye diameter, external vocal sacs in male, 1st finger longer than 2nd finger | - - 5 |
| Tympanum 1/2th the eye diameter, 1st finger shorter than 2nd finger. | - - <u>verrucosa</u> |
| 5. Skin of dorsum with longitudinal broken ridges, mid-dorsal white line mostly present. | - - 6 |
| Skin of dorsum granular and tuberculated, no mid-dorsal white line. | - - <u>cyanophlyctis</u> |
| 6. Colour of dorsum slate-grey and brown, small size frogs. | - - <u>limnocharis</u> |
| Colour of dorsum yellowish grey and green, large size frogs. | - - <u>tigrina.</u> |

2.5.1 TAXONOMY AND SYSTEMATICS

Taxonomic identification of the 21 species described is based both on the study of the skeletal features as well as external morphology. The distribution and relationship of these species can be discussed separately under families to which they belong.

(i) Pelobatidae

The distribution of pelobatids has been reported across the northern hemisphere from Mexico and United States to South-East Asia and Philippines (Noble, 1931). Two different species of Megophrys, viz. Megophrys monticola and Megophrys boettgeri have been reported from Arunachal Pradesh (Annandale, 1912) and Meghalaya (Pillai and Chanda, 1979) respectively in the north-eastern India. The distribution of Megophrys monticola extends in Thailand, Borneo, Sumatra, Java and Philippines (Heusser, 1974). In the present investigation, it has been found in Nagaland. The second species has been identified as Megophrys boettgeri by Chanda at Zoological Survey of India, Calcutta (personal communication). And the third one Megophrys dzünarü is clearly a new species. The status of these 3 species under the same genus have been confirmed with the common features of skeleton as well as morphologically (vertically oval pupil, tympanum indistinct, fingers free, subarticular tubercles absent, vertebral column procoelous, sacral diapophyses greatly dilated, omosternum unforked, coracoid medially overlapped).

It is interesting that these 3 species belong to one natural group Megophryinae which seems to have extended across Burma into Nagaland.

(ii) Bufonidae

I have been able to collect and describe only species Bufo melanostictus. It is a common species distributed throughout south-east Asia including Indian subcontinent (Cochran, 1961 and Heusser, 1974). In the north-eastern India, it was first reported from Dibrugarh by Annandale (1912). It shows wonderful adaptation to hot plains where temperature exceeds 40°C as well as to cold hills more than 3000 m in Himalayas (Satyamurti, 1967) where temperature may reach 0°C or less.

(iii) Hylidae

Hyla annectans is the only species belonging to the family Hylidae described in this work from Nagaland. Though, Noble (1931) doubted its occurrence in Indo-Malayan region, Taylor (1962) reported it from Thailand and Heusser (1974) mentions its distribution in north-eastern India and its neighbouring countries also. I have confirmed the species with the help of the skeletal (vertebral column procoelous, dilated sacral diapophyses, unforked omisternum, presence of intercalary cartilage) as well as external features (tongue nicked at hinder margin, discoloured male throat, large discs). Jerdon (1870) reported it for the first time from Meghalaya at the north-eastern hills of India.

(iv) Ranidae

As many as 18 ranid species exist in north-eastern India (Pillai and Chanda, 1976). I have been able to collect 9 ranid species from Kohima district of Nagaland. Out of these, Amolops afghanus, Rana tigrina, Rana limnocharis, Rana verrucosa, Rana cyanophlyctis, Rana mawphlangensis and Rana liebighii have been included in the list by Pillai and Chanda (1976) also. Rana tigrina

and Rana cyanophlyctis are common in lower altitude and Rana limnocharis is common in warmer plains as well as at higher altitude. Other species, Amolops afghanus, Rana verrucosa, Rana mawphlangensis, Rana liebigii are restricted to higher altitudes only.

I have been able to collect 2 new ranid specimens: 1 new species and 1 new genus. The new species has been named Rana nagalandsis. It has morphological characters different from those of 7 species mentioned above particularly the dorso-lateral folds which are specific to this species. It is commonly available during October and November in Kohima.

I have erected a new genus Pterorana (Ptero (Gr.)- wing, rana (L.)- frog) for the second specimen, due to the presence of peculiar wing like flaps on the lateral sides of the body and thighs and extensive webbing in the toes not reported in any other ranids. These flaps are extended when the frog is in water and contract when the frog is taken out of water. The frog is mainly aquatic in habit and is seen to glide also. The name of the species Pterorana khare is assigned after the supervisor with whom I have been working.

(v) Rhacophoridae

The distribution of rhacophorids extends in Africa, Madagascar and South-East Asia (Cochran, 1961). Of the 6 rhacophorids described in this work from Nagaland, Rhacophorus reinwardtii, Rhacophorus leucomystax and Rhacophorus nigropalmatus have been recorded earlier from other parts of north-eastern India also (Pillai and Chanda, 1976) but Rhacophorus bisacculus identified by Dr. Hoogmoed (personal communication) is a new record from this region and even in India. It is known to occur in Northern Thailand only (Taylor, 1962). The other 2 species are, Philautus annandalei reported also by Annandale

(1912) and Pillai and Chanda (1976) from Assam and Chirixalus vittatus reported by Boulenger (1887) from Burma and Taylor (1962) from Thailand. It is also identified by Dr. Hoogmoed (personal communication); and is a new record from Indian subcontinent. Since, Upper Burma is adjacent to the state of Nagaland, distribution of Chirixalus vittatus extending to Nagaland seems logical.

(vi) Microhylidae

Microhylids are brevipitids, having narrow mouth. Their distribution has been reported from south-eastern Asia and adjoining islands, America, Africa and Madagascar (Noble, 1931 and Cochran, 1961). Microhyla ornata, the only microhylid species which I have described from Nagaland has been reported earlier from other parts of north-eastern India also (Pillai and Chanda, 1976).

2.5.2 VERTICAL DISTRIBUTION

The distribution of anurans studied here extends in different altitudes, ranging between 183-2440 m a.s.l. Though, Rana limnocharis, Rhacophorus leucomystax and Bufo melanostictus occupy widest range of altitude (183-1982.5 m a.s.l.), Rana verrucosa and Megophrys monticola are found at higher altitude (2135-2440 m a.s.l.), and Rana tigrina and Rana cyanophlyctis at lower altitude (183-305 m a.s.l.). Megophrys boettgeri, Megophrys dzünarü, Hyla annectens, Rana mawphlangensis, Rana liebighi, Rana nagalandsis, Amolops afghanus, Pterorana khare, Rhacophorus reinwardtii, Rhacophorus nigropalmatus, Rhacophorus bisacculus, Philautus annandalei, Chirixalus vittatus and Microhyla ornata occupy at an altitude between 1400-1982.5 m a.s.l. North-eastern hills of India particularly hills of Nagaland obviously provide a very congenial biotope in eastern tropics for species diversity and the distribution of frogs and toads.

This chapter deals with a survey and systematics of anuran fauna of Kohima district of Nagaland. In all, following 21 species classified under 10 genera, 6 families and 3 suborders have been described. This includes 2 new records, 1 new genus and 3 new species first described from Indian subcontinent.

Suborder: Anomocoela; Family: Pelobatidae; Subfamily: Megophryinae.

(1) Megophrys monticola: SVL of young adult 14-17 mm, dorsum skin greyish dark or brown and warty, belly dark and granular, vomerine and maxillary teeth present, vertically oval pupil, indistinct tympanum and as large as eye diameter, free fingers and webbed toes both with swollen tips, 1st finger as long as 2nd, TTA (tibio-tarsal articulation) reaching eye level.

(2) Megophrys boettgeri: SVL male: 30-35 mm, female: 43 mm, dorsum skin greyish brown, pinkish and rough, belly dark and granular, vomerine and maxillary teeth present, vertically oval pupil, indistinct tympanum and 1/2 the eye diameter, free fingers and webbed toes both with swollen tips, 1st finger shorter than 2nd, TTA reaching eye level.

(3) Megophrys dzünarü (sp. nov.): SVL male: 93 mm, dorsum skin dark-grey and minutely granular, belly pinkish yellow and smooth, small dorso-lateral folds present, vomerine and maxillary teeth present, vertically oval pupil, indistinct tympanum and 1/2 the eye diameter, free fingers and webbed toes both with swollen tips, 1st finger longer than 2nd, TTA reaching eye level.

Suborder : Procoela

Family : Bufonidae; Subfamily: Bufoninae

(1) Bufo melanostictus: SVL male: 52-89 mm, female: 103 mm, dorsum skin grey or dark and warty, belly grey and rough, vomerine and maxillary teeth lacking, horizontally oval pupil, parotoid glands present, distinct tympanum and $2/3$ rd the eye diameter, free fingers and webbed toes both with slightly dilated tips, 1st finger longer than 2nd, TTA reaching eye level.

Family : Hylidae; Subfamily: Hylinae

(1) Hyla annectens: SVL male: 31-41 mm, female: 41-49 mm, dorsum skin leafy green and smooth, belly white or yellow and coarsely granular, tongue nicked at the hinder margin, vomerine and maxillary teeth present, horizontally oval pupil, distinct tympanum and $2/3$ rd the eye diameter, webbed fingers and toes both with large discs (3rd and 4th finger discs larger than tympanum), 1st finger shorter than 2nd, TTA not reaching eye level.

Suborder : Diplasiocoela

Family : Ranidae; Subfamily: Raninae

(1) Amolops afghanus: SVL male: 73-77 mm, female: 94-107 mm, dorsum skin slate grey or pale green or dark and coarsely granular, belly dark-brown and rough, vomerine and maxillary teeth present, horizontally oval pupil, indistinct tympanum and $1/3$ rd the eye diameter, free fingers and webbed toes both with large discs (Finger discs larger than tympanum), 1st finger shorter than 2nd, TTA reaching snout level.

(2) Rana mawphlangensis: SVL male 110 mm, dorsum skin green and smooth and white belly, vomerine and maxillary teeth present,

horizontally oval pupil, distinct tympanum and $1/3$ rd the eye diameter, free fingers and webbed toes both with large discs (3rd and 4th finger discs larger than tympanum), 1st finger shorter than 2nd, TTA reaching beyond the snout.

(3) Rana naqalandsis (sp. nov.): SVL male: 49-52 mm, female: 66-68 mm, dorsum skin pinkish grey or brown and smooth, belly white and rough, dorso-lateral folds very distinct, vomerine and maxillary teeth present, horizontally oval pupil, distinct tympanum and $1/2$ the eye diameter, free fingers and webbed toes both with discs, 1st finger shorter than 2nd, TTA reaching eye level.

(4) Rana liebigii: SVL male: 109 mm, dorsum skin darkish brown and warty, belly light grey and smooth, a distinct fold across the head behind the eyes, large dorso-lateral glandular folds broken up into chain of warts present, vomerine and maxillary teeth present, tympanum hidden, free fingers and webbed toes both with obtuse tips, 1st finger *as long as* 2nd, conical black horny spines on the first three fingers, TTA reaching snout level.

(5) Rana verrucosa: SVL female: 55 mm, dorsum skin greyish dark and coarsely granular, belly dirty white and smooth, vomerine and maxillary teeth present, horizontally oval pupil, distinct tympanum and $1/2$ the eye diameter, free fingers and webbed toes both with swollen tips, 1st finger ~~shorter~~ than 2nd, TTA reaching nostril level.

(6) Rana cyanophlyctis: SVL male: 33-37 mm, female: 55-58 mm, dorsum skin slate grey or pale and coarsely granular, belly white and smooth, a rear of casque outline of head present, vomerine and maxillary teeth present, horizontally oval pupil, distinct

tympanum and $3/4$ th the eye diameter, free fingers and webbed toes both with swollen tips, 1st finger longer than 2nd, TTA reaching eye level.

(7) Rana limnocharis: SVL male: 31-33 mm, female: 43-65 mm, dorsum skin slate grey or brown and coarsely granular, belly white and smooth, granular broken ridges on dorsal surface, vomerine and maxillary teeth present, horizontally oval pupil, distinct tympanum and $5/6$ th the eye diameter, free fingers and webbed toes both with bluntly pointed tips, 1st finger longer than 2nd. TTA reaching eye or nostril level, a mid-dorsal white line or 2-3 reddish spots on the dorsal surface.

(8) Rana tigrina: SVL male: 93-105 mm, female: 130-132 mm, dorsum skin yellowish green or grey and coarsely granular with mid-dorsal stripe and broken ridges on the dorsal surface, belly white and granular, vomerine and maxillary teeth present, horizontally oval pupil, distinct tympanum and as large as eye diameter, free fingers and webbed toes both with swollen tips, 1st finger longer than 2nd, TTA reaching snout level.

(9) Pterorana khare (gen. and sp. nov.): SVL male: 53-62 mm, dorsum skin slate dark or brown and coarsely granular, belly white and smooth, dorso-lateral ridge distinct, large flaps of skin on each lateral side of the body and thigh, vomerine and maxillary teeth present, horizontally oval pupil, indistinct tympanum and $1/2$ the eye diameter, free fingers and webbed toes both with discs, 1st finger longer than 2nd, horny spines on 1st finger, TTA reaching snout level.

Family : Rhacophoridae; Subfamily : Rhacophorinae.

- (1) Rhacophorus leucomystax: SVL male: 38-65 mm, female: 40-75 mm, dorsum skin grey or brown with spotted or striped or broken striped or an X-shaped marked behind the eye and belly white and coarsely granular, vomerine and maxillary teeth present, horizontally oval pupil, distinct tympanum and 2/3rd the eye diameter, webbed fingers and toes both with large discs (3rd and 4th finger discs larger than tympanum), 1st finger shorter than 2nd, TTA reaching nostril level.
- (2) Rhacophorus reinwardtii: SVL male: 46-48 mm, female: 63 mm, dorsum skin slate or leafy green and smooth, belly yellowish white and rough, vomerine and maxillary teeth present, indistinct tympanum and 4/5th the eye diameter, webbed fingers and toes both with large discs (2nd, 3rd and 4th finger discs larger than tympanum), 1st finger shorter than 2nd, TTA not reaching eye level.
- (3) Rhacophorus nigropalmatus: SVL male: 65-80 mm, female: 92-95 mm, dorsum skin leafy green or dark green and smooth, belly yellowish white and rough, vomerine and maxillary teeth present, horizontally oval pupil, indistinct tympanum and 2/3rd the eye diameter, webbed fingers and toes both with large discs (2nd, 3rd and 4th finger discs larger than tympanum), 1st finger shorter than 2nd, TTA not reaching eye level.
- (4) Rhacophorus bisacculus: SVL male: 30-35 mm, female: 38-46 mm, dorsum skin greyish green with a green star-shaped, belly white, vomerine and maxillary teeth present, horizontally oval pupil, distinct tympanum and 2/3rd the eye diameter, webbed fingers and

toes both with large discs (3rd, and 4th finger discs larger than tympanum), 1st finger shorter than 2nd, TTA not reaching nostril level.

(5) Chirixalus vittatus: SVL male: 23-24 mm, female: 24-27 mm, dorsum skin yellow or grey or green with a pair of white stripes on the dorso-lateral and coarsely granular, belly white or yellow and smooth, vomerine teeth wanting, maxillary teeth present, horizontally oval pupil, indistinct tympanum and $1/2$ the eye diameter, webbed fingers and toes both with large discs (2nd, 3rd and 4th finger discs larger than tympanum), 1st finger shorter than 2nd, TTA reaching eye level.

Subfamily : Philautinae

(1) Philautus annandalei: SVL male: 17-19 mm, dorsum skin greyish dark and warty and belly dark, vomerine teeth lacking, maxillary teeth present, horizontally oval pupil, indistinct tympanum and $1/3$ rd the eye diameter, free fingers and webbed toes both with small oval discs, 1st finger shorter than 2nd, TTA reaching eye level.

Family : Microhylidae; Subfamily : Microhylinae.

(1) Microhyla ornata: SVL male: 21-22 mm, female: 23-24 mm, dorsum skin slate grey or pink or red and coarsely granular, belly white and smooth, rear of casque outline of head present, vomerine and maxillary teeth lacking, circular oval pupil, tympanum hidden, free fingers and webbed toes both with swollen tips, 1st finger shorter than 2nd, TTA not reaching eye level.

The vertical distribution of these species has been discussed.

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PART II
ECOBIOLOGY AND DEVELOPMENT
OF
Rhacophorus leucomystax (Kuhl)

CHAPTER 3
Morphometric Analysis
and
Annual Breeding Cycle

Rhacophorus leucomystax is a common species of frog at Kohima, and neighbouring hills of Nagaland in the North-Eastern India. Its systematic position is:

Phylum : Chordata
Sub-phylum : Gnathostomata
Class : Amphibia
Order : Anura (Salientia)
Sub-order : Diplasiocoela
Family : Rhacophoridae
Sub-family : Rhacophorinae
Genus : Rhacophorus
Species : leucomystax (Kuhl)

Rhacophorus leucomystax is widely distributed in India, Ceylon, China, Formosa, Philippines, Indonesia, Malay Peninsula and Java (Cochran, 1961; Church, 1963 and Heusser, 1974). Pillai and Chanda (1976) reported it from the hills of Meghalaya and also from Arunachal Pradesh. Mansukhani and Sarkar (1981) reported it from Tripura. And now the present author has found it to be a common species of frog at Kohima and neighbouring hills of Nagaland. The taxonomic characters of this species have been described in section 2.4.15.

This chapter deals with the morphometric analysis and a study of the annual breeding cycle of the population of Rhacophorus leucomystax found in Kohima. There are few contributions on the morphometric analysis of different populations of Rhacophorus

leucomystax (Boulenger, 1890; Wolf, 1936; Church, 1963 and Pillai and Chanda, 1979 and 1981), but none on this population. Early references on annual breeding cycles of various anurans have been included by Noble (1931), Wright and Wright (1933), Cochran (1961) and Rugh (1962). Subsequently, many more descriptions of annual breeding cycles have appeared, e.g. Kminiak (1971) on Bombina variegata, Bufo bufo and Rana temporaria, Clarke (1974) on Bufo woodhousei fowleri, Koskela (1975) on Rana temporaria, Harris (1975) on Hyla cadaverina, Toft (1980) on Bufo, Atelopus, Dendrobates, Colostethus and Eleutherodactylus. Recently, annual breeding cycles of 2 frog species, Rana limnocharis and Rana cyanophlyctis inhabiting the North-Eastern hills of India have been described by Roy (1979) and Kumar (1982) respectively. The present work on Rhacophorus leucomystax will be the third study on annual breeding cycle of an anuran from North-Eastern hills of India.

3.2

REVIEW OF LITERATURE

3.2.2

MORPHOMETRIC STUDIES

Review of literature shows that there are not many contributions on the morphometric analysis of rhacophorids. Boulenger (1890) and Wolf (1936) noticed the dorsal patterns of Rhacophorus leucomystax maculatus bearing spots with interorbital cross-bar and an X-shaped on the dorsum behind the eyes. Church (1963) mentioned that, 4 dark bands run anteroposteriorly along the back in the case of Rhacophorus leucomystax quadrilineatus. These 2 sympatric species having various patterns indicate the multiple genes expression as a result of interbreeding in the past between Rhacophorus leucomystax and Rhacophorus crucifer crucifer (Church, 1963). Pillai and Chanda (1979 and 1981) examined specimens of Rhacophorus leucomystax from the hills of Meghalaya and recorded different dorsal patterns such as spotted pattern and striped pattern. They measured that the SVL of the specimens of this species from Khasi Hills was 3.7 - 5.4 cm and Garo Hills was 7.5 cm. For references on morphometric contributions on other anurans, special mention may be made of Boulenger (1920), Tinsley (1973 and 1975), Hoogmoed (1979). Certain workers have laid emphasis on morphometric ratios (Van Dijk, 1966; Altig, 1970 and Tinsley, 1973).

3.2.2

ANNUAL BREEDING CYCLES

As to the annual breeding cycles, many early references on the annual breeding pattern of frogs and toads have been included in text books (e.g. Noble, 1931; Wright and Wright, 1933 and Cochran, 1961) and laboratory manuals (e.g. Rugh, 1962).

Though seasonal variations influence their life activity to a great deal, meteorological factors have been noted to influence their behaviour and their breeding pattern.

(1) Seasonal influence and phases in annual breeding cycles:

The activity of anurans has been observed to be influenced by seasonal variation. Duellman and Klaas (1964) observed that in Mexico the hylid frog, Triprion petasatus seeks refuge in tree holes by day and in the dry season, and comes to breed in pits during the rainy season. Satyamurti (1967) mentioned that Rana limnocharis spawns at the onset of monsoon and aestivates during the dry season under stones and damp places in south India. Koskela (1975) divided the annual breeding cycle of Rana temporaria into 6 phases: (1) Entering the winter place, (2) Wintering, (3) Preemerging, (4) Emerging, (5) Spawning and (6) Feeding. Harris (1975) observed that Hyla cadaverina perches on large boulders near deep pools of water along the course of streams during spring and summer and they move into deep moist crevices in winter located on the hill sides surrounding the streams. Roy (1979) divided the annual breeding cycle of Rana limnocharis into 4 periods: (1) Emerging and prebreeding period, (2) Breeding period, (3) Entering and postbreeding period and (4) Hibernation period. Toft (1980) reported that various species of Bufo, Atelopus, Dendrobates, Colostethus and Eleutherodactylus occur in the leaf litters in the rain forest in Panama but become more abundant in the dry season when there is an abundance of preys. Kumar (1982) divided the annual breeding cycle of the water frog, Rana cyanophlyctis to 3 phases such as (1) Prebreeding phase, (2) Breeding phase and (3) Postbreeding phase. It does not hibernate.

(ii) Meteorological influence:

In addition to seasonal variation it has been observed that the activity of anurans is greatly influenced by meteorological factors individually such as rain, temperature, humidity and photoperiod. Van Gelden and Domen (1970) reported that the breeding choruses and spawning of Rana arvalis are confined to a short period at temperature 4°C to 10°C. Kminiak (1971) observed that certain climatic factors such as temperature of water, atmosphere and air humidity influence the seasonal cycle of the amphibian species to a great deal in Spisska Magura. Koskela (1973) noticed the maximum breeding migration of Rana temporaria at 84% air humidity and during mid day and bright sunshine they become inactive for 2 hours. Clarke (1974) reported that the activity of Bufo woodhousei fowleri reduces when night temperature drops rapidly than on nights when it varies little. Hulse (1979) mentioned the reproduction in Pleurodema cinerea is initiated by rain. Dimmitt and Ruibal (1980) have reported that the emergence of Scaphiopus species is influenced by rainfall. Uwa, Watanabe, Sakakura, Asai and Shiono (1981) have investigated that the spring emergence of Bufo bufo formosus is influenced by the underground temperature. Bider and Morrison (1981) while studying the responses of Bufo americanus to abiotic factors, have observed the activity is increased with rainfall in St. Lawrence Valley and the activity is less peaked after sunset in the far northern part. Jaeger and Hailman (1981) studied the activity of neotropical frogs in relation to ambient light. They reported that Bufo marinus and Leptodactylus pendactylus become active at night, the former in brighter open places and the latter in dimmer forest. The

Dendrobates auratus had 2 types of daily activity one period in the early morning and the other in late evening, whereas, Bufo typhonius and Physalaemus pustulosus become active during the day, the former in the dimmer forest and the latter in the brighter open areas. Haapanen (1982) reported that the spawning of Rana temporaria in Finland begins in spring 1 day after the daily temperature exceeds 5°C. Miyamoto (1982) described the vertical habitat of the frog, Eleutherodactylus species at Costa Rican, and reported that the diurnal frogs become ground-active but at night active individuals become arboreal.

Specimens of Rhacophorus leucomystax were collected from a number of places at Kohima throughout the year. The specimens were brought to the laboratory, their colour patterns were noted down and they were narcotised by chloroform and preserved in 7% formalin. Out of these, 40 adult males and 40 adult females were selected for the morphometric analysis (SVL 38 mm and above for males and 40 mm and above for females). The moist body surface was blotted out and the weight of each frog was taken. Morphometric analysis has been based mainly on the established criteria (Boulenger, 1920; Tinsley, 1973 and 1975; Pillai and Chanda, 1977 and Hoogmoed, 1979). The measurements were taken with a divider. For the study of annual breeding cycle of this species, criteria of Koskela (1973) has been followed.

3.4.1 Morphometric Analysis:(i) Size and Weight:

The snout-vent length (SVL) of the frogs in the sample investigated ranged from 38 mm - 75 mm; 38 mm - 65 mm for males with a mean of 49.2 mm and 40 mm - 75 mm for females with a mean of 56.7 mm as given in the Table 3.1.

The body weight ranged from 5.0 gm - 37.95 gm; males being 5.0 gm - 18.2 gm with a mean of 10.72 gm and females being 5.5 gm - 37.95 gm with a mean of 15.45 gm.

(ii) Distinguishing characters of male: and female:

The males and females of Rhacophorus leucomystax can be distinguished by the following diagnostic characters :

Male (Fig. 3A)

- i) Males are smaller and lighter as compared to the females.
- ii) Body is slender and streamlined.
- iii) Males have concealed vocal sacs and produce croaking sound.
- iv) During breeding season males have a faint thumb-pad at the base of the thumb.

Female (Fig. 3B)

- i) Females are larger and heavier than the males.
- ii) Abdomen is distended and slightly bulged. Bulging depends upon the maturity of the ova in ovaries.
- iii) Females are devoid of vocal sacs and voice.
- iv) Females sometimes have translucent skin on the groin, through which the ova can be seen.

Fig. 3A : Dorsal view of Rhacophorus leucomystax male.

Fig. 3B ; Dorsal view of Rhacophorus leucomystax female.

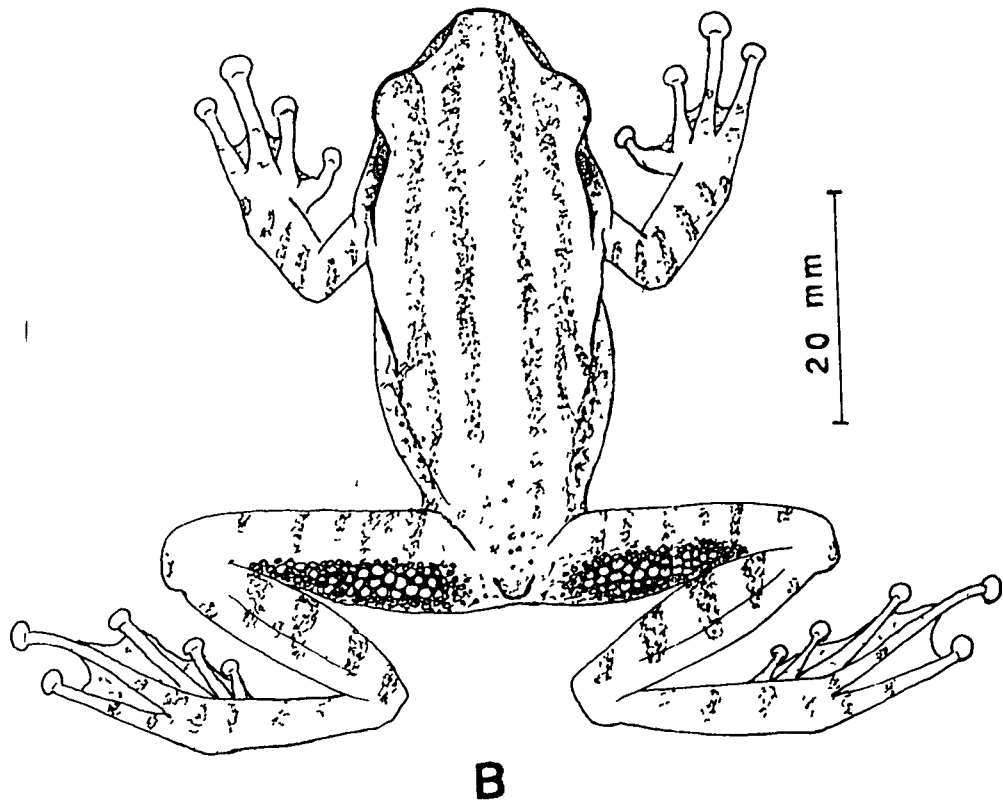
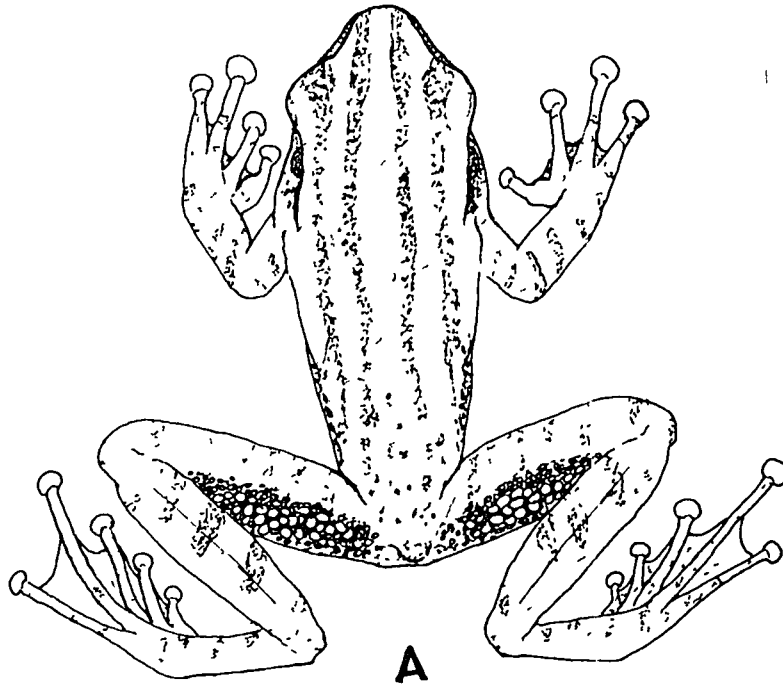


Fig 3

(iii) Diagnostic characters:

A moderate frog. The skin of dorsum and the belly is coarsely granular. The colour of dorsum is grey and brown. The head is as broad as long. The snout is pointed. The pupils are horizontally oval. The tympanum is distinct and $2/3$ rd of the horizontal eye diameter. The vomerine teeth is strong. The upper jaw toothed and the lower jaw without teeth. The fingers are webbed at the base and the toes are almost webbed completely. The fingers and toes have large discs. The 3rd and 4th finger discs are larger than the tympanum. The tibio-tarsal articulation reaches the nostril level.

(iv) Dorsal patterns:

The specimens examined bear various dorsal patterns, such as (i) striped pattern, (ii) spots with interorbital cross-bar pattern, (iii) broken striped pattern and (iv) an X-shaped mark behind the eyes on the dorsum.

(v) Absolute measurements:

In the present study 18 absolute measurements have been considered. The sample had 40 adult males and 40 adult females. Unlike Table 2.15, Table 3.1 provided here includes range and S.D. also.

(vi) Morphometric ratios:

In all, 8 morphometric ratios have been worked out for different size ranges of the specimens in the sample (see Table 3.2).

Table 3.1 : Absolute measurements (dimensions) of Rhacophorus leucomystax.

Sl. No.	Characters	Male			Female		
		Range (mm)	Mean (mm)	S.D.	Range (mm)	Mean (mm)	S.D.
1.	Snout-vent length (SVL)	38.0-65.0	49.2	6.0	40.0-75.0	56.7	6.4
2.	Head width minimum (HW min)	5.3- 8.0	6.2	1.1	5.6- 9.0	6.9	3.0
3.	Head width maximum (HW max)	13.7-20.1	16.4	2.0	15.6-22.6	18.2	2.6
4.	Head length (HL)	13.3-18.6	15.6	2.2	14.0-21.3	17.2	3.0
5.	Eye diameter (ED)	4.8- 5.5	5.2	0.3	5.1- 6.8	5.6	1.0
6.	Inter ocular distance (IOD)	5.6- 6.3	5.9	0.4	6.0- 7.1	6.4	1.0
7.	Nostril diameter (ND)	0.8- 1.5	1.2	0.5	1.0- 1.5	1.1	0.4
8.	Inter narial distance (IND)	4.1- 6.0	4.7	0.9	4.1- 6.1	5.2	0.8
9.	Distance between eye and nostril	3.6- 5.5	4.6	0.8	4.0- 5.2	4.7	0.5
10.	Distance between nostril and tip of snout	2.8- 4.0	3.3	0.4	3.0- 4.8	3.7	0.4
11.	Tympanum diameter (TD)	2.3- 4.6	3.8	0.6	3.8- 5.0	4.2	0.3
12.	Hindlimb length (HLL)	59.3-87.0	72.5	9.1	62.5-110.0	82.4	9.8
13.	Tibia length (TL)	23.7-31.6	26.7	3.3	24.0-42.0	29.0	5.8
14.	5th toe length (5 TL)	9.5-14.5	11.9	1.4	10.0-17.5	13.8	2.4
15.	Total forelimb length (TFL)	20.3-26.6	23.3	2.8	23.3-31.3	27.0	2.9
16.	Lower forelimb length (LFL)	14.1-22.0	16.8	2.2	15.6-24.0	19.3	2.5
17.	1st finger length (1 FL)	4.1- 7.0	5.5	1.1	5.3- 8.0	6.4	1.2
18.	2nd finger length (2 FL)	5.3- 7.5	6.2	1.2	5.8- 9.0	7.1	1.3

Table 3.2 : Size range ratios of the males and females of Rhacophorus leucomystax

Ratio	RATIO (mm) OF SIZE RANGES									
	Male (mm)					Female (mm)				
	43-50	51-55	56-60	61-65	50-55	56-60	61-65	66-70	71-75	
1. Head width minimum/ Head width maximum	0.34	0.33	0.33	0.32	0.33	0.35	0.33	0.32	0.32	
2. Eye diameter/Inter ocular distance	0.82	0.81	0.79	0.80	0.79	0.82	0.80	0.78	0.80	
3. Head width minimum/ Eye diameter	1.10	1.15	1.16	1.09	1.10	1.16	1.16	1.08	1.07	
4. Nostril diameter/ Internarial distance	0.24	0.25	0.28	0.30	0.26	0.24	0.24	0.26	0.26	
5. Tibia length/ 5th toe length	2.36	2.29	2.27	2.34	2.55	2.35	2.38	2.43	2.22	
6. 1st finger length/ Lower forelimb length	0.34	0.37	0.35	0.34	0.36	0.38	0.36	0.38	0.37	
7. Total forelimb length/ Snout vent length	0.48	0.49	0.46	0.48	0.47	0.48	0.47	0.50	0.48	
8. Snout vent length/ Hind limb length	0.64	0.67	0.68	0.66	0.64	0.66	0.66	0.64	0.65	

3.4.2 Annual breeding cycle:

The annual breeding cycle of Rhacophorus leucomystax has been divided into 4 periods (Fig. 3.1):

1. Emerging and pre-breeding period.
2. Spawning and breeding period.
3. Postbreeding and entering period and
4. Hibernation period.

