

**ECOLOGICAL BIOGEOGRAPHY OF FRESHWATER FISHES IN THE  
NORTH-EAST REGIONS OF INDIA**

**ABSTRACT**

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

To



**THE NORTH-EASTERN HILL UNIVERSITY  
SHILLONG - 793001**

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## A B S T R A C T

The present work was undertaken to gain an insight into an ecosystem so rich and diverse in its complexity as the North-Eastern Hill Regions of India. Fish as the study fauna was undertaken to help in understanding their present dynamic status, temporal and spatial distinction and their occupation in the vast ecological niches available in the lotic systems of these regions. The anticipated outcome was not only cataloguing of the different species available, but also to make an observation on their ecological zoogeography and the possibility of the identification of the origin, evolution and radiation of these North-East Indian fish fauna.

The present investigation was confined to the states of Assam, Meghalaya, Nagaland and the two main union territories of Arunachal Pradesh and Mizoram. Collections were made representative of these areas and as far as possible extensive, representative of the total area. However, intensive observations were made in five lotic systems where both population dynamics and community level interactions were observed seasonally. The analysis were made as far as possible from the origin (Headwaters) to the mouth of these rivers/streams.

For both extensive and intensive collections and observations done, cataloguing was made in the form of

checklists and various distribution maps drawn. The former was done for the political entities undertaken and the latter for the drainage of the region. Subsequently, a number of statistical analyses incorporated to highlight the ecological aspects of the distribution of fish, their occurrence, co-occurrence and other related phenomena. Those which were used for this purpose were the Shannon-Weiner Index, the Species Richness Index, Hmax. the evenness and the Redundance Values. All these indicated not only the occurrence of species but their dynamic status during the period of investigation. Further, they also revealed the combination of species and groups of species interacting in the various ecological niches undertaken. In addition, Poisson Distribution and Morisita's Index were done to reveal the randomness, nonrandomness and aggregate behaviour in these fishes. Moreover, the different species of fish and their presence and absence in these major systems were calculated after the Average Faunal Resemblance Index, and this was further substantiated by the incorporation of Sørensen's Quotient of similarity between the systems undertaken.

All the above though confined to the fauna itself, an understanding into their occupation was analysed by the incorporation of habitat diversity indices, measured by the use of three criteria of depth, substrate and current and the correlation between these habitat diversities and species diversities worked out.

The present investigation was representative of all the the superorders, orders, families and genera recorded earlier though they fell short by 30 species. It was seen that the largest group was Cypriniformes with Cyprinidae dominating. It was also seen that 21 species were found commonly occurring in different states and union territories. In general, the present study also revealed that the North-East possessed 1 family, 5 genera and 22 species endemic. The state of Assam had the largest number of 146 species followed by Nagaland and Meghalaya with 85 and 82 species respectively. The Union Territories of Mizoram and Arunachal Pradesh recorded nearly 50 species each.

The occurrence of fish in different drainages as seen in the distributional maps were found to be a maximum of 162 in the Brahmaputra drainage followed by the Meghna with 111 and the Chindwin with 67. Meghna drainage does not possess a unique fauna of its own but harboured some species that were obstructed by the Brahmaputra. The Chindwin drainage contained quite a few endemics in Naga Hills and Manipur while Mizo Hills did not possess a unique fish fauna of its own. Of the different rivers in the Brahmaputra drainage understandably the River Brahmaputra harboured the maximum number of species. This river also was seen to be a barrier in the dispersal of species as was clearly seen by their difference in the species number and composition on the northern and southern sides of this river. Detailed

discussions on the presence and absence of different species in the different drainages have been incorporated.

The intensive collections revealed that a clearcut dominance of Cyprinidae in the summer months and Cobitidae in the winter months existed. Discussion on population dynamics and community analysis using different statistical formulae have been discussed. The higher altitudes harboured highly specialized hill stream fishes like Garra, Psilorhynchus, Balitora, Pseudecheneis, Glyptothorax and Semiplotus, etc., while Schizothorax and Schizothoraichthys were confined to near alpine conditions in Arunachal Pradesh. Universal species like Danio, Barilius, Badis, Mastacembelus and Puntius were seen to be distributed upto moderately high elevations though with varied ecological requirements. Species of Barridae, Cyprinidae, Channidae and Anabantidae preferred the lowlands while Cobitids revealed an enormous range of adaptability. The species which showed remarkable patchyness in distribution were Noeucirrhichthys, Noemacheilus kangjupkhulensis, N. sikmaiensis and N. subfusca. Species like Pillaia indica had very narrow distributional range while P. khajuriae with discontinuity.

The North-East Indian fish fauna represented predominantly South Asian with few endemics, and a high degree of speciation. The richness and species composition in the North-East and its importance in the migrational routes have

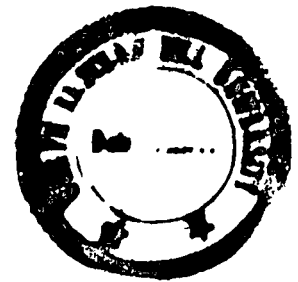
been discussed. Both ecological and geological interpretation, as far as possible have been outlined, to enable the understanding of communities and the associations of species.

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A. PARDHASARADHI

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SCHOOL OF LIFE SCIENCES



SUBMITTED IN FULFILMENT OF THE REQUIREMENT OF  
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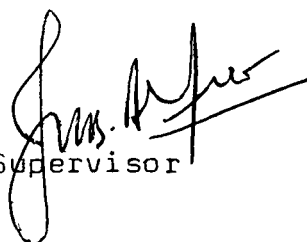
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I certify that the thesis entitled "Ecological Biogeography of Freshwater Fishes in the North-East Regions of India", submitted by Mr. A. Pardhasaradhi for the degree of Doctor of Philosophy of the North-Eastern Hill University, Shillong embodies the 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 Ph.D Degree. This work has not been submitted for any degree of any other University.

Date: 4<sup>th</sup> August 1988

Place: Shillong

  
Supervisor

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The present work embodies in its larger perspective, what one would refer to as biogeography. Ordinarily biogeography would imply the geography of living things in space and time. In recent times the enthusiasm for biogeography and its applications, has stemmed from the tremendous interest in ecology, and this is more so, due to man's present day knowledge and awareness of the degradation and destruction of the natural environment. Therefore, the subject of biogeography incorporates such an enormous breadth, that attempts are rarely made to deal with more than a few facets of the subject. This, is due, partly to the fact that as a subject it lies at the meeting point of several fields of study. Though a research worker is not an expert in more than one or two branches, he cannot afford to be ignorant of the multitude of other branches of interactions, interrelations and affinities. Therefore, biogeography more than any other subject, necessitates a holistic approach.

More specifically, traditionally and classically biogeography has concerned itself with the study of geographical aspects of plant and animal life, especially in terms of their distribution. As recognisable sub-divisions phytogeography deals with plants and zoogeography with animals. Enormous literature is available on phytogeography, but here we confine ourselves for the present work only to zoogeography, for a direct understanding of the subject. The study of zoogeography which explains the distribution of animals over the earth's surface, as seen from the word itself is an interdisciplinary science comprising of the faunal aspects of biology in relation to their geography. These

two disciplines are further interconnected with ecology.

The earliest recognition of the range of biota, the occurrence of similar or related species in the same or adjacent geographical areas and similar species arising from common ancestral species that possessed geographic and ecologic limitations, is attributed to Darwin (1859). A little later, if not simultaneously, Wallace (1876), was probably the first to organise, identify and delineate the limits of zoogeographic units, and build up the concepts of zoogeographical realms, provinces and sub-provinces. This triggered the great scientific expeditions of the nineteenth century which laid the foundation for the knowledge of the world's zoogeographical regions, demarcated at that time, with limited resources and facilities with remarkable precision (Sclater, 1858; Huxley, 1868; Wallace, 1860, 1876 and others).

Since then, zoogeography has been studied as never before, till the intricate knowledge paved the way for the breaking up of zoogeography into its various sub-divisions, built around authorities from different schools of thought. Such trends had begun in the early twentieth century with the development and synthesis of the ideas from scientists like Hesse (1924), Ekman (1927, 1935), Bobrinski (1953), Schilder (1956), Darlington (1957) and de Lattin (1967). However, it was only in the last decade that the major sub-divisions of zoogeography had clear definitions in the text-books, based on the work done at that time and more on the **collation** of earlier available literature on

faunistics. Muller (1974) had given importance to experimental zoogeography and applied zoogeography. The former he felt, was essential as the next step in highlighting facts of distribution, while the latter for the benefit of man. Banarescu (1975) in a review of the zoogeographical understanding of that time, had broadly classed it into three categories (a) descriptive zoogeography, incorporating chorology, faunistics, (b) comparative zoogeography, indicating the comparative faunistics also called systematic zoogeography, geographic zoology or zoologic geography and (c) historical zoogeography. Species distribution, their passive or active dispersal ability based on the environmental factors determining the area of distribution was included in the former. Historical zoogeography though not opposed to ecological zoogeography, incorporated the understanding of distribution in the light of past history, based on the origin and evolution of both the fauna and the landscape.

It was with the above concept that the present work was initiated, primarily with the theoretical hypothesis that biological conservation may be Utilitarian. The preservation of functional ecological systems necessitated cataloging, the first step to any zoogeographical task. With a knowledge that organisms never live alone and are part of ecosystems which are by themselves spatial functional structures, we set about the task of elucidating the underlying phenomena of the capacity of self-regulation in order to be able at a future stage to predict the distribution of fauna on the time scale. This led us to ask ourselves questions directed at arriving with answers, serving as

beacons to brighten-up and classify that which we were groping for in the dark. We identified one group of fauna which we felt confident to handle, the fish. The reason for the study of zoogeography of fish in these regions was endowed with the benefit that it was still untouched by the cruel forces of man. Among the questions which we felt puzzled about and needed answers were, 1) Why do certain species live where they do?, 2) Do the North-Eastern Regions of India possess a highly distinctive fish fauna and if so why?, 3) Are the ecosystems studied responsive to climate, or otherwise?, 4) Do the fish community patterns in the North-East differ from the generalized tropics?, 5) Does the diversity in fish species directly depend on habitat, or Does habitat diversity control fish species and their numbers?, 6) What are the major barriers especially in lotic systems responsible for the discontinuity or disjunct distribution? 7) Has plate-tectonics played a major role in North-East India?, 8) What are the limits of distribution for particular species of the region?, 9) Is the present day geomorphology a sufficient indicator of past geology? and finally 10) Where the centre of origin, evolution and radiation of these North-East Indian fish fauna could possibly be?

Before launching into the programme the preliminary work was to browse through the literature on Indian zoogeography. Holloway (1969, 1974) with the application of cluster analysis, derived faunal centres, though he used species of Indian butterflies for coincident geographic distribution and concentration, with probable routes of migration and colonization in

India. Prakash (1974) working on mammals had indicated the possible route of migration either from the Indo-Chinese-Malayan region to the Great Indian Desert through North India, or from the Indian Deccan through Gujarat into the Indian Desert. Similarly, the distributional peculiarities, with a possibility of isolation due to monsoon, of termites, (Sen-Sarma, 1974) and Amphibia (Jayaram, 1974b) have been done. Further, the major division of India into Peninsular and Extra-peninsular and its geological history, in particular glaciation were attributed as factors for the present-day distribution of Indian Diptera by Singh (1974). Jayaram (1974b) again, in his work on reptiles was of the opinion that the Yunnan-Burma amphitheatre could be the centre of origin of the bulk of land vertebrates. In addition to the above, Mani (1974a) had collated the works prior to 1950 which were done on either invertebrates or vertebrates, indicative of the major sub-divisions of India on a possible zoogeographical idea, though, as he rightly puts it "each proposed their own zoogeographical sub-divisions of India".

The above indicates that not all groups of animals possess the same status for zoogeographical studies. We identified fish as our group of study, and literature revealed that the earliest in India was Hora (1937g, 1949a) to whom credit goes as the pioneer in identifying the present day distribution of fishes in India and Upper Asia by the successions of river captures. Since then, the only comprehensive review available for fish zoogeography in India has been brought out by

Jayaram (1974b), who has not only culled his information from literature of other workers but has also included his own contributions in the most lucid form possible.

All these works have primarily been aimed at descriptive zoogeography based on the cataloging of species of individual faunal groups undertaken. We felt that the ecological community helping in the assemblage of fauna was most essential before identifying the causative factors for distribution. It was therefore felt that co-occurrence was the first requirement for co-evolution, though the presence of antagonistic pairs of species persisting together without driving the other extinct could only be clarified by studies of species diversity. Biological variability indicative of such degree of low or high species diversity is only another form of environmental variation. It is reasonable, therefore, that not only with the cataloging of species and their index of diversity but also the importance of habitat diversity plays a major role in the process of co-evolution and distribution. This is more so within habitats since the nature and number of macrohabitats is an important factor to be reckoned with. Further, this diversity helps in representing the dynamic equilibrium between contemporary rates of colonization and extinction. The key to the understanding of community diversity patterns among lotic fishes, would, therefore, involve the measurements of habitat characteristics over the seasons.

All these mentioned above, helped us to gain an insight of the ecosystem, where an attempt was made using the data available, and the present work to bring about the descriptive zoogeography, **by** not only cataloging the species but also indicating their present dynamic status, along with ecological zoogeography, where the community and the environment interacted with each other, helping in both temporal and spatial distinctions. In addition, the evolution of hypotheses based on historical zoogeography, as far as feasible was done with the help of the concept of geology being responsible for the creation of ecological niches in the present geomorphological features for fish in the running waters of North-East India.

With the basic understanding of general zoogeography the need was felt to identify, from existing literature the position of North-East India under the divisions or sub-divisions of the zoogeographical Realms. Based only on animals it is seen that the continental areas of the world are divided into Regions representing mosaic formations of patterns where different groups of animals are distributed differentially.

The usually accepted Realms and Regions are of Scalter (1858) and Wallace (1976) which still hold good for many higher vertebrates and terrestrial invertebrates. They have broadly divided the world into three Realms, Meagagea (Arctogea), Neogea and Notogea. These Realms have been further sub-divided, the latter two into one region each, the Neotropical and the Australian respectively while the former into four Regions named the Ethiopian, Oriental, Palaeartic and the Nearctic. Of these, for the present investigation our interest lies in the Oriental Region which includes the general tropics of Asia with the associated continental islands of Ceylon (now Sri Lanka), Sumatra, Java, Borneo, Formosa and some adjacent smaller islands (Darlington, 1957; Hubbs, 1958; George, 1962; de Lattin, 1967; Udavardy, 1969, 1975; Neill, 1969; Baranescu and Boscain, 1973; Muller, 1974; Briggs, 1974a, and Banarescu, 1975). The influence of the Palaeartic Region which includes Eurasia above the tropics and the temperate northern corner of Africa, North of the Atlas mountains, is also to some extent important for our studies.

This Oriental Region is considered very important in the geological history of the world, yet precise sub-divisions from the faunistic point of view is lacking. The divisioning of this Region, follows the one as early as 1876 after Wallace, who identified four Sub-regions within the Oriental Region. These are the Indo-Chinese, Indo-Malayan, Indian and Ceylonese. From our position in North-Eastern India the important sub-regions considered are the Indo-Chinese, which includes the Himalayas from the base of the mountains to an elevation of nearly 3000 m, to the far West upto Kashmir and all the areas east and north-east of the Bay of Bengal, inclusive of the landmasses of Assam-Burma-Southern China-Thailand and Cochinchina. The next is the Indo-Malayan sub-region which includes the Malayan Peninsula and the Malayan Archipelago. In part, the Indian sub-region also could be considered as it includes the whole of Peninsular India north of Srirangapatam and Goa till the foot of the Himalayas.