(i) Emerging and pre-breeding period (April-May):

The beginning of April marks the 'period of emergence' of Rhacophorus leucomystax from hibernation. They come out of hibernation and live in bamboo holes (Pl. 3.1). During this period average atmospheric temperature was recorded to be 12°C (min) and 20.8°C (max), rainfall 77.4-96.0 mm and relative humidity 75%-95%. The period from the time of emergence and till the beginning of amplexus and spawning can be designated as 'Pre-breeding period'. This period lasts from April to May. In May, the atmospheric temperature increases to 14.2°C (min) and 23.9°C (max), rainfall 174.2-211.2 mm and relative humidity 77%-100%.

(ii) Spawning and breeding period (June-July):

During this period the frogs live in pools. They show amplexus and spawn. They spawn for 3-4 days, and then the frequency of spawning becomes irregular. The beginning of this period is marked with the first shower of rains in June. Atmospheric temperature was noted to be 15.50°C (min) and 25.1°C (max), rainfall 146.8-285.7 mm and relative humidity 81%-100%. The spawning was observed in June and large number of larvae were seen in July. Average water temperature during spawning was noted

Fig. 3.1 Annual breeding cycle of Rhacophorus
leucomystax at Kohima.

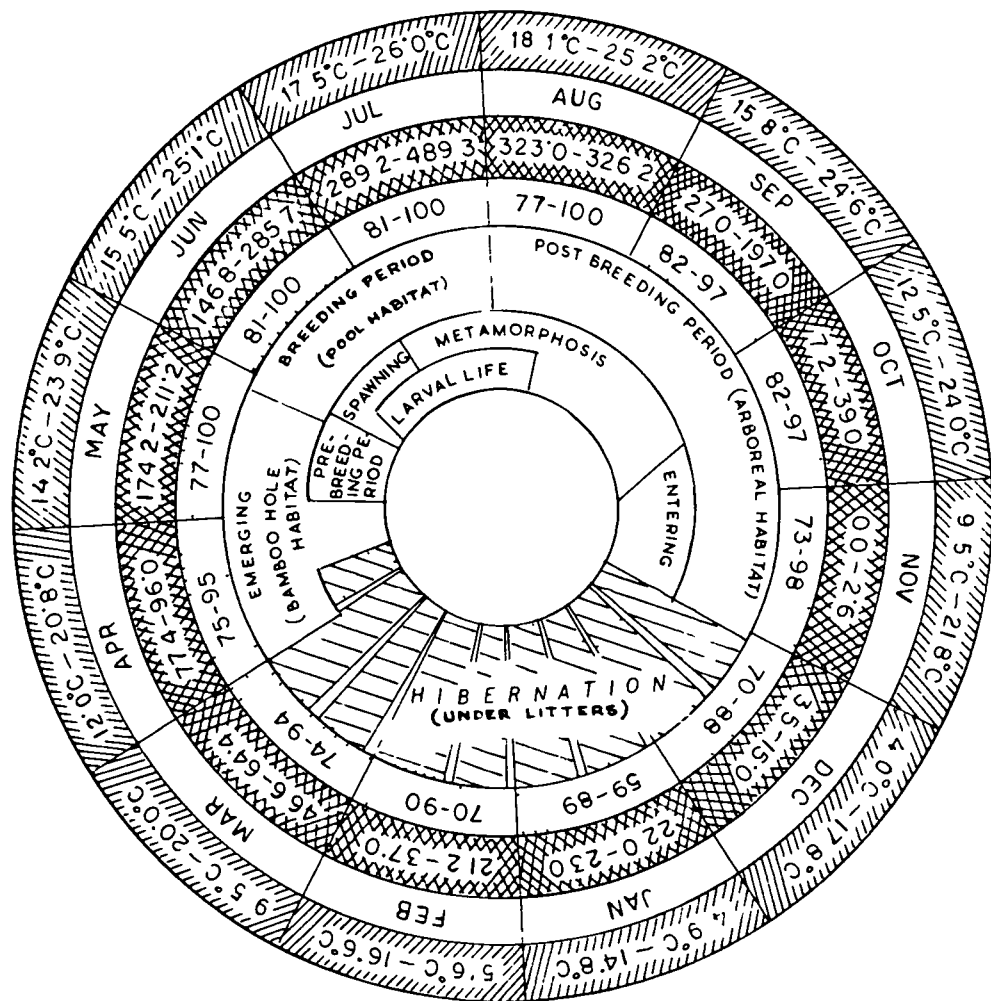
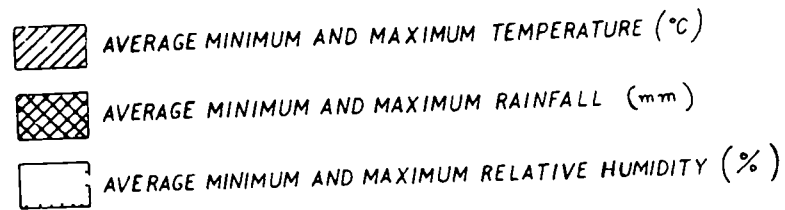


Fig 3-1

Pl. 3.1 Specimen of Rhacophorus leucomystax in a
bamboo hole (shown by arrow)

Pl. 3.2 Specimen of Rhacophorus leucomystax on a tree
(shown by arrow)



PLATE 3.1



PLATE 3.2

to be 19°C-20°C. The breeding activity lasted till July when the average atmospheric temperature reached 17.5°C (min) and 26°C (max), rainfall 289.2-489.3 mm and relative humidity 81%-100%.

(iii) Postbreeding and entering period (August-November):

During this period population of Rhacophorus leucomystax was predominantly arboreal on forest trees and banana plants. Their number decreased in the breeding pools and increased on the trees.

The average atmospheric temperature was recorded to be 18.1°C (min) and 25.2°C (max) in August; 15.8°C (min) and 24.6°C (max) in September and 12.5°C (min) and 24°C (max) in October. The rainfall gradually decreased, fluctuating between 323-326.3 mm during August; 27-197 mm during September and 7.3-39 mm during October. The relative humidity ranged between 77%-100% during August and 82%-97% during September and October. During August to October they were found mostly on trees and below the covering sheaths of banana stems (Pls. 3.2 and 3.3). By the end of October they started entering under the ground litters in the forest.

Entering continued throughout November. Throughout this month after an evening shower of rains, they were found in large number under the litters. The average atmospheric temperature during November was recorded to be 9.5°C (min) and 21.8°C (max), rainfall 2.6 mm and relative humidity 73%-98%.

(iv) Hibernation period (December-March):

The period from December to March can be designated as the hibernation period. Huge number of frogs was collected during December under the litters in the forest (Pl. 3.4). During

Pl. 3.3 Specimen of Rhacophorus leucomystax under
the sheath of banana stem (shown by arrow)

Pl. 3.4 Specimen of Rhacophorus leucomystax under
the litters in the forest (shown by arrow)



PLATE 3.3



PLATE 3.4

December the average atmospheric temperature was recorded to be 4°C (min) and 17.8°C (max) and occasionally there were mild shower of rains in the evening. The average rainfall during this month ranged from 3.5-15 mm and relative humidity 70%-88%. In January, the average atmospheric temperature was low, 4.9°C (min) and 14.8°C (max), increased rainfall 22-23 mm and relative humidity was recorded to be 59%-89%. In February, the average atmospheric temperature was recorded to be 5.6°C (min) and 16.6°C (max), rainfall 21.2-37 mm and relative humidity 70%-90%. During March the average atmospheric temperature was 9.5°C (min) and 20°C (max), rainfall 46.6-64.4 mm and relative humidity 74%-94%. During January and February frogs were collected under the litters in good numbers but during March very few were collected from below the litters apparently because they start moving to bamboo holes.

3.5.1

Morphological and Ecological considerations:

Tinsley (1973) while studying the ecology and systematics of the clawed toads, the genus Xenopus, analysed in detail the characteristic features, dimensions as well as ratios of Xenopus kigesiensis sp.n. and pointed out that certain morphological characters and morphometric ratios showed considerable intra-specific variation in individuals from different geographical ranges. In the present study, 18 absolute measurements and 8 morphometric ratios of the various body parts of Rhacophorus leucomystax have been taken into consideration. Pillai and Chanda (1979) studied a population of Rhacophorus leucomystax from the Khasi hills. Its SVL ranged between 37 - 54 mm. They also described one specimen from the Garo hills in 1981. Its SVL measured 75 mm. The population of Rhacophorus leucomystax at Kohima has the following body dimensions. SVL : males 38 - 65 mm and females 40 - 75 mm. Body weight : males 5.0 - 18.2 gm and females 5.5 - 37.95 gm. The specimens available at Kohima do not show any important variation in size in comparison to those of the Khasi and Garo hills (Pillai and Chanda, 1979 and 1981).

The population of Rhacophorus leucomystax at Kohima bears different dorsal patterns, such as striped, spotted with inter-orbital cross-bar, broken striped and an X-shaped mark behind the eyes on the dorsum. Earlier, these dorsal patterns have also been noticed in the population of Rhacophorus leucomystax from different parts of south-eastern Asia (Church, 1963).

The value of morphometric ratios in taxonomy of adult anurans (Tinsley, 1973 and 1975) has been found useful as they are fairly constant for any population and do not show variations like absolute measurement. It appears true for the population of Rhacophorus leucomystax also. The ratios show a fairly constant values for males as well as females of different size ranges in the samples examined.

3.5.2

Annual breeding cycle

There is a rich assemblage of anuran species in north-eastern hills of India. But there are only few systematic studies on their annual breeding cycles. Recently, annual breeding cycles of Rana limnocharis and Rana cyanophlyctis were investigated in detail at Shillong by Roy (1979) and Kumar (1982) respectively. Satyamurti (1967) described that populations of Rana limnocharis in south India, spawn at the onset of monsoon and aestivate during dry season, whereas, Roy (1979) reported its populations on subtropical climate of Shillong hills spawn soon after hibernation coinciding with the start of local rains and they do not aestivate. Koskela (1975) described the annual breeding cycle of Rana temporaria and divided its annual breeding cycle into 6 phases according to time and behaviour: (1) Entering the winter place. (2) Wintering. (3) Preemerging. (4) Emerging. (5) Spawning and (6) Feeding.

In the present study, the annual breeding cycle of Rhacophorus leucomystax has been divided into 4 periods based on the activity of the frogs in relation to seasonal variations and meteorological factors. In the present study these frogs emerged

in April when the temperature was recorded to be 12°C (min) and 20.8°C (max), rainfall 77.4-96.0 mm and relative humidity 75%-95%. Obviously, these factors influenced the emergence of Rhacophorus leucomystax from hibernation. Dimmitt and Ruibal (1980) also mentioned that environmental factors influence the emergence of spadefoot toads, Scaphiopus from hibernation. During pre-breeding period many individuals of Rhacophorus leucomystax are observed to start visiting the pools from the bamboo holes.

The breeding period starts in late May or early June when atmospheric temperature was recorded to be 15.5°C (min) and 25.1°C (max), rainfall 146.8-285.7 mm and relative humidity 81%-100%. Though summer and rain are favourable for the breeding, this activity is also accelerated by meteorological factors. This happens whenever there is evening shower of rain during this period, because at this time this species swarms in large numbers into the pools. Mating calls are heard. They show amplexus and spawn for 3-4 days mostly when the temperature ranges between 19°C to 20°C. After few days, the frequency of spawning declines and the adults start moving away from the breeding pools. As Clarke (1974) described on Bufo woodhousei fowleri that after the peak, the number diminishes until the last one is seen.

During the postbreeding period from August onwards the population of Rhacophorus leucomystax moves away to trees and banana plants. And by mid-October they begin to enter into hibernation. They are seen entering hibernation throughout November after every evening shower of rains. During this month the atmospheric temperature is reduced to 9.5°C (min) and 21.8°C

(max), rainfall 2.6 mm and relative humidity 73%-98%. During hibernation the frogs hide under the litters in the forest when there is high reduction in atmospheric temperature to 4°C (min) and 17.8°C (max), rainfall 3.5-15 mm and relative humidity 70%-88%. Toft (1980) mentioned occurrence of frogs and toads in leaf litters in the rain forests and their abundance in the dry season in Panama. Clarke (1974) observed the winter dormancy of Bufo woodhousei fowleri populations for 7 months. Though in the present investigation, Rhacophorus leucomystax winter hibernate for 4 months of the year.

The specimens of Kohima population of Rhacophorus leucomystax have following measurements, SVL : males 38 - 65 mm and females 40 - 75 mm. Body weight : males 5.0 - 18.2 gm and females 5.5 - 37.95 gm. The dorsal patterns are striped, spotted with interorbital cross-bar, broken striped and an X-shaped mark behind the eyes on the dorsum. The morphometric ratios of males and females of different sizes are similar.

Based on breeding and non-breeding phases, the annual breeding cycle of Rhacophorus leucomystax has been divided into 4 periods: (1) Emerging and pre-breeding period, which lasts from April to May, the frogs come out of hibernation in early April and live mainly in holes of bamboo vegetation during this period. (2) Spawning and breeding period, this is the period of summer and rain.. The frogs migrate to the rain pools, show amplexus and start spawning and building egg nest in the first part of June. The period lasts upto the end of July. (3) Post-breeding and entering period, this period start in August, the frogs migrate from breeding pools to the trees and banana plants, atmospheric temperature and rainfall and humidity decrease.. The period lasts upto November, when the frogs are seen taking shelter under forest litters and (4) Hibernation period, this period lasts from December to March, this is the period of winter sleep for frogs, they hibernate under forest litters throughout this period.

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CHAPTER 4
Breeding Behaviour
and
Population Dynamics

The Rhacophorids are tree frogs. Their breeding behaviour is of specialised nature. The croaking of males, Rhacophorus leucomystax near the breeding site guide the females to their mating place and the females construct the foamy nests have been known during the breeding season (Cochran, 1961 and Hausser, 1974). Cochran (1961) mentioned that Rhacophorus leucomystax makes foam nests in shallow water pools and paddy fields. Church (1963) described that these frogs attach the foam nests on a concrete wall, a foot above the water surface of the pools. Mallick, Mallick and Das (1980) while observing the spawning behaviour of Rhacophorus species, noticed the attachment of froth close to the aquatic bushes. The present study was taken up to examine the breeding behaviour of Rhacophorus leucomystax at the breeding site. This includes study of breeding site; courtship, spawning and nest construction; nest structure, egg number and development; parasite of eggs and sex ratio at the breeding site.

Population dynamics is the distribution and density of animals and the changes in the populations in natural habitat (Nicholson, 1954). This estimation of population has been studied for certain anurans also (Bullock, 1969; Clarke, 1974; Christein and Taylor, 1978 and Barbault and Rodrigues, 1979 among others). This chapter includes an analysis of the population dynamics of Rhacophorus leucomystax at Kohima as it was felt necessary to have an idea of its distribution and density in the area.

4.2.1 Breeding behaviour

Many early references on breeding behaviour of anurans have been included in Gadow (1901), Noble (1931), Wright and Wright (1933), Cochran (1961), Rugh (1962) and Heusser (1974). Various aspects of breeding behaviour investigated in recent years deal with meteorological influence; mode of reproduction and oviposition site; chorusing; courtship, spawning and nest construction; egg number, development and parasite; sex ratio at the breeding site; breeding aggregation, territoriality and defence. Contributions on these aspects can be reviewed separately.

(i) Meteorological influence on breeding

Among meteorological factors, breeding of anurans has been reported to be stimulated by rain as well as atmospheric temperature. Forge and Barbault (1977) noticed the egg-laying of females, Bufo pentoni in 24 hours after the 1st rains during rainy season. Hulse (1979) also investigated that reproduction in Pleurodema cinerea is initiated by rain. Haapanan (1982) reported that the spawning of Rana temporaria in Finland begins 1 day after the daily atmospheric temperature exceeds 5°C in spring. Hillis, Hillis and Martin (1984) observed that a rise in minimum air temperature to above 14°C initiates the breeding activity of Bufo houstonensis.

(ii) Mode of reproduction and oviposition site

Generally all anurans visit water bodies for breeding. They show different modes of reproduction and oviposition sites. Crump (1974) studied 81 anurans species and reported 10 modes of

reproduction at Santa Cecilia, namely: (1) eggs deposited in the ditches, puddles, swamps, ponds, lakes and streams, (2) eggs deposited in the cavity above ground, (3) eggs deposited in basin constructed on ground by the male, (4) eggs deposited on vegetation above water, (5) eggs deposited in foam nest on or near water, (6) eggs deposited on land, (7) eggs deposited in foam nest on land and larvae developed within foam, (8) eggs deposited out of water, (9) eggs carried in depressions on dorsum of aquatic female and (1) eggs carried in depressions on dorsum of terrestrial female. Cooke (1975) reported that Rana temporaria spawns in shallow water (15 cm deep) and Bufo bufo in deeper water (18-46 cm deep). Woodruff (1976) observed that males of Pseudophryne bibroni, Pseudophryne dendyi and Pseudophryne semimarmorata prepare site for nest on land in a situation which is expected to be flooded after autumn rain storms. Korotkova and Korotkova (1977) have reported that the populations of Rana chensinensis lay eggs in different water bodies at different times to ensure preservation of progeny for the varying spring climatic conditions. Collins and Wilbur (1979) observed that frogs breed in all aquatic ~~habits~~ such as temporary and permanent ponds.

(iii) Chorusing

During breeding season males produce sound, which orients the females to move to the breeding pond for spawning. Harris (1975) observed that spring and summer are associated with foraging and breeding behaviour of Hyla cadeverina, where males were seen vocalizing after foraging. Garton and Brandon (1975) noticed that nocturnal chorusing of the green frog, Hyla cinerea starts at night below 20°C. They are found calling on emergent vegetation

which serves as substrate for eggs and as habitat for tadpoles. / Obert (1975) reported that males of Rana esculenta and Rana ridibunda call 1 or 2 days after the start of warm sunny days. Schmidt (1978) observed that spawning of Kaloula pulchra is accompanied with loud calls of males. Wells (1979) reported the explosive breeding system of Bufo typhonius with most choruses last less than 1 day and they ovoposit in permanent streams and pools. Roberts (1981) investigated that males of Australian leptodactylid frog, Myobatrachus gouldii call on ground after rain in spring and early and late summer. The females are oriented to calling males, but amplexus do not occur on the surface as the eggs are deposited 1 m deep in the sand.

(iv) Courtship, mating spawning and nest construction

Courtship is followed by mating, spawning and nest construction. Cochran (1961) mentioned that the females of Rhacophorus leucomystax mate and construct their foam nests in shallow water pools or rice paddy fields. Coe (1967 and 1974) observed the participation of 3 males in mating and nest construction with a female in rhacophorid, Chiromantis on twigs overhanging temporary ponds. Philibosian, Ruibal, Shoemaker and Mc Clanahan (1974) observed the nest construction of Leptodactylus bufonius on muddy shores and that it is stimulated by rains. Hulse (1979) observed the foam nests of Pleurodema cinerea to be oval-shaped measuring 7 to 10 cm in diameter. And the eggs are eventually distributed throughout the matrix of the foam. Mallick, Mallick and Das (1980) observed the spawning behaviour of Rhacophorus species and the attachment of froth close to aquatic bushes which measured 8-10 cm in diameter.

(v) Egg number, development and parasite

Among contributions on egg number, development and parasite, more important ones are: Church (1963) counted that there were approximately 250 eggs per egg mass of Rhacophorus leucomystax at Bandung, Java. Coe (1974) described the early development of Chiromantis. The embryonic development occurs in egg foam; and then after hatching the tadpoles are dripped down into the pools below by rains. Yorke (1983) while studying the survival of embryos and larvae of frog, observed a calliphorid fly infesting and destroying the egg masses of Polypedates leucomystax.

(vi) Sex ratio at the breeding site

So far as the sex ratio of male and female at the breeding site is concerned, some following recent informations have been provided. Christein and Taylor (1978) monitored 2 breeding ponds of Bufo americanus and found males greatly outnumbered the females (7:1) and further mentioned that the breeding males are more active and breeding females less active than their non-breeding counterparts. Shaub and Larsen (1978) reported that females of Hyla regilla have more turn-over rate than the males in their breeding ponds. Michael (1980) recorded the sex ratio of breeding population of Rana catesbeiana skew towards the males. Beshkow and Jameson (1980) reported the population of Bombina variegata sex ratio as 3 males to 1 female during the spawning season. Gittins, Parker and Slater (1980) observed the population of Bufo bufo visiting site and found that the sex ratio was 3:1 for males and females.

(vi) Breeding aggregation, territoriality and defence

Certain workers have investigated aggregation behaviour during the breeding and mating chances (e.g. Scott and Starrett,

1974; Kruse, 1981 and Berven, 1981) and have pointed out the possibility of body size in selection of mating and also competition among males. Others (e.g. Woodruff, 1977; Howard, 1979; Michael, 1980 and Greer and Wells, 1980) described territoriality and defence of breeding site by males.

4.2.2

Population dynamics

So far as population dynamics is concerned, workers have used different techniques: Few methods for marking of animals are made available. The important ones are: Woodbury (1956) who used tagging for marking amphibians. Clarke (1972) and 1974) adopted toe-clipping as a means of recognising individuals for the population of Bufo woodhousei fowleri. Daugherty (1976) applied brand copper wires and irons to the light coloured ventral surface for marking of anurans. Kumar (1982) used paint and colour thread as bands around the thigh to mark the population of Rana cyanophlyctis following Krekorian (1976) technique of marking animals. The paint was not retained for long. Smirina (1983) marked the young of the year of Rana temporaria by amputating the finger.

Bullock (1969) estimated the population of Amolops larutensis using capture and recapture method and found that most of the frogs were recaptured close to the original point of capture. Brown and Alcala (1970) while studying the population ecology of the frog, Rana erythraea have used capture-mark-recapture technique and the recapture data showed the maximum life span in the 2 populations to be 3-4 years. Fitzgerald and Bider (1974) while investigating the seasonal activity of Bufo americanus used sand-transect technique and found the highest

activity at temperature 50°F or 10°C nights. Clarke (1974) used capture-mark-recapture by toe-clipping system to study the population structure of Bufo woodhousei fowleri and noted that marked toads were recaptured at an average distance of 21.8 m to 23.0 m, though in certain cases it shifted its home range to about 85 m. He also noticed that adults are strictly nocturnal with a maximum activity shortly after sunset and decreases until dawn. Gibbons and Bennett (1974) used drift fences and pitfall traps for determination of anuran terrestrial activity and found that number of captures increased with the amount of rainfall. Kratochvil (1976) observed the population of Rana lessonae between May and September and noted that males are predominating the females in small ponds during this period in Neusiedler lake. Werner and McCune (1979) adopted mark-recapture by toe-clipping system while investigating the seasonal changes in anuran populations in a northern Michigan pond and noticed a sharp increase in anuran population in August because of newly metamorphosed frogs. Barbault and Rodriques (1979) mentioned that there are seasonal and year to year changes in the density and demographic structure of the population of tropical frogs, Arthroleptis poecilonotus at Lanto Savannas. Beshkov and Jameson (1980) used mark-release-recapture method for studying the population structure of Bombina variegata and reported that the ratio of male to female as 3:1 during spawning and 2:1 in other parts of summer. Hodrova (1981) also followed mark-recapture procedure and estimated the population of Bufo bufo in Central Elbeside and reported that the females stayed in water for a shorter time than the males.

A simple technique of catch per unit time for population studies prescribed by Andrewartha (1970), has also been followed for anurans by some recent workers (Roy, 1979 and Kumar, 1982).

The present study was conducted in 2 temporary rain pools situated about 2 km north-east of Kohima village. The observations were made twice a week from May to July at night mostly after the sun set. During the study period the nature of male selecting the site for courtship, spawning, location and typical nature of nest construction on the branches and leaves overhanging the water surface or on rocks or on grassy edges of the pools were observed. The size of the nest and the diameter of the eggs were recorded. Since the nests were found to be infested by some dipteran larvae, the nature of this infestation and damage caused was also studied. The sex ratio of males and females at the breeding site was computed.

The study on population dynamics was conducted both during the breeding and non-breeding periods based on catch per hour taken as unit time at weekly interval (and then computed for every month) throughout the year as per the technique of Andrewartha (1970). Capture mark-released-recapture by toe-clipping technique was also started, but as there was too much disturbance due to poaching by the villagers in the area, this was not continued.

4.4.1 Breeding behaviour

The observations have been made on the following aspects:

(i) Breeding site; (ii) Courtship, spawning and nest construction; (iii) Nest structure, egg number and development; (iv) Parasite of eggs and (v) Sex ratio at breeding site.

(i) Breeding site

The study site had 2 temporary rain pools, separated by a stretch of 18 m land. The pool towards the eastern side was 14 m long, 6 m wide and 1 m deep in the centre, and it was surrounded by Eupatorium sp. and mesophytes. Approximately half of the pool was covered with water plants. The other pool was more towards the northern side and was 30 m long, 20 m wide and 1 m deep in the centre. The pool was surrounded by a large stretch of grassy land. The area was very close to a forest which had thick growth of bamboo at the boundary (Fig. 4.1).

(ii) Courtship, spawning and nest construction

During the breeding season in late May, and throughout June and July in 1982, 1983 and 1984 a number of males were heard croaking on the grassy edges and branches of Eupatorium sp. overhanging the water. The frequency of croaking was remarkably high in the evening after rains.

In 1982, the first afternoon shower occurred on 16th June, this was followed by swarming of frogs to the pools on 19th and 20th June. In 1983 and 1984 we had the first shower on 1st June, followed by swarming of frogs to the pools on 2nd and 3rd June,

Fig. 4.1 Map of breeding site of
Rhacophorus leucomystax.

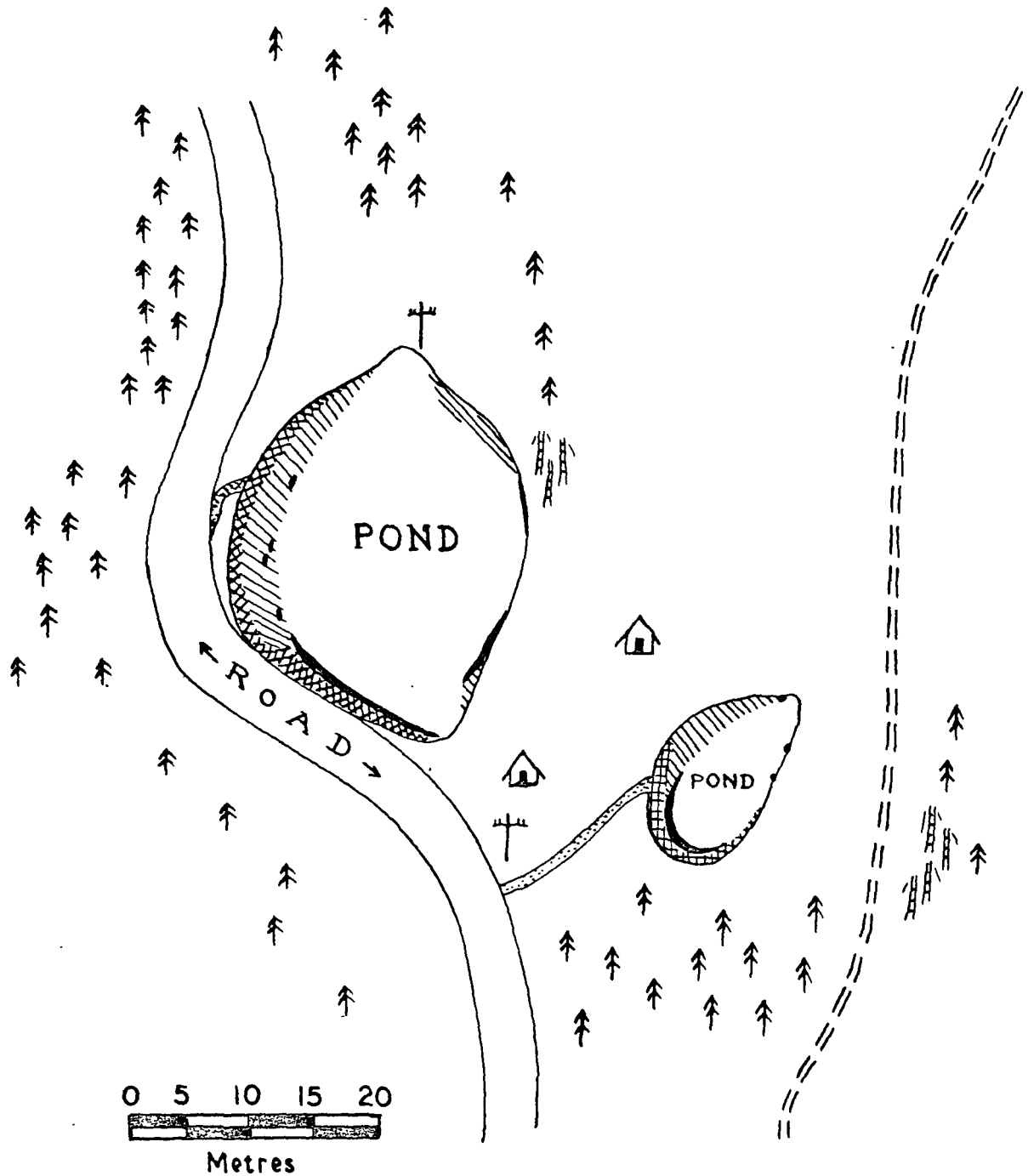
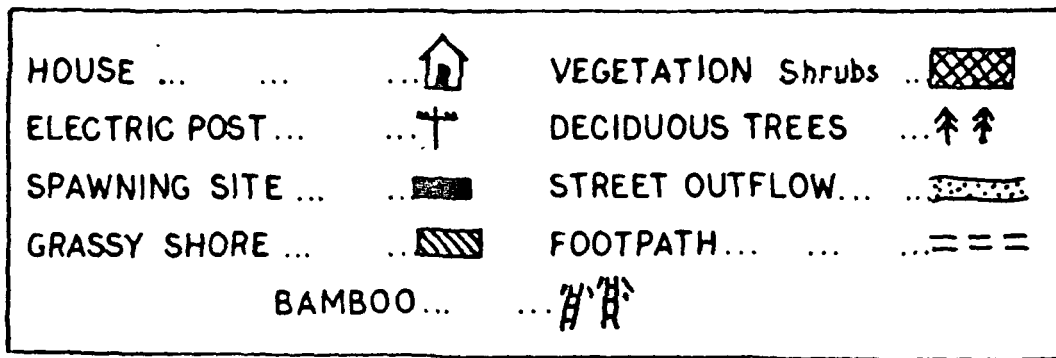


Fig 4-1

Plate 4.1 Amplexus of Rhacophorus leucomystax
on Eupatorium plants.

Plate 4.2 Egg nests and masses of Rhacophorus
leucomystax.



PLATE 4.1



PLATE 4.2

1983 and 1st, 2nd and 3rd June, 1984. The swarming of frogs to the pools also coincided with the early moon phases.

In 1982, on the 19th and 20th June, when the weather was favourable, the atmospheric temperature fluctuated between 19°C and 20°C, there was evening rain followed by little precipitation, early moon phases and moist vegetation, they showed amplexus (Pl. 4.1) and constructed 20 nests in 2 nights. On 2nd and 3rd June, 1983 and on 1st, 2nd and 3rd June, 1984 again when the weather was favourable, 15 and 22 nests respectively were constructed around the same pools. It was also observed that in certain cases several nests were deposited in masses (Pl. 4.2).

It was noticed that the males arrived at the breeding pools earlier than the females and started calling. On 19th June, 1982 it was observed that a male came early and selected a suitable site on the branches of Eupatorium sp. overhanging the water and started croaking at 19.00 hours. When disturbed by a torch it stopped, but started croaking again after few minutes. The amplexus was noticed at about 21.00 hours and soon after this, the female was seen laying her eggs.

The females shaped their nests on the substratum previously selected by the male members. And all the nests were constructed between 20.00 to 23.00 hours. After egg-laying, the females returned to the forest, but the males were observed to live in the breeding site for a longer time.

(iii) Nest structure, egg number and development

The egg nests were constructed on branches of Eupatorium sp. overhanging the water surface or on rocks or on grasses adjoining

Plate 4.3 Dipteran larvae infesting the eggs
of Rhacophorus leucomystax
(e-eggs; p-parasite maggoe).