It is seen that the North-Eastern Regions of India, though considered under the general Oriental Region has elements of the Palaeartic, affecting the Regions on their periphery. In addition, at the sub-region levels, North-East India could be placed at the junction of the Indian and the Indo-Chinese sub-regions. In a larger perspective it therefore falls in an area of tri-junction where the Regions and the sub-regions intermingle and cross roads exist. This is established by the fact that the Indo-Chinese sub-region possesses a high number of

monotypic genera which is known to be habitable also in North-East India along with Palearctic species. All these probably migrated through the gateway of then Assam. (Mell, 1958; Gross, 1961, Kurup, 1974). The formation of a transitional zone, is therefore possible, where species have established themselves in all the possible ecological niches available, where the microhabitats, in contrast to the general habitats are numerous and possess conducive environments similar to their original home lands.

The North-Eastern part of India is the region where the original obliteration of the Tethys Sea began. With the emergence of the rising Himalayas, dispersal could understandably have taken place only through the North-western or the North-eastern passes for most fauna except the mountain species. The desertification of the North-West dwindled the importance of that gateway and the distribution, dispersal would mostly have occurred through the North-eastern passes, as is proved by the Indo-Chinese mammals and their spread through the Garo-Rajmahal Gap (Kurup, 1974). However, compared to the larger Peninsula, North-East India abounds with phylogenetically plastic forms of highly evolved Asiatic groups which are also very young with a comparative-dwindling of the ancient Gondwana elements.

Species of fishes are richer in their endemism in North-East India compared to the North-West, resulting in the colonization of the Indo-Chinese mountainous areas. The North-East in addition, possess the intrinsic quality of the western

most point, for the Indo-Chinese elements and southern-most point of Palaearctic establishments. Though included under the general Oriental, the Palaearctic does play a decisive role. The transitional nature of these areas would therefore evoke a terminology of its own as it has very little comparisons with any other region of the world. We would like to term it as the North-East Indian Transitional Zone.

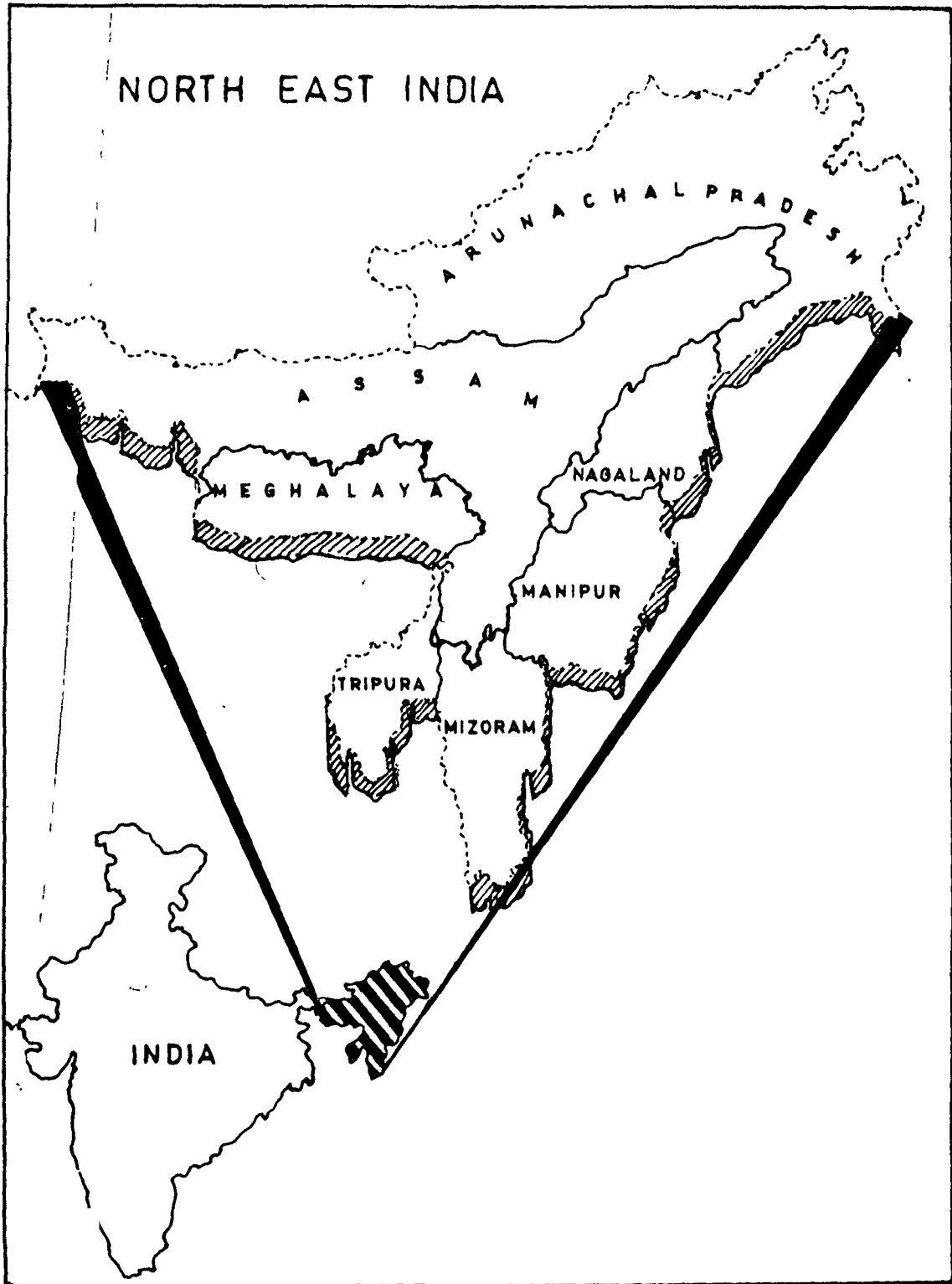
## LOCATION

The location of the study area chosen occupies the greater part of East and North-East India. It is enclosed by the political limits of India on the North where the Chinese border lies, on the East by Burma and on the South-west and South bordering with East Bengal, now Bangladesh, and the Indian part of West Bengal and finally Bhutan on the West. The general area under consideration is situated between  $21^{\circ} 51'$  to  $29^{\circ} 58'$  and  $89^{\circ} 42'$  to  $97^{\circ} 25'$  E, made up of the political states of Assam, Manipur, Meghalaya, Nagaland and Tripura along with the two union territories of Arunachal Pradesh and Mizoram. The area enclosed is nearly  $257,295 \text{ km}^2$  (Map I).

For the present investigation the states of Assam, Meghalaya, Nagaland and the 2 union territories of Arunachal Pradesh and Mizoram only are studied in detail because of accessibility and geographical location. These, however are representative of the total area, since the tail ends of the drainage are occupied by Tripura on one side and Manipur on the other, with Mizoram in between.

Arunachal Pradesh lies between  $26^{\circ} 36'$  to  $29^{\circ} 58'$  N and  $91^{\circ} 36'$  to  $97^{\circ} 25'$  E and has probably the largest area ( $83,744 \text{ km}^2$ ) under North-East India with Assam coming next ( $78,437 \text{ km}^2$ ) situated  $24^{\circ} 09'$  to  $27^{\circ} 57'$  N and  $80^{\circ} 42'$  to  $91^{\circ} 01'$  E. After these two, according to the area covered Mizoram ( $23,980 \text{ km}^2$ ) which lies between  $21^{\circ} 56'$  to  $24^{\circ} 35'$  N and  $92^{\circ} 17'$  to  $93^{\circ} 26'$  E

Map I: Location of the study area.



comes next, followed by the State of Meghalaya which is about 1000 km<sup>2</sup> less (23,000 km<sup>2</sup>) and lies between 25° 02' to 26° 07' N and 89° 49' to 92° 49' E. Nagaland occupies an area (16,581 km<sup>2</sup>), comparatively smaller than all these, situated between 25° 13' to 27° 02' N and 93° 20' to 95° 15' E.

Though the collections were done in the regions mentioned above, the work was more extensive for the larger areas and as far as possible, collections made were representative of that area. However, intensive work was carried out in 5 lotic systems to enable the knowledge of fish population dynamics in these areas. For these latter studies the five systems chosen were three rivers, the Pagladiya in Assam, the Simsang (Someswari) and Damrang (Krishnai) in Garo Hills (Meghalaya) and two hill streams Sumer and Umkhrah in East Khasi Hills again in Meghalaya. However, the stations chosen on the major river systems were representative of other rivers and tributaries joining one or more of these above systems. When so done, the stations of Pagladiya, I to IV (Plates I & II) were the Chowki, Subhankhata, Nabasti and West of Kamalpur, occupying 26° 51' N - 91° 25' E, 26° 45' N - 92° 28' E, 26° 41' N - 91° 30' E and 26° 37' N - 91° 31' E respectively. The rivers of Garo Hills similarly had four stations each. Simsang (Plates III & IV) covered places, called Bonsomgiri, William Nagar, Mangalibra, and Bagmara situated 25° 33' N - 90° 29' E, 25° 32' N - 90° 36' E, 25° 28' N - 98° 42' E and 25° 20' N - 90° 41' E respectively, while Damrang covered places like Gabel, Rongri,

Plate I: Pagladiya river  
a. Station I  
b. Station II

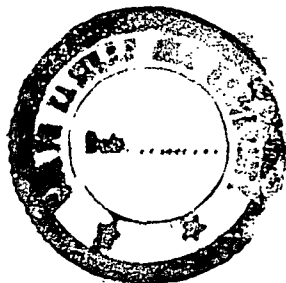


Plate II: Pagladiya river

a. Station III

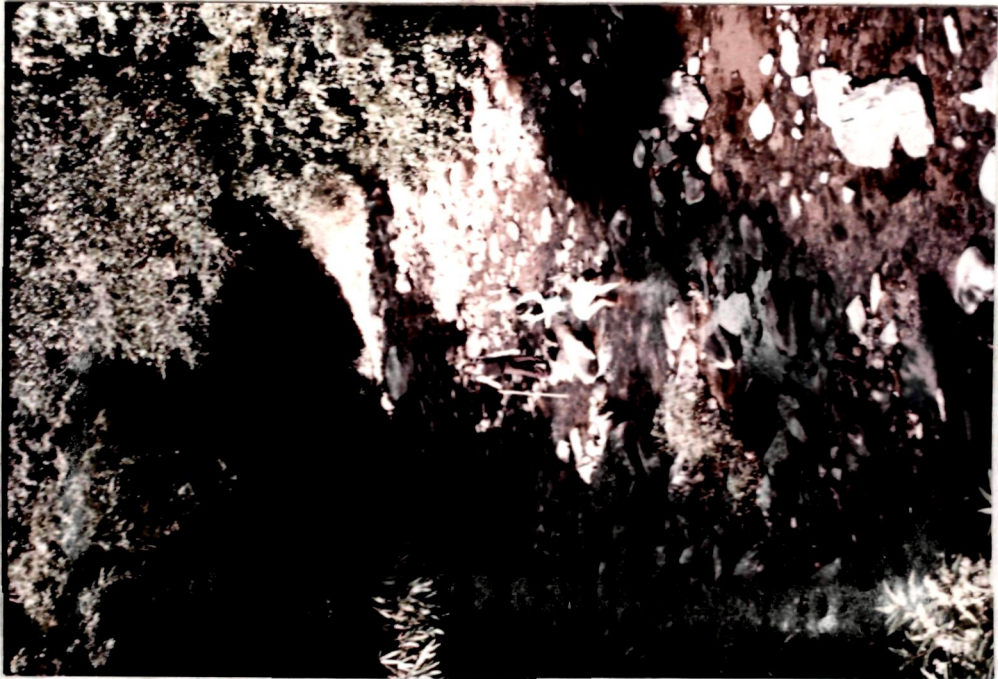
b. Station IV

a



b

Plate III: Sinsong river  
a. Station I  
b. Station II



a



b

Plate IV: Samsong river  
a. Station III  
b. Station IV



a



b

Mendipathar and Krishnai as its four stations (Plates V & VI) 25° 41' N and 90° 24' E, 25° 42' N and 90° 26' E, 25° 51' N and 90° 36' E and 26° 02' N and 90° 41' E respectively.

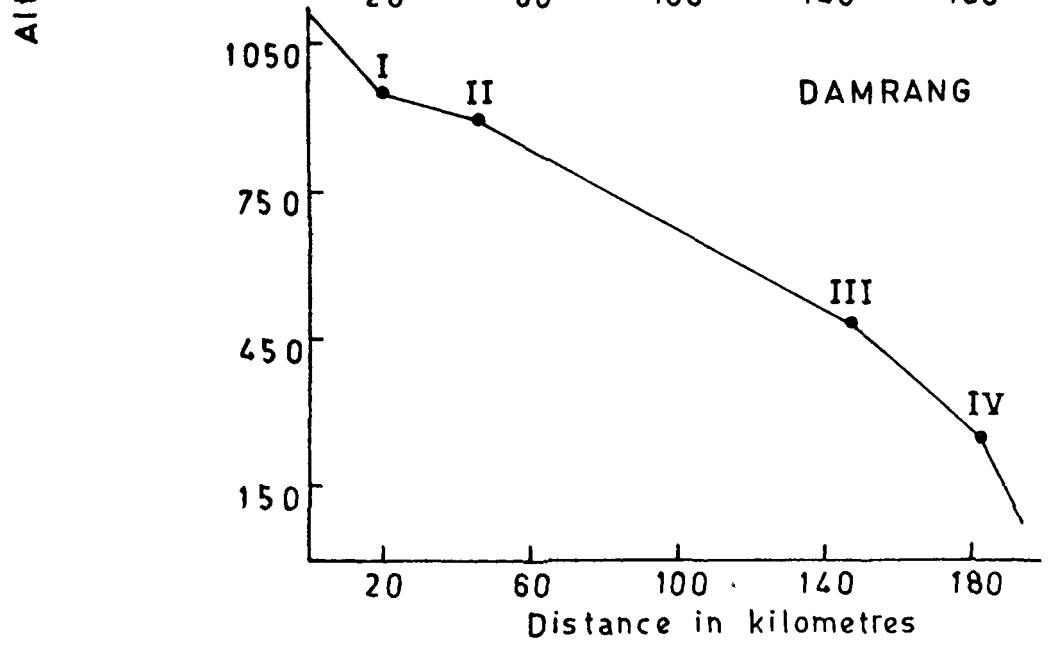
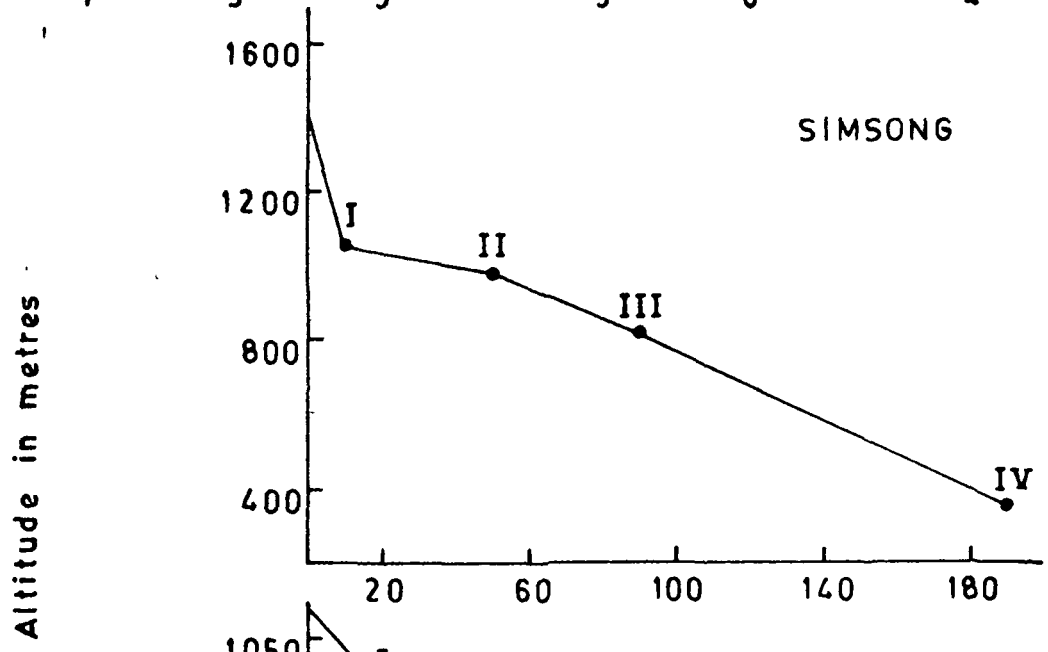
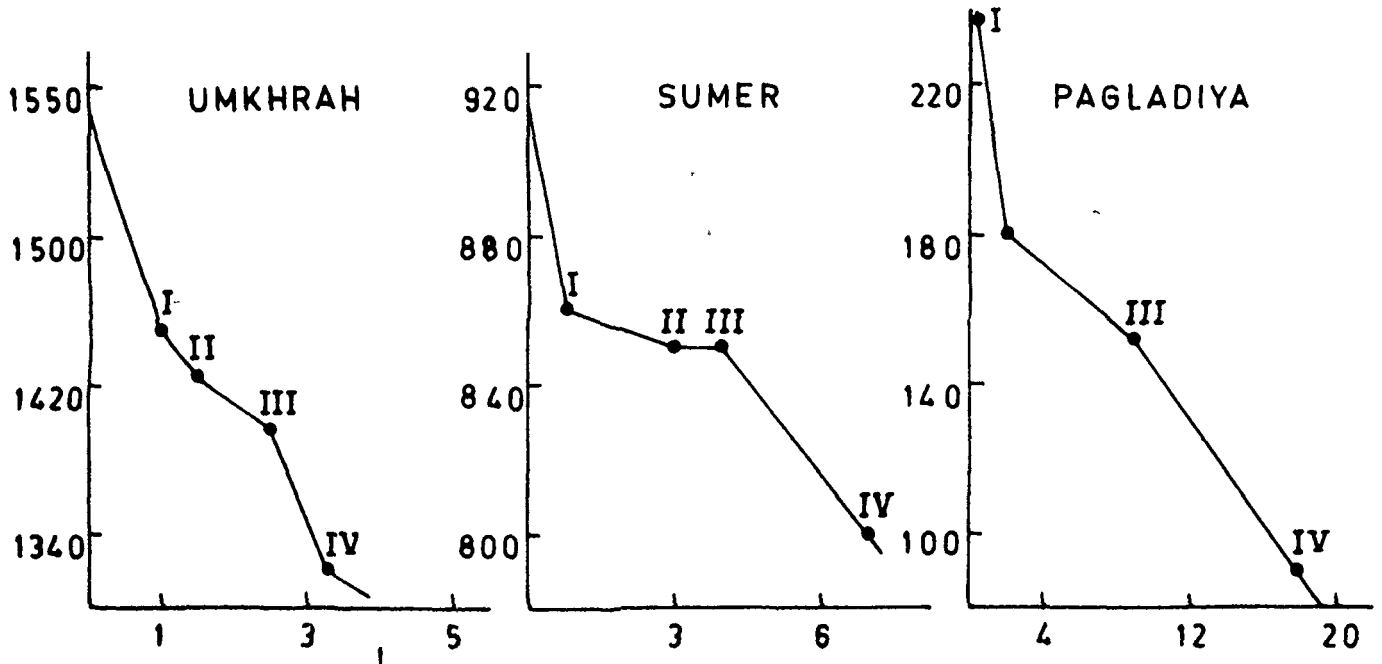
The two hill streams in the East Khasi Hills were comparatively smaller than the above major river systems and though four stations were chosen, they were more representative of the gradient within the short distance they covered rather than the area through which they traversed (Fig. 1). The summer stream (Plates VII & VIII) lies between 25° 45' N - 91° 51' E while the stream of Umkhras lies in and around Shillong (24° 51' N and 91° 89' E) (Plates IX & X).

## CLIMATE

### North-East India :

The North-Eastern Regions of India have a varied and diverse climate depending on the location and the altitude. This area is probably representative of all the world's climates. The climate on the whole could be called a humid and sub-tropical type, though with altitude and especially in Arunachal Pradesh the sub-tropical and the temperate overlap and the winter months have snowfall as a common feature. The temperature therefore varies between 0°C and 35°C. Moreover, this point is also one of the wettest places in the world because the tropical South-West monsoon hits these hills and mountains and sheds the greater part of its moisture in these regions. The heavy showers are preceded by strong winds and thunderstorms with infrequent

Fig.1: River/Stream gradient showing the collection sites of the five systems chosen for seasonal study.



Altitude in metres

Distance in kilometres

Plate V: Damrang river  
a. Station I  
b. Station II



a

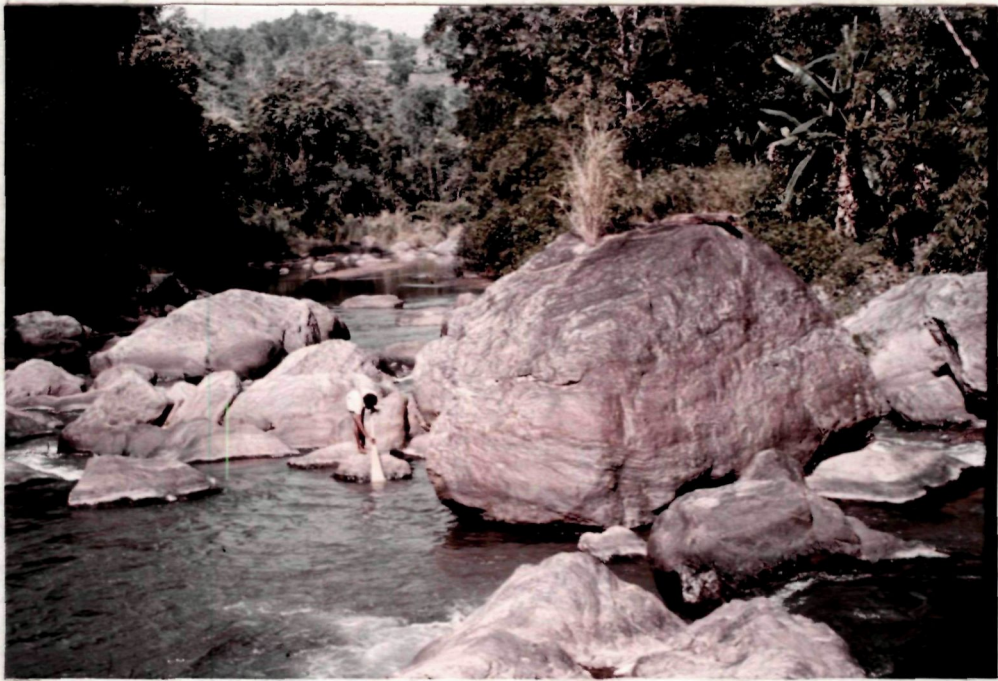


b

Plate VI: Damrang river

a. Station III

b. Station IV

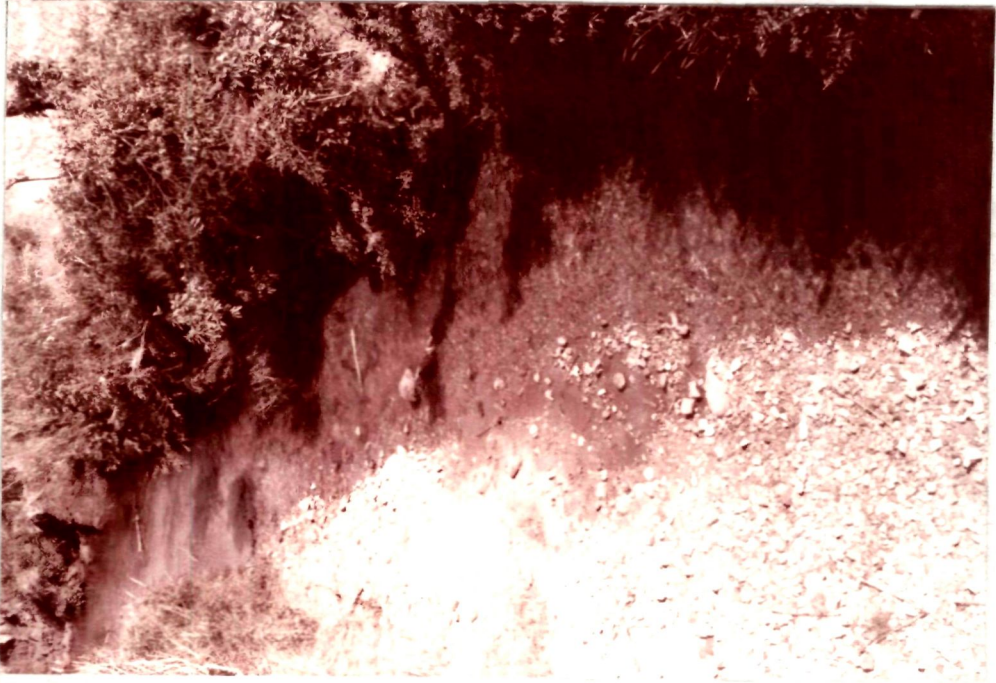


a

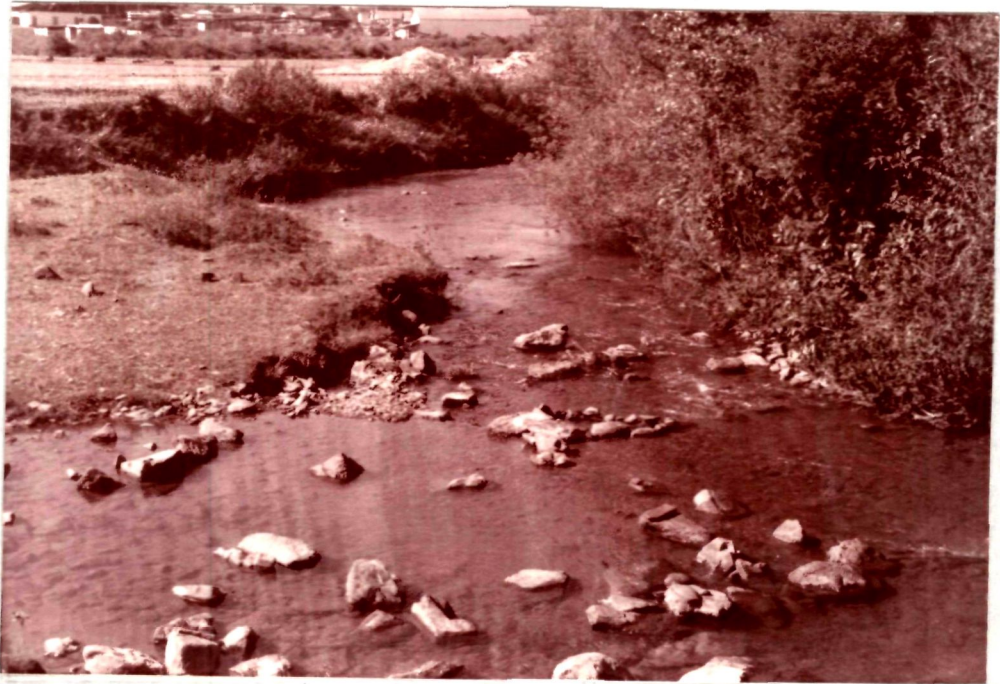


b

Plate VII: Sumer stream  
a. Station I  
b. Station II

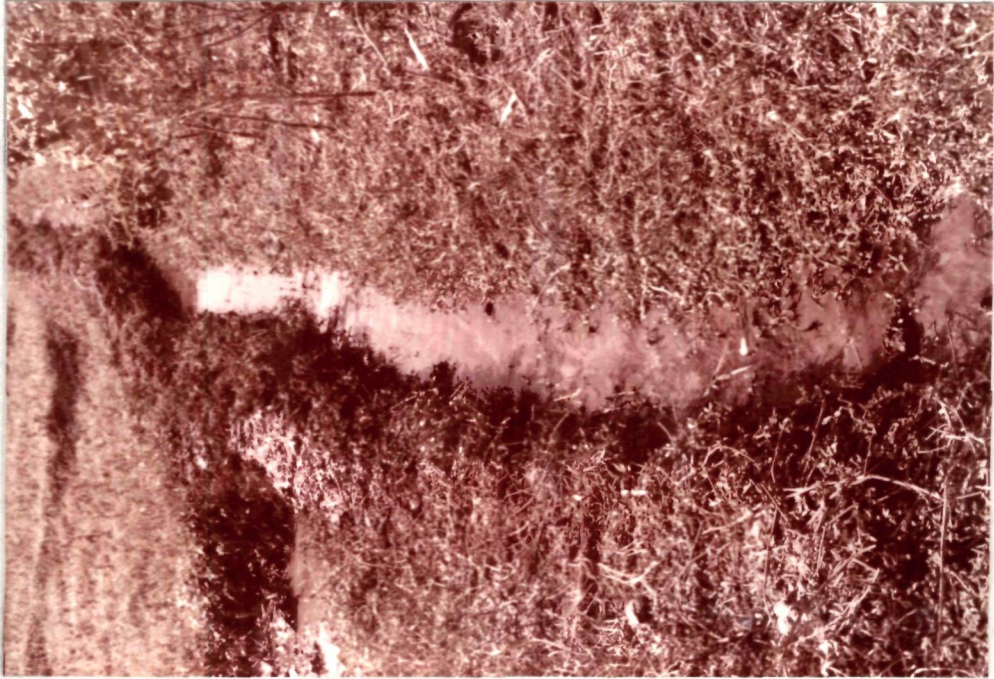


a



b

Plate VIII: Sumer stream  
a. Station III  
b. Station IV



a



b

Plate IX: Umkhrab stream  
a. Station I  
b. Station II



a



b

Plate X: Umkhras stream  
a. Station III  
b. Station IV



a



b

hailstorms. Cherrapunjee and Mawsynram of the Shillong Plateau possess the enviable locations having records for the heaviest rainfall in the world averaging an annual rainfall of 1143 cm. Except for the north of Arunachal Pradesh and beyond the timber line, snowfall is not recorded in these areas. The characteristic feature, especially at higher elevations in Shillong, Kohima and Pfcutsiro is the occurrence of hoar frost on the ground during winter.

Arunachal Pradesh : The general climate of Arunachal Pradesh is sub-tropical, sub-temperate and temperate. This is due in part to the varying altitudes in this region, from the valleys to the snow-clad peaks. The temperature variations are also diverse, for example, the outer valleys record 24° C and 14° C as their maximum and minimum temperature respectively while the higher slopes 19° C and -5° C. Very heavy rainfall is another dominant feature, recording on an average 400 cm. per annum both from the South-West and North-East monsoons.