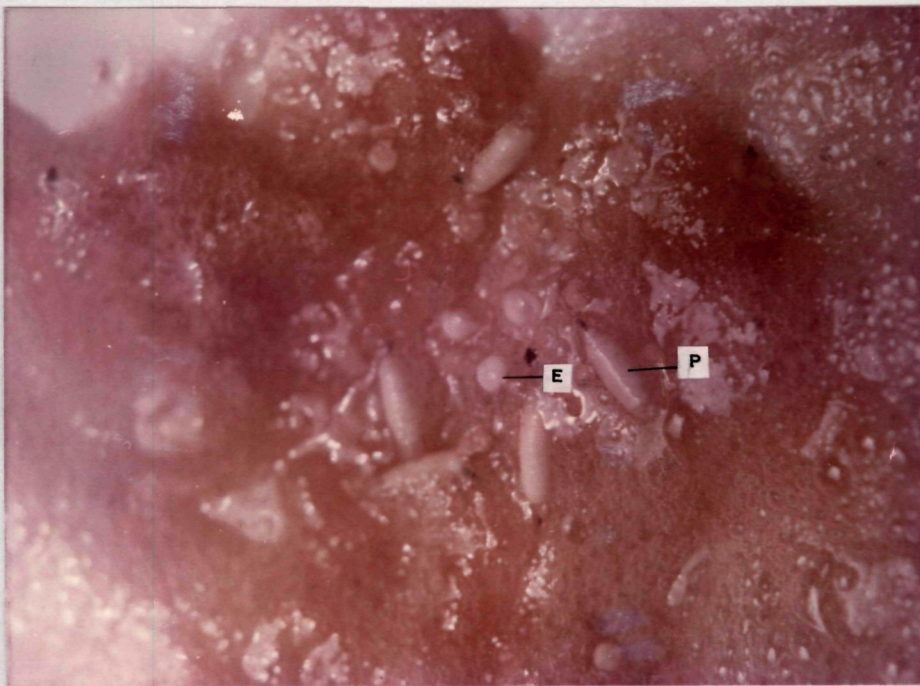


PLATE 4.3

the water surface, 3 cm to 35 cm from the water surface. The nests were almost oval-shaped. Each nest had an outer hard coat of foam and inner soft foam in which eggs were found embedded. The nests measured 7.0 cm-10.5 cm long; 6.0 cm-7.5 cm broad and 3.0 cm-4.5 cm high. In all, 5 nests were removed and eggs were counted. The number of eggs varied between 220 to 280 eggs in different nests. The eggs measured 1.73 mm-1.75 mm in diameter. The eggs were white in colour, devoid of pigment.

The hard covering of the nest protects the eggs and early embryonic stages from the scorching heat, direct rain and sinking. The eggs develop and hatch in the soft foam and later released into the pool water during rains. However, in dry weather, when tadpoles were retained for too long in the foam, they die due to dissication.

(iv) Parasite of eggs

The egg nests were found infested with certain dipteran larvae which damaged the eggs. It was observed that about 20 larvae destroyed all the eggs in one nest in 4-5 hours. About 50% of the nests inspected were infested by these larvae. The infested nests turned light reddish and produced some foul odours (Pl. 4.3). After eating away the eggs, these larvae pupate on the edges of the pool.

(v) Sex ratio at breeding site

In 1982, during May, June and July, the total number of males collected was 17, 113 and 23 respectively and that of females was 8, 27 and 9 respectively. In 1983, during May, June and July, the total number of males collected was 14, 115 and 18 respectively and that of females was 3, 25 and 3 respectively.

In all, a total of 153 males and 44 females were collected during May, June and July of 1982 and 147 males and 31 females in 1983. During collection, both immature and mature males were equally collected, but few immature females as compared to mature females.

4.4.2 Population dynamics

A 12 -monthly analysis of population structure of Rhacophorus leucomystax was studied at Kohima (Fig. 4.2).

During pre-breeding period from April to March, the number of males was collectively higher than females as well as juveniles. The collection was made mostly from the stumps of bamboo internodes during this period. Amplexus and spawning start by the end of May.

The number of males collected was highest during June followed by females and juveniles. In July, the number of males collected was followed by juveniles and females. The collection was made in breeding site and a huge number of frogs was collected during this breeding period.

From August to October, the young metamorphosed froglets outnumbered the males as well as females. During this period they were collected mostly below the covering sheaths of banana stems. Collection was very low. They start entering under the ground litters in the forest by the end of October and continue throughout November. So, collection of frogs increased as it was easier to collect.

During hibernation period, they hide under the litters in the forest. Huge number of frogs was collected again, especially

Fig. 4.2 Population dynamics of Rhacophorus
leucomystax at Kohima.

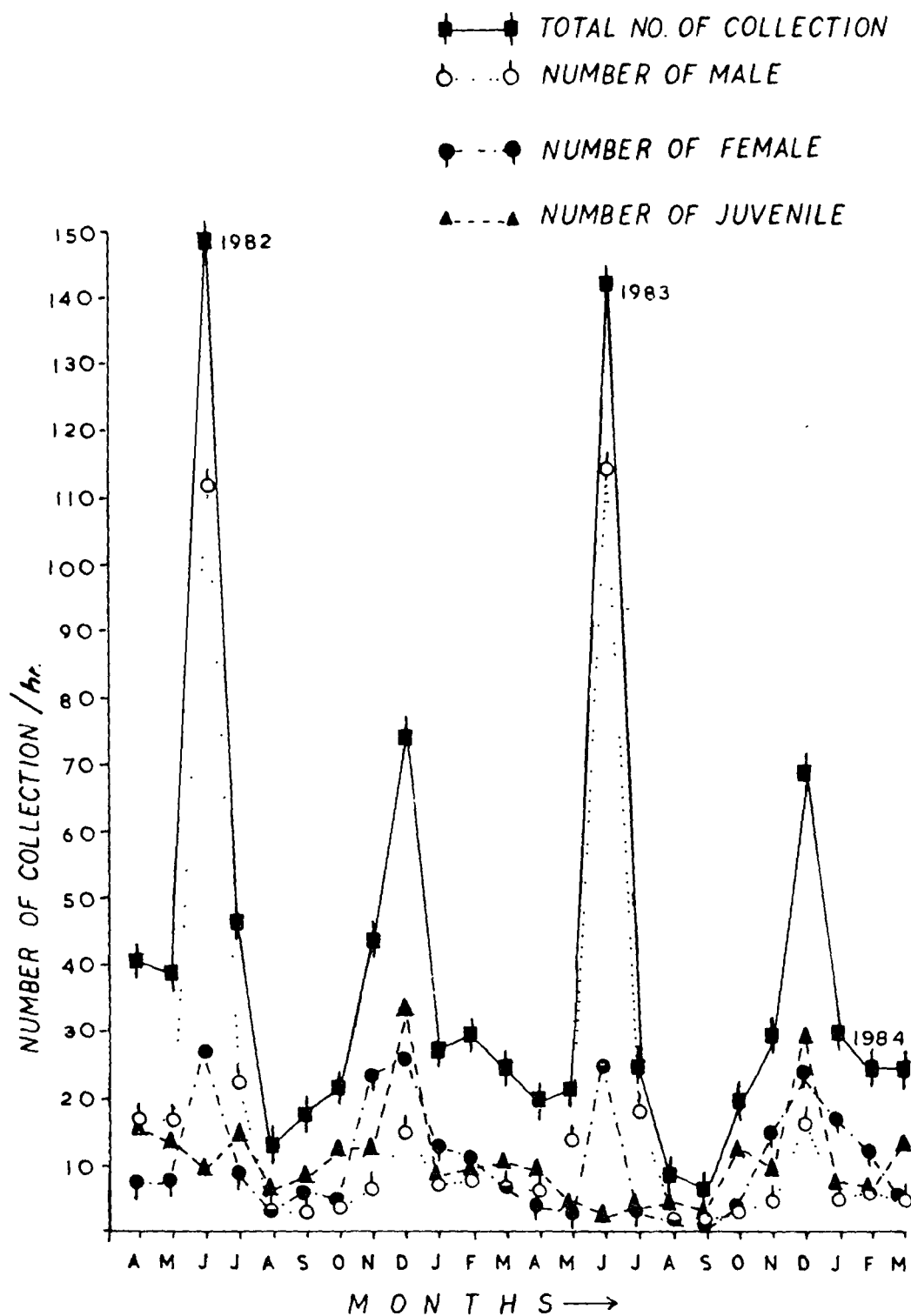


Fig 4.2

in December as the frogs remain dormant so it was easier to collect. But the number decreased after this months till the end of the period.

4.5.1 Breeding behaviour

Rhacophorus leucomystax is a seasonal breeder. During the course of the present study they were found to breed during late May and throughout June and July in temporary rain pools at Kohima. The observations suggest early moon phases, heavy shower of rains followed by sparse precipitation and atmospheric temperature at 19°C to 20°C influence swarming of frogs and induce them to amplexus, spawning and to construct nests.

It was observed in the present study that the males of Rhacophorus leucomystax arrive early at their breeding site, select the nest site and croak. This probably stimulates the females to arrive. After their arrival, they show amplexus, nest construction and egg-laying. Only the female were seen to take active part in nest construction. Cochran (1961) also reported that females of Rhacophorus leucomystax construct nests. He did not mention participation of males but Coe (1967 and 1974) has described participation of males, Chiromantis rufescens in the nest construction with a female.

Nest construction was observed between 20.00 to 23.00 hours. This observation conforms with the observation of Coe (1974) on Chiromantis rufescens which construct their nests mostly between 19.00 and 22.00 hours.

Rhacophorus leucomystax constructs nests on branches overhanging the water surface or on rocks or grassy edges 3 cm to 35 cm above the water surface. Church (1963) collected egg masses of Rhacophorus leucomystax about a foot above the water surface on

a concrete wall in Java, however, Cochran (1961) mentioned that Rhacophorus leucomystax place their foam nests in the shallow water of pools and paddy fields. The number of eggs in the nests varied between 220 to 280 eggs in different nests. As Church (1963) also reported approximately 250 eggs in each egg mass of Rhacophorus leucomystax found in Java.

Though the nests are deposited on the vegetation at the edges of the pool, the development of eggs after hatching is dependent upon rain which flush them in pool water otherwise the nests dry up and larvae die. The egg nests are also infested with the dipteran larvae which damage the eggs. Yorke (1983) also reported a frog, Polypedates leucomystax (Rhacophorus leucomystax) egg masses infested with the larvae of a calliphorid fly.

Scott and Starrett (1974) mentioned that a continuous forest near the pond is immediately accessible for the post metamorphic dispersal. Such a situation exists at the breeding site of the present study also. The adjoining bamboo vegetation and forest provide a favourable biotope for the dispersal of the newly metamorphosed froglets and adults for arboreal habit of this species.

Christein and Taylor (1978) recorded the sex ratio between male and female as 7:1 on Bufo americanus at the breeding pond and 3:1 on Bombina variegata during spawning (Beshkov and Jameson, 1980). The similar ratio has been observed on Rhacophorus leucomystax in the present investigation at the breeding site and the males were found to outnumber the females (approximately 4:1). Irrespective of age both immature and mature males equally visit the breeding site and were collected, but only a few immature as

compared to mature females. Moreover, the males catches were higher because of their easy location due to croaking.

4.5.2 Population dynamics

So far as the population structure is concerned the catches of Rhacophorus leucomystax during emerging and pre-breeding period is small (20 to 41). The largest number of frogs were collected in the catches in June (143 to 149) which marks their active breeding period. A number of frogs are seen to throng to the breeding site. From August to October, number of frogs collected was low (6 to 22), as most of them move to trees during this period. Newly metamorphosed froglets outnumbered the males and females at this time. The number of catches^{es} increases when they start entering under the ground litters in the forest in November (30 to 44). During hibernation, the number of frogs collected was higher (25 to 75). Now they live under the litters in the forest and are almost dormant.

This chapter deals with the breeding behaviour and population dynamics of Rhacophorus leucomystax at the breeding site. It provides a description of the 2 pools at the study site adjoining a forest bounded by a row of boundary of thickly growing bamboos. Observations were made on courtship, spawning, nest structure and construction, clutch number, development, parasitic infection and sex ratio. It was noted that the frogs swarm to the pools on early summer evenings preferably after rain in a period coinciding with early moon phases. On reaching the pools the frogs take part in courtship and mating. Mating pairs deposit eggs in a foamy nest on the vegetation adjoining the edges of the pools. The inner layer, the froth surrounding the eggs is soft and ^{the} outer is hard. The eggs develop upto hatching in the froth however, later development is possible only when these nests are flushed into the pools by rain water. These nests are sometimes infested with dipteran parasites resulting into heavy mortality of the embryos. At the breeding site, males outnumbered the females (4:1).

The number of catch per hour was highest in June during breeding period. The second peak was recorded in December during hibernation period. The number of frogs collected was lowest in postbreeding period.

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CHAPTER 5

Food and Feeding Habits

In recent years increasing interest is being shown by workers on food and feeding habits. Noteworthy contributions are ^{following.} Clarke (1974) reported that toads were indiscriminate feeders but feed more on insects. Blackith and Speight (1974) discussed the movement pattern of frogs, was connected in capturing prey in any habitat. Loman (1979) stated that the size of predator was responsible for determining the prey size. Roy (1979 unpublished) recorded that there was a seasonal variation in the prey availability and also in the diet. Dimmitt and Ruibal (1980) pointed out the importance of coincidence and appearance of prey and predator in forming the major constituent of diet. Importance of frogs as natural agents in removing insect pests which comprise part of their diet has been reported by various workers (Liu and Chen, 1932; Khan, 1973 and Roy, 1979). Besides, ecology, the diet has also been used in the anuran taxonomy (Noble, 1931; Tinsley, 1973; Loman, 1979 among others).

Rhacophorus leucomystax is an important frog in Nagaland not only from ecological but also from economic point of view. Nagas, the inhabitants of Nagaland use it as a delicious food item. As such, there may be a possibility of its culture in the near future. From both angles it was felt logical to have an idea of its food and feeding habits. This chapter has therefore been devoted to the study of percentage composition and volume of food intake at monthly intervals both during breeding and non-breeding periods.

Review of literature reveals that knowledge of anurans diet has not only helped in understanding their food and feeding habits but also in their ecology and taxonomy (see for reference, Noble, 1931; Tinsley, 1973; Blackith and Speight, 1974; Sirbu, 1976; Loman, 1979 among others). Various contributions which appeared in literature in recent past can be summarized below.

(i) Opportunistic feeders

Certain frogs eat whatever they get. Many workers have observed e.g. Bruggers (1973) on Rana catesbeiana, Houston (1973) on Rana temporaria and Mohanty-Hejmadi and Acharya (1982) on Rhacophorus maculatus.

(ii) Frequency of food items in the diet

The availability of prey items and also preference of frogs for certain preys available seems to account for frequency of various food items taken by them, Fulk and Whitaker (1969) studied the diet of Rana catesbeiana which is greatly influenced by the availability of animals as food and it also takes any moving object of appropriate size. Pengilley (1971) reported that the diet of the genus Pseudophryne consists mainly of ants or termites. Clarke (1974) examined the stomach contents of Bufo woodhousei fowleri, where ants and beetles comprised 81% of all the food items eaten. Isaac and Rege (1975) reported that the food of Rana tigrina was composed mainly of insects and crabs. Roy (1979) recorded formicida as the highest percentage of diet in Rana limnocharis (unpublished). Tyler and Hoestenbach (1979) investigated the differences in food of Rana catesbeiana

inhabiting ponds and streams, and found that pond-inhabiting frogs fed primarily on insects comprising 82% and stream-inhabiting frogs contained crayfish constituting 75% by weight of all food items. Dimmitt and Ruibal (1980) determined the exploitation of food resources by Scaphiopus, which composed primarily of termites and may consume 55% of its body weight at one feeding. Drewes and Roth (1981) found Montane Ethiopian frogs specialized in selecting terrestrial gastropod mollusks as revealed by analysing the gut contents.

(iii) Taxonomic feature

The study of gut contents of frogs has been reported to reflect the taxonomic composition of animals as prey items available in the vicinity. Tinsley (1973) while studying the ecology and systematics of Xenopus kigesiensis from western Uganda analysed their stomach contents and assessed the taxonomic distribution of their preys. Medvedev (1974) also sorted out the species composition of animals found in the amphibian stomachs in the Seversky Donets River. Blackith and Speight (1974) analysed the prey organisms of Rana temporaria and suggested that this frog is an effective predation of ground living predatory and parasitic insects. Sirbu (1976) recorded the food of Bombina variagata comprised both aquatic and terrestrial organisms. Benkivskaya (1978) reported that with the analysis of the stomach contents of mature anurans it is possible to determine the most prevalent insects in a given area. Loman (1979) recorded the taxonomic composition of food in the 2 species, Rana arvalis and Rana temporaria to be almost identical.

(iv) Feeding rhythm

Certain workers have worked out rhythmic pattern of feeding habits of anurans. Sin, Lacatsusu and Teodoresen (1975) mentioned Rana ridibunda feeding accordingly involves a nightly and monthly rhythm. Toft (1980) investigated the diet of 13 species of anurans belonging to 3 families foraging diurnally for arthropods in the leaf litters in a seasonal environment at Rio Llullapichis in Amazonian Resu.

(v) Cannibalism and Carnivorous

Cannibalistic behaviour of frogs has been reported by Kalusche (1973) on Rana esculenta. Dushin (1974) on Rana ridibunda and Rana esculenta and Hulse (1978) on Lepidobatrachus llanensis. Viertel (1976) noticed that Rana esculenta preys on small mammals also.

(vi) Seasonal variation in food intake

Food intake of anurans may vary at different periods. For example, Chlodny and Mazur (1969) have reported that food intake of Rana arvalis is maximum in June and July but decreases in October and November. Geelen, Gelder and Sax (1970) analysed the stomach contents of Rana esculenta during breeding period and found the males with empty stomachs but no female had empty stomachs. Johnson and Christiansen (1976) reported that food consumption was greater in larger frogs of Acris crepitans blenchardi. Roy (1979 unpublished) recorded the maximum food intake during breeding period and minimum during hibernation period in Rana limnocharis.

(vii) Prey size

Size of prey and mouth gape has been investigated as an important factor for diet selection in anurans e.g. Blackith and Speight (1974) noticed the mouth-gape of Rana temporaria in determining the size of prey. Labanick (1976) reported that prey size was increased linearly with the size of frog. Christian (1982) observed that Pseudocris triseriata small frogs eat prey as they are encountered in the environment, large frogs selected larger prey which are rarer in the community and intermediate sized frogs thrived on intermediate prey. Mohanty-Hejmadi and Acharya (1982) while studying the food habits of 6 species of Indian frogs reported that smaller species prey on smaller prey as compared to their counterpart larger species.

The frogs were collected at monthly intervals throughout the year at Kohima (Nagaland). Soon after the collection, they were chloroformed. A small incision was made in their abdomen and they were preserved in 7% formalin to check further digestion of food materials. In all 149 specimens of Rhacophorus leucomystax were examined (about 12 specimens per month, and 50 specimens of adult males, 48 adult females and 51 juveniles). The specimens were weighed and their SVL measured. SVL of adult males and females was about 38 mm and 40 mm respectively and that of juveniles was less than these. The stomachs were cut opened and their contents were analysed. The contents of each stomach was transferred to a 10 ml graduated tube having 5 ml of water. The volume of food contents was determined by the amount of water displaced. The food items were then transferred to a watch glass and examined under a dissecting binocular microscope and percentage of each item was calculated. Animals taken as food items were sorted out upto species level whenever possible.

Morphometric data on snout-vent length (SVL) and body weight of the specimens examined have been taken (Table 5.1). The volume of food intake by these animals, frequency of occurrence of different food items taken and percentage composition of these have been analysed at regular monthly intervals.

5.4.1 Body dimensions and volume of food intake

(Av. of 12)

Volume of food intake[^] has been shown in relation of size groups of frogs as illustrated in Table 5.2 and Fig. 5.1. In general the highest volume of food intake was recorded in breeding period and lowest in hibernation period. During breeding period, the amount of food taken by females was much higher than that of males.

5.4.2 Analysis of food contents

In all 149 specimens were examined and out of which 57 stomachs were empty. The frequency of empty stomachs was high in the post-breeding period (17 stomachs) and hibernation period (22 stomachs). Analysis of stomach contents from a 12-month data showed a fluctuation of food items in different months.

(a) Food items and their annual percentage

The stomach contents were removed on slides and frequency of various food items was recorded. Various groups of food items recorded are shown in Table 5.3 and described below:

(1) Arachnida (Aranae : Spiders)

Spiders as diet of frogs were identified by their cephalothorax, six pairs of cephalothoracic appendages and slender

Table 5.1 : Body dimensions and volume of food intake

Period	Age Group	SVL (mm)	Body weight (gm)	Food volume (ml)
Emerging and Pre-breeding period	Adult Male	45 - 64	3.7 - 14.5	0.21 - 0.26
	Adult Female	52 - 75	5.3 - 37.95	0.23 - 0.28
	Juvenile	32 - 38	2.95 - 3.5	0.09 - 0.1
Breeding period	Adult Male	46 - 63	4.2 - 18.2	0.39 - 0.43
	Adult Female	52 - 70	4.7 - 28.3	0.44 - 1.0
	Juvenile	32 - 37	2.4 - 3.6	0.11 - 0.16
Postbreeding and Entering period	Adult Male	43 - 65	4.2 - 18.7	0.18 - 0.38
	Adult Female	50 - 75	4.9 - 28.25	0.23 - 0.45
	Juvenile	18 - 37	1.2 - 4.0	0.03 - 0.15
Hibernation period	Adult Male	45 - 57	3.62 - 13.2	0.06 - 0.17
	Adult Female	53 - 75	5.8 - 25.6	0.12 - 0.23
	Juvenile	28 - 38	2.7 - 4.25	0.02 - 0.09

Table 5.2 : The volume of food intake by Rhacophorus leucomystax during different months of the annual cycle.

Age Group	Volume of food intake (ml) in different months											
	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Adult Male	0.21	0.26	0.43	0.39	0.38	0.3	0.3	0.18	0.16	0.06	0.17	0.2
Adult Female	0.23	0.28	1.0	0.44	0.45	0.25	0.43	0.23	0.22	0.23	0.2	0.12
Juvenile	0.1	0.09	0.11	0.16	0.15	0.15	0.12	0.03	0.08	0.02	0.08	0.09

Table 5.3 : Annual electivity of food items of Rhacophorus leucomystax arranged in order of preference.

Food items	Frequency of occurrence	Percentage composition	Order of preference
Arachnida	39	33.33	I
Isoptera	17	14.52	II
Coleoptera	17	14.52	II
Insect larvae and nymphs	16	13.67	III
Orthoptera	13	11.11	IV
Lepidoptera	4	3.41	V
Myriapoda	3	2.56	VI
Frog	3	2.56	VI
Hemiptera	1	0.85	VII
Hymenoptera	1	0.85	VII
Diptera	1	0.85	VII
Dermaptera	1	0.85	VII
Mollusca	1	0.85	VII

pedical connecting cephalothorax with abdomen. They comprised 33.33% of the total food items.

(2) Myriapoda (Centipeds)

The representatives of myriapoda were identified by numerous body segmentations, numerous walking legs and cylindrical body. They contributed 2.56% of the total food items of the frogs.

(3) Insecta (Isoptera : Termites)

Termites representing Isoptera were identified by their equally elongated wings, biting and chewing type of mouth-parts and typical isopteran abdomen. They formed 14.52% of the total food items of the stomach contents. In certain cases, termites formed the bulk of contents in a single stomach.

(4) Insecta (Coleoptera : Beetles)

Small beetles were identified by hard fore-wings, membranous hindwings, large prothorax and biting type of mouth-parts. Coleoptera comprised 14.52% of the total food contents.

(5) Insecta (Insecta larvae and nymphs)

Insecta larvae and nymphs, complete or fragmented, formed 13.67% of the total food contents.

(6) Insecta (Orthoptera : Grasshoppers)

Fragments of grasshoppers, partly digested body, jumping legs, abdomen with ovipositor were found in stomach contents which formed 11.11% of the total food items.

(7) Insecta (Lepidoptera : Butterflies and Moths)

Fragments of lepidopterans, coiled proboscis and body parts formed 3.41% of the total food items of the stomach contents.

Fig. 5.1 Monthly analysis of volume of the
stomach contents of Rhacophorus leucomystax.

Fig. 5.2 Percentage of food items in the stomachs of
Rhacophorus leucomystax during annual breeding cycle.

Abbreviations :

Ara.	:	Arachnida
Col.	:	Coleoptera
Der.	:	Dermaptera
Dip.	:	Diptera
Fro.	:	Frog
Hem.	:	Hemiptera
Hym.	:	Hymenoptera
Iso.	:	Isoptera
Lar.	:	Insect larvae
Lep.	:	Lepidoptera
Mol.	:	Mollusca
Myr.	:	Myriapoda
Ort.	:	Orthoptera

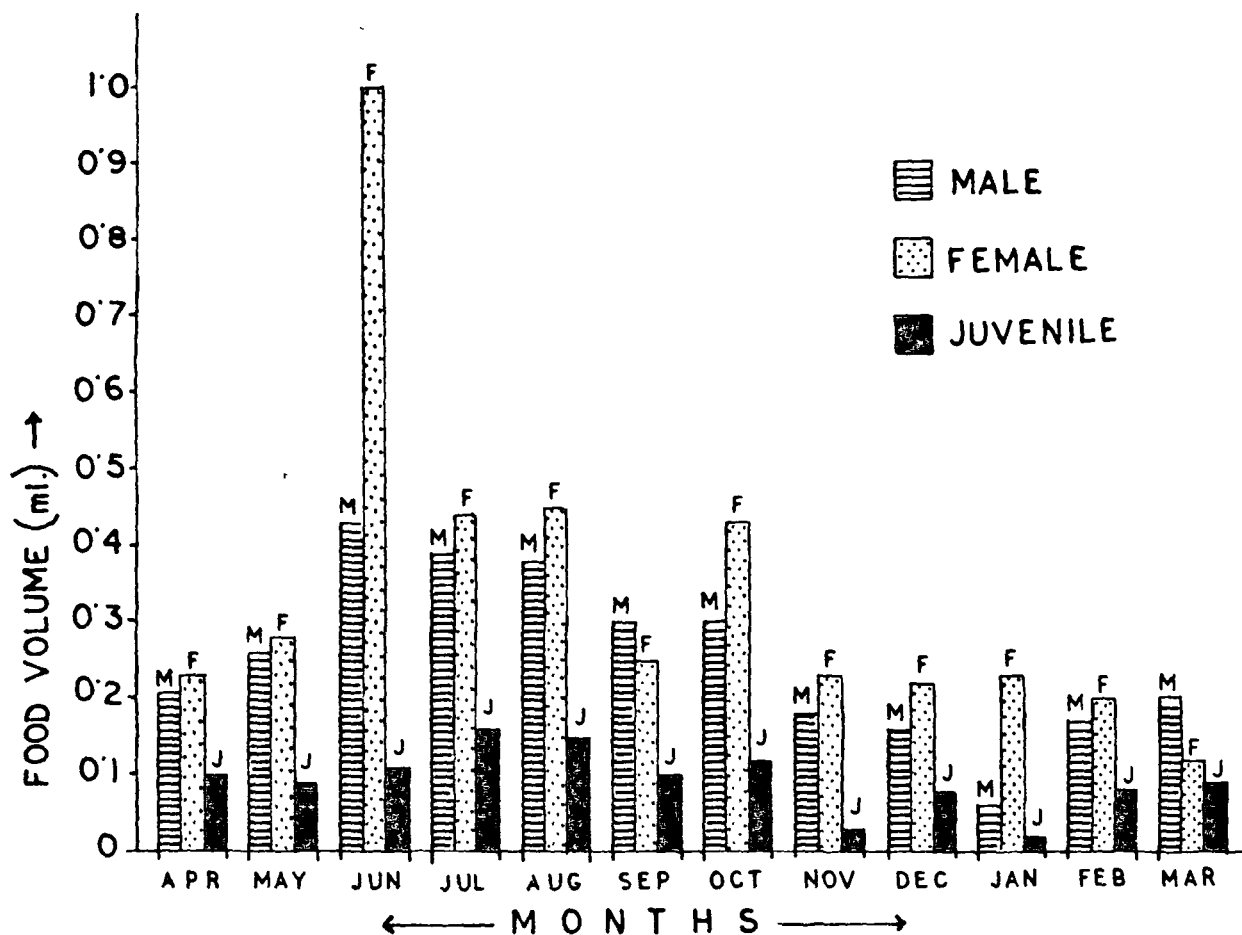


Fig 5.1

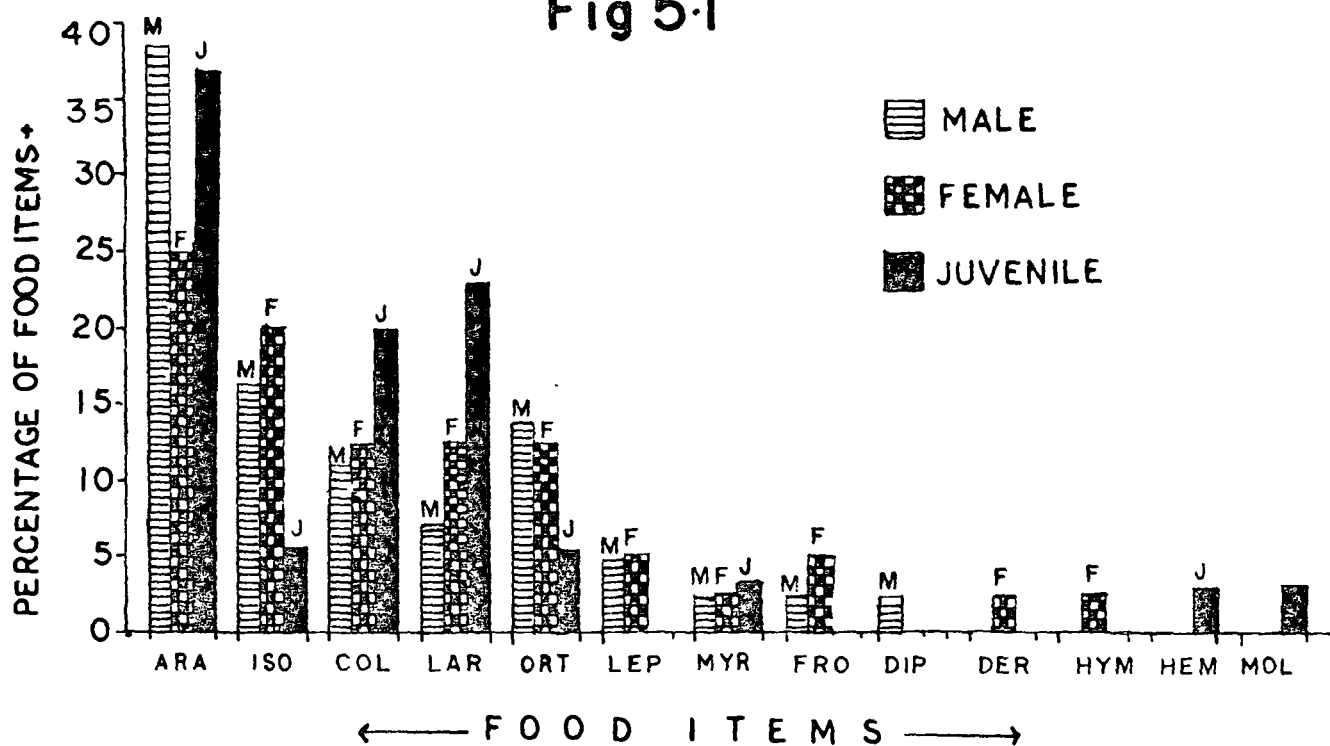


Fig 5.2

(8) Insecta (Hymenoptera : Ants)

Ants representing the order Hymenoptera in the diet of frogs were identified by their chewing type of mouth-parts, a pair of membranous wings and piercing ovipositor. 0.85% of the total food items were formed by the hymenopterans.

(9) Insecta (Hemiptera : Bugs)

The bugs were identified by their piercing and sucking type of mouth-parts and typical hemipteran wings. Hemipterans comprised 0.85% of the total stomach contents examined.

(10) Insecta (Diptera : Flies)

Dipteran flies were identified by a pair of membranous wings, a pair of halteres and sponging, sucking type of mouth-parts. They contributed a small fraction (0.85%) of the total stomach contents.

(11) Insecta (Dermaptera : Earwigs)

Earwigs were identified by long curved cerci and wingpads. They comprised 0.85% of the total stomach contents.

(12) Mollusca (Gastropoda : Snails)

Fragments of terrestrial gastropod comprised 0.85% of the total stomach contents of frogs examined.

(13) Amphibia (Anura : Frogs)

Frog pieces were also found as partly digested body, skull, limb bones and phalanges. They formed 2.56% of the total food items.

(b) Analysis of food items in Males, Females and Juveniles.

Analysis of food items were made separately in males, females and juveniles as shown in Table 5.4 and Fig. 5.2. In the case of males, the Arachnida comprised 38.08%, the Isoptera 16.66%,

Table 5.4 : Food items of different age groups of Rhacophorus leucomystax.

Food Items	Male N=50		Female N=48		Juveniles N=51	
	(Empty stomach Frequency of occurrence	Percentage composition	(Empty stomach Frequency of occurrence	Percentage composition	(Empty stomach Frequency of occurrence	Percentage composition
Arachnida	16	38.09	10	25.00	13	37.14
Myriapoda	1	2.38	1	2.50	1	2.85
Isoptera	7	16.66	8	20.00	2	5.71
Hymenoptera			1	2.50		
Coleoptera	5	11.90	5	12.50	7	20.00
Orthoptera	6	14.28	5	12.50	2	5.71
Insect larvae and nymphs	3	7.14	5	12.50	8	22.85
Lepidoptera	2	4.76	2	5.00		
Hemiptera					1	2.85
Diptera	1	2.38				
Dermaptera			1	2.50		
Mollusca					1	2.85
Frog	1	2.38	2	5.00		

the Orthoptera 14.28%, the Coleoptera 11.90%, the insect larvae and nymphs 7.14%, the Lepidoptera 4.76%, the Myriapoda 2.38%, the Diptera 2.38% and the frogs 2.38% of the total diet of male frogs.

In the females, the Arachnida comprised 25.00%, the Isoptera 20.00%, the Coleoptera 12.50%, the Orthoptera 12.50%, the insect larvae and nymphs 12.50%, the Lepidoptera 5.00%, the frogs 5.00%, the Myriapoda 2.50%, the Hymenoptera 2.50% and the Dermaptera 2.50% of the females' total food items.

In the juvenile stomachs, the Arachnida comprised 37.14%, the insect larvae and nymphs 22.85%, the Coleoptera 20.00%, the Orthoptera 5.71%, the Isoptera 5.71%, the Myriapoda 2.85%, the Hemiptera 2.85% and the Mollusca 2.85% of the total diet of the juveniles.

(c) Monthly percentage composition of food items

The percentage composition of food items showed a high fluctuation in different months (Fig. 5.3).

(1) Arachnida: The spiders were recorded in the stomach contents throughout the year fluctuating from 8.33%-100.00% in different months.

(2) Myriapoda: The centipeds fluctuated from 5.88%-12.50% during May, July and December.

(3) Orthoptera: The grasshoppers comprised 7.14%-40% in different months throughout the year except January, March and June.

(4) Insect larvae and nymphs: The fragments of insect larvae and

Fig. 5.3 12-Monthly analysis of percentage of
different food items in the stomach
of Rhacophorus leucomystax.

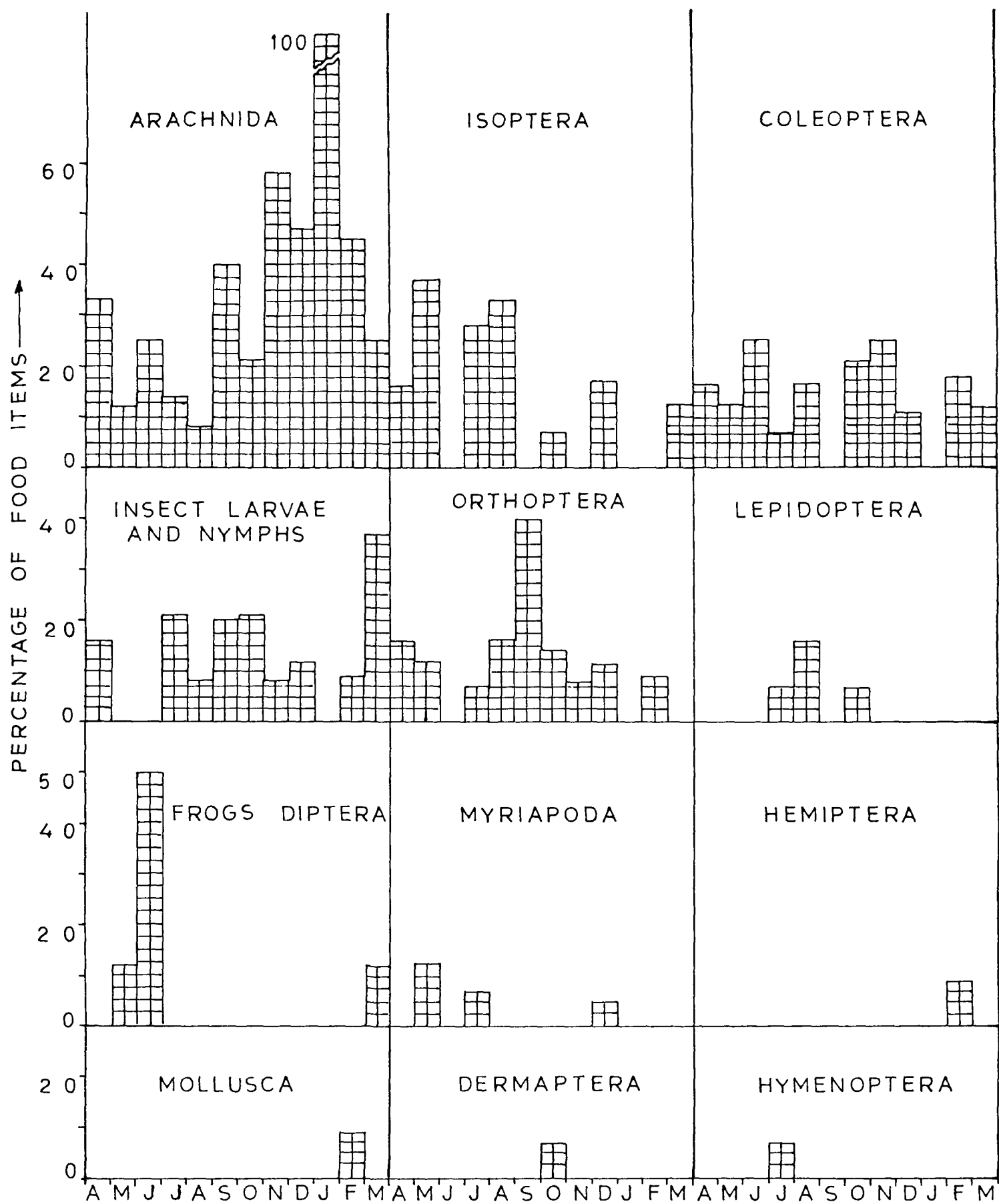


Fig 5.3

nymphs fluctuated from 8.33%-37.5% in the stomach contents throughout the year except January, May and June.

(5) Isoptera: The termites were recorded throughout the year except June, September, November, January and February. Their amount fluctuated from 7.14%-37.5% during different months.

(6) Coleoptera: The beetles were recorded throughout the year except in January which fluctuated from 7.14%-25% in different months.

(7) Lepidoptera: The butterflies and moths were recorded in the stomach contents during July, August and October fluctuating from 7.14%-16.66% in different months.

(8) Diptera: The flies belonging to order Diptera formed 12.5% of the stomach contents of March frog samples examined.

(9) Hemiptera: The bugs were present in the frog stomachs of March. They formed 9.09% of the stomach contents.

(10) Hymenoptera: The ants were recorded during July. They formed 7.14% of the stomach contents.

(11) Dermaptera: The earwigs were recorded from October samples. They formed 7.14% of the stomach contents.

(12) Gastropod: The gastropods formed 9.09% of the stomach contents during February. They were not recorded in the samples of other months.

(13) Anura: The frogs as food items were recorded in the stomachs of frog samples during May and June. They comprised 12.5%-50% during May and June.

(d) Percentage composition of food items during breeding and non-breeding periods.

Percentage composition of food items showed a fluctuation in different periods (Table 5.5 and Fig. 5.4).

Emerging and pre-breeding period: During emerging and pre-breeding period, the Isoptera comprised 28.57%, the Arachnida 21.42%, the Orthoptera 14.28%, the Coleoptera 14.28%, the insect larvae and nymphs 7.14%, the Myriapoda 7.14% and the frogs 7.14% of the food items.

Breeding period: During breeding period, the Isoptera comprised 22.22%, the Arachnida 16.66%, the insect larvae and nymphs 16.66%, the Coleoptera 11.11%, the frog 11.11%, the Orthoptera 5.55%, the Hymenoptera 5.55%, the Myriapoda 5.55% and the Lepidoptera 5.55% of the breeding frog's food items.

Post-breeding and entering: During post-breeding and entering period, the Arachnida comprised 29.54%, the Coleoptera 20.45%, the Orthoptera 15.9%, the insect larvae and nymphs 13.63%, the Isoptera 11.36%, the Lepidoptera 6.81% and the Dermaptera 2.27% of the frog stomach contents.

Hibernation period: During hibernation period, the Arachnida comprised 48.78%, the insect larvae and nymphs 14.63%, the Coleoptera 9.75%, the Isoptera 9.75%, the Orthoptera 7.31%, the Myriapoda 2.43%, the Hemiptera 2.43%, the Diptera 2.32% and the Mollusca 2.32% of the hibernating frogs food items.

Table 5.5 : Food items of Rhacophorus leucomystax during different periods of the annual breeding cycle.

Food Items	Emerging and pre-breeding period		Breeding period		Post-breeding and entering period		Hibernation period	
	Frequency of occurrence	Percentage composition	Frequency of occurrence	Percentage composition	Frequency of occurrence	Percentage composition	Frequency of occurrence	Percentage composition
Arachnida	3	21.42	3	16.66	13	29.54	20	48.78
Myriapoda	1	7.14	1	5.55			1	2.43
Isoptera	4	28.57	4	22.22	5	11.36	4	9.75
Hymenoptera			1	5.55				
Coleoptera	2	14.28	2	11.11	9	20.45	4	9.75
Orthoptera	2	14.28	1	5.55	7	15.90	3	7.31
Insect larvae and nymphs	1	7.14	3	16.66	6	13.63	6	14.63
Lepidoptera			1	5.55	3	6.81		
Hemiptera							1	2.43
Diptera							1	2.43
Dermaptera					1	2.27		
Mollusca							1	2.43
Frog	1	7.14	2	11.11				

Fig. 5.4 Percentage of food items in the stomach of Rhacophorus leucomystax during different periods of annual breeding cycle.

Abbreviations :

Ara.	: Arachnida
Col.	: Coleoptera
Der.	: Dermaptera
Dip.	: Diptera
Fro.	: Frog
Hem.	: Hemiptera
Hym.	: Hymenoptera
Iso.	: Isoptera
Lar.	: Insect larvae
Lep.	: Lepidoptera
Mol.	: Mollusca
Myr.	: Myriapoda
Ort.	: Orthoptera

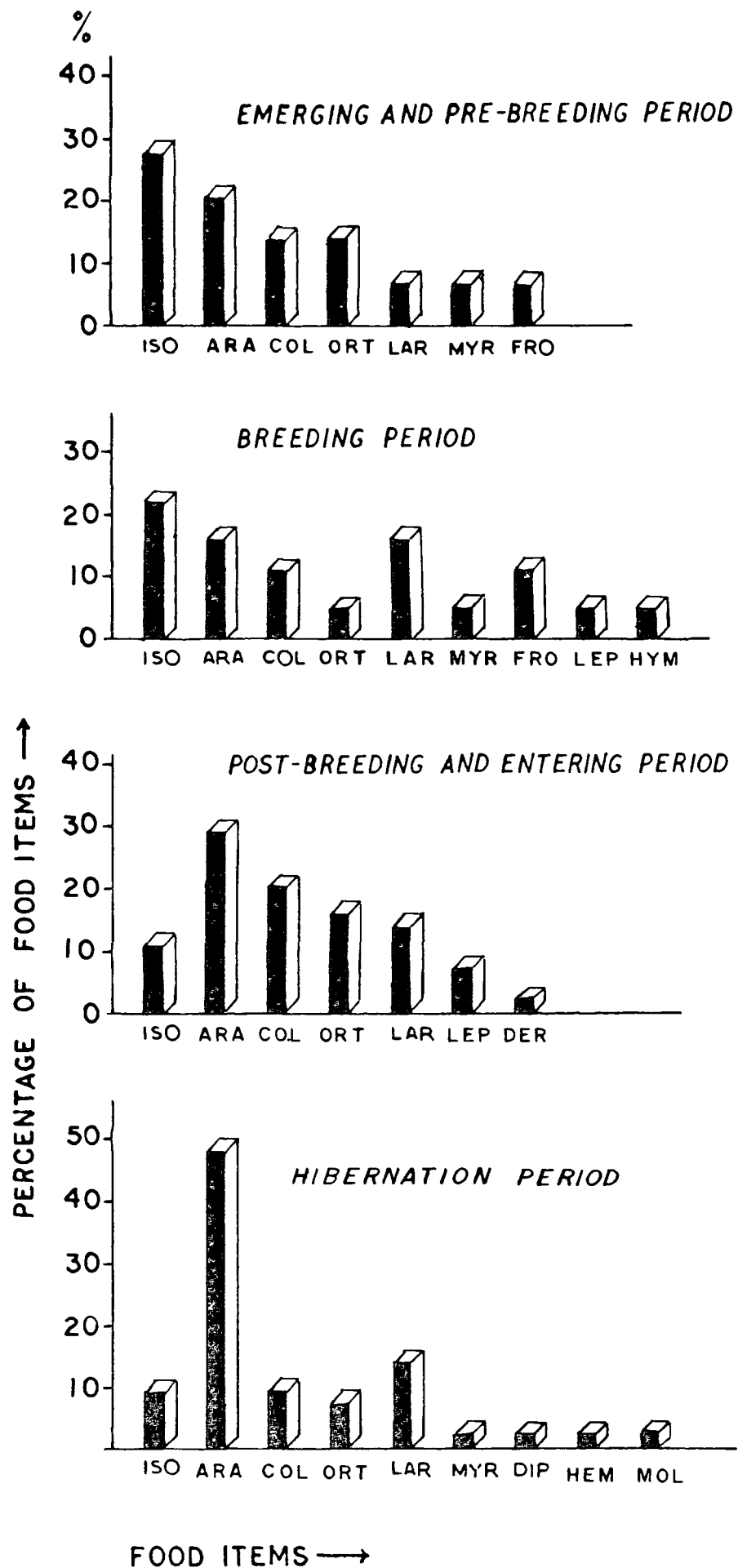


Fig 5.4

5.5.1 Food preference

The present study indicates great variability in the food preference in different periods of annual breeding cycle. For example, the isopterans formed the highest percentage (28.57%) of the diet during emerging and pre-breeding period and (22.22%) of the diet during breeding period. The archnids comprised the highest percentage (29.54%) of the diet during postbreeding and entering period and (48.78%) of the diet during hibernation period. There are very few contributions dealing with variation in anuran diet through their annual breeding cycle. Labanick (1976) and Roy (1979) also mentioned the seasonal variation according to the availability of prey as food items.

Taking the total food intake in a year, the ar^achnids formed the first preference food item recorded in the diet throughout the year, comprising about 33% of the total stomach contents. The isopterans and coleopterans formed the second food preference, comprising about 14% of the total stomach contents. The insect larvae and nymphs comprised 13.67% and formed the third food preference. The orthopterans formed the fourth preference of food items being 11.11%. The lepidopterans, 3.41% and formed the fifth food preference. The myriapods and frogs comprised 2.56% each and formed the sixth preference food items. The hymenopterans, the dipterans, the dermapterans, the hemipterans and the molluscs comprised 0.85% each and formed the seventh preference food items.

The insect alone formed 60% of the stomach contents and serve as a preference food of frogs. Tyler and Hoestenbach (1979) reported that insects comprise 82% of the total weight of food items in Rana catesbeiana. Rhacophorus leucomystax is cannibalistic in nature as small frogs upto SVL 40 mm have been recorded in the stomach contents of this species as also reported by several workers. Hulse (1978) has reported Lepidobatrachus llanensis to be a cannibalistic species as parts of frogs were found in its diet. The present observations are somewhat different from Clarke (1974) where ants and beetles formed 81% of all food items eaten by Bufo woodhousei fowleri and Roy (1979) where Formicoidea formed the first food preference in Rana limnocharis. The variation is probably because of the difference in species, locality and their types of food preference.

Most of the stomachs examined contained only one type of food especially termites or ants or arachnids in large numbers. This reflects that termites, ants and arachnids were perhaps the major items available in the surrounding. Dimmitt and Ruibal (1980) reported Scaphiopus cauchi diet primarily composed of termites and may consume 55% of its body weight at one feeding. About 35% stomachs were empty probably because they were not voracious eaters or their arboreal habit might be depriving them of food in most cases. Both adults and juveniles in general take similar preys. Though the female members take on more varieties of preys.

All 13 types of food items recorded in the stomach contents were terrestrial organisms. This suggests that Rhacophorus leucomystax is undoubtedly a terrestrial feeder.

5.5.2 Volume of food intake

The food volume was found to be 0.12 ml-1.0 ml in females, 0.06 ml-0.43 ml in males and 0.03-ml-0.16 ml in juveniles. So the amount of food intake was higher in females than in males and juveniles. Higher consumption of food by females may be due to their bigger size or higher metabolic needs required for production of ova.

The volume of food was maximum during breeding period (0.39 ml-0.43 ml in males, 0.44 ml-1.0 ml in females and 0.11ml-0.16 ml in juveniles) showing their greatest feeding activity during this period. During hibernation period the food volume was the lowest (0.06 ml-0.17 ml in males, 0.12 ml-0.23 ml in females and 0.02 ml-0.09 ml in juveniles) suggesting their feeding activity continues during this period also but in lesser amount. During emerging and pre-breeding period (0.21 ml-0.26 ml in males, 0.23 ml-0.28 ml in females and 0.09 ml-0.1 ml in juveniles) and postbreeding and entering period (0.18 ml-0.38 ml in males, 0.23 ml-0.45 ml in females and 0.03 ml-0.15 ml in juveniles), they shows an intermediate feeding activity.

5.5.3 Frog food and biological control

Liu and Chen (1932) and Khan (1973) reported Rana tigrina as biological control agent of harmful crop pests. Roy (1979) recorded Rana limnocharis as biological control agent of paddy pests, the grasshoppers and bugs. In the present investigation a good percentage of spiders, termites, grasshoppers and bugs were recorded from Rhacophorus leucomystax diet. So, it can be used as a biological control agent for webbers and other forest pests.

This chapter deals with food and feeding habits of Rhacophorus leucomystax. It was noted that food intake of the frogs was highest during breeding period and lowest during hibernation period. During breeding period the amount of food taken by females was much higher than that of males. 12-month analysis of the food items removed from the stomachs reveal that arachnids and insects formed a high percentage of food items, but among the insects, isopterans and coleopterans formed the highest percentage. Small percentage of molluscs as food items and cannibalism was also recorded. An analysis of food intake also suggests the nature of organisms present in the biotope. It was noted that frogs eat during hibernation period also, although the volume of food intake was lowest during this period.

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CHAPTER 6

Pituitary - Gonadal Cycle

The role of pituitary gland in somatotrophic and gonadotrophic functions of vertebrates is well known. Van Dordt (1963) while working on pars distalis of Xenopus, Rana and Bufo species described 2 types of cells, acidophils and basophils. He further divided acidophils in 2 types and basophils in 3 types. Lakshman (1965) investigated the pituitary gland during different seasons of the year on Rana cyanophlyctis, Rana tigrina, Rana hexadactyla, Bufo melanostictus and Uperodon systoma. He used different staining techniques and identified 4 types of cells in the anterior pituitary gland such as acidophils, 2 types of basophils and chromophobes. Van Dordt, Van Dongen and Lofts (1968) recorded morphological, 3 basophilic types and 2 acidophilic types in the pars distalis of the male Rana temporaria during annual cycle. Zysk (1975) identified 4 types of cells: acidophils or α cell, 2 types of basophils (β -cells and δ -cells), and chromophobes in the pars distalis of Rana temporaria during the annual breeding cycle.

It is known that acidophilic cells release somatotrophic hormones (Kerr, 1965 and Van Kemenade, 1974) and basophilic cells gonadotrophic hormones (Lakshman, 1965 and Zysk, 1975). Van Beurden (1979) described gametogenesis in Cyclorana platycephallus; and Chieffi, Rastogi, Milone and Iela (1980) described seasonal testicular cycle in Rana esculenta in relation to secretion of pituitary hormones.

The present study has been carried out on the cytological changes of acidophils (α cells), basophils (β cells) and

chromophobes of the pars distalis of Rhacophorus leucomystax in relation to changes in the testis in the males and ovary in the females during different periods of the annual breeding cycle.

6.2.1 The Pituitary Gland

During last 3 decades a fairly good insight has been attained in our knowledge on pituitary. One of the important aspects of pituitary investigated by workers is cell types, their secretory activity and relationships with gonadal changes during annual breeding cycle:

(a) Cell types: Though during early phases of study on pituitary there was some dispute among workers on the identification of cell types of pars distalis, a uniform nomenclature has been accepted in recent years (see for review Harris and Donovan, 1966; Purves, 1966 and Hanke, 1976). Among workers who extensively studied in recent past the cell types of pars distalis, mention can be made of Van oordt (1963) in the pars distalis of Xenopus, Rana and Bufo. He identified 2 types of cells: acidophils and basophils. He further classified acidophils into 2 types and basophils into 3 types. Kerr (1965) studied the distal lobe of pituitary of Xenopus laevis and described 2 types of acidophils (acidophils 1 and 11) and 3 types of basophils (basophils 1, 11 and 111). While working on the pituitary gland of Rana cyanophlyctis, Rana tigrina, Rana hexadactyla, Bufo melanostictus and Uperodon systoma Lakshman (1965) identified 4 types of cells: acidophils, 2 types of basophils (PAS-purple and red basophils) and chromophobes in the anterior lobe of the anuran pituitary. On the basis of cytological observations, colouration and histochemical reactions on the anterior hypophysis of Pelobates cultrives, Reyrel (1967) identified 6 cellular types: 3 acidophils and 3 basophils. Van Oordt, Van Dongen and Lofts (1968) while working on the seasonal

changes in the pars distalis of male Rana temporaria described 2 types of acidophils (acidophils 1 and 11) and 3 types of basophils (basophils 1, 11 and 111) using different histochemical staining reactions. Mira-Moser (1970) described 2 types of acidophils (acidophils 1 and 11) and 4 types of basophils (basophils 1, 11, 111 and IV) in Bufo bufo. Rastogi and Chieffi (1970) studied the cytological changes of pars distalis of Rana esculenta during the reproductive cycle and reported acidophil number as the smallest during egg-laying period. Pehlemann (1974) and Van Kemenade (1974) have described 2 types of acidophils (acidophils 1 and 11) and 3 types of basophils (basophils 1, 11 and 111) in amphibia. Doerr-Schott (1974) has described 3 types of cells: acidophils, basophils and amphophils in the amphibia. Recently, Zysk (1975) has analysed the quantitative changes of cells in the pars distalis of the pituitary in Rana temporaria during the annual cycle and described acidophils or α cells, basophils or β cells and chromophobes. Roy (1979) also studied the behaviour of 3 cell types: acidophils, basophils and chromophobes in Rana limnocharis.

(b) Secretory activity of different cell types: So far as secretory activity of the cells of the anterior pituitary is concerned, a number of workers have contributed to our information in recent years. Lakshman (1965) reported that PAS-purle basophils are responsible for follicular stimulating hormone (FSH) factor and PAS-red basophils possibly the luteinizing hormone (LH) factor exclusive for ovulation in frogs and toads. Kerr (1965) described that acidophil 1 secretes somatotrophic hormone (STH) and LH and acidophil 11 secretes luteotrophic hormone (LTH) in Xenopus laevis.

Van Oordt, Van Dongen and Lofts (1968) attributed basophil 1 to be the source of thyroid-stimulating hormone (TSH), basophil 11 to be the source of gonadotrophic hormone (GTH) and basophil 111 may be a source of adreno-corticotrophic hormone (ACTH) which control the production of testis hormone and corticoids from the testis in Rana temporaria. Mira-Moser (1970) attributed that acidophils secrete STH, basophils secrete FSH in Bufo bufo. Ackermann, Nowicki and Sarmacka-Keller (1971) suggested the chromophobes to be precursors of other cell types. Van Kemenade (1974) reported that acidophil 1 secretes LTH, acidophil 11 secretes STH, basophil 1 secretes thyroid-stimulating hormone (TSH), basophil 11 secretes FSH and LH and basophil 111 secretes ACTH in amphibia. Pehlmann (1974) reported that acidophils secrete STH and basophils secrete FSH and LH in Xenopus. Doerr-Schott (1974) attributed that amphophils secrete FSH and LH in Rana. Zysk (1975) discussed that basophilic cells are closely involved in the production of GTH and basophilic cells secrete TSH and ACTH in Rana temporaria.

6.2.2 The Gonads

The seasonal changes in the gonads of anurans have been studied in a number of species. Rugh (1962) has provided a detailed description on histomorphology of gonads of Rana pipiens. Among recent references more important of these are following:

(a) Testis: Jenssen (1972) reported the testes of Rana clamitans as heaviest in weight during the breeding period from May through August. Schroeder (1974) studied the histological sections of the testes of Rana catesbeiana and found that they become mature by

2nd full season. Obert (1976) observed that spermatogenesis in Bombina variegata variegata was not continuous at the spermatocyte or the spermatogonia formation stage but there were periods of stagnation and proliferation during which the male toad produced mating calls. Van Beurden (1979) studied the gametogenesis of Cyclorana platycephallus and found that regardless of size, male individuals have mature sperms in their testes. Maruyana (1979) noted that spermatogenesis in Rana nigromaculata almost stop before winter. Jorgensen, Larsen and Lofts (1979) recorded that the spermatogenetic activity in male toads, Bufo bufo bufo starts shortly after the spawning period and it reached a maximum during summer. Sun (1979) studied the histological sections of the testes of Rana limnocharis in winters and observed many seminiferous tubules with different stages like germinal cyst, spermatogonia, spermatocytes, spermatids and spermatozoa and noted the spermatogenesis to be active and continuous. Chieffi, Rastogi, Milone and Iela (1980) recorded that spermatogenesis in Rana limnocharis starts in early spring just before the onset of breeding and continues through autumn with a brief winter stasis. Recently Saxena and Lal (1981) studied the seasonal changes in the testes of Bufo marinus in relation to environmental factors.

(b) Ovary: Oogenesis in female anurans can be reviewed among the most recent and more important contributions as the following: Jenssen (1972) noticed that the females of Rana clamitatus marked the maximum reproductive readiness in June and July. Maruyana (1979) reported that ovaries of Rana nigromaculata grows rapidly in August and winter. The ovaries showed a 3-fold increased in relation to weight. Van Beurden (1979) noticed large female

individuals of Cyclorana platycephallus had mature ova.

Jorgensen, Larsen and Lofts (1979) noted that the ovarian cycle of Bufo bufo bufo was initiated during summer. Revera-G, Zegarra-A, Bornaz-A, Alaron-L and Paz-A (1980) studied the histological aspects of oogenesis of anuran, Telmatobius arequipensis and divided the oogenesis into 5 stages based on general appearance of oocytes: stage I. oocytes colourless; stage II. oocytes white in colour; stage III. oocytes have pigment uniformly distribution; stage IV. oocytes have differentiation of animal and vegetal hemispheres distinguished and stage V. oocytes reached its maximum size with a hemisphere clearly delineated.

The frogs were captured at regular monthly intervals at Kohima, and brought to the laboratory, pithed and dissected for the present study. The pituitary and gonads were collected every month and fixed as soon as possible to avoid postmortem changes.

6.3.1 Pituitary Gland

The pituitary was collected as per the technique of Rugh (1962) and fixed in Bouin's Picro-formol. It was dehydrated through graded mixtures of Ethanol and Butanol and embedded in wax for microtomy. The sections were cut at 5-6 μ m and stained by several techniques such as: Aldehyde-Fuchsin method, Heidenhain's Azan method, Matsuo Tetrachrome stain, Periodic Acid-Schiff (PAS) although Mallory's triple staining method and Delafield's haematoxylin-Eosin method provided clear identification of 3 cell types: (i) acidophils, (ii) basophils and (iii) chromophobes.

The size of cells were measured with ocular and stage-micrometers. The number of different types of cells was counted per unit area ($\pi r^2 = 0.123$ sq.mm). The histological details were observed under oil immersion (magnification 1000X).

6.3.2 Gonads

The gonads (testis and ovary) were dissected out and fixed in Bouin's Picro-formol. Pieces of gonads were dehydrated through graded mixtures of Ethanol and Butanol and embedded in paraffin wax. The sections were cut at a thickness of 7-8 μ m and stained in Delafield's haematoxylin and counter-stained in Eosin. Observations for spermatogenic cells in the seminiferous tubules were made under high magnification (1000X) and for ovary under low magnification (100X).

6.4

6.4.1 Pituitary Gland(i) Morphological structure

The pituitary gland of Rhacophorus leucomystax is found at the base of the cranium floor (diencephalon) just behind the optic chiasma on the ventral side of the brain (Fig. 6.1). It has 2 parts:

(a) Adenohypophysis

Adenohypophysis is ventro-caudal to the neurohypophysis and composed of the pars distalis, pars intermedia and pars tuberalis (Fig. 6.2).

Pars distalis: Pars distalis forms the bulk of the adenohypophysis. It is transversely elongated, bean-shaped and pinkish in colour. It connects pars intermedia by a connective tissue along its mid-anterodorsal margin and lies antero-ventral to median eminence.

Pars intermedia: It lies postero-ventral to neurohypophysis (pars nervosa) and form a slender, long transverse bar. Pars intermedia is longer and slender than pars distalis.

Pars tuberalis: A pair of small projecting epithelial, attached to the surface of tubers in front of pituitary proper.

(b) Neurohypophysis

It is composed of median eminence and pars nervosa. The neurohypophysis is situated antero-dorsal to adenohypophysis. It is made up of neural tissues and neurosecretory cells and fibres.

Median eminence: It is situated antero-dorsal to adenohypophysis

Fig. 6.1 Ventral view of brain of Rhacophorus
leucomystax showing the pituitary gland.

Abbreviations :

Cbhem. : Cerebral hemisphere
Eyeb. : Eye ball orbit.
Inf. : Infundibulum
Med. : Medulla oblongata
Opch. : Optic chiasma
Pty. : Pituitary gland

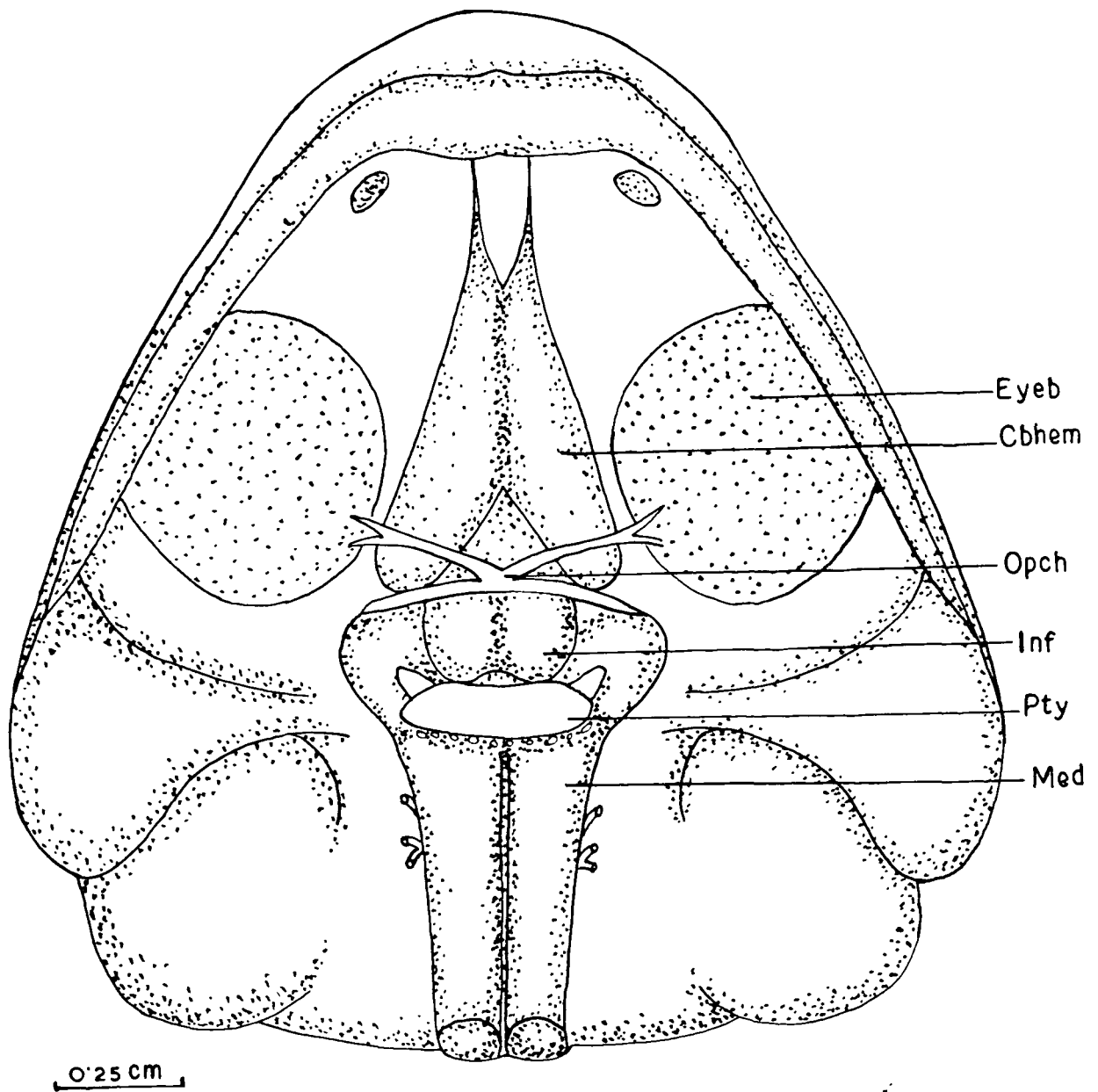


Fig 6.1

Fig. 6.2 Diagrammatic representation of median sagittal section of the anuran pituitary gland.