Assam : Assam is predominantly sub-tropical and in some lower foothills highly tropical. Temperature variations never go below 4° C in winter but the mercury touches a maximum of 37° C during the summer months. The South-West monsoon has a pre-dominant influence in this region and strong winds, hailstorms, thunder-showers and occasional cyclones occur during most parts of the year.

Meghalaya : The region has a typical sub-tropical monsoon climate with the temperature oscillating between 25°C and 9°C with isolated periodic deviation to the freezing point marked by ground frost in winter nights. Though the average rainfall is around 205 cm. the maximum average recorded is 1143 cm. around Cherrapunjee and in particular Mawsynram.

Mizoram : The climate in Mizoram generally lacks wide fluctuations, with summers being cool and the winters not very cold. It, therefore, varies between the general sub-tropical and tropical climates with the average rainfall of 250 cm. in a year. Winter temperatures lie between 11°C and 24°C while in summer it is 18°C and 29°C.

Nagaland : Nagaland has a typical, tropical, monsoon climate. Rainfall records nearly 195 cm. on an average with temperature in summer upto 40°C. The remarkable feature is that like Meghalaya, records of freezing points also exist during winter.

#### PHYSIOGRAPHY :

The topography of North East India is diverse and varied and is inclusive of a range from the snow clad peaks of Himalayas in the Arunachal Pradesh to the Barail Ranges to the Arakan Yoma (Chin and Lushai Hills) in the south-east and east. The centre is occupied by the Naga and the Patkai Hills and the Mikir Hills. Approaching the south are the Khasi, Jaintia and Garo Hills, to the Surma Valley and its plain till the sea line.

The major sub-divisions according to their features identified as the physiographic regions of the area, are the Eastern Himalayas (Bhutan and Assam Himalayas) the Assam and Burma ranges, the Shillong Plateau, the valleys of Brahmaputra and the Surma Valley. A detailed analysis of these physiographic regions is essential as the area is marked by varying altitudes, which would highlight the existence of possible passes and traps.

1. Eastern Himalayas (Bhutan and Assam Himalayas) :

Nearly 75% of the total area of the present union territory of Arunachal Pradesh constitutes these Himalayas. They extend through the districts of Kameng, Subhansiri and Siang in a North-Easterly direction with the imposing gorge of the Siang river, which is the continuation of Tsan-Po towards the east. In the Lohit district on the southeast and the Tirap into the eastern part, these Himalayas take an orographic swerve. In addition, the composition of Sub-Himalayan ranges (1,700 M) and the Lower Himalayan ranges (3,500 M) culminate into the Greater Himalayas (4,500 M) where established peaks like Gorichan (6,538 M) and Kongtu (7,090 M) exist. However, the Sub-Himalayan belt is insignificant in Lohit district while the outer Himalayas possess altitudes of about 3,800 m due to the Daphabum Range.

2. Assam and Burma Ranges :

The hills and mountains lying between India and Burma are in the form of a continuous curve beginning from the North

East of Assam to cape Nagrais. A broad categorisation of these ranges into two distinct identities can be made as follows:

- a) the border hills inclusive of the Patkai, Naga, Lushai and Chin hills and
- b) the Barail Ranges.

a) Border hills : The Patkai Hills traversing North-East and South-West about the Himalayas near the Tirap district of Arunachal Pradesh, get broadened into Naga Hills in Nagaland on one hand and the Plateau of Manipur on the other. The Naga Hills themselves have peaks like Saramathi (3,826 M) and Mathoksiang (3,420 M) in its extreme east. Between Mao and Kohima there are several peaks which include the well known Japvo (2,750 M). These main ranges start declining in height, north of Kohima and do so as far North as Mokokchung where the Japukong Range has elevations of only 750 M.

The Lushai (Mizo) and Chin Hills from the ~~Manipur Plateau~~ extend southwards as the narrow Arakan Yoma. These hill ranges, running north-south, increase in their altitude and tend to be higher in the central portions of Mizoram. These hills have an average altitude of 900 M, with the Blue mountain (Phawnpui, 2,065 M) as its highest peak situated on the southern portions of Mizoram.

b) Barail Ranges : These arise as a branch of Naga Hills and the Plateau of Manipur extending into Assam as the Barail Ranges.

These are separated by a col or a saddle by the Jaintia, Khasi and Garo Hills. Thereafter it re-enters Nagaland near the South-West corner running in North-East direction up to Kohima where they merge with the general Naga Hills extending till Manipur. The main range possesses a distinct northerly trend (North Cachar Hills in Assam) merging with the Mikir Hills in the North and the Naga Hills, on the South-East. They have an average range of elevation between 1,300 and 1,600 M.

3. Shillong Plateau : The remnant of an ancient plateau of the Pre-Cambrian Indian Peninsular shield as a block uplifted to its present height (1,600 to 1,800 M) is the present physiographic feature of this plateau. At the western end of the plateau near Tura it rises to 1,200 M where the Garo Hills, constituting the western extremity rise sharply from the places of the south till the hills attain a maximal elevation of 1,468 M (Nokerek Peak, East of Tura). The North Khasi Hills gradually rise from the southern plains of Assam by a succession of low hills while the hills on the south rise abruptly from the level plains to elevations of 1,200 M. In contrast the Jaintia Hills, slope more gently to the plains than the Khasi Hills.

4. Brahmaputra Valley : This is situated between the Arunachal Himalayas in the north and north-east, the Patkai, Naga, Lushai (Mizo) Hills in the south-east and the Shillong Plateau in the South. It extends from the townships of Dibrugarh and Dubri and is nearly 750 km long with a maximum width of 80 km. The valley

probably could be taken as the easterly extension of the Indo-Gangetic alluvium between the Himalayan and Naga, Patkai and Lushai upheavals by the wedge like fragment of Peninsular India, Shillong Plateau and Mikir Hills, forming the floor of its basis (Anon, 1974).

5. Surma Valley : This valley is formed as an extension of the alluvial plains of Bangladesh from Assam extending southwards. It is enclosed in a triangle with maximum width and length of 100 km respectively, enclosed on the north by Meghalaya, the east by the North Cachar and Manipur Hills and on the South by Mizoram and Tripura Hills.

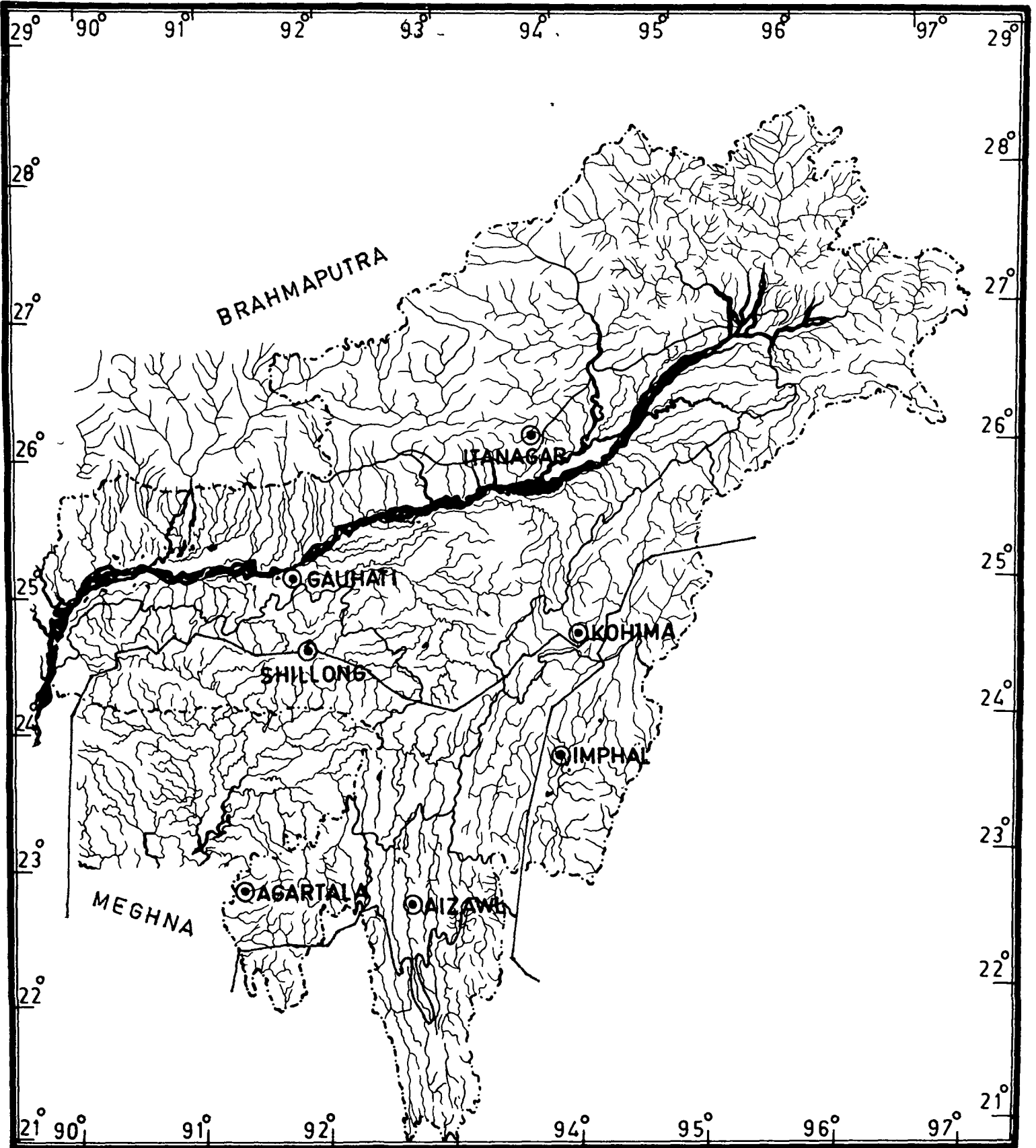
#### Drainage :

One important factor of geomorphology which plays a great role in ecological zoogeography is the drainage and its patterns in the watershed of any area. Peninsular India has a characteristic radial pattern, with Chambal, Banar, Sindh, Betwa, Ken and Son as the north flowing rivers, Damodar and Mahanadi and their tributaries east flowing, the southwest flowir, Swarnarekha, the south flowing Wainganga,, Wardha (the tributaries of R. Godavari) and the westerly flowing rivers Narmada and Tapti. Of these the Chambal, Sindh, Betwa and Son reveal a typical anterior drainage pattern and are older than the Ganga and Yamuna Rivers into which they flow. The drainage on the western paths of Peninsula are trillis in nature and especially seen south of Bombay for the rivers Amba, Kundalik,

Savitri, Vasishtha, Shastri, Khajvi and Vaghotan. Their courses cut through the Deccan lava. All these peninsular rivers are monsoon fed in their entirety.

In contrast to the above, the Extra Peninsular rivers are part of the drainage system of the Himalayas, and therefore not dependent on monsoon rains but primarily fed by the melting snow. All the rivers are mostly antecedent except the river Ganga which was consequent with the Himalayan uplift (Mani, 1974b). The most important systems are the Indus, Ganga and Brahmaputra, where the former flowing through Pakistan enters the Arabian while the Ganga after traversing through the Indo-Gangetic plains flows into Bay of Bengal, near Sagar Island. For our purposes the river Brahmaputra is of significant importance, as the major watershed of North East India is primarily due to this river and its tributaries (Map-Ia). The river is known as Tsan-Po in Tibet and Siang where it flows through the gorges of the Himalayas. Of the total length of the river only a short distance does it flow through the North-East of the Indian territory. As Tsan-Po it travels for nearly 1600 km when it turns abruptly to the south all around the Namcha Barwa Peak in the central part of the Eastern Himalayas and this southward affluent is called as the Siang after the name of the district in Arunachal Pradesh. Thereafter, flowing through a tortuous course, it emerges on to the plains of Assam and is called the Brahmaputra and meets the largest tributary Dihong which in turn is fed by the Dihong, Sissiri, Lohit and Noa Dihing all from the east and south-east of Arunachal Pradesh around

Ia



Saikhowaghat. From here the Brahmaputra swells and first flows to southwest for some distance when it takes a nearly total right turn west flowing between the Himalayas of Arunachal Pradesh on the north banks and the Patkai, Naga Hills, Assam Ranges and Shillong Plateau on the South. The north bank is traversed with tributaries adding not only more water but increased velocity. These are Subhansiri, Ronga Nadi, Dikhron, and Gabbhara, from Arunachal Pradesh and Pagladiya, Manas, Aie, Beki, Champamati, Gangadhar and Raidek from the Bhutan Himalayas. The south Bank also like its north counterpart possesses tributaries of importance such as Beni Dihing, Disong, Dikhu and South Dhansiri from the Naga Patkai Hills, the Kopili of the North Cachar Hills while Kallong, Digari, Bharalu, Kulsi, Singra, Dudhnai and Krishnai from the Shillong Plateau. Both these north and south tributaries of the Brahmaputra possess a parallel drainage pattern before they enter the system even though, in their respective places of origin, they are dendritic.

In addition to the above the North-East Regions possess two main rivers far south of Brahmaputra, the Surma from North Cachar Hills and Barak from north Manipur. The latter flows west through Cachar where it first meets Kushiara and then unite with Surma to form the Meghna drainage in Bangladesh. This Meghna system is formed by rivers Tlwang (Dhaleswari), Tuirial (Sonai) and Tuivawl from Mizoram while the Lubha, Myntdu, Umngot, Umsohryngkew, Umngi, Kynchiang, Mahadeo, Simsang (Someswari) and the Dirong from the southern slopes of Shillong Plateau. In addition to these major drainages the State of

Tripura which also forms a substantial part of North-East India comes under the general drainage of the Meghna system. The rivers Kowai, Dolai, Manu, Juri and Lungai occupy the north, while Gempti flows in the west and Fenny and Mohari in the South-west. They have dendritic, parallel, sub-parallel and rectangular drainage patterns before they get interspersed into the Meghna system.

The third drainage system of importance after the Brahmaputra and the Meghna in North-East India is the Chindwin. It comprises of two main tributaries the Tizu and Imphal in Nagaland and Manipur respectively. The Tizu river originates in the Tuensang district of Nagaland traversing through the Phek district. Imphal on the other hand, emerges in the north-eastern parts of Manipur and flowing south enters Burma where it joins the Chindwin. Another river called Koladyne starts from Burma, flows all along the eastern side of Mizoram before entering into Burma again.

The North-East Regions of India in general show a parallel to sub-parallel drainage in Meghalaya, Arunachal Pradesh and Mizoram while Nagaland and Manipur possess dendritic and deranged pattern.

#### GEOLOGY :

Geologically India could broadly be categorised into Peninsular and Extra Peninsular areas. The extra Peninsular

area is formed as a result of the advancement of the Peninsular area, called the Gondwana block from the south due to the intense squeezing of the Tethyan geosyncline in the North between Laurasia. Mountain building movements produced therefrom facing, the convex side of the Himalayan area, resulted in the opposition with the Asiatic Continental masses. However, it is not continuous but is made up of three strips separated by transverse ridge-like structures at the west of Delhi and east of Cooch-Bihar (Krishnan, 1974).

The consequences, of the above series of orogenic movements separated by periods of relative quiescence, is supposed to have been initiated during the Upper Cretaceous continuing through the Middle Miocene and ending with Pliocene, Pliostocene and some Recent time. Of these the Middle Miocene represents the period of maximum orogeny. As a result the present geomorphological features identified based on the upliftment of Himalayas are the Burmese Arc, the Himalayan Arc, the Sub-Himalayan zone, the Central Himalayan zone, the Tethyan zone, the Assam Himalayas, the Shillong Plateau and the Mikir Hills. In the present investigation, only the Burmese Arc, the Assam Himalayas, and the Shillong Plateau with the Mikir Hills are of importance.