Abbreviations :

Inf. : Infundibulum
Mem. : Median eminence
Pdi. : Pars distalis
Pin. : Pars intermedia
Pne. : Pars nervosa

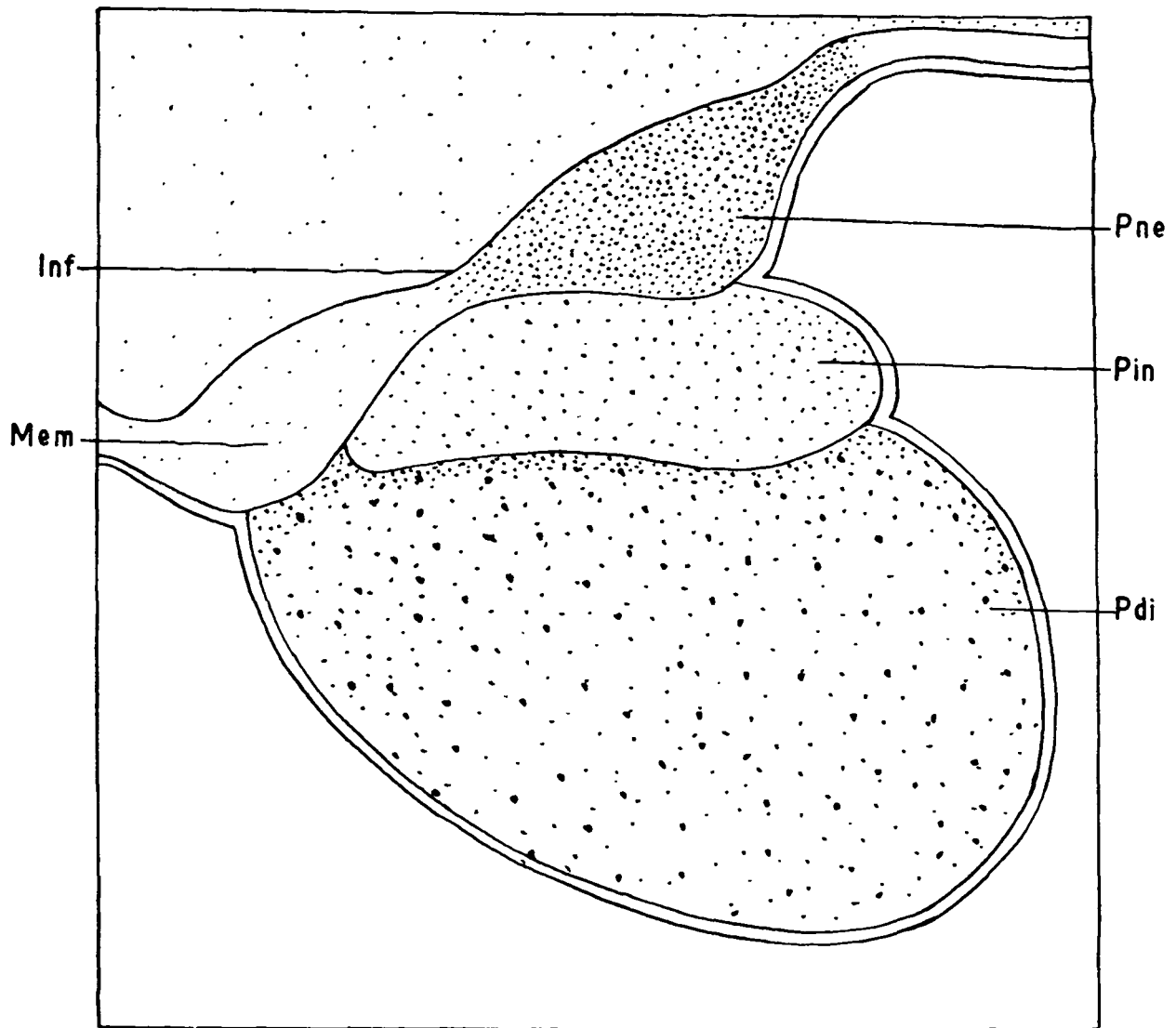


Fig 6·2

in contact with pars distalis at the antero-ventral portion and with pars intermedia at the postero-ventral portion.

Pars nervosa: Pars nervosa is situated posterior to median eminence and dorsal to pars intermedia.

(ii) Histological structure of pars distalis

In cross sections, the pars distalis is seen composed of cells in branching cords in more or less radiating patterns, separated by capillaries (Fig. 6,3; Pls. 6.1A and B).

At the peripheral region, the cells were found more compact, separated by small sinusoids and thin connective tissues. In the central region, cells were found less compact and loosely packed, separated by larger sinusoids and connective tissues. The 3 major types of cells namely, acidophils or α cells, basophils or β cells and chromophobes were identified as follows.

Acidophils or α cells

The acidophils or α cells are oval, polyhedral, columnar and ellipsoidal with a centric nucleus. The cytoplasmic granules show strong acidic property. They are found usually along the sinusoids, mostly in the central region. They are believed to secrete somatotrophic hormone (STH).

Basophils or β cells

The basophils or β cells are usually the largest cell type observed. They are spherical, oval, polyhedral in shape with an eccentric nucleus. The cytoplasmic granules are with strong basic property. They are scattered, usually more in the peripheral region. The basophil cells are believed to secrete gonadotrophic hormone (GTH).

Fig. 6.3 Schematic diagram of a portion cross-section of the pars distalis of Rhacophorus leucomystax.

Abbreviations :

Chr. : Chromophobe cells

Sinu. : Sinusoids

α : Acidophil cells

β : Basophil cells

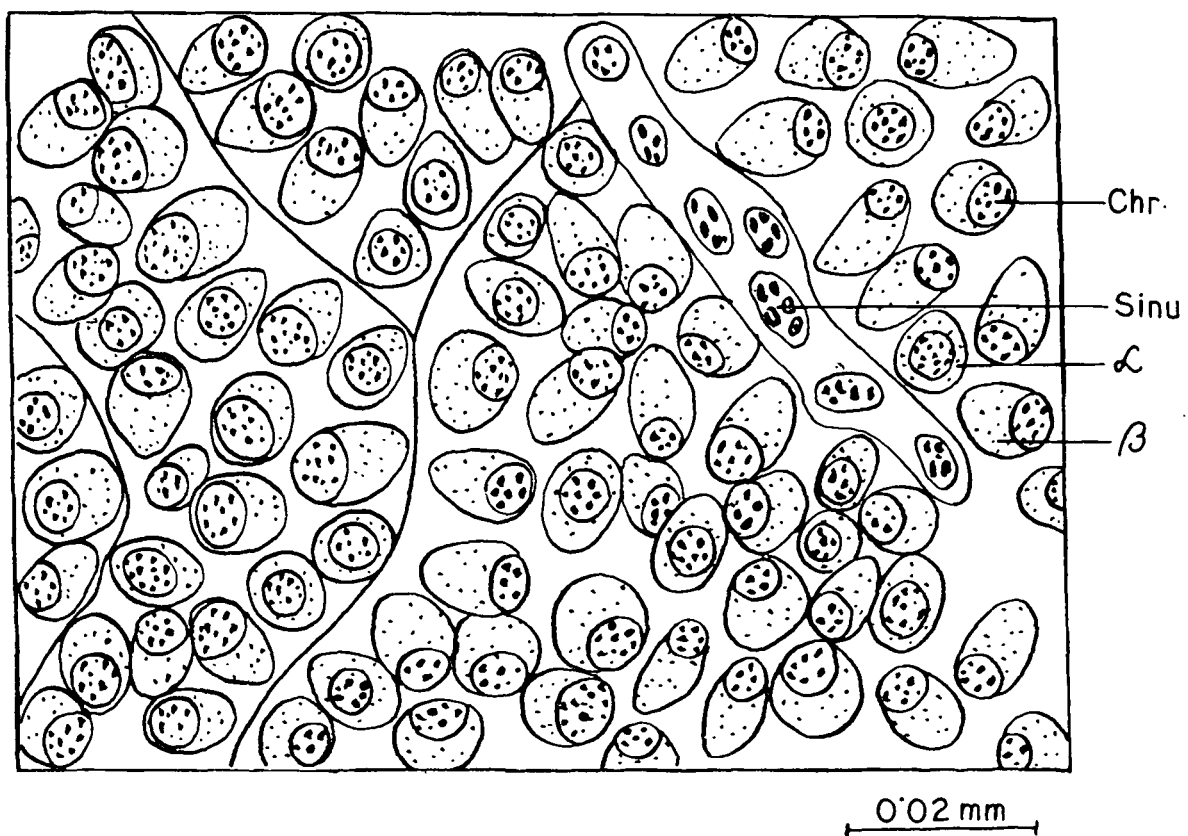
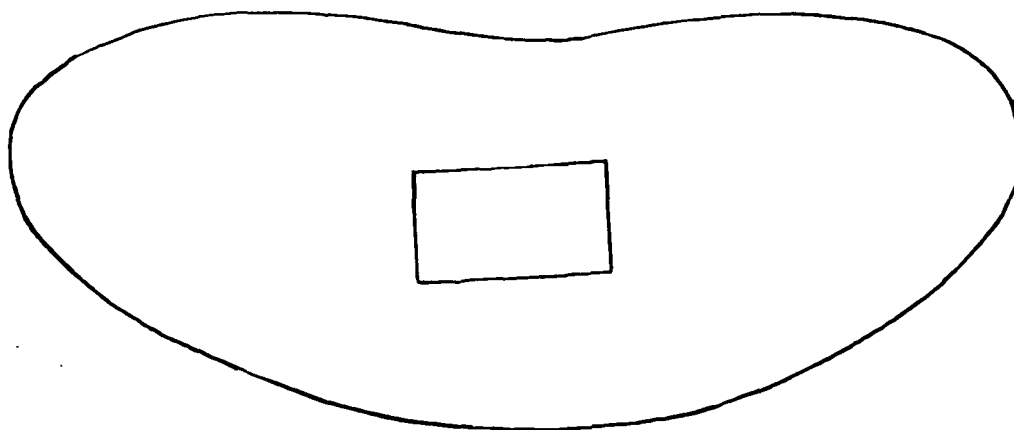


Fig 6.3

Plate 6.1A : A portion of the cross section of the pars distalis of Rhacophorus leucomystax during breeding periods (X400).

Plate 6.1B : A portion of the cross section of the pars distalis of Rhacophorus leucomystax during non-breeding periods (X400).

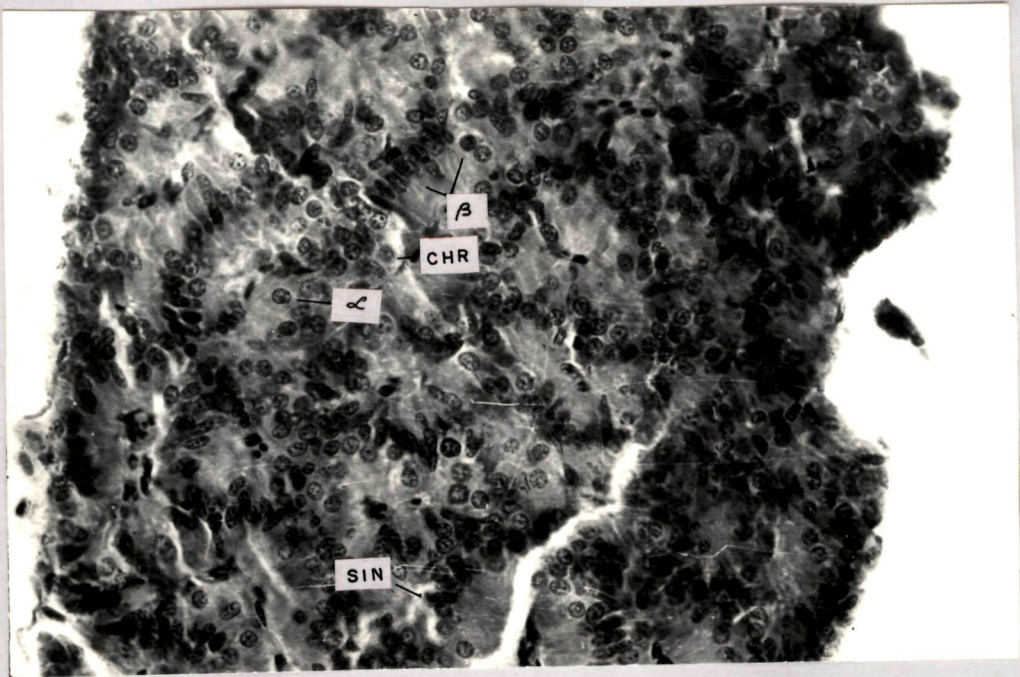
Abbreviations:

CHR : Chromophobe cells

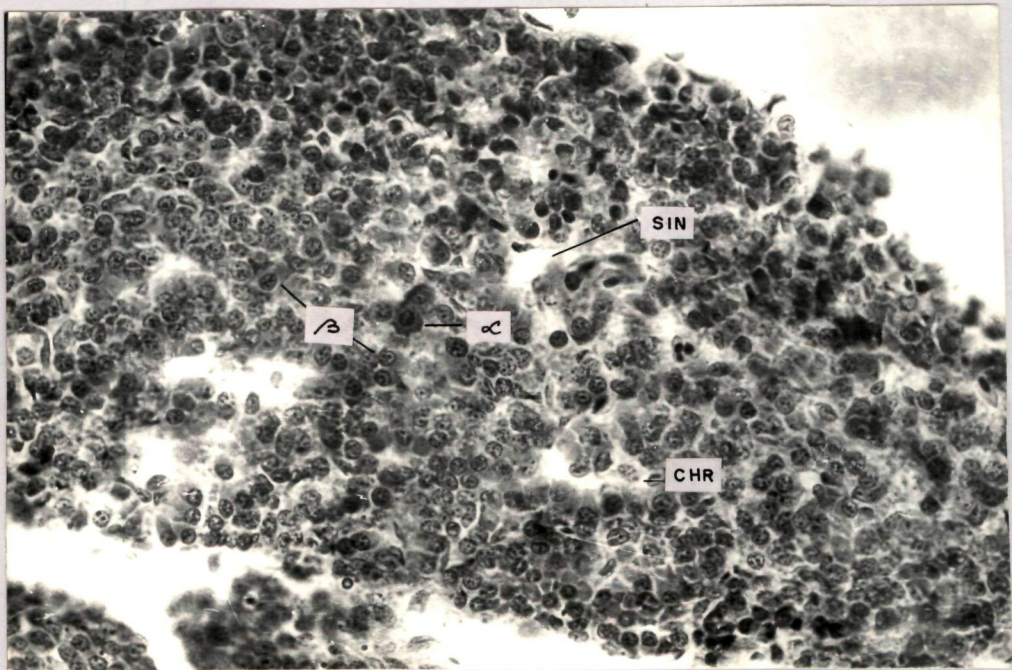
SIN : Sinusoids

α : Acidophil cells

β : Basophil cells



A



B

PLATE 6.1

Chromophobe cells

The chromophobe cells are oval, ellipsoidal in shape with an eccentric nucleus. Cells may be small or large with poor stained cytoplasmic granules. Cells may occur singly or in pairs. They are believed to be the precursors of other differentiating cells, but their definite function is still not clear.

(iii) Behaviour of cell types of pars distalis during annual breeding cycle

The behaviour of the 3 cell types (number/unit area and the size of cells) has been illustrated in Tables 6.1 and 6.2; Fig. 6.4.

Acidophil cells: The cell cytoplasm was granulated in all the periods. The number of these cells/unit area was minimum in early breeding (spawning) period and maximum in late breeding period. The cells and nuclei were smallest in size in the late breeding period and largest during the hibernation period (winter sleep).

Basophil cells: The cells had non-granulated cytoplasm during pre-breeding and breeding periods and granulated during postbreeding and hibernation periods. The number of cells/unit area was minimum in the early breeding (spawning) period and maximum during the hibernation period (winter sleep). The cells and nuclei were smallest in size during the breeding period and largest during the hibernation period.

Chromophobe cells: The number of chromophobe cells was maximum in the early breeding (spawning) period and minimum during the post-breeding period. The cells and nuclei were smallest in size during postbreeding period and largest during hibernation period (winter sleep).

Table 6.1 : Average number of the major cell types per unit area (0.123 sq. mm) found in the pars distalis (anterior pituitary gland) of Rhacophorus leucomystax during annual breeding cycle.

Month of Investigation	Acidophil or α cell	Basophil or β cell	Chromophobe cell
January	18.18	45.28	2.33
February	18.20	43.50	2.62
March	18.12	50.87	3.00
April	18.83	47.33	3.16
May	18.42	45.85	4.43
June	18.10	37.50	4.75
July	21.87	40.37	3.30
August	20.43	41.57	3.00
September	19.28	43.00	2.71
October	18.87	49.88	1.62
November	18.37	48.60	1.87
December	19.00	44.37	2.00

Table 6.2 : Average cell size and nuclear diameter (μ or micron) of different cell types in the pars distalis (anterior pituitary gland) of Rhacophorus leucomystax during annual breeding cycle.

Month of Investigation	Acidophil cell		Nuclear Diameter	Basophil cell		Nuclear Diameter	Chromophobe cell		Nuclear Diameter
	Length	Width		Length	Width		Length	Width	
January	10.2	8.0	6.4	11.7	7.9	6.5	10.8	6.8	6.1
February	10.3	8.6	6.4	11.9	7.8	6.3	10.5	7.2	6.0
March	9.5	7.7	5.6	11.2	7.7	6.0	9.8	7.0	5.1
April	9.8	7.5	5.3	10.5	7.0	5.9	10.7	6.7	5.6
May	9.3	7.5	5.2	10.9	7.8	6.4	10.1	7.2	5.3
June	9.1	8.1	4.9	10.0	8.0	5.6	10.5	7.3	5.1
July	8.8	7.5	4.6	9.8	7.5	5.2	10.0	7.7	5.2
August	9.6	7.7	5.1	10.1	7.9	6.4	10.1	7.5	4.9
September	9.8	7.4	5.3	10.3	7.0	5.8	9.3	7.0	5.1
October	9.2	7.8	5.9	10.6	7.7	5.9	9.5	6.8	5.3
November	9.5	8.2	5.7	10.3	7.6	6.1	10.2	6.3	5.6
December	9.8	7.2	5.8	11.4	7.3	5.6	10.3	6.5	5.8

Fig. 6.4 Average number of α , β and chromophobe cells of the pars distalis of Rhacophorus leucomystax during annual breeding cycle.

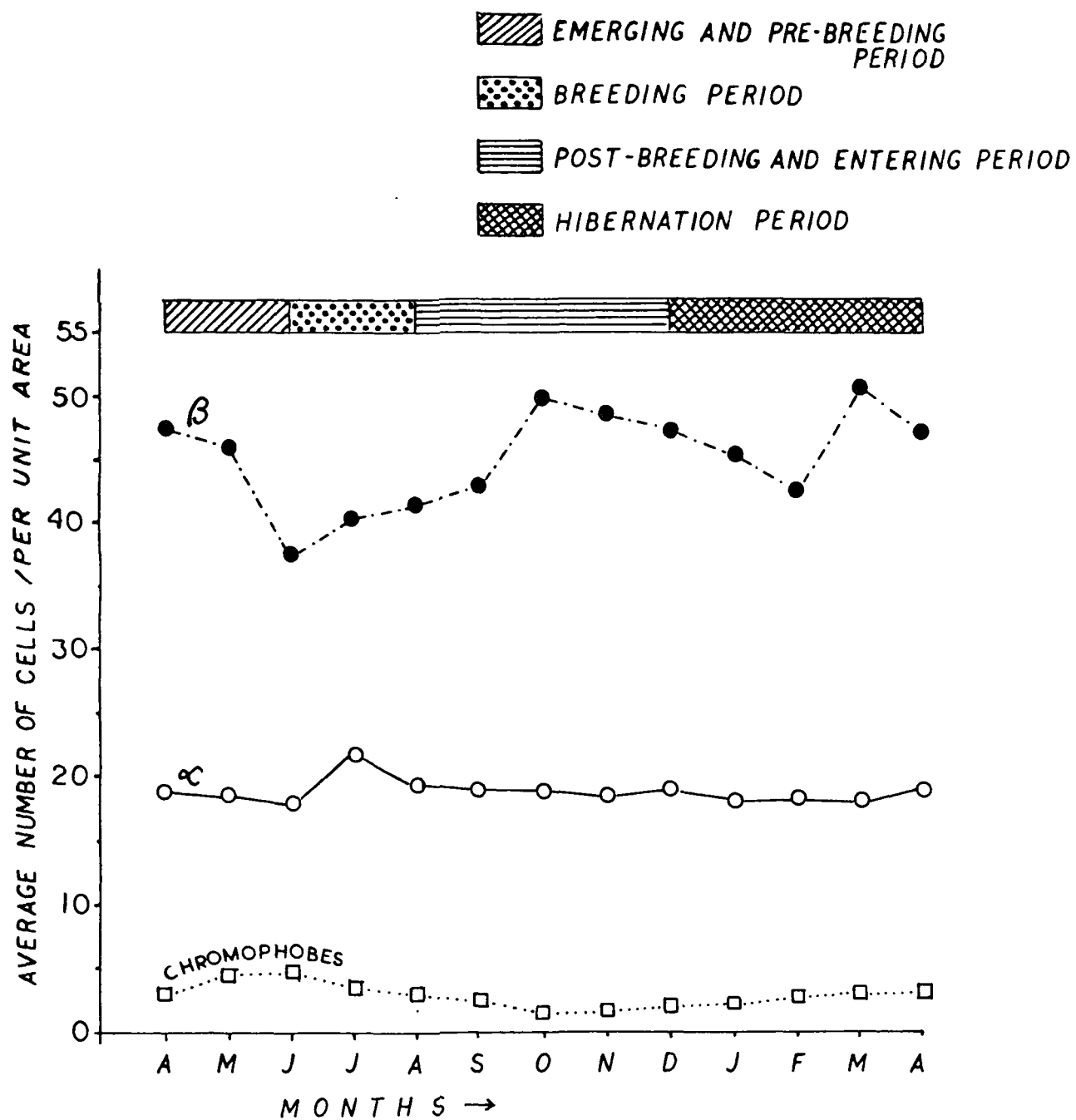


Fig 6.4

6.4.2 Gonads(A) Testis(i) Shape and position

The two testes are white in colour and oval-shaped attached at the antero-ventral end of each kidney with the help of a double fold of peritoneum, called mesorchium (Pl. 6.2).

(ii) Histological structure of testis

Each testis is composed of a number of constructed seminiferous tubules. In sections, each seminiferous tubule is oval or tubular and is separated from other by a thin partition of connective tissue. It is lined by stratified germinal epithelium from which arise internally sertoli cells and spermatogenic cells (Pls. 6.3A,B,C and D).

(a) Sertoli cells: Each sertoli cell is large, columnar and has an ovoid nucleus. They are irregularly arranged and extend from the basal lamina toward the lumen.

(b) Spermatogenic cells: The spermatogenic cells occupy the space between the basal lamina and the lumen of the tubule. Starting from the basal lamina they are: spermatogonia, primary and secondary spermatocytes, spermatids and spermatozoa.

Spermatogonia: The spermatogonial cells are rounded or cuboidal in shape, each with a spherical nucleus.

Primary spermatocytes: The primary spermatocytes are comparatively larger than the spermatogonia. These cells are oval, spherical in shape, each with a spherical nucleus.

Secondary spermatocytes: The secondary spermatocytes are oval in

Plate 6.2 Dissection of male Rhacophorus
leucomystax showing the testis.

Abbreviations:

Fb : Fat body

K : Kidney

T : Testis

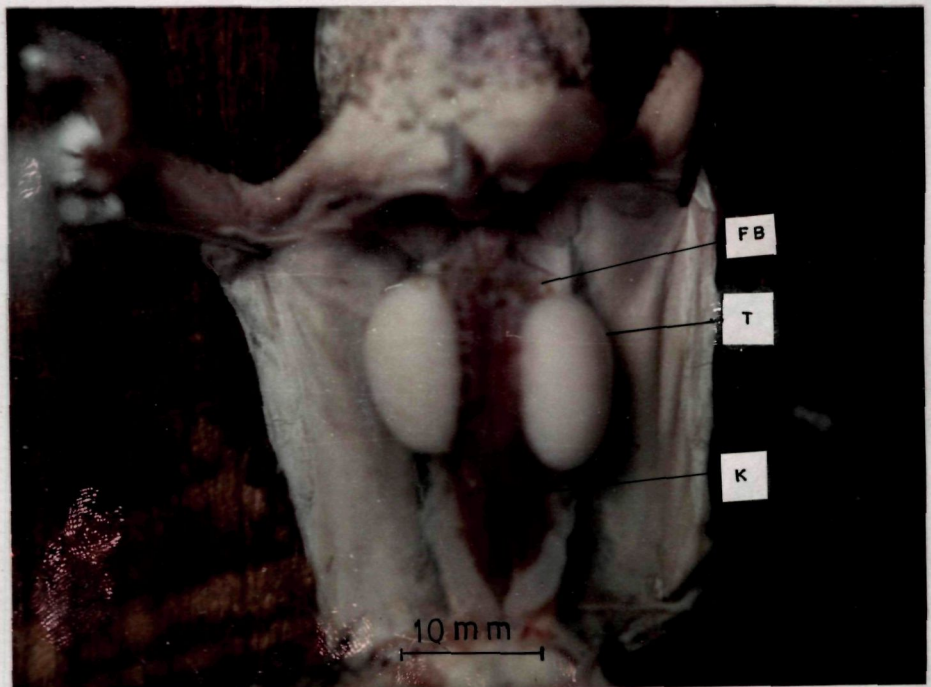


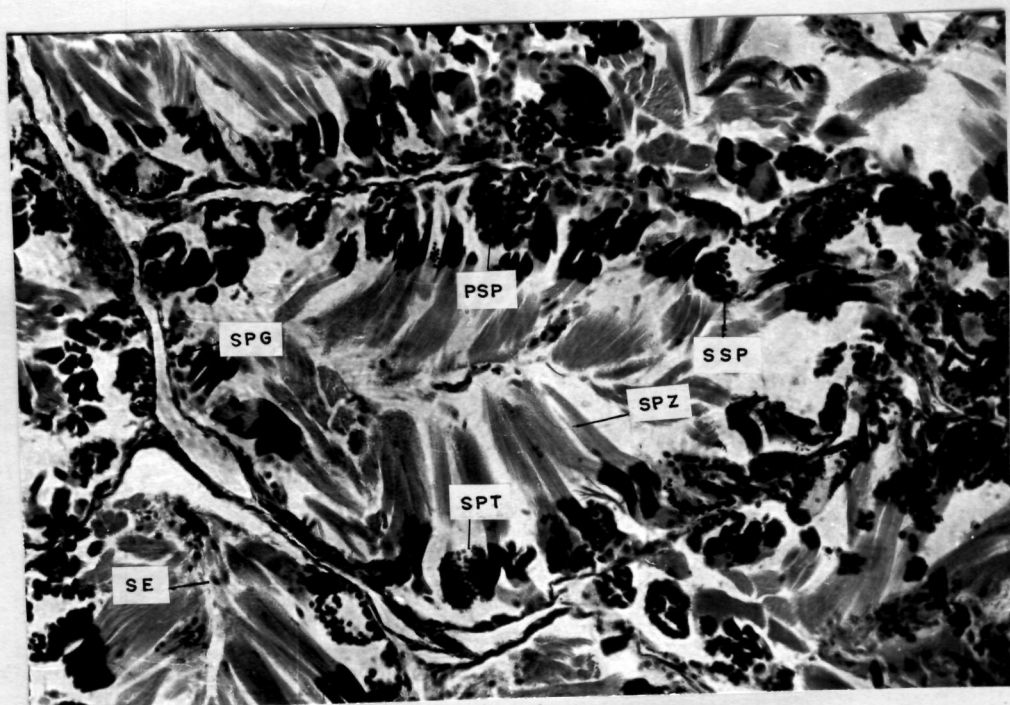
PLATE 6.2

Plate 6.3A A portion of the cross section of the
testis of Rhacophorus leucomystax
during pre-breeding period (X250).

Plate 6.3B A portion of the cross section of the
testis of Rhacophorus leucomystax
during breeding period (X250).

Abbreviations:

SE : Sertoli cells
SPG : Spermatogonia
PSP : Primary spermatocyte
SSP : Secondary spermatocyte
SPT : Spermatid
SPZ : Spermatozoa



A



B

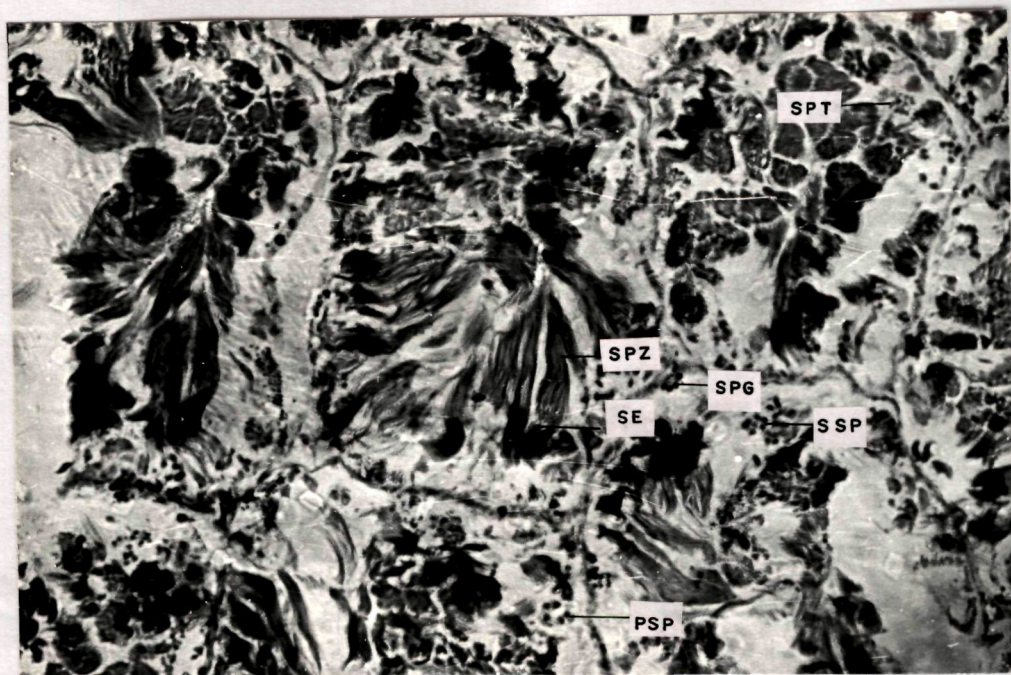
PLATE 6.3

Plate 6.3C A portion of the cross section of the testis of Rhacophorus leucomystax during post-breeding period (X250).

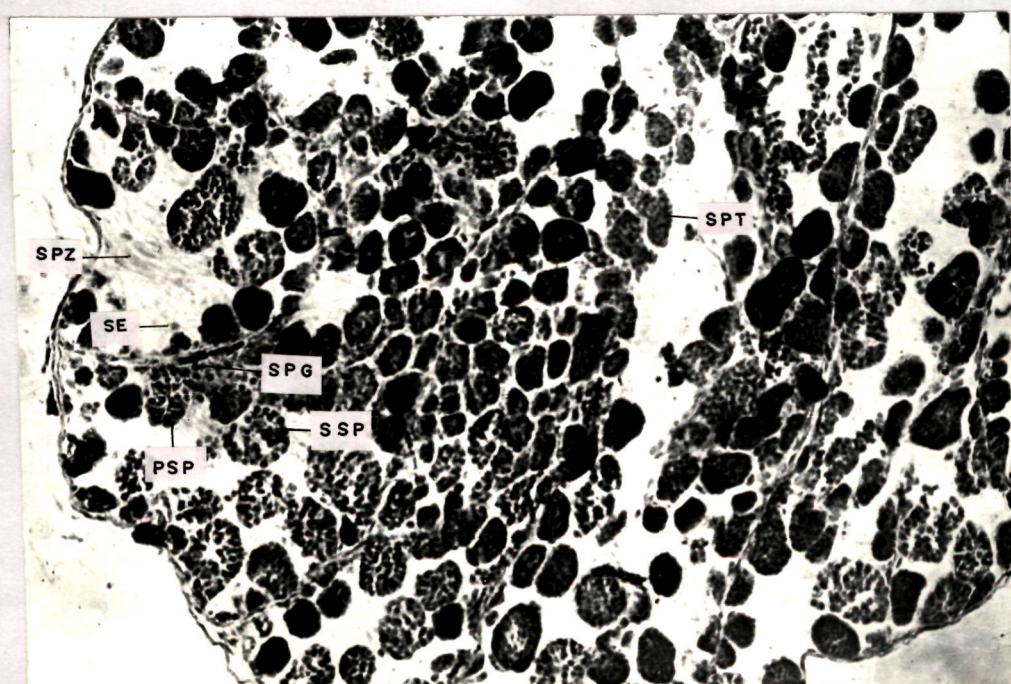
Plate 6.3D A portion of the cross section of the testis of Rhacophorus leucomystax during hibernation period (X250).

Abbreviations:

SE : Sertoli cells
SPG : Spermatogonia
PSP : Primary spermatocyte
SSP : Secondary spermatocyte
SPT : Spermatid
SPZ : Spermatozoa



C



D

PLATE 6.3

shape with a rounded nucleus and almost half the size of the primary spermatocytes. They are derived from the first division of primary spermatocytes and lie internally toward the lumen of the tubule.

Spermatids: The spermatids are smaller than secondary spermatocytes with an irregularly shaped nucleus. They are derived from the division of secondary spermatocytes and are located near the lumen of the tubule.

Spermatozoa: Each spermatozoon is slender and consists of a head and an elongated tail. The mature spermatozoa occur together in bundle with their heads in close association with the cytoplasm of the sertoli cells and tails extending freely into the lumen of the tubule.