The Burmese Arc is the curve formation southwards of the Himalayas as the Burma-Arakan Ranges sweep through Arakan and the Andaman Islands to Sumatra and beyond. The Andaman and Nicobar Islands are the remnants of the unsubmerged peaks of this

arc, while most of it is either hidden under the Ganga-Brahmaputra delta or submerged in the Bay of Bengal. It is thought to be Post-Cretaceous, primarily due to its proximity to India. On the Assam side of this Burmese Arc, overthrusts, minor thrusts and reversed faults, as seen in the Naga and Haflong-Disong Hill regions are found (Powell, et al. 1981).

The Assam Himalayas rise very rapidly from the foot hills and execute a very sharp bend before they turn southwards forming the border ranges between Assam and Burma. The actual location is between the Namcha-Barwa Peak in the Mishmi Hills east of which the Tsan-Po (Brahmaputra) takes a sharp turn southwards, and the Tista river in the west.

An isolated Pre-Cambrian province or a Pre-Cambrian uplifted shield could be the appropriate geological terminology attributed to the Shillong Plateau and the Mikir Hills. The rocks comprise of amphibolites, mica-schists, sillimanite-schists, crystalline limestone and ferruginous rocks akin to those of Bihar, and hence probably of Middle and Upper Pre-Cambrian ages. It is believed that the Shillong Plateau got displaced eastwards from its original position in North Bihar mica belt during the Himalayan orogenic phases of the Miocene and Pliocene/pliestocene.

#### GEOLOGICAL EVOLUTION OF NORTH EAST INDIAN REGIONS :

A brief summary of the geological evolution of different provinces in the North East India is given below:

ASSAM-NAGALAND :

These areas represent a formation of geosynclinal belts during the Tertiary, and initiated during the Jurassic by Sylhet volcanism and Upper Cretaceous by the subsequent marine transgression. The Southern margins of the Shillong Plateau which links Assam are supposed to be Eocene Shelf sediments deposited during shallow marine and lagoon environment periods. These sediments were controlled by the general block movements along basement faults and the shelf to geosyncline passage marked by steepening of the basement slope through stepfaults development in the basin. The shallowing of the Naga-Patkai geosyncline marks the end of Eocene, indicated by arenaceous characters of the upper most Disangs conformably passing into overlying Barails (Oligocene). These latter were deposited in shallow, steady, and rhythmically subsiding Oligocene basin in which sedimentation took place pari passu with subsidence. The oscillatory movements of deposition all along the estuary of a gradually receding sea in Upper Assam led to the present core formation structures, and the end of Oligocene marked remarkably by the Barail Range emergence (present North Cachar Hills). The Lower Miocene movements subsequently were the results of reactivation of the basement trend beginning with the north south tilt along the eastwest Daukifault. With the Barail Range uplifted, upper Assam and Burma Valley separated were the two main foredeeps and the East Himalayan foredeep connected probably with that of Upper Assam. The subsidence of foredeep

basins and intramountain troughs simultaneous with the emergence of Naga-Patkai-Lushai and East Himalayan mountain chain by sharp increase in frontal and inner uplifts are characteristic movements of the Upper Miocene. These geosynclinal belts got converted into land masses during Mio-Pliocene time, except for the Shillong Plateau upliftment along the Dauki-fault which resulted in the continuous deposition of unconformable continental Dupi-Tila group rocks in localized basins. The end of Miocene is marked in Upper Assam where the Naga-Patkai Range started rising and criss-cross faults in the platform got reactivated giving rise to shallow lacustrine and fluvial basins though intermittently indicative of the Namsong (Mio-Pliocene) and Dihing (Pliocene) deposits.

MEGHALAYA : Meghalaya is supposedly the Archaen basement, a remnant of the north-eastern extension of Indian Peninsula. The central part covering the Eastern Khasi and Jaintia Hills developed a trough over which sediments of Shillong group rocks got laid in. This was followed in the Post Pre-Cambrian till Jurassic time when the landmass resulted in the formation of a flat levelled surface over the plateau as it exists to-day. The end of the Jurassic especially on the southern margin of the Khasi Hills experienced eruption of plateau basalts, the Sylhet Traps through east west fissures also called Raibha Fault along which the southern block subsided and the northern block upheaved. Those which remained landmasses till Mid-Eocene were the Eastern Jaintia and Garo Blocks to the east and west

respectively, experiencing progressive down sinking and subsequent deposition of coal bearing sandstone, followed thereafter by limestone beds comparable with the Upper Sylhet limestone of the Khasi Hills. This sedimentation continued interruptedly over the submerged south parts of the Garo Hills and the Southern and South-eastern fringes of Khasi and Jaintia Hills till the end of the Oligocene when to the south of the Jaintia Hills the great landmass formed was the Barail Range. It was at the end of the Miocene that the major upliftment of the plateau as a whole began resulting into the formation of land locked shallow water lacustrine basin along the southern fringes of Khasi and Garo Hills. It was here that the Pliocene (Dupi-Tila) sediments got deposited in these basins. The southern border of Khasi and Jaintia Hills and the southern and western border of Garo Hills possessing the Sub-Recent older alluvium deposits are the fluviatile deposits along the old river valley.

MIZORAM : This area lies within the part of Tripura-Mizoram Miogeosynclinal basin (southern extension of the Surma Valley) evolved after the Barail group of regional segment upliftment. This could be therefore related with the plate behaviour of the subduction zone west of Arakan Yoma after the spreading of Indian Ocean (Anon, 1974). From geological technique analysis it is apparent that the sediments deposition of this part took place subsequent to the uplift of the Barial geosyncline in a great tectonic trough of Miogeosynclinal character possessing a bell-shaped pattern. Again from the various geological

structural analysis the sediment transport in the present area might have taken place along the canyons and canyon extension valleys to the lower slopes or the continental rise where deposition took place from turbid currents. This can be seen by the thick bedded turbidite greywackes with typical features deposited in the channel areas as proximal deposits while the silt/shale interlaminations deposited in the interchannel distal areas. The spatial association therefore, is due to the shifting and migration of fan channel system both in the submarine fan and fan valleys. The presence of large scale planar and rough cross bedding along with coarse grain sandstone with less clay in the top of synclinal cores could probably be evidence of the existence of a shallow sea during the late Bokha Bil times.

ARUNACHAL PRADESH : The general Himalayas of Arunachal Pradesh as shown by bending/foliation and major tectonic lineaments seem to be regionally disposed in ENE-WSW to NE-SW of the Kameng-Subansiri, Siang Sector. The sediments belong to the Tertiaries, Gondwanas Bichom group and the metamorphites. The last are folded into synforms and antiforms exposing sediments underlying these metamorphites in the Subansiri Valley and Salari area in Digong Valley north of Bomdila. The Tertiaries occur in two NE-SW blocks, the south comprising the middle upper rock units upfaulted against the southern. The stratigraphic orders in the Gondwana and Bichom groups could be regarded as para-autochthonous zones with intricate internal structures. The sediments giving rise to parametamorphites or the Sela group (Higher Himalayas)

may probably be of Pre-Cambrian age but cannot be said with certainty. Like Himalayas of other parts of Arunachal Pradesh metamorphic belts display evidences of phases of deformation, metamorphism and granitic activities. In addition the volcanic activity represented by the Abor volcanics which was of platform type, is confined within the lower and middle parts of the Bichom groups, with the absence of the Tertiaries and the Gondwanas the only well-known and accepted phenomena is the orographic swerver from NE-SW in the Kameng-Subhansiri-Siang Himalayas to NW-SW in Lohit Himalayas. The former districts have been identified by some as Tipams and Dihings while others preferred the inclusion of these within Siwaliks. The Lohit Himalayas forming the eastern most part of the Eastern Himalayan chain is supposedly the extension of Burma axial. The regional trends are NW-SW unlike NE-SW of Siang district, the Siwalik and Gondwana rock a characteristic feature of Siang are absent on the frontal part of Lohit Himalayas and finally the extension zone of ultrabasic rocks for nearly 100 km between Tidding and Tulong valleys.

#### VEGETATION :

Vegetation, with all its ecological and geographical complexity is evident in these regions. The dominance of relatively young intrusive elements is a characteristic feature along with the ancient forms of comparatively less importance. The composition and distributional patterns reveal the profound influence of the dual role of the Himalayan uplift and human

interference (Mani, 1974c). A categorization of major floristic groups has been identified. They are 1) the exotic naturalised species 2) the humid tropical Asiatic or Indo-Chinese or Malayan species, 3) the temperate European species, 4) the steppes elements, 5) the Mediterranean elements 6) the tropical East African elements, 7) Peninsular and other Indian endemics, 8) Pleistocene relicts and 9) Miscellaneous types. This, therefore, reveals a conglomeration of associations of occurrences and co-occurrences interspersed throughout the sub-continent of India and also in isolated patches.

The North-Eastern Regions of India could probably be attributed with all these above types, with its abundance of forests, meadows, marshes and swamps with its characteristic plants. Phytogeographically the flora of these regions are identified as an admixture of Asiatic and Indian Peninsula flora. The present work does not demand the scrutiny of all the vegetation in the region and we therefore confine ourselves to the forests which play possibly a great role in the distribution of fauna especially in the lotic systems of the region. Three types of forests can be categorized based mainly on their trends in the altitude, 1) the tropical, 2) temperate and 3) subalpine and alpine.

#### Tropical forests :

These comprise of evergreen and semi-evergreen forests to moist and dry deciduous forests interspersed with grassland,

sub-tropical mixed forests and sub-tropical pine forests. These are met with in altitude ranges of 900 m and 1500 m. The evergreen and semievergreen forests are abundant in the Assam valley, lower elevations of Khasi Hills, Naga Hills and the districts of Kameng, Subhansiri, Siang, Lohit and Tirap in Arunachal Pradesh. The tropical moist and dry deciduous forests occupy the districts of Goalpara, Kamrup, Nowgong and Darrang of Assam and some parts of Meghalaya particularly the lower elevations on the southern and northern fringes of the plateau. The subtropical pine and mixed forests are confined to the Khasi and Jaintia Hills of Meghalaya and the Rupa Valley of Kameng district of Arunachal Pradesh and in Tuensang district of Nagaland.

#### Temperate forests :

These occupy altitudes of 1800 m to 2500 m and are interspersed along with the others and especially in the peaks of the hills chiefly in Shillong Plateau, Naga Hills, Mizo Hills, Mikir Hills and the Arunachal Himalayas.

#### Sub-alpine and alpine forests :

These occupy the highest elevations beginning 3000 m till 4500 m and possibly till the end of the **timber line**. Aka Hills of Kameng district, the Upper Duhi and Diphu valleys of Lohit districts are probably the representative areas of north-east in Arunachal Pradesh for these forest types.

Based on their taxonomic position and their affinities, many primitive plants have been identified as present in North-East India and Burma while absent in other parts of India with the possibility of placement of these ~~is~~ distinctive phyto-geographical units (Rao, 1974). However, large intrusive elements or its affinities with China, Burma, and Malaya among the North-East Indian flora is a feature to be reckoned with.

#### Fauna :

Like the flora the distributional patterns, composition and evolutionary trends of Indian fauna represent a profound influence of the flux of either Extra Peninsular fauna or those passing these areas mainly from the north-east along with Pleistocene glaciations and the pressure of human expansion and civilization. The present day faunal structures could be grouped into two major groups : 1) the derivation of the older fauna differentiated in a southern landmass, called the Gondwana fauna and 2) the derivatives of the younger fauna differentiated in Asia, mainly the Tertiary mountain fauna. The peninsula has received equal proportions of fauna from the north-east (the humid Asiatic mountains), the north (the Himalayan) and northwest (Mediterranean and Ethiopian) all equally strong. The distributional pattern possesses a high degree of localized concentration with wide isolation and therefore discontinuity with an almost total absence of altitudinal zonation. There seems the limitation of progression eastwards and the northwards. The validity of a total obliteration of

geographical radiation remains questionable here.

This becomes evident more so when the faunal character of North-East seems to be distinctive, rich and diversified. The North East fauna are possibly the component elements, viz. 1) Asiatic derivatives, 2) Indo-Chinese-Malayan, 3) Peninsular isolates and 4) Australian and Gondwana outliers. Of these, the Asiatic derivatives seem to play a major role by 1) local endemics, as in Burma and north-east Burma 2) Indo-Chinese and South-Chinese elements 3) Malayan elements 4) Manchurian and Siberian outliers. As a whole the Indo-Chinese and Malayan elements seem to be dominant though for some groups the Malayan affinities seem stronger and in other groups equal. A detailed analysis of the present day fauna, their structural affinities based on their possible routes of migration and establishment is extensively documented by Mani (1974 d).

MATERIALS AND METHODS :

The aquatic systems chosen for the collection of fish were most representative of the general study area which were classed into various study sites. These study sites included the the areas demarcated by political boundaries, for help in the identification and cataloging of fish species in these regions. Five study sites were identified comprising of three states and two union territories. They were Arunachal Pradesh, Assam, Meghalaya, Mizoram and Nagaland. Since the headquarters was situated in Shillong, Meghalaya, collections to be made in these different study sites were so done that most of these areas were covered, though extreme communication problems exist. Therefore collections in Arunachal Pradesh, Mizoram and Nagaland were confined to about three or four times in a year for nearly two years and as far as possible during the different seasons, keeping in mind particularly the monsoon. At these sites, fishes were caught using cast nets of mesh size 2.25 cm x 1.0 cm and with a length of 2 m., enclosing a total catching area of 3.14 sq. m., gill-nets with a mesh size of 1.25 cm x 1.5 cm, with a length of 25 m. and a height of 2 m. In addition, iron mesh sieves with a mesh size of 0.25 cm and with a length, height and width of 80, 25 and 60 cm. respectively, and finally with the help of dragnet sieves, 4.5 m. long and 1.75 m. broad, having a mesh size of 0.64 sq. cm. were used.

This was done also for the two states of Assam and Meghalaya. In addition two hill streams in East Khasi Hills and

two rivers in East Garo Hills both from Meghalaya and one river in Kamrup in Assam were selected for a detailed seasonal study of the fish population dynamics. The nets used for the seasonal analysis were the same as described above. At each of these lotic systems, monthly collections were made at four different stations selected on the basis of the gradient. Hence, station-I, was as far as possible near the source of either the stream or river, while station-IV near its mouth where it either joins another major river or combines with lotic systems of similar nature to become a larger system. Stations-II and III lay midway and represented places where there was a change in the gradient level, substrate, current or depth.

In the East Khasi Hills the two streams chosen were called as Umkhrah and Sumer. In the former, monthly collections were made from August, 1977 to July, 1979 at different stations and in the latter from September, 1977 to August, 1979. In the East Garo Hills, the two rivers chosen, were the Simsang (Someswari) and Damrong (Krishnai). Here also four stations were chosen, but due to the large distance between Shillong and these rivers, collections were confined to only once in two months. At both these rivers the period covered was between the months of August, 1978 and February, 1980.

In addition to the two streams and two rivers in Meghalaya, one river chosen in Assam for such seasonal studies was called the Pagladiya river. As in the earlier lotic systems collections were made at four different stations once in two

months from May, 1978 to November, 1979. All the fish samples collected were preserved in 10% formalin and deposited at the Department of Zoology, N.E.H.U., Shillong.