(iii) Histological changes in the testis during annual breeding cycle

The number/unit area and the cellular size have been summarised in Tables 6.3 and 6.4.

The number of spermatogenic cells during annual breeding cycle is illustrated in Fig. 6.5.

The phases of spermatogenesis can be summarised below.

Seminiferous tubules: The size of seminiferous tubules was largest during spawning period and smallest in late postbreeding period.

Sertoli cells: The number of these cells was maximum during pre-breeding period and minimum during postbreeding period. Their size was largest during pre-breeding period and smallest during post-breeding period.

Table 6.3 : Average number of different structural elements of the seminiferous tubules per unit area (0.123 sq. mm) observed in the testes of Rhacophorus leucomystax during annual breeding cycle.

Month of Investigation	Sertoli cell	Spermatogonia cell	Primary spermatocyte	Secondary spermatocyte	Spermatid	Spermatozoa
January	4.66	18.16	27.00	24.50	10.00	5.14
February	3.85	15.60	17.75	29.00	44.50	9.67
March	4.75	14.25	14.40	27.60	35.66	26.80
April	6.34	7.00	14.33	19.67	30.50	60.00
May	7.50	5.33	8.00	11.00	20.67	90.00
June	6.25	5.00	7.69	9.20	17.00	100.00
July	4.66	9.12	7.00	9.28	14.00	75.00
August	3.40	27.44	11.00	5.40	3.50	40.00
September	4.50	23.80	12.16	2.67	1.25	6.00
October	3.20	22.00	20.66	2.57	1.50	2.33
November	3.14	20.22	21.62	13.25	2.40	2.28
December	3.60	18.25	22.33	16.85	3.50	2.25

Table 6.4 : Size of seminiferous tubules and diameter of Sertoli and Spermatogenic cells and nuclei (μ or micron) found in the testes of Rhacophorus leucomystax during annual breeding cycle.

Month of investigation	Seminiferous tubule		Sertoli Cell		Spermatogenous cell		Primary spermatocyte		Secondary spermatocyte		Spermatid	
	Length	Width	Cellular dia.	Nuclear diameter	Cellular dia.	Nuclear diameter	Cellular dia.	Nuclear diameter	Cellular dia.	Nuclear diameter	Cellular dia.	Nuclear diameter
Jan.	434.4	248.4	9.9	6.6	7.8	5.3	8.9	5.6	6.0	4.4	4.1	2.8
Feb.	441.6	234.6	10.5	6.5	7.9	4.8	8.5	5.9	6.3	4.5	4.3	2.9
Mar.	455.4	255.3	11.2	6.6	7.9	4.7	8.6	5.2	6.0	4.2	3.7	2.5
Apr.	483.0	303.6	11.4	7.0	7.4	4.3	8.4	5.0	5.5	3.5	3.5	2.1
May	469.2	358.8	10.8	6.3	7.5	4.5	8.1	4.9	5.6	3.3	3.2	2.2
Jun.	496.8	365.7	10.1	7.0	7.7	4.9	8.6	5.4	5.3	2.8	3.0	2.2
Jul.	487.5	334.6	9.9	6.5	7.8	5.6	8.8	6.0	5.4	2.9	2.9	2.1
Aug.	441.6	276.0	9.8	6.1	8.2	5.3	9.1	6.0	5.7	3.4	3.5	2.3
Sep.	431.9	179.4	10.0	5.7	7.7	5.8	8.9	6.1	5.6	3.9	3.9	2.5
Oct.	395.5	207.0	10.1	5.8	7.8	5.4	8.7	6.0	5.7	4.1	3.6	2.2
Nov.	420.9	174.7	9.6	5.4	8.1	5.6	8.4	5.9	5.9	3.7	4.0	2.6
Dec.	448.5	227.7	9.8	5.5	7.7	5.4	8.9	5.8	5.7	4.0	3.9	2.3

Fig. 6.5 Average number of spermatogenic cells
in the testes of males, Rhacophorus
leucomystax during annual breeding cycle.

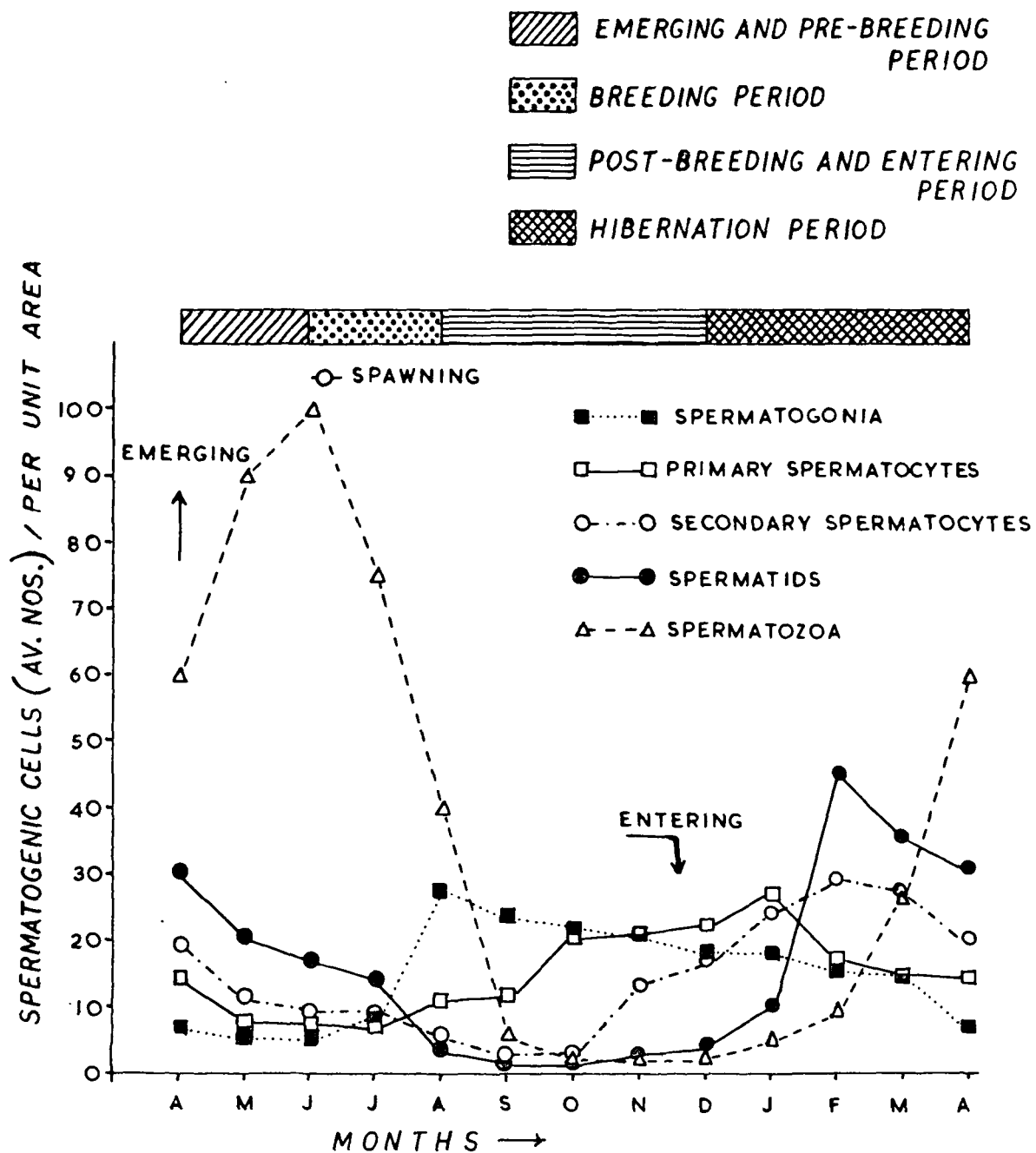


Fig 6.5

Spermatogonial cells: The number of these cells was maximum during postbreeding period and minimum during spawning period. The cell size was largest during postbreeding and smallest during pre-breeding periods.

Primary spermatocytes: Their number was maximum during hibernation period and minimum during active breeding period. The cell size was largest during postbreeding period and smallest during pre-breeding period.

Secondary spermatocytes: Their number was maximum during hibernation period and minimum during postbreeding period. The cell size was largest during hibernation period and smallest during breeding period.

Spermatids: Their number was maximum during late hibernation and early pre-breeding periods and minimum during postbreeding period. The cell size was largest during hibernation period and smallest during breeding period.

Spermatozoa: The number of spermatozoa was maximum during late pre-breeding and early breeding periods and minimum during late postbreeding and hibernation periods.

(B) Ovary

(i) Shape and position

Ovaries are paired, multilobed organs. They lie attached to the dorsal wall of the abdomen by a double-layered extension of the peritoneum, called mesovarium which further covers the entire ovary as the theca externa. There are several lobes on each side

Plate 6.4 Dissection of female Rhacophorus leucomystax
showing the ovary and oviduct.

Abbreviations:

Eg : Eggs

K : Kidney

Od : Oviduct

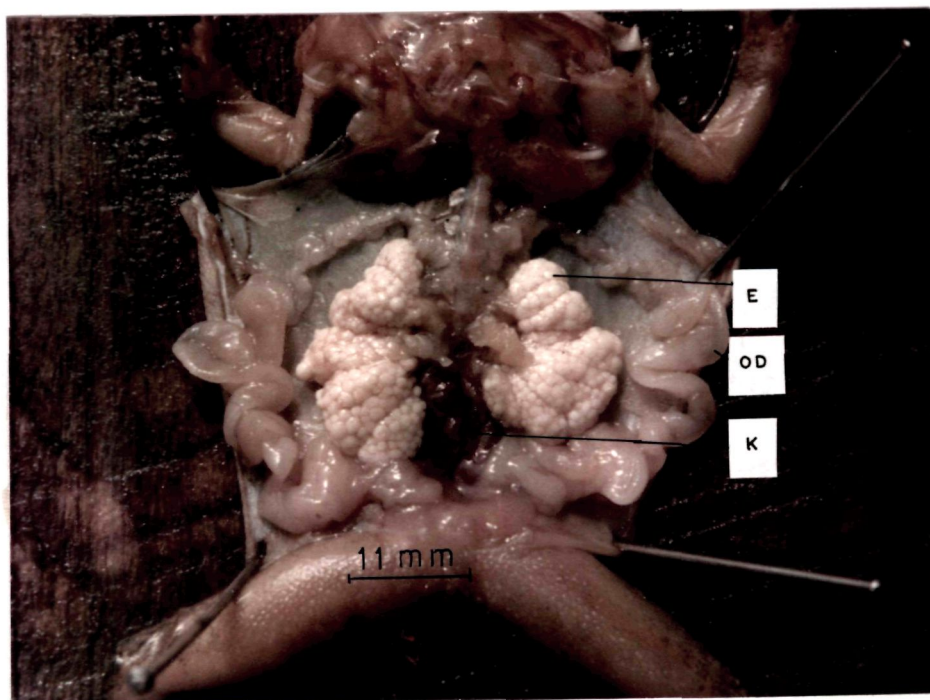


PLATE 6.4

and each lobe is hollow. The ovary size varies depending on the maturity of the ova in the ovary in different seasons (Pl. 6.4).

(ii) Histological structure of ovary

The ovary is externally covered by the theca externa and internally has a number of lobules, each is covered by theca interna. The theca interna and the follicle cells together comprise the ovarian follicle. The theca externa and the theca interna form the ovarian stroma and contain blood vessels and nerves. In each follicle there are oval follicle cells originated from oogonia. The follicle cells form the covering of the developing oocyte till its maturation. Each mature oocyte is found covered by a non-cellular and transparent membrane, the vitelline membrane.

The sections of ovary show large number of oogonia arising from the germinal epithelium. Each oogonium has little yolk and is covered by follicle cells. There are varying sizes of primary oocytes and secondary oocytes having a nucleus toward the animal hemisphere (Fig. 6.6; Pl. 6.5). The nucleus has deeply staining chromatin and nucleoli. The nucleus enlarges to form germinal vesicle with a wavy outline. The mature oocyte has no pigmentation. It has a large amount of yolk and a germinal vesicle at the animal hemisphere and large amount of yolk at the vegetal hemisphere (Fig. 6.7).

(iii) Histological changes in the ovary during annual breeding cycle:

In the present study, the gross changes in the ovary during different periods in the annual breeding cycle has been investigated (see Table 6.5).

Table 6.5 : Average weight of ovaries and size of oocytes of Rhacophorus leucomystax during annual breeding cycle.

Month of Investigation	Weight of ovary (gm)	Different sizes of oocyte (%)		
		< 0.5 mm	0.5 mm - 1.5 mm	1.5 mm <
January	0.645	69	31	
February	0.720	74	26	
March	1.155	61	36	3
April	1.965	46	29	25
May	2.020	41	22	37
June	2.215	53	13	34
July	1.210	88	6	6
August	0.307	88	12	
September	0.325	83	17	
October	0.335	82	18	
November	0.360	84	16	
December	0.405	75	25	

Fig. 6.6 A portion of cross-section of the ovary of Rhacophorus leucomystax.

Fig. 6.7 Enlarged view of a section of a mature oocyte of Rhacophorus leucomystax.

Abbreviations :

Apl.	: Animal pole
Blv.	: Blood vessel
Flc.	: Follicular cell
Nclo.	: Nucleolus
Nucl.	: Nucleus
Oocy.	: Oocyte
Pfr.	: Point of follicular rupture
Tex.	: Theca externa
Tin.	: Theca interna
Vpl.	: Vegetal pole

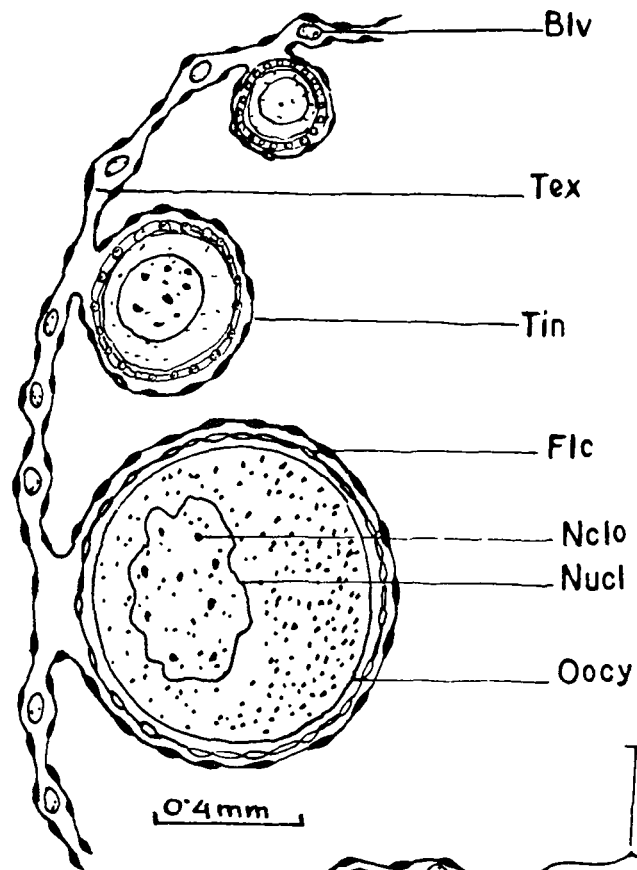


Fig 6.6

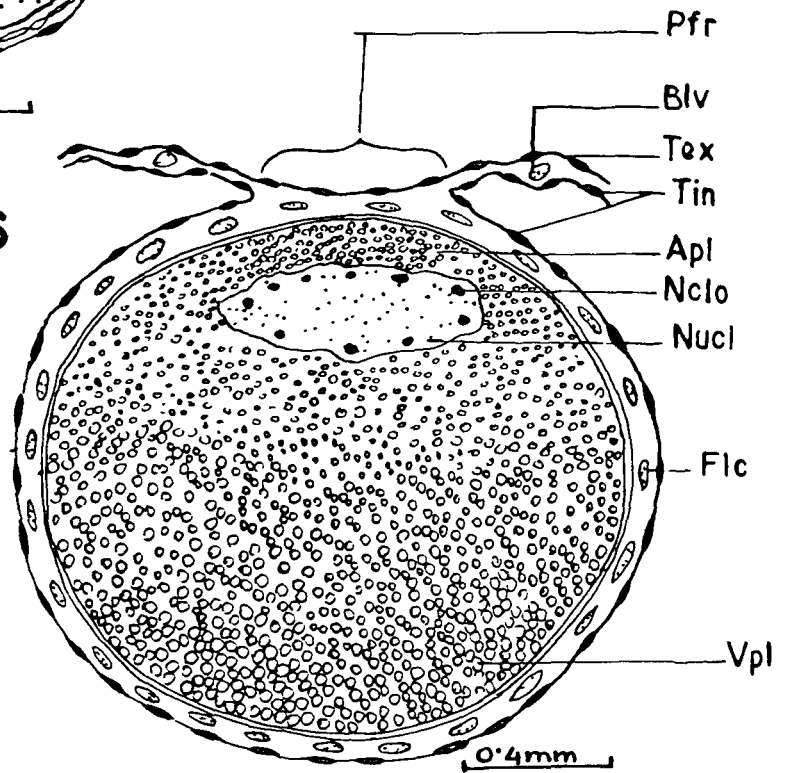


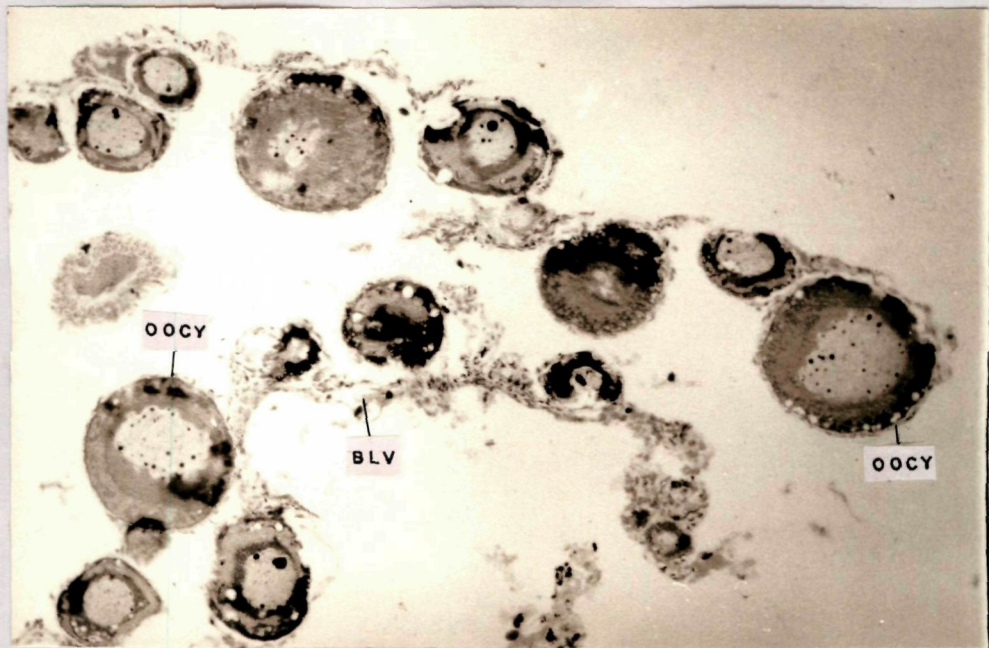
Fig 6.7

Plate 6.5A : A portion of the cross section of the ovary of Rhacophorus leucomystax showing different sizes of oocytes (X40).

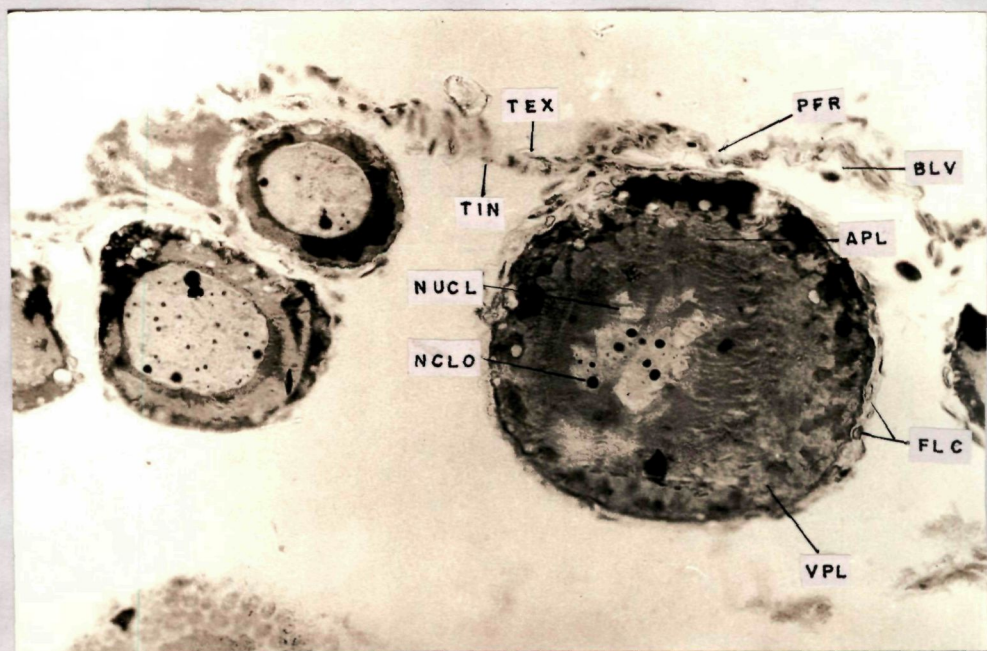
Plate 6.5B : A portion of the cross section of the ovary of Rhacophorus leucomystax showing an enlarged oocyte (X100).

Abbreviations:

Apl : Animal pole
Blv : Blood vessels
Flc : Follicle cells
Nclo : Nucleolus
Nucl : Nucleus
Oocy : Oocytes
Pfr : Point of follicular rupture
Tex : Theca externa
Tin : Theca interna
Vpl : Vegetal pole



A



B

PLATE 6.5

Fig. 6.8 Average weight of ovaries of Rhacophorus
leucomystax during annual breeding cycle

Fig. 6.9 Percentage of different sizes of oocytes
found in the ovaries of Rhacophorus
leucomystax during annual breeding cycle

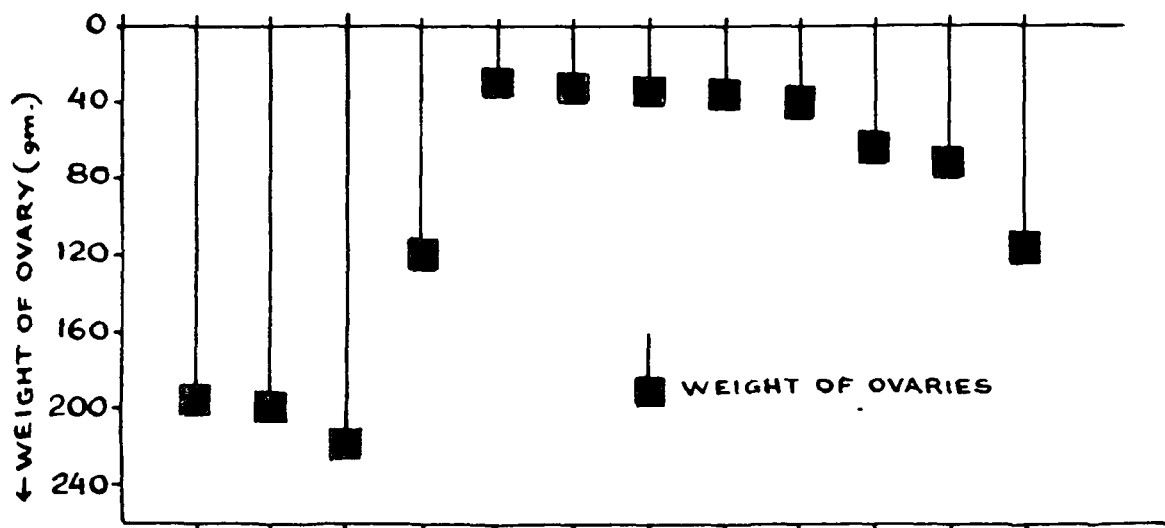


Fig 6.8

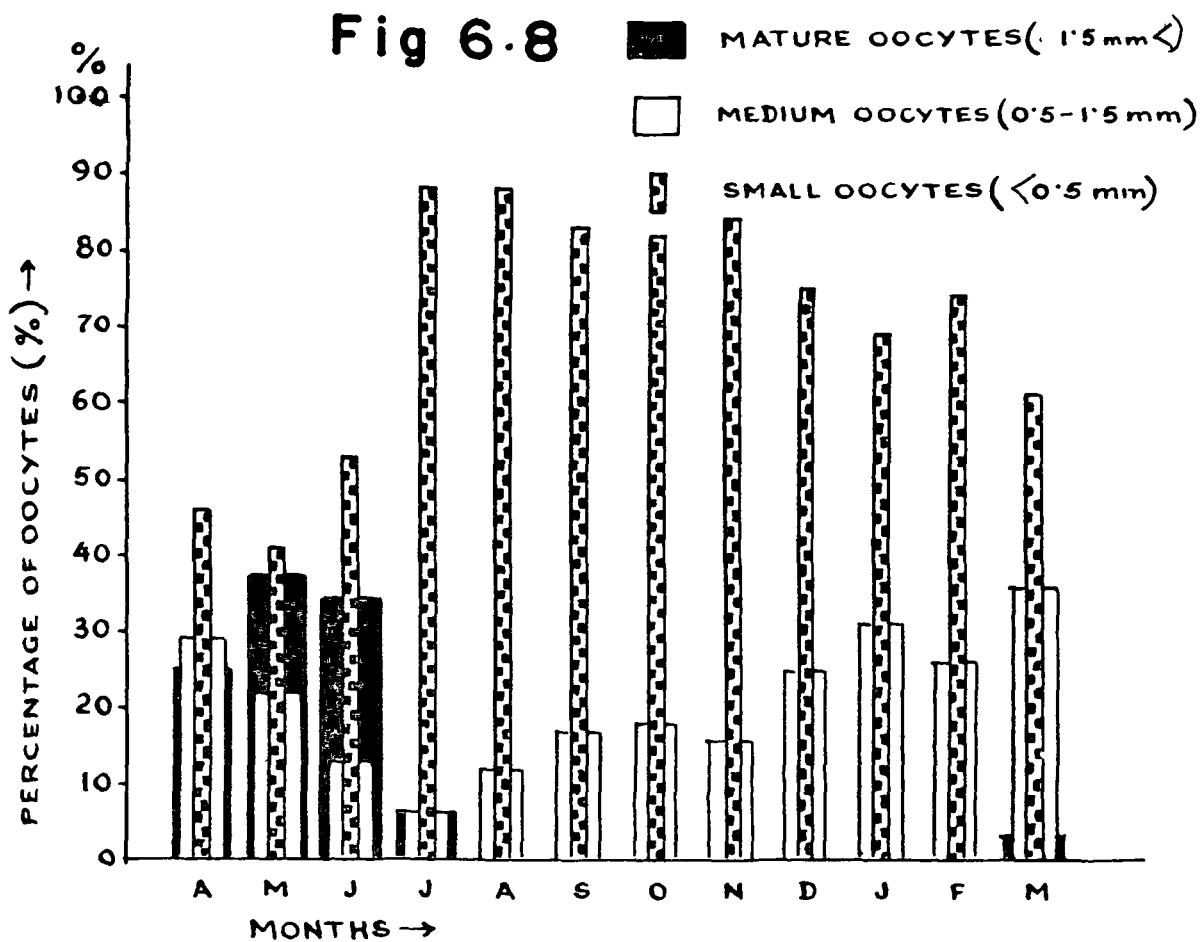


Fig 6.9

The observations on the data on weight of ovaries and size of oocytes during annual breeding cycle are summarised below (Figs. 6.8 and 6.9).

Weight of ovaries: The weight of ovaries was lowest in the post-breeding period. It increases gradually so that ovaries acquire enormous size and become heaviest in late pre-breeding and early breeding periods.

Size of oocytes: Mature oocytes were seen in the ovaries in the late hibernation, pre-breeding and breeding periods. Percentage of mature oocytes was high in late pre-breeding and early breeding periods.

Medium oocytes occurred in the ovaries throughout the annual breeding cycle. Their percentage was high during hibernation period and low during breeding period.

Small oocytes occurred in the ovaries in large number throughout the annual breeding cycle. Their percentage was maximum during late breeding period and postbreeding period and minimum during pre-breeding period.

There are 3 major types of cells, acidophils, basophils and chromophobes responsible for endocrine function of pars distalis of the pituitary (see for review Lakshman, 1965; Harris and Donovan, 1966; Purves, 1966; Zysk, 1975 and Hanke, 1976). In recent past, sub-types of acidophils and basophils have also been described (Van Oordt, 1963; Kerr, 1965; Reyrel, 1967; Van Oordt, Van Dongen and Lofts, 1968; Mira-Moser, 1970 and Pehlemann, 1974). The cyclic changes in the secretory activity of these cells have also been investigated in relation to annual cycle of anurans for somatotrophic activity (Kerr, 1965; Mira-Moser, 1970; Pehlemann, 1974 and Van Komenade, 1974) as well as gonadotrophic activity (Lakshman, 1965; Kerr, 1965; Mira-Moser, 1970; Doerr-Schott, 1974; Pehlemann, 1974 and Zysk, 1975).

In the present study the behaviour of 3 major types of cells has been studied in relation to breeding activity. It involves 3 aspects: (1) Development and maturation of gonadal cells, ova and spermatozoa. (2) Breeding behaviour and spawning and (3) Changes in the cellular types of the pars distalis.

6.5.1 Development and maturation of gonadal cells

So far as this first aspect is concerned, continuous spermatogenesis has been observed throughout the year in Rhacophorus leucomystax, the frequency of formation of spermatogenetic stages differs of course, in different seasons. The formation of spermatids increase during the later part of hibernation (44.50/unit area) and maximum number of spermatozoa (100/unit area) during early

spawning season. Their number per unit area decreases in late breeding period and reaches about 2.25/unit area during early period of winter sleep in December. Jorgenson, Largen and Lofts (1979) reported that spermatogenic activity in Bufo bufo bufo starts soon after the spawning period. The largest number of spermatogonial cells are observed in early part of postbreeding period, primary spermatocytes during early hibernation, secondary spermatocytes and spermatids during late hibernation followed by high number of spermatozoa in early spawning period. Chieffi, Rastogi, Milone and Iela (1980) described the starts of spermatogenesis in early spring and it continues through autumn with a brief winter stasis in Rana esculenta. Oberts (1976) reported that spermatogenesis is interrupted during the period when toads produce mating call. We have not been able to recall such observations.

The observations on the ovary of Rhacophorus leucomystax reveals that large mature oocytes filled up the ovary during the early spawning season, during late breeding and postbreeding periods large number of multiply oögonial cells and primary oocytes are seen, during hibernation the oocytes grow, but their growth is very fast during the pre-breeding period. Rapid growth of oocytes has also been studied in winter in Rana nigromaculata by Maruyana (1979).

6.5.2 Breeding behaviour and spawning

The second aspect concerns the breeding activity of the frogs, i.e. its movement to the pools, amplexus and spawning. Gametogenesis has 2 main important stages: (1) when gametogonial

cells are multiplying and transformation of one stage is occurring into another and (2) when the oocytes grow very fast and become ready for ovulation. The first stage need more somatotrophic hormone and second stage need more gonadotrophic hormone. Gonadal hormones also have a role of inducing the liver, so that precursors of yolk are transported to the growing oocytes. The breeding activity again needs level of gonadotrophic hormone which induces formation of more gonadal hormones and frogs undergo amplexus and they start spawning.

6.5.3 Changes in the cellular types of the pars distalis

Coming to the third aspect, the behaviour of pars distalis, we have to see how their activity is related to somatotrophic and gonadotrophic aspects mentioned above. The observations reveal that number of acidophils is minimum (18.10/unit area) in early spawning period and maximum (21.8/unit area) by late breeding period. The acidophils have been described to control somatotrophic aspect. Their high number during late and postbreeding periods correlates well with the onset of gametogenetic activity in the gonads. Lakshman (1965), Rastogi and Chieffi (1970) and Zysk (1975) also reported similar observations. The number of basophils was maximum (50.87/unit area) during late hibernation period and minimum (37.50/unit area) during late egg-laying period. Zysk (1975) also described increase in basophils and their granular cytoplasm during hibernation period. The basophils secrete gonadotrophin such as follicle stimulating hormone (FSH) and luteinizing hormone (LH) (Ramaswani and Lakshman, 1959; Van Oordt, 1961 and Zysk, 1975). There seems to be some mechanisms by which the FSH must be controlling the growth of the oocytes and LH

which helps ovulation. It is to be noted that number of basophils is always higher than the acidophils, perhaps because the gametogenesis continues throughout the year in Rhacophorus leucomystax. Along with the increase of these cells the cytoplasm become more granulated when concentration of hormone reaches an optimum limit.

The chromophobes are said to be precursors of acidophils as well as basophils (Ackermann, Nowicki and Sarnecka-Keller, 1971 and Zysk, 1975). Rastogi and Chieffi (1970) suggested chromophobes as degranulated basophils. In the present study maximum number of chromophobes (4.74/unit area) was observed in early breeding season and (1.1/unit area) during postbreeding season. But, it is difficult to comment on their role.

This chapter deals with histological changes of 3 major types of cells, acidophils, basophils and chromophobes of the pars distalis of Rhacophorus leucomystax and their relationship with histomorphological changes in the testis and ovary during different periods of the annual breeding cycle. It was noted that though gametogenesis was continuous throughout the year; number of spermatids and spermatozoa in the seminiferous tubules were highest during pre-breeding and breeding periods. The growth of oocytes is fast during hibernation period and very fast during pre-breeding period. The cycle of oogenesis is renewed soon after spawning is over. The activity of basophil (gonadotrophic) cells was seen to be very high during late hibernation and pre-breeding periods. The acidophil (somatotrophic) cells showed increased activity during late and postbreeding periods, apparently controlling the multiplication of gametogonial cells and their growth.

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CHAPTER 7

Normal Table of Development

Normal table of development of any organism is basic to the needs of workers in the field of Developmental Biology. Developmental tables of various anurans have been prepared and many of them have been included in several laboratory manuals (e.g. Hamburger, 1947; Rugh, 1962; New, 1966 and Nieuwkoop and Faber, 1967). In 1960, Gosner provided a simplified table for staging anuran embryos and larvae. Nieuwkoop and Faber (1967) prepared an elaborate normal table of development of Xenopus laevis based on both external and internal morphological changes for experimental purposes. So far as the species of frogs of the Indian subcontinent are concerned, we have the following developmental tables: Rana cyanophlyctis upto larval stage by Ramaswani and Lakshman (1959) and completed by Kumar (1982), Rana tigrina by Agarwal and Niazi (1977), Rana limnocharis by Roy and Khare (1978) and Rana breviceps by Mohanty-Hejmadi, Dutta and Parida (1979). The present study provides a complete developmental table of Rhacophorus leucomystax, as there is none like this on this species. The development has been described in 46 stages from the time of fertilization till the metamorphosis of tadpole into the young froglet stage. The external morphological changes have been taken as per the criteria of Gosner (1960). A comparison has been made with the normal table of embryonic stages only of Rhacophorus leucomystax prepared by Ting (1970) and complete table of Rhacophorus arboreus described by Iwasawa and Kawasaki (1979).

The studies on normal table of development of anurans were started in late 19th Century. We shall review these works in a family-wise manner.

(i) Ranidae

The development of anurans have been more thoroughly investigated in family Ranidae. Among ranids the first detailed normal table of development was described by Pollister and Moore (1937) for Rana sylvatica. A more detailed description came from Shumway (1940) who described the development of Rana pipiens from unfertilized eggs to the complete operculum stage into 25 stages. The table was completed when Taylor and Kollros (1946) described the postembryonic development of Rana pipiens and divided it into 25 stages. After these workers, a large number of development on ranids have been described. More important among these are Moser (1950) on Rana temporaria, Kopsch (1952) on Rana fusca and Cambar and Marrot (1954) on Rana dalmatina. All these and other workers (see other families) described the development of anurans into a number of stages, each based on new morphogenetic events but there are lot of variation in staging. To bring a compromise, Gosner (1960) provided a simple criteria for the staging of anuran embryos and tadpoles and he prescribed 46 stages, based on external changes only, for complete development from the egg to froglet stages. Nevertheless, later workers have always not adhered to these numbering of stages as there is always temporal variation in certain morphogenetic events (see for example, developmental tables of Rana limnocharis by Hock and Wen, 1970 and Roy and Khare, 1978; Rana ridibunda by Sin, 1975 and Rana brevipoda porosa by Iwasawa and Morita, 1980).

Among contributions on development tables on ranids in the Indian subcontinent in recent years, mention can be made of Dutta and Mohanty-Hejmadi (1976) who described the development of Rana tigrina into 25 stages, Agarwal and Niazi (1977) who described the development of Rana tigrina into 55 stages, Roy and Khare (1978) who described the development of Rana limnocharis into 32 stages, Mohanty-Hejmadi, Dutta and Parida (1979) who described the development of Rana breviceps into 46 stages and Kumar (1982, unpublished) who described the development of Rana cyanophlyctis into 40 stages.

(ii) Bufonidae

Notable contributions on the development of the bufonids are the following. Alder (1901) described the development of Bufo vulgaris from neurula stage to metamorphosis stage in 15 stages. Del Conte and Sirlin (1952) described the development of Bufo arenarum from the unfertilized egg to the complete operculum stage in 25 stages. Limbaugh and Volpe (1957) divided the development of Bufo valliceps into 46 stages. Khan (1965) provided a developmental table of Bufo melanostictus giving 43 stages. Sit and Kanagasuntheram (1973) presented the chronological sequence of Bufo melanostictus embryonic development only.

(iii) Pipidae

Among pipids the tongueless toad, Xenopus laevis, the south African clawed toad has been a favoured anuran for developmental studies (Peter, 1931; Gasche, 1944; Weisz, 1945; Bretscherm, 1949 and Nieuwkoop and Faber, 1967). Nieuwkoop and Faber (1967) provided a fine description of development of Xenopus laevis dividing it into 66 stages based on both external

as well as internal morphological changes. This has proved to be of immense use to workers as this species is a common experimental animal for developmental studies throughout Western world.

(iv) Discoglossidae

In 1951, Gallien and Houillon described the development of Discoglossus pictus from the egg-fertilization to the hind limb bud stage into 32 stages. Most recently, Michael (1981) described the development of Bombina orientalis in 19 stages from the egg-fertilization to the neural groove-closed stage and observed its development in relation to various temperature.

(v) Leptodactylidae

Jorquera and Pugin (1975) provided the development of a Chilean frog, Calyptocephalella caudiverbera from the unfertilized egg to the organogenesis stage in 14 stages. This seems to be the only contribution on the development from the family Leptodactylidae.

(vi) Hylidae

The development of tree frogs has been investigated for the last 4 decades but the information is still meagre. Eakin (1946) described the developmental table of Hyla regilla from stage 15 to stage 24 only. Leon (1975) observed the development of Hyla x-sigmata from egg to the full development of larvae in 28 stages. Anstis (1976) described the development of Litoria verreaux into 46 stages.

(vii) Rhacophoridae

Among rhacophorids, the following are few notable contributions. Church (1963) reared tadpoles of Rhacophorus leucomystax

from 4 egg masses at Bandung, Java. The eggs hatch within 3 days. Ting (1970) described the early development of Rhacophorus leucomystax into 25 stages from Singapore following Shumway's normal series of Rana pipiens. Coe (1974) described the development of a rhacophorid, Chiromantis. He described that they hatch on the 4th day and external gills develop on the 6th day. Iwasawa and Kawasaki (1979) provided the developmental table of Rhacophorus arboreus into 46 stages in 44 days at 22°C.

During the spawning period in June, several spawn nests of Rhacophorus leucomystax were collected just after they were deposited by the mating females. The time of egg laying has also been taken as time of fertilization, and the nests were brought to the laboratory. The eggs were separated from the foam of each nest with the help of forceps, and 40 to 50 eggs were transferred to the culture dishes (Diameter 23 cm; height 7 cm), each containing 500 ml of pool water. The development was observed under stereoscope dissecting binocular microscope. Time of each new stage was noted and each stage was regularly fixed and preserved in Bouin's fluid. The larvae hatched were fed with green-algae. For metamorphosis the tadpoles were transferred into an aquarium (size: 140 cm by 85 cm and 15 cm depth) set with algae and water plants and steep sand and mud base on one side, so as to create an amphibious environment. Pool water was replenished every day. The temperature of water in the laboratory ranged from 15°C-24°C during the developmental period. Each stage has been based on a new external morphological change as per the criteria of Gosner's (1960). Diagrams have been drawn with Camera Lucida and photomicrographs were taken with an Asahi Pentax photomicrographic camera.

The initiation of cleavage is observed approximately 50 minutes after the fertilization. Hatching occurs on the 3rd or 4th day and metamorphosis is completed by 57 to 58 days at 15°C -24°C. The observations have been made on the basis of external morphological changes, and the development of Rhacophorus leucomystax has been described in 46 stages.

Fertilization stages:

Stage 1: Fertilized egg (Fig. 7.1; Pl. 7.1) Age: 0 hr.

The time when the egg is laid and fertilized, it is one cell, spherical in shape and completely white in colour, devoid of pigment. Egg diameter - 1.75 mm.

Stage 2: Uncleaved egg (Fig. 7.2; Pl. 7.2) Age: 0-0.50 hr.

The egg is uncleaved but the upper part becomes flattened. Egg diameter - 1.75 mm. The phenomenon is similar to that observed by Iwasawa and Kawasaki (1979).

Cleavage stages:

Stage 3: 2 cells (Fig. 7.3; Pl. 7.3) Age: 0.50-2.40 hrs.

The first cleavage occurs in the meridional plane on the upper flattened part and proceeds to the vegetal pole. Egg diameter - 1.75 mm.

Stage 4: 4 cells (Fig. 7.4; Pl. 7.4) Age: 2.40-3.25 hrs.

The second cleavage also occurs in the meridional plane, bisecting at right angle to the first cleavage. Egg diameter - 1.8 mm.

Fig. 7.1	Stage 1	Fertilized egg.
Fig. 7.2	Stage 2	Uncleaved egg.
Fig. 7.3a, 3b	Stage 3	First cleavage showing 2 cells.
Figs. 7.4a, 4b	Stage 4	Second cleavage showing 4 cells.
Figs. 7.5a, 5b	Stage 5	Third cleavage showing 8 cells.
Figs. 7.6a, 6b	Stage 6	Fourth cleavage showing 16 cells.
Figs. 7.7a, 7b	Stage 7	Fifth cleavage showing 32 cells.
Figs. 7.8a, 8b	Stage 8	Solid ball of cells, Morula.
Figs. 7.9a, 9b	Stage 9	Early blastula.
Figs. 7.10a, 10b	Stage 10	Mid-blastula.
Figs. 7.11a, 11b	Stage 11	Late blastula.
Figs. 7.12a, 12b	Stage 12	Initial gastrulation.
Figs. 7.13a, 13b	Stage 13	Horse shoe shaped blastopore.

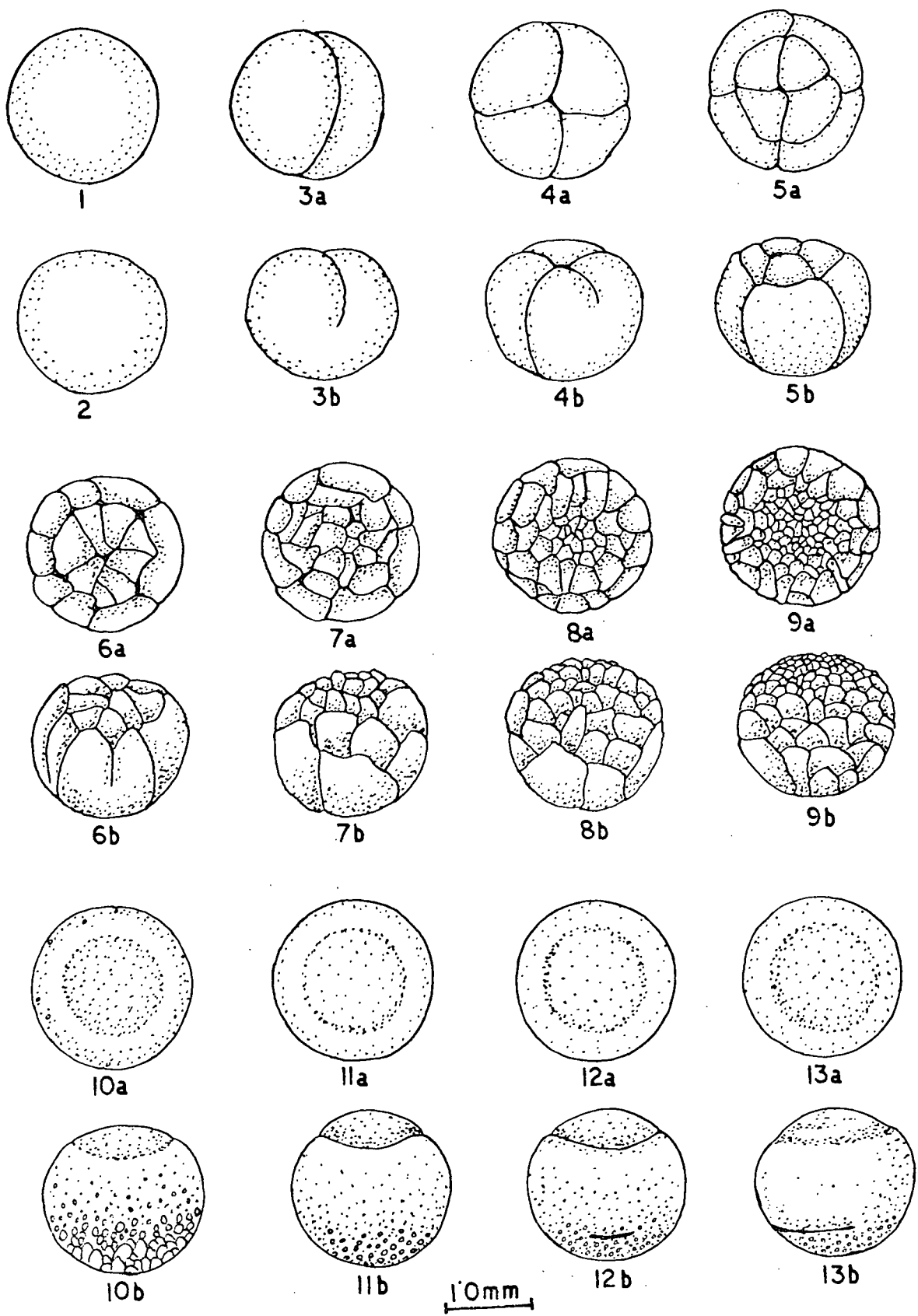


Fig 7.(1-13)

Stage 5: 8 cells (Fig. 7.5; Pl. 7.5) Age: 3.25-4.10 hrs.

The third cleavage occurs in the latitudinal plane resulting into four micromeres on the upper animal portion and four on the lower vegetal portion. Embryo diameter - 1.8 mm.

Stage 6: 16 cells (Fig. 7.6; Pl. 7.6) Age: 4.10-4.55 hrs.

The fourth cleavage occurs in the meridional plane. The upper micromeres divide first followed by the lower macromeres. Embryo diameter - 1.8 mm.

Stage 7: 32 cells (Fig. 7.7; Pl. 7.7) Age: 4.55-5.45 hrs.

The fifth cleavage occurs in the latitudinal plane but irregularly. Embryo diameter - 1.8 mm.

Stage 8: Morula (Fig. 7.8; Pl. 7.8) Age: 5.45-7.00 hrs.

The sixth cleavage is not clearly followed. The number of the upper micromeres is more than that of the lower macromeres. Embryo diameter - 1.8 mm.

Blastulation stages:

Stage 9: Early blastula (Fig. 7.9; Pl. 7.9) Age: 7.00-10.00 hrs.

The micromeres are more numerous than macromeres. The embryo appears as a cluster of beads. Embryo diameter - 1.82 mm.

Stage 10: Mid-blastula (Fig. 7.10; Pl. 7.10) Age: 10.00-14.00 hrs.

The blastomeres are minute or fine celled. Blastocoel is recognised as a translucent area. Embryo diameter - 1.82 mm.

Stage 11: Late blastula (Fig. 7.11; Pl. 7.11) Age: 14-19 hrs.

The translucent area is demarcated by a depression being $\frac{2}{3}$ rd of the embryo diameter at the animal half. Embryo diameter - 1.82 mm.

Plate 7. (1-2) Fertilization stages (X12).

Plate 7. (3-8) Cleavage stages (X12).

Plate 7. (9-11) Blastulation stages (X12).

Plate 7. (12-16) Gastrulation stages (X12).

Plate 7. (17-19) Neurulation stages (X12).

Plate 7. (20-22) Early tail bud stages (X12).

Plate 7. (23-24) Hatching and ramification of gill buds (X12).

Plate 7. (25-26) External gills formation stages (X17).

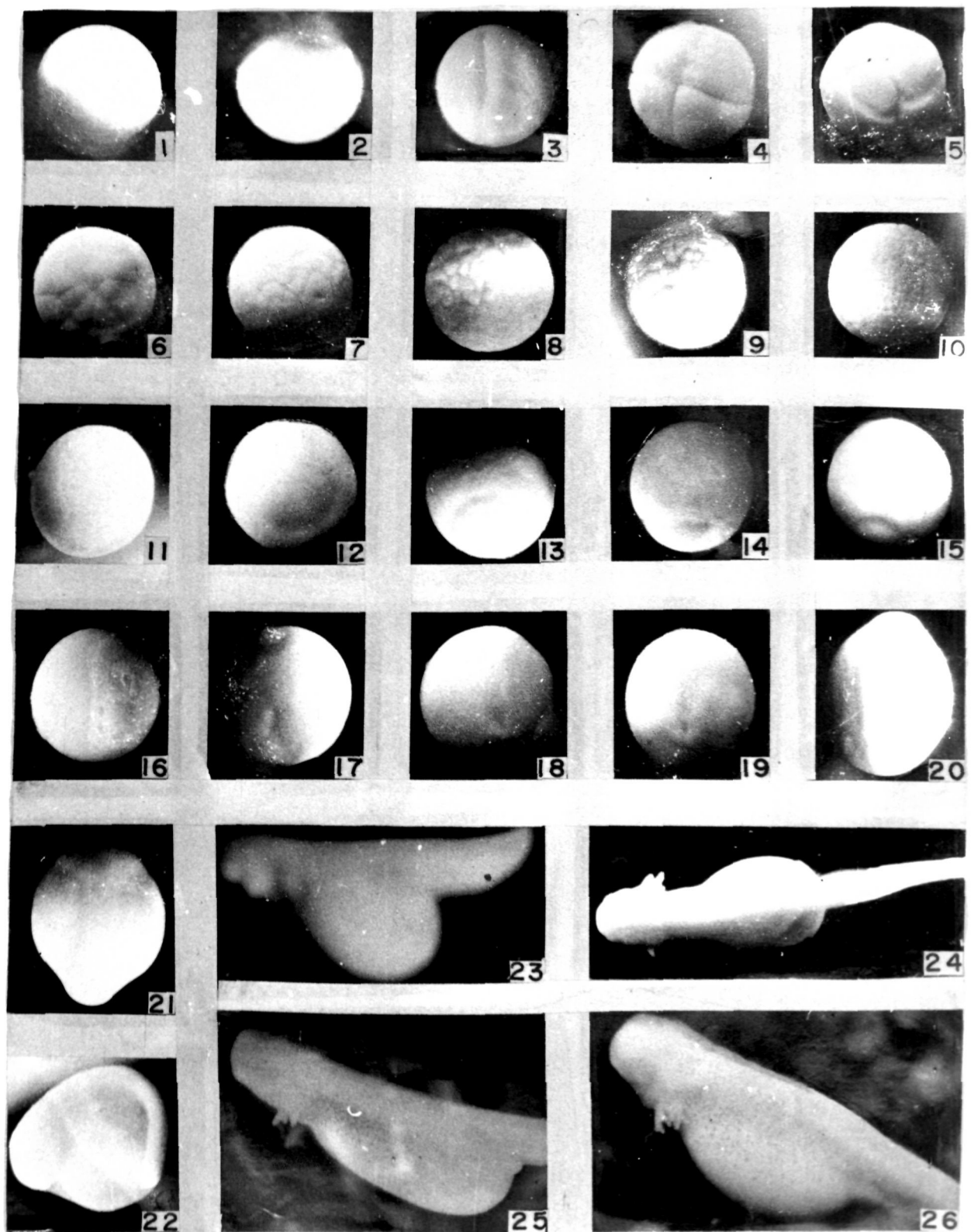


PLATE 7.(1-26)

Gastrulation stages:

Stage 12: Initial gastrula (Fig. 7.12; Pl. 7.12) Age: 19-21 hrs.

The dorsal lip appears as crescent-shaped. The translucent area is $2/3$ rd of the embryo diameter. Embryo diameter-1.82 mm.

Stage 13: Horse shoe-shaped blastopore (Fig. 7.13; Pl. 7.13) Age: 21-24 hrs.

The lateral lips of blastopore appear and assume a horse shoe-shaped. Translucent area $2/3$ rd of the embryo diameter at the animal region. Embryo diameter - 1.82 mm.

Stage 14: Large yolk plug (Fig. 7.14; Pl. 7.14) Age: 24-28 hrs.

Yolk plug is large, circular in shape and is $2/3$ rd of the embryo diameter. Embryo diameter - 1.82 mm.

Stage 15: Middle yolk plug (Fig. 7.15; Pl. 7.15) Age: 28-33 hrs.

The yolk plug is circular in shape and $1/2$ of the embryo diameter. Translucent area disappears. Embryo diameter - 1.82 mm.

Stage 16: Small yolk plug (Fig. 7.16; Pl. 7.16) Age: 33-37 hrs.

The blastopore and yolk plug are now smaller, circular and $1/5$ th of the embryo diameter, which is 1.82 mm.

Neurulation stages:

Stage 17: Primary neural fold (Fig. 7.17; Pl. 7.17) Age: 37-39 hrs.

Primary neural folds appear and form along the antero-posterior of the embryo. The embryo is elongated slightly, measuring 1.85 mm.

Figs. 7.14a, 14b	Stage 14	Large yold plug visible.
Figs. 7.15a, 15b	Stage 15	Yold plug reduced to median size.
Figs. 7.16a, 16b	Stage 16	A small yold plug is seen.
Figs. 7.17a, 17b	Stage 17	Primary neural fold formed.
Figs. 7.18a, 18b	Stage 18	Secondary neural fold appeared.
Figs. 7.19a, 19b	Stage 19	Neural groove formed.
Figs. 7.20a, 20b	Stage 20	A small tail bud visible.
Figs. 7.21a, 21b	Stage 21	Tail bud elongated.
Figs. 7.22a, 22b	Stage 22	Gill buds appeared.
Figs. 7.23a, 23b	Stage 23	Gill buds branching.
Figs. 7.24a, 24b	Stage 24	Gill buds ramified.

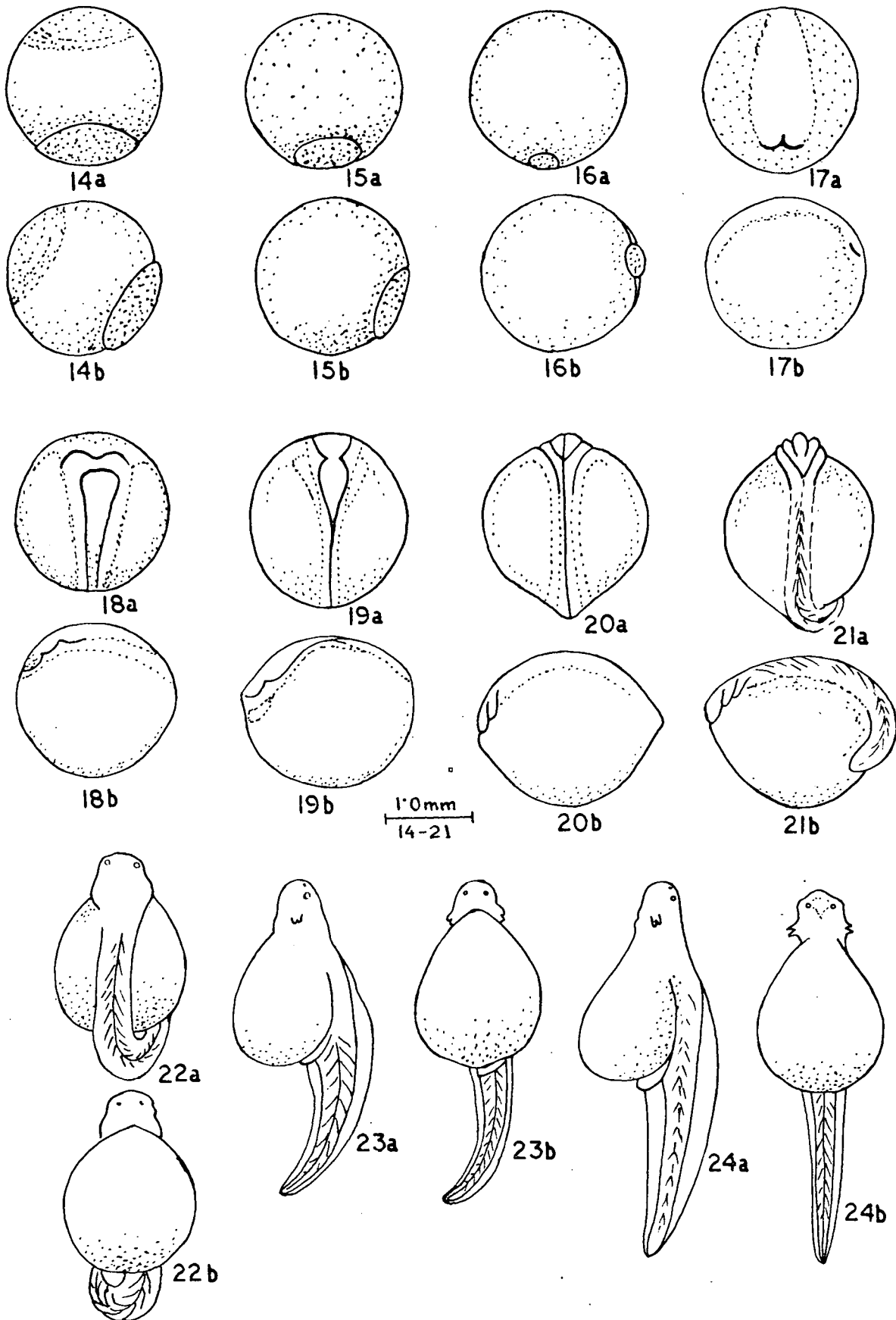


Fig 7.(14-24)

Stage 18: Secondary neural fold (Fig. 7.18; Pl. 7.18) Age: 39-43.30 hrs.

Secondary neural folds appear with an anterior oblong end. Neural folds gradually approach each other from the blastopore end towards the anterior. Embryo measures 1.85 mm in length.

Stage 19: Neural groove (Fig. 7.19; Pl. 7.19) Age: 43.30-55 hrs.

The left and right neural folds meet in the median line. The embryo is further elongated to 2.0 mm in length.

Tail bud and gill formation stages:

Stage 20: Appearance of tail bud (Fig. 7.20; Pl. 7.20) Age: 55-60 hrs.

A small tail bud protrudes at the posterior end. Embryo is 2.1 mm in length.

Stage 21: Tail bud developed (Fig. 7.21; Pl. 7.21) Age: 60-64 hrs.

Tail bud elongates and is curved antero-ventrally. Optic vesicles appear. Embryo is 2.3 mm in length.

Stage 22: Appearance of gill buds (Fig. 7.22; Pl. 7.22) Age: 64-82 hrs.

Rudimentary gill buds protruding. Eyes visible. A pair of adhesive suckers appear on the lower jaw. Myotomes appear, response to mechanical stimuli. Tail greatly elongated antero-ventrally. Embryo measures 3.2 mm in length.

Stage 23: Beginning of gill buds ramification (Fig. 7.23; Pl. 7.23) Age: 82-86 hrs.

Gill buds begin to ramify. Hatching begins. Nasal pit appears. Tail further elongates but still curved slightly, tail is with an outer transparent and inner translucent myotome bands. Head-trunk length is 2.5 mm and tail length - 2.0 mm.

Figs. 7.25a, 25b Stage 25 External gills appeared.

Figs. 7.26a, 26b Stage 26 Growth of external gills
observed.

Figs. 7.27a, 27b Stage 27 External gills fully-developed.

Figs. 7.28a, 28b Stage 28 Opercular fold formation.

Figs. 7.29a, 29b Stage 29 Opercular fold begins to close
on right.

Figs. 7.30a, 30b Stage 30 Opercular fold closed on right.

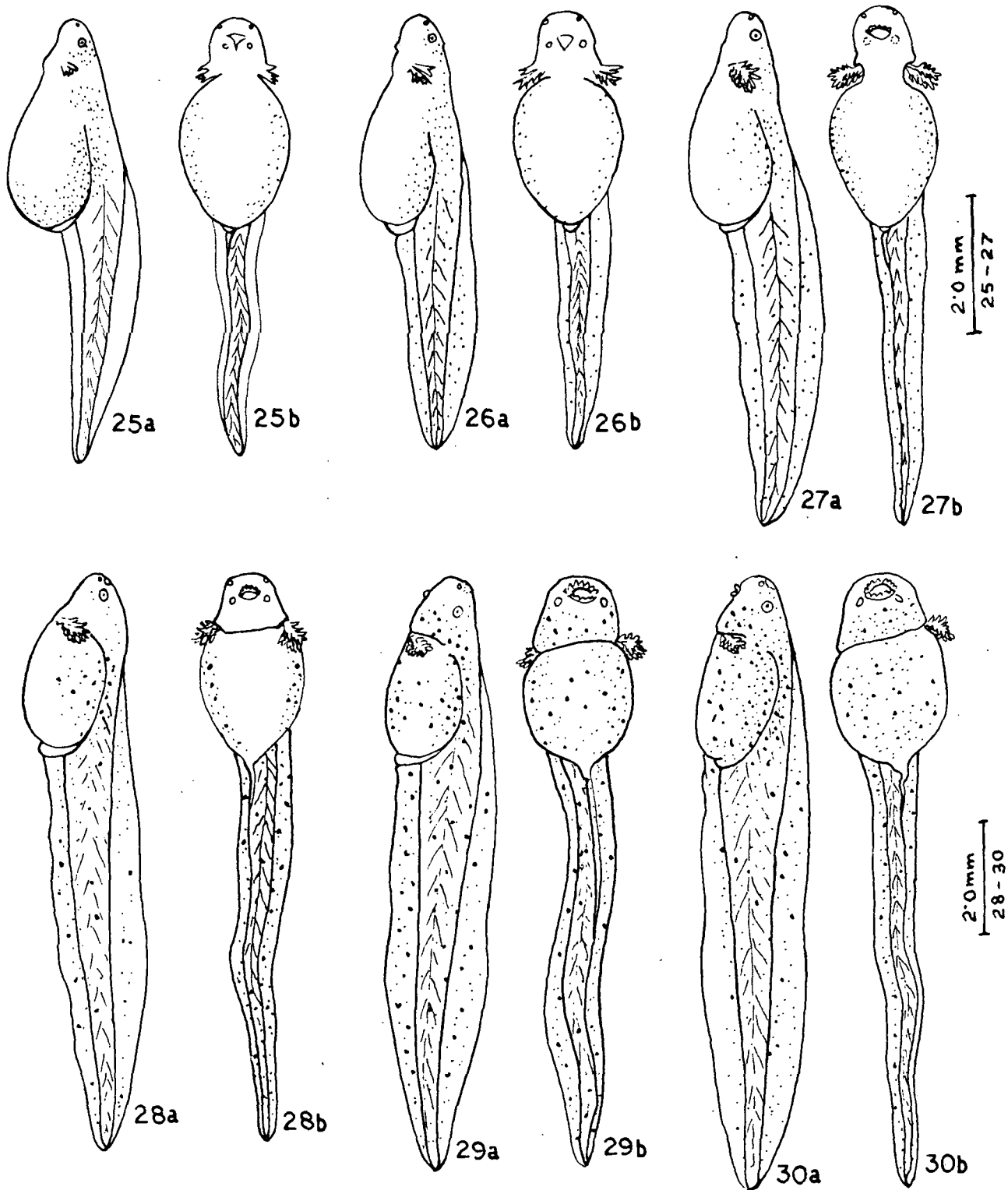


Fig 7.(25-30)

Stage 24: Gill buds ramified (Fig. 7.24; Pl. 7.24) Age: 86-105 hrs.

Gill buds are well developed. Hatching continues. Heart beat begins. Melanophores appear on the dorsal surface. A faint mouth outline appears. Head-trunk length - 2.8 mm and tail length is 2.4 mm.

Stage 25: Early external gills (Fig. 7.25; Pl. 7.25) Age: 105-114 hrs.

External gills begin to grow. Mouth opens. Eyes with white pupil in the centre. Tadpole head-trunk length is 3.0 mm and tail length is 3.2 mm.

Stage 26: Growth of external gills (Fig. 7.26; Pl. 7.26) Age: 114-125 hrs.

Further growth of external gills and branching into finger-like filaments. Melanophores now disperse towards the tadpole ventral surface and tail region. Tadpole head-trunk length is 3.0 mm and tail length is 3.4 mm.

Stage 27: Fully developed external gills (Fig. 7.27; Pl. 7.27) Age: 125-152 hrs.

Tadpole external gills completely developed. Opercular fold cover the base of the gills. Oral sucker appears on the jaw. Anal opening. Tadpole head-trunk length is 3.0 mm and tail length is 4.5 mm.

Opercular fold formation stages:

Stage 28: Opercular fold formation (Fig. 7.28; Pl. 7.28) Age: 152-175 hrs.

The left and right opercular folds join. Gills length shortens. Labial teeth visible. Tadpole develops large and small melanophores on the body surface. A white spot appears on the tip of the snout. Tadpole head-trunk length is 3.1 mm and tail length - 6.8 mm.

Plate 7.27 External gills well developed (X12).

Plate 7. (28-31) Opercular fold formation stages (X12).

Plate 7.32 Operculum complete (X14).

Plate 7.(33-34) Early hindlimb bud stages (X5).

Plate 7. (35-37) Hindlimb bud longer than wide to
hindlimb knee formation stages (X10).

Plate 7. (38-39) Indentation of 3rd, 4th and 5th toes
stages (X10).