The catches represented nearly 80% and above. This was done by placing the seines at the lower end of the sampling area always up stream and at least two seine sweeps were made downstream. This was used for the riffles and pools. For complex habitats, stations were broken into smaller units and seiving was done until the capture rate declined to nil. This required nearly 5 to 12 hauls in these units (Fig. 1a). From the collections a cataloging was done in the form of a checklist and the distribution maps drawn. Subsequently, a number of statistical analyses were incorporated to highlight the ecological aspects of their distribution, occurrence, co-occurrence and other related phenomena.

1) The species diversity was calculated after Shannon-Weiner Index proposed by Shannon and Weaver (1949) using the formula.

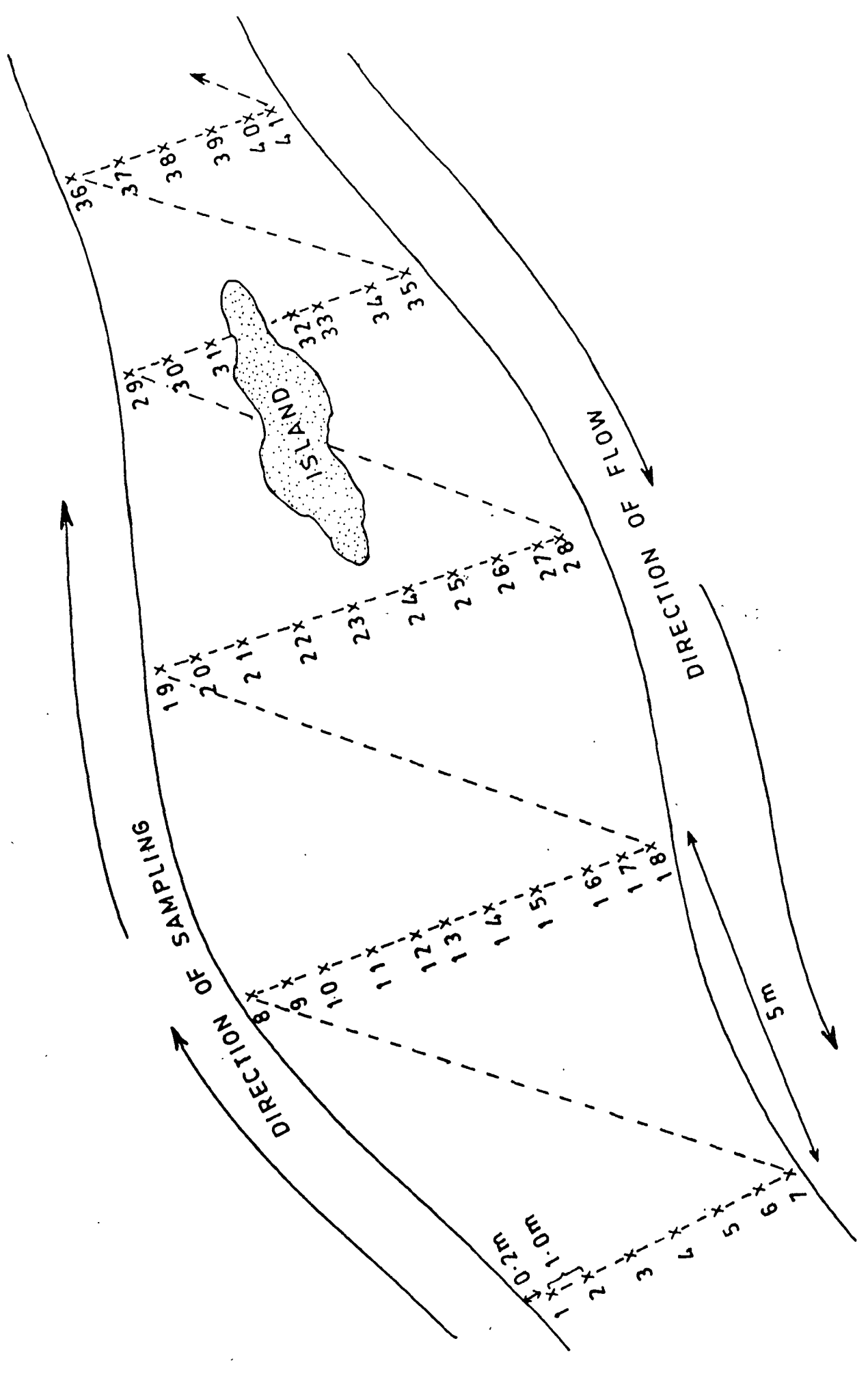
$$H' = - \sum_{i=1}^S p_i \log p_i$$

where  $H'$  = measure of diversity

$s$  is the number of species and

$p_i$  is the proportion of the total number of individuals consisting of the  $i$ th species.

Fig. 1a : Method of fish sampling from various lotic systems in the present investigation.



2) The species richness index was after Margalef (1968) using the formula.

$$D' = (S-1)/\log_e N$$

where  $D'$  = species richness index

$S$  is the number of species and

$N$  is the number of individuals.

3) The  $H'$  max.

4)  $J$  values of evenness by  $H'/H'$  max.

5) The redundancy values  $R = 1-J$ . These were done for the seasonal analysis studies for different systems as well as for the total collection in the different study sites.

6) In addition, the dominant and a representative of each genera for the whole area was analysed for their poisson distribution and Morisita's Index to show their randomness, non-randomness and aggregate behaviour.

The different species of fish were also tabulated for their presence and absence in the major systems and a faunal similarity index was worked out based on the formula discussed by Long (1963).

$$7) \text{ Average Faunal Resemblance} = \frac{C(N_1 + N_2)}{2N_1N_2} \cdot 100$$

where  $C$  is the number of species common to drainage 1 and 2 and  $N_1$  and  $N_2$  are the total number of species in drainage 1 and 2 respectively.

8) The coefficients of similarity of Sørensen (1948) (Q/S) using the formula was also carried out.

$$Q/S = \frac{2J}{(a+b)} \times 100$$

where J is the number of species common to both samples.  
a = the number of species recorded from sample A and  
b = the number of species recorded from sample B. The Q/S values were worked out for the five systems which were done seasonally not only between the stations of the individual system but also between the systems.

Simultaneously along with the collection of fish species the structures of the environment were also analysed. The lotic habitat was measured using the three criteria of depth, substrate and current. For convenience and a total representation, seven depths, eight substrates and six current categories were identified in the systems where captures were made. 5 to 20 cm. deep corresponded to the shallow margins of the stream/river (riffles); 20 to 50 cm., to shallow pools; 50 to 70 cm., to moderate pools; 75 to 100 cm., to deep pools; 100-150 cm., to deeper pools and finally 150-200 cm., to the deepest areas.

The substrates or bottom types were categorized based on their physical and biotic structures. 1-6 categories corresponded to the material of substrates increasing in size from silt to large boulders. The seventh category incorporated the litter

and vegetation along with twigs, leaves and branches. The last category under this was miscellaneous in that it included structures such as large tree trunks or bed rock slabs, tins, glass and cloth pieces and large sheets of rocks.

The current was estimated by the movement of water about a measuring pole and assigned to six categories related to the respective corresponding velocities calibrated with a float and stop watch (Table 1).

The habitat structures were analysed by the incorporation of point samples with regularity at each study site and station of the system. 10 to 20 cm. beginning from left bank, points were taken at 5 metres across river and 1 meter across for stream. Very narrow streams which had only 1 m. as their maximum width, 0.33 m. intervals were used. Such points were repeated as sets moving up stream. The initial sampling necessitated 60 to 100 points for an adequate measurement of the habitat.

The data for habitat was also analysed for the usual diversity indices as for the fish populations. The indices so obtained were utilized for the coefficient correlation analysis between habitat diversity and species diversity. The major habitats were used at the family levels of the fish population for an Average Gradient Index and worked out for each drainage. The ranks and categories were 1 to 6. They were lowland, lowland-upland, lowland-upland- Montane, upland, upland-Montane and finally montane. This provided the gradient estimate

Table 1 : Description of categories used in measuring stream/river habitat.

TABLE-1

Dimension		Category number and description						
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
Depth	Range (cm)	0-5	5-20	20-40	40-60	60-80	80-100	>100
	Description	Very Shallow	Shallow	Moderately shallow	Moderate	Moderately deep	Deep	Very deep
Current	Flow velocity (m/s)	0-0.05	0.05 - 0.2	0.2 - 0.4	0.4 - 0.7	0.7 - 1.0	>1.0	
	Description.	Very slow	slow	Moderate	Fast	Very Fast	Torrent	
* Substrate	Diameter (mm)	<0.05	0.05 - 2	2-10	10-20	20-40	> 40	
	Description	Silt	Sand	Gravel	Pebble	Stone	Boulder	

\* Additional substrate categories include (7) Litter/vegetation (Biotic) and (8) Miscellaneous (Abiotic) Tins, Cloth pieces, Glass pieces, Logs, Wood pieces and large sheets of rock.

occupied by the members in a family. The method<sup>4</sup> incorporated for the present study was seen to be as far as possible a help in the total understanding of the species, their populations in a community structure based on their functional behaviour due to their ecological niches occupied.

HISTORICAL SKETCH AND PRESENT STATUS OF  
ICHTHYOGRAPHY

Fishes in general and freshwater fishes in particular, possess the advantage of being steady animals in reference to particularly their zoogeographical aspects, except for some few species which are eurycious. The freshwater fishes are necessarily confined to the inland lotic and lentic systems of the continents of the world. Fish distribution and their zoogeographical significance has therefore been studied by several workers primarily with an aim of constructing checklists for different places enabling Palaeodistributional pattern in larger regions and continents and to possibly predict and identify the evolutionary and radiation centres.

The criteria of zoogeographical divisions as a cause related to the effect of distribution of fish have since long been studied (Gunther, 1880; Berg, 1912, 1932, 1948-1949; Banarescu, 1960). Similarly, such general studies but with Palaeogeography as the criteria were carried out for different groups of fish in various climatic zones of the world (Myers, 1949; Schaeffer, 1956, 1969, Romer, 1966; Nelson, 1969 a, b, c; Patterson, 1975; Wiley, 1976). Simultaneously, works were carried out on specialised groups of fishes like Ostariophysi and its distributional pattern (Regan, 1922), Zoogeography of freshwater fishes (Darlington, 1948, 1957), fish classification based on their zoogeographical importance from fish faunal studies (Beaufort, 1951), Teleost taxonomy and zoogeographical studies (Banarescu, 1964, 1968b, 1975) and a further extension on Ostariophysan classification and distribution (Greenwood et al, 1966). Mc Allister, (1968) and Mc Dowall (1973b) extended

the idea of distribution of fishes and their zoogeographical importance based on taxonomical works. It was Cracraft (1974) and Croizat et al (1974) who could be attributed the earliest in fish historical biogeography who gave evidences based on continental drift, thereby identifying centres of origin and distributional patterns of biota. Simultaneously, the effect of zoogeographical barriers in the distribution and dispersal of fish was shown by Briggs (1974b). Immediately, thereafter, for a couple of years and a little more, fish distributional aspects in relation to zoogeography was carried out in individual groups like the phylogeny and zoogeography of Salmoniform fishes (Rosen, 1974), modern Siluroids and their zoogeographical distributional patterns (Goseline, 1975), early biogeographic history of Ostariophysan fishes (Novacek & Marshall, 1976) and fish fauna in old lakes with their zoogeographical significance (Banarescu, 1977).

Though such general studies or individual groups of important fishes were carried out and dealt with on general zoogeographical aspects, two works of such a total zoogeographical nature are those of Mc Dowall (1978) who laid down the generalized tracks of dispersal and other criteria in fish distribution, and Briggs (1979) who gave the idea of radiation and evolution along with the zoogeographical significance by an indepth study of one particular group namely the Ostariophysan fishes. All the works mentioned above to a very large extent cover the entire globe as it were, but the subject of

fish zoogeography have primarily been established on regional orientation and thereafter in a general understanding of larger areas. Such works necessitates taking up a review, on the major fish zoogeographical divisions of the earth.

The Neotropical fish fauna was studied as early as 1909 and 1928 by Eigenmann who revealed the similarities between the South American and African fish fauna. He also worked on the freshwater fishes of Chile and showed their distributional patterns. Thereafter Jordan et al (1930) worked on the fish fauna of Central America, while Schultz (1944) on Venezuelan cat fishes, Schaeffer (1947, 1952) on the Cretaceous and Tertiary fish of Brazil, identified enough evidences along with the present freshwater fishes for a possibility of land connection across the South Atlantic. Goseline (1944, 1972) followed the work of Eigenmann to further the knowledge of similarities between South American and African fishes. Hubbs (1953) worked on the Panama and Equador fish systematics and distribution while a similar work on South American freshwater fish fauna was done by Gery (1969). Roberts (1972) did a comparative study of the Congo and Amazon basin fishes while Geisler et al (1975) and Fink & Fock (1979) did an extensive and intensive survey respectively on the ecology and systematics of the Amazon fish fauna.

Faunal works on fish have been extensively done in the Holarctic Region beginning with the works of Heckel (1843, 1845) on fish systematics of Europe, Asia and Africa. Girard (1859)

studying the fish fauna of Mexican and the United States' boundary, identified the faunal limits between the two countries. Freshwater fishes of U.S.A. (Jordan, 1928), fish fauna of U.S.S.R. and adjacent countries (Svetovidov, 1945, 1952; Berg, 1948-1949), distributional pattern on Turcmenian loaches (Nikolsky, 1947), fish distribution based on hydrographic history of Western United States (Hubbs & Miller, 1948), zoogeographical positioning of fish fauna of Near-East and Perimediterranean regions (Kosswig, 1955, 1973), Texas fish distributional patterns (Hubbs, 1957), Romanian fish studies (Banarescu, 1957), origin and affinities of Western North American fishes (Miller, 1959), systematics and zoogeography of Poiciliid fishes (Rosen & Baily, 1963) were regional studies or on special fish groups. Miller (1965) worked on Quaternary fishes of North America, Miller (1966) and Myers (1966) on the geographical distribution of Central American fishes while Willock (1969) did similar works on the Missouri fishes in Canada. The Pliocene and Recent fishes of the Holarctic along with their distributional pattern was done by Ross (1970). Thereafter, highly regional studies were carried out, like the systematics and distribution of Carassius from Danube (Hensel, 1971), the distribution history of South Appalachian fishes (Jenkins et al. 1972), fish fauna of Oligotrophic glacial lakes in Europe (Toivonen, 1972), geographical variations in cobitid fishes from Europe (Banarescu, et al. 1972) and zoogeography of Euromediterranean fish fauna (Banarescu, 1973). The late seventies were works of similar nature though with greater

clarity like the zoogeography of Maryland fishes (Lee, 1976), ichthyofauna of Central Kazagistan rivers (Dukravets & Biryukov, 1976), freshwater fishes of Netherlands (Nijssen & de Groot, 1976), Percid systematics and zoogeography (Collette & Banarescu, 1977), and the classical works on percid fishes in relation to Palaeographical and ecological succession of reproductive guilds (Balon, et al 1977). One of the latest works from these regions is that of Lee et al. (1980) on North American freshwater fishes and their distribution.