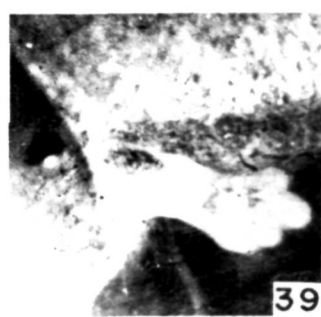
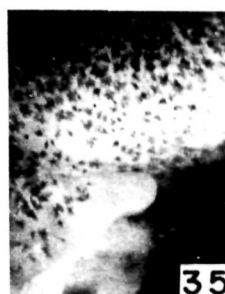


PLATE 7.(27-39)

Stage 29: Opercular fold begins to close on right (Fig. 7.29; Pl. 7.29) Age: 175-206 hrs.

The opercular fold covers the right gills, so only a small tip of the gills is seen on the right side. Tadpole head-trunk length - 3.2 mm and tail length - 7.0 mm.

Stage 30: Opercular fold closed on right (Fig. 7.30; Pl. 7.30) Age: 206-228 hrs.

The right operculum closes. The left external gills shorten. Tadpole head-trunk length is 3.3 mm and tail length - 7.3 mm.

Stage 31: Opercular fold begins to close on left (Fig. 7.31; Pl. 7.31) Age: 228-250 hrs.

Left opercular fold closing. The left external gills tip is seen protruding outside. Tadpole head-trunk length is 3.4 mm and tail length - 7.6 mm.

Stage 32: Operculum complete (Fig. 7.32; Pl. 7.32) Age: 250-261 hrs.

Operculum is complete on left and forms a spiracle on the left side. Tadpole head-trunk length - 3.7 mm and tail length is 7.7 mm.

Hindlimb bud stages:

Stage 33: Hindlimb bud wider than long (Fig. 7.33; Pl. 7.33) Age: 261 hrs-15 days

Hindlimb buds appear at the junction of the trunk and tail on either side of the cloacal tail-piece. Neuromast line develops on the dorsal side of the trunk and lateral side of the tail. The coiled intestine is visible. Tadpole head-trunk length is 9.0 mm and tail length is 16 mm.

Figs. 7.31a, 31b Stage 31 Opercular fold begins
to close on right.

Figs. 7.32a, 32b Stage 32 Opercular folds complete.

Figs. 7.33a, 33b Stage 33 Hindlimb bud appeared,
wider than long.

Figs. 7.34a, 34b Stage 34 Hindlimb bud as long as wide.

Figs. 7.35a, 35b Stage 35 Hindlimb bud longer than broad.

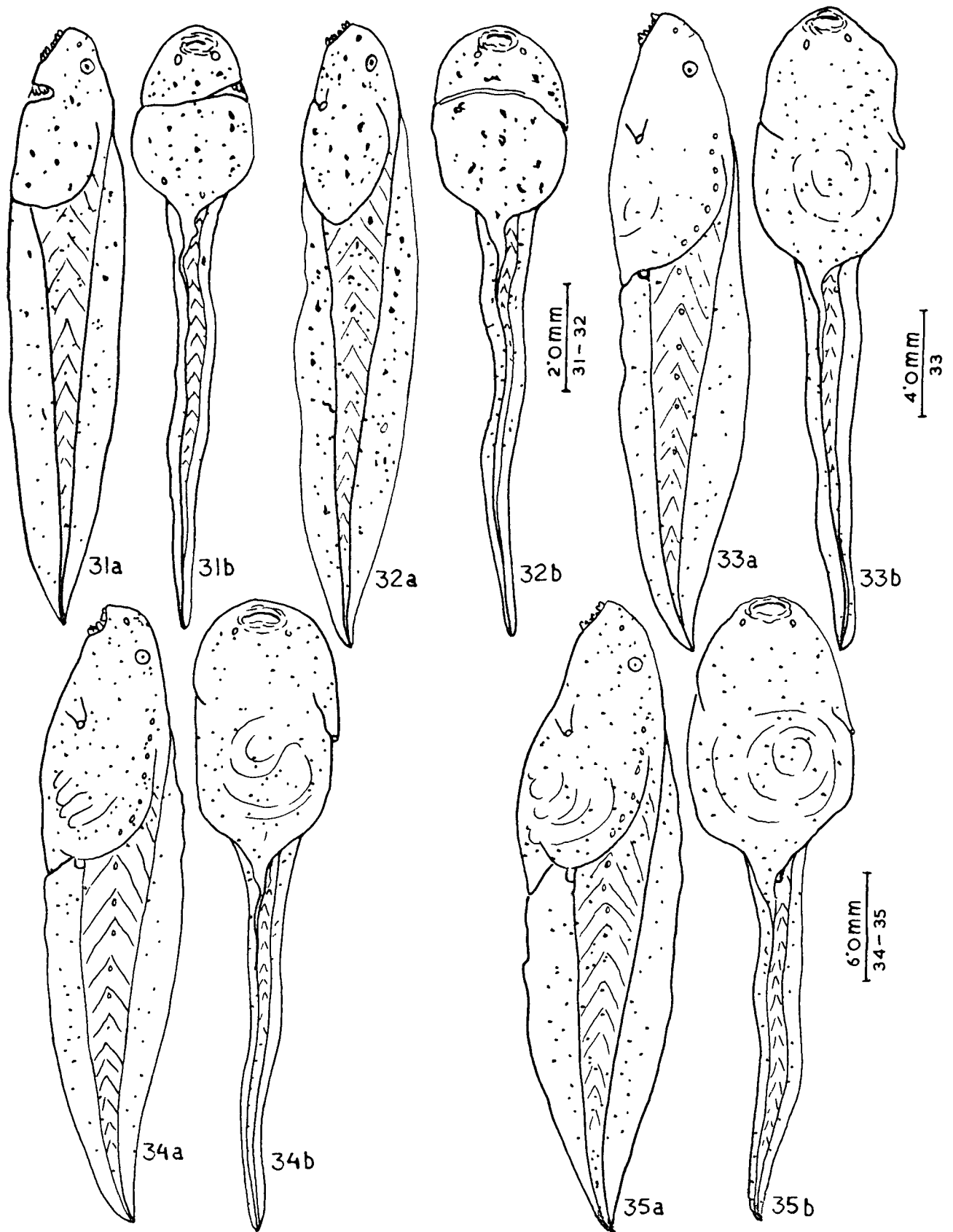


Fig 7.(31-35)

Figs. 7.36a, 36b Stage 36 Foot spatula appeared.

Figs. 7.37a, 37b Stage 37 Knee junction formed.

Figs. 7.38a, 38b Stage 38 Indentation of 4th and
5th toes.

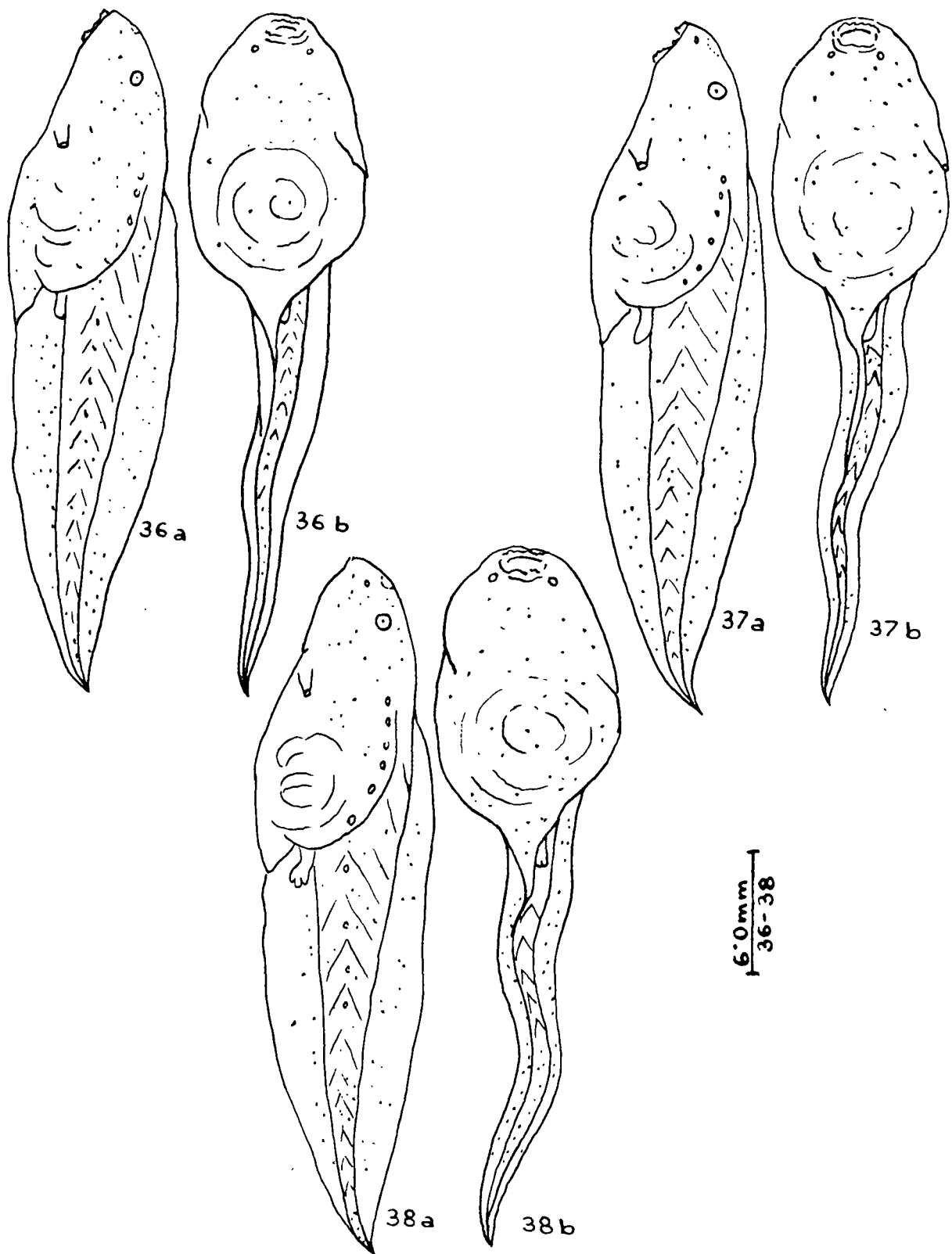


Fig 7.(36-38)

Stage 34: Hindlimb bud as long as wide (Fig. 7.34; Pl. 7.34) Age: 15-20 days

Length of hindlimb bud as long as its basal width.

Head-trunk length is 11 mm and the tail length is 17 mm.

Stage 35: Hindlimb bud longer than wide (Fig. 7.35; Pl. 7.35) Age: 20-22 days

Length of hindlimb bud is longer than its basal width.

Head-trunk length is 12 mm and tail length is 19 mm.

Stage 36: Foot-spatula (Fig. 7.36; Pl. 7.36) Age: 22-25 days

Length of hindlimb bud is twice as long as its basal width, the distal end is spatula in shape. Head-trunk length is 13.5 mm and tail length is 20 mm.

Stage 37: Appearance of knee junction (Fig. 7.37; Pl. 7.37) Age: 25-30 days

Hindlimb is now 2.0 mm in length and slightly bent with a distal foot-paddle. Tadpole head-trunk length is 14 mm and tail length is 20 mm.

Toe indentation stages:

Stage 38: Indentation of 4th and 5th toes (Fig. 7.38; Pl. 7.38) Age: 30-34 days

Hindlimb is now measuring 2.5 mm in length and tadpole hindlimb is with the interdigital indentation of 4th and 5th toes. Tadpole head-trunk length is 15 mm and tail length is 21 mm.

Stage 39: Indentation of 3rd toe (Fig. 7.39; Pl. 7.39) Age: 34-35 days

Tadpole hindlimb is 3 mm in length and interdigital indentation of 3rd toe occurs. Tadpole head-trunk length is 16 mm and tail length is 23 mm.

Figs. 7.39a, 39b Stage 39 Indentation of 3rd toe.

Figs. 7.40a, 40b Stage 40 Indentation of 1st and 2nd
toes.

Figs. 7.41a, 41b Stage 41 Toe discs and webs developed.

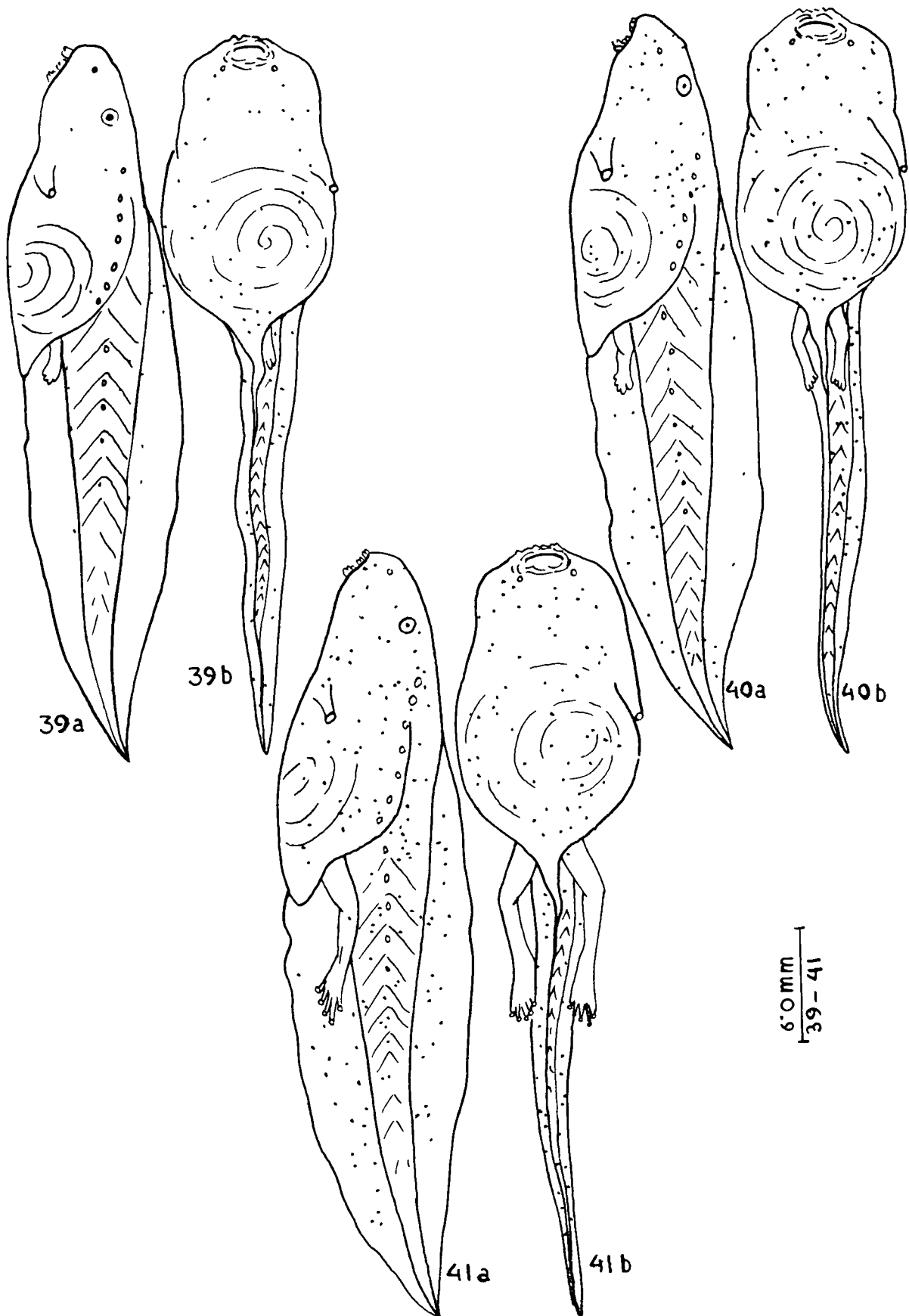


Fig 7.(39-41)

Stage 40: Indentation of 1st and 2nd toes (Fig. 7.40; Pl. 7.40) Age: 35-39 days

Tadpole hindlimb is now longer, measuring 4 mm in length and the foot is with interdigital indentation of 1st and 2nd toes, so all the 5 toes are formed. Tadpole head-trunk length is 16 mm and tail length is 24 mm.

Stage 41: Toe discs and webs developed (Fig. 7.41; Pl. 7.41) Age: 39-45 days

Disc developed on each tip of toe and webbing occurs between the toes. Hindlimb length is 9 mm. Tadpole head-trunk length is 16 mm and tail length is 25 mm.

Metamorphosis stages:

Stage 42: Involution of cloacal tail-piece (Fig. 7.42; Pl. 7.42) Age: 45-52 days

Tadpole cloacal tail-piece involuting and the bases of the thighs are about to fuse medially. Adhesive suckers, oral suckers and labial teeth are disappearing. Hindlimb is now well-developed. In this stage, tadpole attains the maximum size. Tadpole head-trunk length is 17 mm and tail length is 30 mm.

Stage 43: Both limbs developed (Fig. 7.43; Pl. 7.43) Age: 52-53 days

Tadpole develops fore and hindlimbs. Nictating membrane and tympanic disc form. Dark bands form on the dorsal surface of the body and limbs. Tadpole undergoing metamorphosis. Tail-piece reduces slightly. Tadpole head-trunk length is 17 mm and tail length is 29 mm.

Stage 44: Tail shortened (Fig. 7.44; Pl. 7.44) Age: 53-55 days

Tail is shortened to 10 mm. The angle of the mouth is about to reach the anterior margin of the eye. Eye-ball protrusion is notable. Tadpole head-trunk now measures 18 mm in length.

Figs. 7.42a, 42b Stage 42 Involution of the cloacal
tail-piece.

Figs. 7.43a, 43b Stage 43 Both limbs developed.

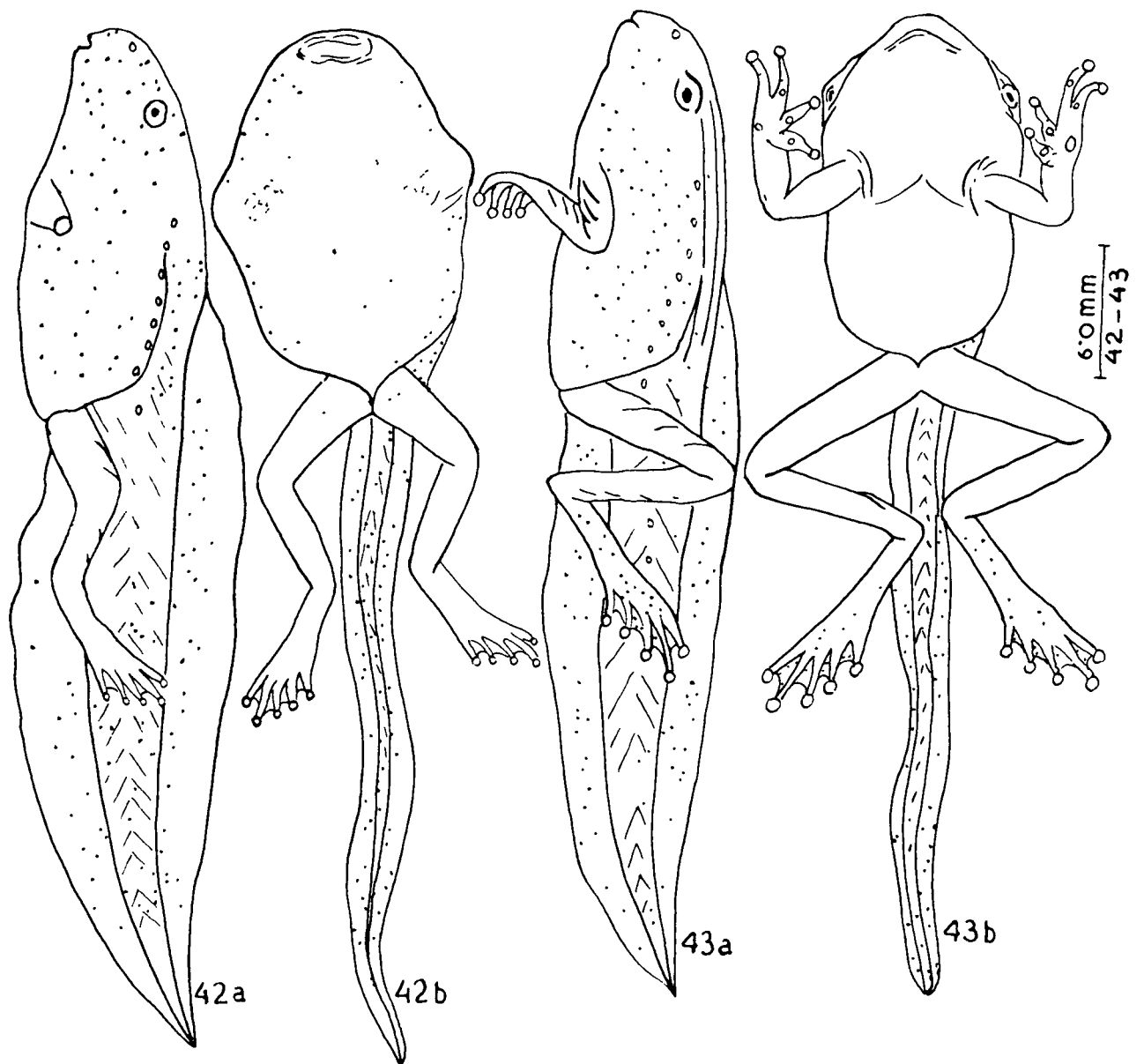


Fig 7.(42 - 43)

Figs. 7.44a, 44b Stage 44 Tail shortened.

Figs. 7.45a, 45b Stage 45 Tail stub remaining.

Figs. 7.46a, 46b Stage 46 Complete metamorphosis.

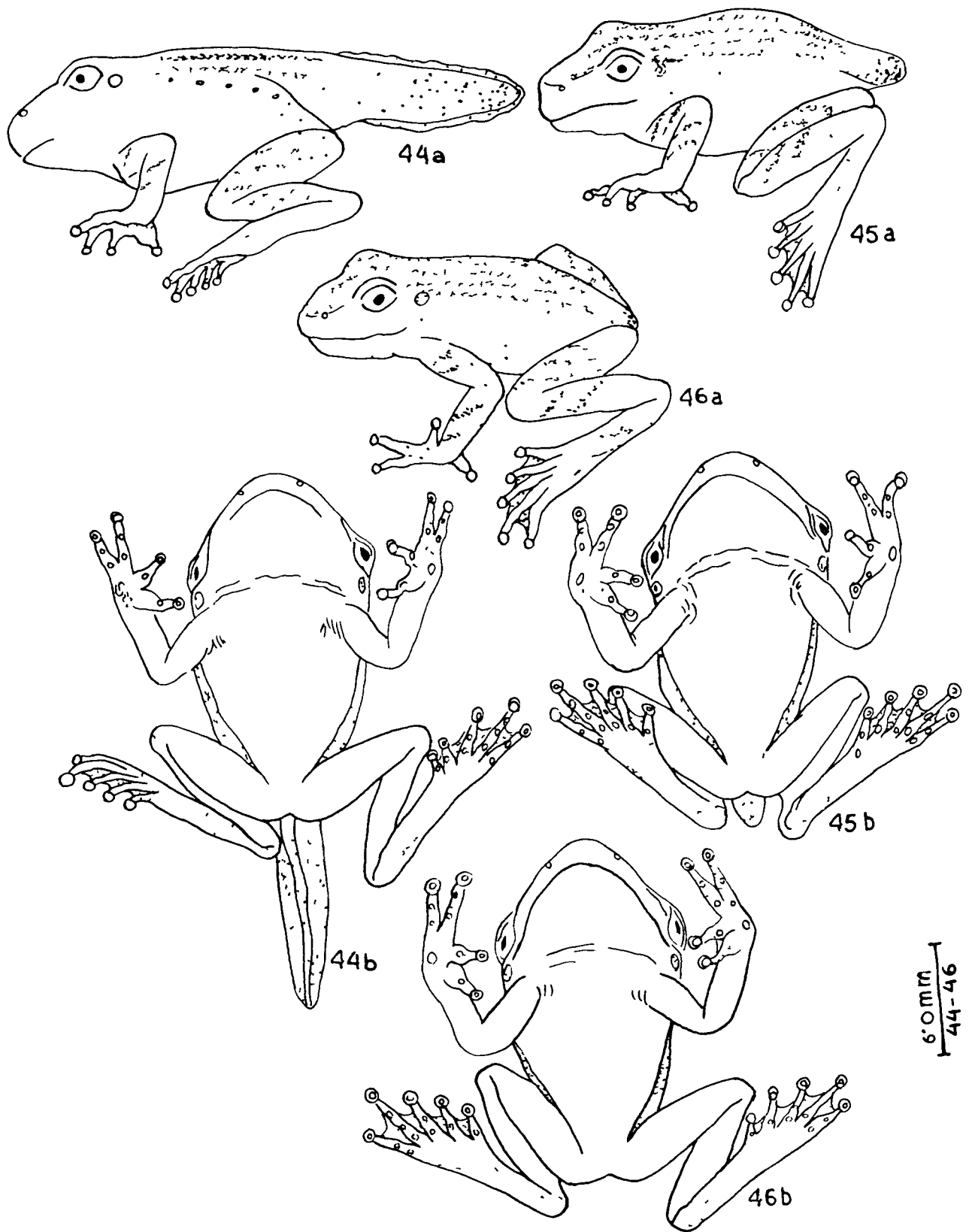


Fig 7.(44-46)

Stage 45: Tail stub (Fig. 7.45; Pl. 7.45) Age: 55-57 days

Tail stub triangular and measures 2 mm in length which is darker than other parts. Mouth angle reaching the posterior margin of the eye. Tympanic folds appear. Neuromast line disappear. Head-trunk length of the tadpole measures 18 mm.

Stage 46: Complete metamorphosis Age: 57-58 days
(Fig. 7.46; Pl. 7.46)

Fully developed young froglet with all the anuran characters emerge out. Young froglet snout-vent length measures 18 mm in length.

Plate 7. 40 All the 5 toes formed (X10).

Plate 7. (41-42) Toe discs and webs formation and involution
of cloacal tail-piece stages (X6.5).

Plate 7.43 Both limbs developed (X1.6).

Plate 7.44 Tail shortened (X1.5).

Plate 7.45 Tail stub remained (X1.6).

Plate 7.46 Complete metamorphosis (X1.5).

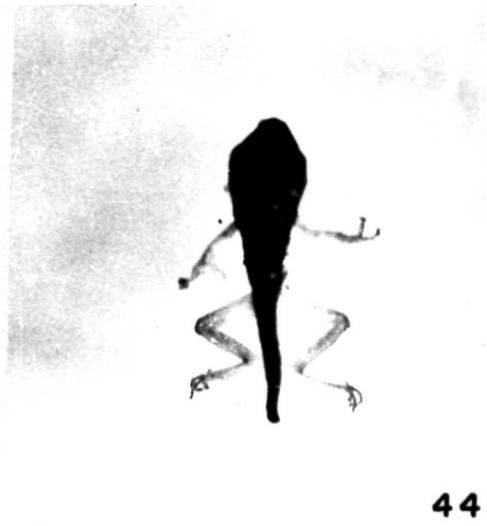
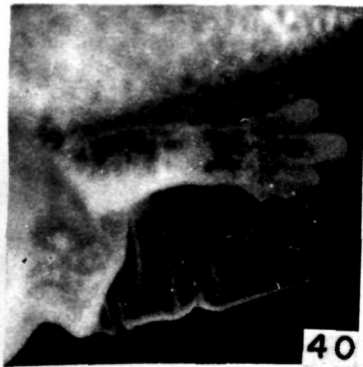


PLATE 7.(40-46)

7.5.1 Development of rhacophorids

There are few contributions on development of rhacophorids. Church (1963) reared Rhacophorus leucomystax tadpoles from 4 egg masses at Bandung, Java. Ting (1970) provided a table of embryonic stages only of Rhacophorus leucomystax. Coe (1974) described the development of a rhacophorid, Chiromantis. He described that they hatch on the 4th day and external gills develop on the 6th day. Recently, Iwasawa and Kawasaki (1979) described the development of Rhacophorus arboreus in detail. It hatches on the 4th day and completes metamorphosis in 56 days at 22°C. In the present study hatching of Rhacophorus leucomystax occurs on the 3rd or 4th day and metamorphosis is completed in 57 to 58 days at normal water temperatures (15°C at night and 24°C during day). These observations are in conformity with Iwasawa and Kawasaki (1979).

7.5.2 Staging of embryos and larvae

Staging is a prime necessity for the developmental studies of any species. The numbering of stages and developmental patterns of body parts vary from species to species. Though different authors have followed similar criteria i.e. a new morphogenetic event for staging, variations occur due to temporal sequence of morphogenetic events. Nieuwkoop and Faber (1967) adopted both external and internal changes for staging of Xenopus laevis embryos, as it was needed for experimental work. They provided the comparison of many early developmental tables also (Adler, 1901; Pollister and Moore, 1937; Shumway, 1940; Weiz, 1945; Taylor and Kollros, 1946; Eakin, 1946; Bretscher, 1949; Moser, 1950;

Gallien and Houillon, 1951; Del Conte and Sirlin, 1952; Kopsch, 1952; Cambar and Marrot, 1954). Other authors have followed mainly the external morphogenetic changes for staging of embryos and larvae.

Among early references Shumway (1940) who described 25 stages for embryonic development of Rana pipiens, Taylor and Kollros (1946) who described 25 stages for postembryonic development of Rana pipiens, the common Leopard frog of the United States of America, provided an easy criteria for staging. Gosner (1960) proposed 46 stages with simplified criteria for staging developmental events in pelobatids, bufonids, ranids and hylids.

These authors divided the complete development under 11 major sub-headings: (i) Egg stages: many included unfertilized egg and fertilized egg and few included fertilized egg. (ii) Cleavage: 5 stages. (iii) Blastula: 2 stages. (iv) Gastrula: 3 stages. (v) Neurula: 4 stages. (vi) Tail bud: 2 stages. (vii) Gills: 4 stages. (viii) Operculum formation: 3 stages. (ix) Hindlimb bud: 6 stages. (x) Toe indentation: 8 stages and (xi) Metamorphosis: 7 stages (total: 46 stages). Though almost all authors have followed the above groupings for their description (e.g. Khan, 1965; Hock and Wen, 1970; Agarwal and Niazi, 1977; Roy and Khare, 1978; Mohanty-Hejmadi, Dutta and Parida, 1979; Iwasawa and Kawasaki, 1979; Iwasawa and Morita, 1980 and Kumar, 1982 among others). Some variations in the numbering of specific stages are always noted.

In the present study, the developmental stages of Rhacophorus leucomystax are based on following pattern: Fertilization: 2 stages;

Cleavage: 6 stages; Blastulation: 3 stages; Gastrulation: 5 stages; Neurulation: 3 stages; tail bud and gill formation: 8 stages; Opercular fold formation: 5 stages; Hindlimb bud: 5 stages; Toe indentation: 4 stages and Metamorphosis: 5 stages.

Among rhacophorids, Iwasawa and Kawasaki (1979) provided a developmental table of Rhacophorus arboreus from Japan. In the present study, the development of Rhacophorus leucomystax has been divided into 46 stages based on the criteria of Gosner (1960). I have taken the fertilized egg as stage 1, as also described by Iwasawa and Kawasaki (1979). An important difference which the present author noted in comparison to Rhacophorus arboreus is the formation of a tail bud which showed 2 distinct stages only, just as described by Gosner (1960). As to the formation of operculum, it is felt that it should be divided into 5 stages (stage 28: Opercular fold formation, stage 29: Right opercular fold begins to close, stage 30: Right opercular fold closes, stage 31: Left opercular fold begins to close, stage 32: Operculum complete). Total number of stages however, remain 46 as also described by Iwasawa and Kawasaki (1979).

The development of Rhacophorus leucomystax exhibits certain peculiar features: (1) Soon after fertilization there is flattening of animal pole. (2) During late blastula and early gastrula a clear translucent bulged area (enclosing blastocoel) is seen at the animal region. (3) The yolky portion is proportionately very large at the tail bud and following stages until hatching.

7.5.3 Development time

Under normal condition of atmospheric and water temperatures and rainfall, the development of Rhacophorus leucomystax takes 57

to 58 days. Its embryonic development is completed by 3rd to 4th day but postembryonic development takes about 54 days. This is much different from the development of ranids studied under the climatic condition of neighbouring hills for example, Rana limnocharis hatches on 5th to 6th day and completes metamorphosis by 30 days (Roy and Khare, 1978), Rana cyanophlyctis hatches on 4th to 5th day and completes metamorphosis on the 68th day (Kumar, 1982). The duration of development of Rhacophorus leucomystax however, is similar to other rhacophorids (Iwasawa and Kawasaki, 1979) and certain ranids in the tropical plains of the Indo-Pak subcontinent (Khan, 1965 and Agarwal and Niazi, 1977) where embryonic period is too short and the postembryonic period is highly prolonged.

This chapter describes a normal table of development of Rhacophorus leucomystax. It deposits the eggs in a foamy nest on the vegetation overhanging the edges of the pools. The eggs are devoid of pigment, they hatch in 3 to 4 days and the larvae metamorphose into young froglets in 57 to 58 days. The development has been described in 46 stages, each based on a new morphogenetic event: Fertilization: 2 stages; Cleavage: 6 stages; Blastulation: 3 stages; Gastrulation: 5 stages; Neurulation : 3 stages; tail bud and gill formation: 8 stages; Opercular fold formation: 5 stages; Hind limb bud: 5 stages; Toe indentation: 4 stages and Metamorphosis: 5 stages. The development of Rhacophorus leucomystax exhibits certain peculiar features:

- (1) Soon after fertilization there is flattening of animal pole.
- (2) During late blastula and early gastrula a clear translucent bulged area is seen at the animal region, this encloses blastocoel.
- (3) The yolky portion of the embryo is proportionately very large at the tail bud and following stages until hatching.

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