The Ethiopian and Madagascan Regions fish faunal works could be traced to Steindachner (1870) and Gunther (1880) on the fish fauna of Senegal and affinities of African freshwater fishes with Oriental Regions including India, respectively as the earliest studies. Since then distribution, systematics and affinities of African freshwater fishes (Boulenger, 1905, 1909-1916), the relationships of Nile fish fauna with African fishes (Nichols, 1928b) and Gongo fish faunal systematics and their distribution (David & Poll, 1937), were carried out. Limnological studies of African Lakes in relation to fish fauna was done by Worthington (1937), and continued by Trewavas (1949) who worked on African Cichlid fishes, their origin and evolution. The extensive Palaeontological studies of African fishes was initiated ten years later and continued till the mid seventies (Greenwood, 1959, 1972a, b, 1974; Greenwood and Patterson, 1967). During the same time works were carried out on Madagascan fish fauna (Arnoult, 1959, 1963) on Gambian and Volta fish fauna (Daget, 1960, a, b) on the relationships between drainage

basins and freshwater fishes of South Africa and their distribution (Jubb, 1964, 1967), on the Central African and Zambesi fish faunal systematics and distribution (Bell-Cross, 1965, 1972), on the systematics of African Bagrid fishes (Jayaram, 1966b), on the Kafue and Middle Zambesi river fish fauna and their barriers (Bell-Cross, 1967), on the relationships of African Percid and Badid fishes (Barlow, et al, 1968) and on the composition and ecological aspects of Crater Lakes' fish (Trewavas et al, 1972). A total analysis of the geographical distribution of African freshwater fishes was carried out by Poll (1973) and Roberts (1975). Balon (1975) around the same time did an indepth study on Lake Kariba eels and identified the distributional aspects. Later holistic studies were those of Bowmaker et al, (1978) who did an extensive work on the biogeography and ecology of South African freshwater fishes. The distribution of fish fauna and the possible nature of separation due to the barrier of Kapaclaira Falls between Malawi Lake and Zambesi river was shown by Tweddle et al, (1979).

The earliest works on the Australian and New Zealand Regions could be traced to Gray (1842) who did a systematic study of New Zealand freshwater fish fauna, followed by Ramsay & Ogilby (1887) on similar studies from New Guinea. It was Weber & Beaufort (1911-1962) who probably initiated in addition to systematics, the distribution and zoogeography of the Indo-Australian Archipelago fishes followed by Phillipps (1926a, b), on the origin and distribution of New Zealand fishes. Hills

(1934), pointed out the importance of Tertiary fishes from Southern Queensland in his Australian fish faunal studies while Iredale & Whitley (1938) partitioned Australia into fish faunal regions. Thereafter regional works of specialized fish faunal groups and their studies were undertaken either in terms of their systematics or on aspects of zoogeography and distribution both in the larger areas of New Zealand and Australia (Stokell, 1950, 1955, 1972; Allen, 1956; Whitley, 1959; Munro, 1964, 1967; Mc Dowall, 1964, 1966, 1973a; Burnet et al. 1969). With this in background the present status and knowledge of New Zealand fish fauna was worked out by Hopkins & Mc Dowall (1970) and on the systematics and distribution of fishes in Australian rivers by Lake (1971, 1975). Once again works on fish faunal studies were done in smaller areas to make an indepth study of the present day fishes and with the help of their affinities and distribution to trace the origin and evolution for that region or for a specialized group of fish (Frankenberg, 1974; Mc Dowall & Whitaker, 1975; Berra et al. 1975; Roberts, 1978).

For the present work it was ideal to trace the literature for the Sino-Indian (Oriental) Region to a large extent and in part to the South-West Pacific Region also. Since the present work is a region within the sub-continent of India, therefore necessitates to identify works first to the Oriental Region excluding India and to deal the latter in greater detail. When so done, general Oriental works, confined to specialized groups of fishes without regional basis have been done by Regan

(1910) on the Anabantid fishes of Asia, Sufi (1956) on the systematics and distribution of Mastacembeloid fishes of Oriental Region, Silas (1958a) on the systematics of the Oriental genus Chela, Banarescu (1971) on the systematics and distribution of another Oriental genus Nematobramis and Dekkers (1975) who reviewed the distribution of Tetraodon, the Asiatic genus.

In addition to the above, extensive works on systematics, distribution, ecology and ichthyography have been carried out on general Oriental fishes (Bleeker, 1849a, b, 1852, 1853, 1865 and 1873), Malayan fishes (Cantor, 1849), fish fauna of Sitang river (Blyth, 1860), fishes from China, Yantzekiang and Afghanistan (Gunther, 1873, 1888, 1889), Afghanistan, Burma and Ceylon fishes (Day, 1880, 1889), Siam freshwater fishes (Sauvage, 1883), Cochin-Chinese and Cambodian fishes (Tirant, 1885), Burmese and Palestine fishes (Vinciguerra, 1890, 1926), Borneo fishes (Vaillant, 1893, 1902), fishes of Southern Shan states and Borneo (Boulenger, 1893, 1894), Celebes and Borneo fishes and an attempt into insular zoogeography of South East Asian islands (Weber, 1894, 1895, 1911). The twentieth century in this region began not only with works on systematics but greater stress was laid on the distributional aspects, their origin, and affinities based on studies for some particular region, or for specialized groups of economically important fishes, their genera, and species (Volz, 1903, 1904, 1906; Popta, 1905, 1906; Regan, 1905a, b; Lloyd, 1908; Chaudhuri, 1908, 1911,

1919; Zugmayer, 1912; Beaufort, 1913, 1926, 1964; Hora, 1923a, b, 1924b, 1933a, b, 1935b, 1937b; Annandale & Hora, 1920, Hora & Mukerji, 1934a, b; Nichols, 1926, 1928a, 1943; Holly, 1929a, b; Werner, 1929; Prashad & Mukerji, 1930; Wu, 1930a, b; Deraniyagala, 1930, 1933; Chevey, 1932, 1936; Mukerji, 1932, 1933; Miao, 1934; Tchang & Shih, 1934; Suvatti, 1936; Herre & Myers, 1937; Mori, 1938; Chevey & Le Poulain, 1940; Pelligrin & Fang, 1940; Pelligrin & Chevey, 1940; Smith, 1945). These were followed with similar studies but with larger regions under consideration and the areas covered were in terms of both political boundaries and zoogeographical regions also. Regions covered were generally the Malayan Archipelago including Singapore, Thailand, Bangladesh and the East Asian regions upto Japan and Korea, Pakistan, Afghanistan, Sri Lanka, Iran, Iraq (Haig, 1950; Tweedie, 1952; Mori, 1952; Hora, 1952b, d, e; Hora & Jayaram, 1952; Deraniyagala, 1952; Ahmad, 1953; Inger, 1955; Munro, 1955; Silas, 1955; Fowler & Steinitz, 1956; Boeseman, 1957; Sufi, 1957, 1958, 1963; Alfred, 1961, 1966; Inger & Chin, 1959, 1961, 1962; Johnson, 1960, 1967; Okada, 1960; Khalaf, 1962; Lindsey, 1963; Ahmed & Mirza, 1963a, b; Qureshi, 1965; Banarescu & Mirza, 1965, 1972; Mirza, 1965, 1966, 1968, 1969, 1970a, b, c, 1971a, b, 1972, 1973, 1974, 1975, 1977; Mirza & Naik, 1965a, b, 1966, 1967, 1969; Jayaram, 1968; Mirza et al, 1969, 1970; Fernando & Indrasena, 1969; Mankoprasit, 1969; Balon & Hensel, 1970; Shiraishni, 1970; Monkolprasit et al, 1971; Roberts, 1971; Taki, 1972, 1974; Gosse, 1972; Banarescu, 1972; Doha, 1973; Rahman, 1973, 1974, 1975; Banarescu & Nalbant, 1974;

Kim, 1974). The late seventies were indepth studies on the systematics, distribution and affinities of Arabian Peninsular fishes (Banister & Clark, 1975), studies on the Chinese cat fish Macrones sinenses (Jayaram & Boeseman, 1976) and systematics and distribution of Pakistan fishes (Mirza & Hameed, 1975; Omar & Mirza, 1975; Sheri & Seied, 1975; Ahmad et al, 1976; Mirza & Awan, 1977; Mirza & Nijssen, 1978). Regions still not touched and certain important groups of fishes were taken up thereafter like the Southern Iraq fishes (Al-Daham et al, 1977), Sisord fishes of Nepal (Yonzon, 1977), Puntius species from Ceylon (De Silva & Kartmoulder, 1977), cobited loaches of a new sub family Vallaintellinae from South East Asia (Nalbant & Banarescu, 1977), Iran fishes (Coad, 1980a), their distribution and the factors governing it (Coad, 1980b).

With the general Oriental Region considered it was felt to treat the sub-continent of India and North-East India in particular for literature related to the present work. It was better to identify and separate general taxonomic and systematic works for both these regions before going into the works of zoogeography or its affinities in relation to fish fauna either for India as whole or North-East India in particular. With the exception of a few overlaps it was seen that most of the Indian works have begun primarily with systematics, identification of faunal lists, preparation of check lists of fishes in a particular region without any distributional aspects mentioned other than the place of collection and locality where collections were made. Some of the important papers of such systematic nature

though purely descriptive was necessary to understand the totality of the presence and absence of fish species in these regions (Hamilton, 1822; Sykes, 1838; Mc Clelland, 1838, 1839, 1842; Valenciennes, 1842; Gunther, 1860, 1864, 1868; Bleeker, 1862; Day, 1865a, b, 1867a, b, 1878b, 1889; Steindachner, 1867; Jenkins, 1909; Chaudhuri, 1912, 1913, 1915; Raj, 1916; Annandale, 1919a, b; Prashad, 1919; Hora, 1920, 1922b, 1925b, c, 1930, 1932, 1936a, b, c, d, 1937f, g, j, 1941a, b, c, 1942, 1953b; Rao, 1920; Pillay, 1929; Hora & Chabanaud, 1930; John, 1936; D'Abrue, 1936; Hora & Misra, 1937, 1938, 1942; Das, 1939; Bhimachar & Rao, 1941; Hora & Law, 1942; Hora & Nair, 1942; Bhimachar, 1942; Frager, 1942a, b; Suter, 1944; Chauhan, 1947; Hora & Menon, 1949; Menon, 1949, 1950a, b, c, 1951c, 1962, 1964, 1967, 1971, 1974; Pillay, 1951; Mazumdar, 1951; Silas, 1951a, b, 1954, 1958a, b, 1960; David, 1952, 1953; Kulkarni, 1952; Mathur, 1952, Jayaram, 1952, 1953, 1955b, c, 1959, 1962, 1966a, 1971b, 1972, 1973, 1974a, 1977a, b, c; Chauhan & Ramakrishna, 1954; Chacko et al, 1954; Britton, 1954; Menon, 1954; Rajan, 1955; Kalawar & Kelkar, 1956; Motwani & David, 1957; Dubey & Mehra, 1959; De Witt, 1960; Das, 1960, 1965, 1966a, b, 1971; Misra, 1962, 1976; Tonapi & Mulherkar, 1963; Singh, 1964; Dutta & Mazumdar, 1964; Das & Nath, 1965; Parameswaran et al, 1967; Srivatsava, 1968; Saxena, 1968; Mathur & Yazdani, 1969, 1970; Thind & Tandon, 1969; Tilak, 1969, 1974, 1976a; Yazdani & Bhargava, 1969; Yazdani, 1971; Sehgal et al, 1971; Dutt & Murthy, 1971, 1976; Tilak & Tiwari, 1971, 1976; Tandon & Johal, 1972;

Rao, 1974; Tilak & Hussain, 1974, 1977a, b; Motwani & Saigal, 1974; Husain, 1975; Jayaram et al, 1976; Yazdani & Rao, 1976; Srivastava et al, 1976; Yazdani & Mahabal, 1976; Tilak & Talwar, 1976; Jayaram & Mazumdar, 1976; Sen, 1976; Rao & Yazdani, 1977; Murthy, 1977; Jayaram & Dhanze, 1978; Bhatnagar & Sugunan, 1978; Kamal & Ahsan, 1978; Chhapgar & Sane, 1979; Khan & Kamal, 1979; Gupta et al, 1980; Nath, 1981).

The earliest of such studies for North-East India could be traced to Mc Clelland (1842) who worked on the fish fauna from Assam and Khasi Hills followed by De (1910) who recorded 154 species of fish from the then Eastern Bengal and Assam. Chaudhury (1912, 1913) recorded new species from hill streams of northern Manipur and adjoining hills. An intensive study was initiated by Hora (1921a, b) when he listed fishes from Manipur and Naga Hills, 38 species of fishes from Darjeeling and N.E. Burma, the peculiarities of torrential fishes from Khasi Hills, description of 8 fish species from Siju caves Garo Hills (Hora, 1924a), a new species in 1925 again from Garo Hills (Hora, 1925a). Mukerji (1934) recorded 26 species of fish from Naga Hills and Burma while Hora (1935a) described 9 species from Darjeeling and Upper Burma with particular reference to Neomacheilus. During the same year Hora & Mukerji (1935) recorded 44 species from Naga Hills and in the subsequent year, Hora (1936e) revealed that the total fish species of Naga Hills was 49. The North Bengal region was covered by Shaw & Shabbeare (1938) recording as many as 431

species while Hora et al. (1939) showed the variation of morphometric characters of B. ticto from North-East and Peninsular India. Hora & Gupta (1941) supplementing the work of Shaw & Shebbeare described fishes from Siliguri and Kalimpong. Menon (1952) and Menon (1954a) did an extensive survey of Manipur fishes while Sehgal (1956, 1959) listed fishes of Assam, Khasi and Jaintia Hills. A record of 121 fish species from Brahmaputra river was shown by Motwani et al. (1962). Higher in the altitudes in the Kameng district of Arunachal Pradesh, Jayaram (1963) and Jayaram & Mazumdar (1964) recorded 19 fish species. The systematic position of the genus Salmostoma was worked out by Banarescu (1968a) on species from North East India, Burma and Peninsular India. Banarescu & Nalbant (1968) described 8 cobitid species from various districts in Assam while Malhotra & Suri (1969) recorded 14 fish species from the Mokokchung district of Nagaland. Jayaram (1971a) recorded Pimelodus chandramara (Hamilton) nearly 150 years after Hamilton from North Bengal region. Yazdani & Chanda (1971), Yazdani (1972) and Pillai & Yazdani (1974) worked on Channid fishes, Mastacembeloid and cobitid species respectively from Assam and Meghalaya. Dey (1975, 1976) recorded 51 species of fish from the Pagladiya river in Assam while Yazdani & Talukdar (1975) recorded a new species of Puntius from Khasi & Jaintia Hills. Dutta and Sen (1976) worked on the fishes belonging to the genus Labeo from Assam. Yazdani (1977) created a new family Pillaiidae while Talwar et al. (1977) recorded a second new species of the same family from Assam and Meghalaya. Jayaram & Singh (1977) working on the collections of fishes from North Bengal reported 96 species while Dutta (1977) reported the

existence of 48 species from Tripura.

All these above have been either the records of species, occurrence of new species or a checklist. The idea of a zoogeographical study with possibilities of affinities from different parts of the world could be traced to Day (1876, 1879, 1885) who showed the presence of Malayan affinities in Indian fish fauna. Gunther (1880) and Annandale (1914) revealed the presence of African elements in the freshwater fishes of India with the latter giving evidences of Africa being the centre of origin for Indian freshwater fishes. The distinctiveness in fish fauna on the northern and southern ranges of the Himalayas indicative of a barrier and therefore revealing distributional effects was done by Day (1878a), Stewart (1909) and Hora (1937g, h). Hora (1937a, i), on a detailed study on the Cyprinid genera showed the possible origin and distribution due to possible land connections between India and adjoining countries on character variation in the fish species. The distribution of fishes due to drainage patterns in peninsular India was first revealed by Hora (1938c, d). Further, (Hora 1938e, f, 1940, 1949b, c; Das, 1939; Hora & Nair, 1942) showed the importance of Satpura Ranges enabling Malayan fishes to be in Peninsular India. A similarity between fish species in the Western Ghats of Peninsular India with those of Sumatra and Borneo was shown by Hora (1942). The Malayan elements in the fishes of India and the possible migration of Malayan forms through waves at different periods was substantiated by many works of Hora (1944, 1947, 1948, 1949a,

1950, 1953a, c, 1955a) and Bhimachar (1945). The migration of hill stream fishes to Peninsular India was shown by Hora (1949d, e) as due to glaciations and climatic factors playing a great role in their discontinuity. The Malayan and Indian fish faunal similarities were substantiated to a large extent with the works of Menon (1951a, b, 1955a, b, 1973, 1980), Silas (1952) and Hora (1951a). Hora (1951b) also revealed four Indian fish faunal divisions, confirming these on the distributional peculiarities, (Hora, 1952a) and palaeogeographic patterns (Hora, 1952c). Based on extinct Dipnoi, Ganoid and teleostean fishes, the plaeodistribution of these fishes was shown to have a bearing on the origin of fish fauna of India (Hora & Menon, 1952, 1953). Menon (1954b) described peculiarities in the distribution of the Himalayan fishes, while Hora (1955c) stressed on the importance of tectonics in the distribution of fish. Jayaram (1955a) observed Palaeartic elements in Indian fishes, while Silas (1955) traced the origin of Ceylon fishes to Peninsular India. The evolution of torrential fish fauna progressing with the evolution of the habitat was observed by Hora (1955b). Studies thereafter were confined to zoogeographical affinities of a particular region or that of an individual fish group (Kaushiva, 1951; Mazumdar, 1952; Menon, 1961, 1963; Das & Subla, 1963; Menon & Sen, 1965; Tilak, 1976b; Ravishchandra, 1976; Govind & Raj Gopal, 1977). A final compilation of the Indian fish fauna from both its ecology and biogeographical aspects dealing with the possible routes of migration, centres of origin, evolution and radiation has been extensively reviewed by Jayaram (1974b, 1977d, e).

Though the above deals primarily with the zoogeographical affinities of the Peninsular Indian fishes and to some extent to those of the North East, yet the earliest consideration of North-East India as an important region goes to Hora & Mukerji (1935) and Menon (1954a) who recorded the importance of Chindwin drainage in North-East India. Later, Motwani et al. (1962), observed the commonness of fish species more on the eastern side of the Brahmaputra river than on the west. Mani (1974e) pointed out the importance of North-East as a transitional zone and a gateway along with Jayaram (1974b) who indicated the North-East as an area of rich speciation. However, very little work exist on the status of North-East fish fauna in relation to zoogeographical areas. The works of Pardhasaradhi & Alfred (1979, 1980a) could probably be attributed as the pioneers on these lines, who have pointed out the importance of distributional peculiarities both at specific and generic levels and with the phenomenon of isolation. The latter was extended in some species to show geographical relictness in some areas of the North-East (Pardhasaradhi & Alfred, 1981).

These studies have been confined to ecological or descriptive zoogeography based on the present records or collections of fish species in these areas. In contrast historical zoogeography or palaeogeographical studies have been in sporadic areas with records of fossil fishes in different geological periods. Other than the records of such studies no

one has traced the present day fish fauna to these studies in detail. Works exist on fossils from North Kashmir to North-East India and to the South upto Godavari basin in Peninsular India (Oldham, 1859; Miall, 1878; Lydekker, 1886; Woodward, 1890, 1909; Annandale & Hora, 1925; Hora, 1937c, d, e, 1938a, g, 1939; Menon & Prasad, 1958; Prasad & Rao, 1958; Menon, 1959; Jain, 1959; Misra & Saxena, 1964; Bakshi, 1972; Shaw & Satsangi, 1974; Sahni & Chhabra, 1976; Khorana & Tirkey, 1977; Yadgiri & Prasad, 1977).

The foregoing review of literature which helps in the understanding of present day species of fish and their distribution, either for geological past or geomorphological present is not very helpful beyond a certain stage. This was primarily due to the reason that animal communities in general and fish communities in particular reach remarkable richness and this is probably the only index of such a diversity whether low or high useful in predicting centres of origin, radiation and evolution. It is ideal, however, to incorporate both these, where species are identified along with their individuals and looked at from a community level for different habitats (Mac Arthur, 1972; Ross, 1972). Such a relationship of species richness with the habitat conceived in terms of multidimensional co-ordinate systems and the various resource gradients both in space and time helping to fit the community in niche-hyper volumes has been detailed and worked out by Mac Arthur (1957). These aspects have since been made as indepth studies in various groups of fauna and flora. The most important works which have left an

impression on the importance of community studies have been on bird species diversity (Mac Arthur, 1957, 1960, 1964, 1965, 1969, 1970, 1972; Mac Arthur & Mac Arthur, 1961; Mac Arthur et al. 1962; Cody, 1966, 1968, 1970; Mac Arthur & Wilson, 1967; Karr, 1968, 1971, 1976a, b, 1980; Orians, 1969; Recher, 1969; Diamond, 1969; Tramer, 1969), and diversity in lizard communities (Pianka, 1966, 1967, 1973, 1980). Similar work exist on amphibians and reptiles (Inger & Colwell, 1977), on some marine benthic species (Sanders, 1968, 1969; Hessler & Sanders, 1967), on foraminiferal assemblage diversity (Parker, 1954; Pielou, 1979), on Plankton diversity (Margalef, 1958b, 1961, 1967, 1968; Whittaker & Fairbanks, 1958; Sager & Hasler, 1969), Molluscan diversity (Green, 1971, Kohn & Leviten, 1976; Aho, 1978) diversity of fossilforms (Deevey, 1969; Rosenzweig, 1975; Rosengweig & Taylor, 1980), on steam benthic macro-invertebrates' diversity (Wilhm, 1966; Young et al. 1976; Clifford, 1978), insect species diversity (Whittaker, 1952; Menhinick, 1964; Stout & Vadermeer, 1975; Hart, 1978), Arthropod species diversity (Simberloff & Wilson, 1970), Diatom communities (Patrick, 1968), ant communities (Wilson & Taylor, 1967) and on various plant species diversities (Dahl, 1960; Whittaker, 1965, 1969, 1972; Whittaker & Niering, 1965; Pielou, 1966a, b, 1969, 1975; Monk, 1967; Daubenmire & Daubenmire, 1968; Mc Naughton, 1968; Peet, 1971; Whittaker & Woodwell, 1969; Auclair & Goff, 1971).

One group of animals which has been dealt with in detail from aquatic habitats is the fish. Fish community structure and factors affecting the status of the community, and the diversity

of fish, has been major fields in aquatic ecology as they also form the terminal link in aquatic trophic levels. Diversity with longitudinal distances from the river or stream sources has been worked out in fishes to prove their richness, addition and replacement of species from the source to the mouth of lotic systems (Forbes, 1907; Shelford, 1911; Hutchinson, 1939; Burton & Odum, 1945; Sheldon, 1968; Jenkins & Freeman, 1972; Jenkins et al. 1972; Tramer & Rogers, 1973; Harima & Mundy, 1974; Stauffer et al. 1975; Cashner & Brown, 1977; Swalder, 1977; Horwitz, 1978; Evans & Noble, 1979; Swaidner & Berra, 1979). A similar work on lentic systems has been done and in particular to large standing water bodies like lakes, by Greenwood (1964), and Barbour & Brown (1974). The effect of thermal discharge on the diversity of fishes has been worked out by Hillman et al. (1977) while estuarine fishes and their diversity was shown by Hoff & Ibara (1977). The importance of stream order, zonation, habitats and the general drainage and watershed affecting the diversity of fish fauna have been worked out in detail here and abroad (Trautman, 1942; Kuehne, 1962; Herrel et al., 1967; Vincent & Miller, 1969; Whiteside & Mc Natt, 1972; Hocutt & Stauffer, 1975; Gorman & Karr, 1978; Platts, 1979; Matthews & Hill, 1980; Pardhasaradhi & Alfred, 1980b; Barila et al., 1981). In addition fish community studies and their diversities have been done in reefs (Molles, 1978; Dale, 1978) and in marshes (Kushlan, 1976). The effect of Physico-chemical factors on habitat selection and morphological features and variations in determining fish community structure have been shown by Matthews & Hill (1979) and Gatz (1979a, b)

respectively.

Among the Indian works, Hora (1922a, 1936f, 1938b) showed the importance of substratum as an important factor, while Jayaram & Motwani (1963) identified water quality to be important in either the distribution or community richness of species. The formation of communities and their richness to enable different zones of habitats has been shown by Jayaram (1979).

A step further in understanding the trueness of species richness or species diversity is the phenomenon of evenness apportioned among them. This ratio between the observed diversity index and the maximum possible existence of diversity on a community is an indicator to enable the explanation of a community utilizing the possible ecological niche in that habitat (Pielou, 1975). This is preferably done as a supplement to the poisson distribution enabling the randomness and independency of populations to be reflective of a community structure. Particular ecological niches in addition to their independent dispersal pattern also reveal clumps or patches of populations and is possible to be indicative by the Morisita's Index of aggregation (Morisita, 1959). For our studies in addition to the above to bring about a conclusion in the possible prediction of distribution of fishes, Sørensen's Coefficient of Similarity ( $Q/S$ ) indicated the lack of amount of diversity enabling the limits of horizontal distribution (Sørensen, 1948).

The present work, since it deals with fishes, the importance of the drainage, the watershed and the gradient involved in the different lotic systems would throw light on a total understanding for development of communities or migrations of fishes by the use of Average Gradient Indices.

A final analysis of all this would help in understanding the present day distribution and patterns of succession in the future colonizing of the lotic systems of North-East India.

North-East India

From the checklist (Table 2), prepared for all the species of fish in North-East India, which includes the collections from the present work also, the region is observed to possess 199 species comprising of 88 genera, grouped into 31 families. These families come under 11 orders and 5 superorders under the sub class, Actinopterygii. Of those in the checklist, our collections comprised of 169 species distributed in only 81 genera but representative of all the families, orders and superorders. The orders which comprised in the present investigation as well as those reported earlier are Cypriniformes, Siluriformes, Perciformes, Channiformes, Mastacembeliformes, Clupeiformes, Atheriniformes, Osteoglossiformes, Tetraodontiformes, Gasterosteiformes, and Symbranchiiformes.

Of these the order Cypriniformes comprised of 91 species forming nearly 53.8% followed by Siluriformes with 43 species and made up of 25.4%. The third important order was Perciformes which had only 13 species and comprising only 7.7%. The remaining orders all comprised of less than 10 species each, with some having only one and their percentages all below 5% (Table 3). Since Cypriniformes formed the dominant order it was felt to analyse the dominant families under this order. When so done the family Cyprinidae comprised up of the largest number of species nearing 67 and made up of 73.6% of all the families. This was followed by the family Cobitidae representative of only

TABLE-2

Class: Osteichthyes	49) Labeo bata (Hamilton)
Subclass: Actinopterygii	50) Labeo boga (Hamilton)
Superorder: Clupeomorpha	51) Labeo calbasu (Hamilton)
Order: Clupeiformes	52) Labeo gonius (Hamilton)
Suborder: Clupeoidei	53) Labeo dero (Hamilton)
Family: Clupeidae	54) Labeo pangusia (Hamilton)
1) <i>Hilsa ilisha</i> (Hamilton)	55) Labeo mandina (Hamilton)
2) <i>Gadusia chapra</i> (Hamilton)	56) Labeo rohita (Hamilton)
3) <i>Gadusia variegata</i> (Day)	57) <i>Oreochthys cosuatis</i> (Hamilton)
Family: Engraulidae	58) <i>Osteobrama cotio cotio</i> (Hamilton)
4) <i>Setipinna phasa</i> (Hamilton)	59) <i>Osteobrama cotio cunna</i> (Day)
Superorder: Osteoglossomorpha	60) <i>Osteobrama belangeri</i> (Valenciennes)
Order: Osteoglossiformes	61) <i>Puntius chola</i> (Hamilton)
Suborder: Notopteroidei	62) <i>Puntius clavatus</i> (Mc Clelland)
Family: Notopteridae	63) <i>Puntius conchonius</i> (Hamilton)
5) <i>Notoptenes chitala</i> (Hamilton)	64) <i>Puntius gelius</i> (Hamilton)
6) <i>Notoptenes notopterus</i> (Pallas)	65) <i>Puntius guganio</i> (Hamilton)
Superorder: Ostariophysii	66) <i>Puntius phutunio</i> (Hamilton)
Order: Cypriniformes	67) <i>Puntius sophore</i> (Hamilton)
Suborder: Cyprinoidei	68) <i>Puntius sarana</i> (Hamilton)
Family: Cyprinidae	69) <i>Puntius terio</i> (Hamilton)
7) <i>Chela cachius</i> (Hamilton)	70) <i>Puntius ticto</i> (Hamilton)
8) <i>Chela laubuca</i> (Hamilton)	71) <i>Puntius shalynius</i> Yazdani & Talukdar
9) <i>Oxygaster gora</i> (Hamilton)	72) <i>Schizothorax richadsonii</i> (Gray)
10) <i>Salmostoma bacaila</i> (Hamilton)	73) <i>Schizothoracichthys progastus</i> (Mc Clelland)
11) <i>Salmostoma phulo phulo</i> (Hamilton)	74) <i>Semiplotus semiplotus</i> (Mc Clelland)
12) <i>Barilius barila</i> (Hamilton)	75) <i>Semiplotus gangulyi</i> Dey
13) <i>Barilius barne</i> (Hamilton)	76) <i>Tor putitora</i> (Hamilton)
14) <i>Barilius berdelisis</i> (Hamilton)	77) <i>Tor tor</i> (Hamilton)
15) <i>Barilius bola</i> (Hamilton)	Family: Psilorhynchidae
16) <i>Barilius shacra</i> (Hamilton)	78) <i>Psilorhynchus balitora</i> (Hamilton)
17) <i>Barilius dogarsinghi</i> Hora	79) <i>Psilorhynchus homaloptera</i> Hora & Mukerji
18) <i>Barilius tileo</i> (Hamilton)	80) <i>Psilorhynchus sucatio</i> (Hamilton)
19) <i>Barilius vagra</i> (Hamilton)	Family: HOMALOPTERIDAE
20) <i>Barilius guttatus</i> (Day)	81) <i>Balitora Brucei</i> Gray
21) <i>Danio (Danio) acqipinnatus</i> (Mc Clelland)	82) <i>Balitora maculata</i> Gray
22) <i>Danio (Brachydanio) rerio</i> (Hamilton)	Family: Cobitidae
23) <i>Danio (Danio) dangila</i> (Hamilton)	83) <i>Aborichthys elongatus</i> Hora
24) <i>Danio (Brachydanio) acuticephala</i> Hora	84) <i>Aborichthys garoensis</i> Hora
25) <i>Danio (Danio) devario</i> (Hamilton)	85) <i>Aborichthys kempii</i> Chaudhuri
26) <i>Danio (Danio) naganensis</i> Chaudhuri	86) <i>Acanthophtalmus pangia</i> (Hamilton)
27) <i>Esomus danricus</i> (Hamilton)	87) <i>Botia bermorei</i> (Blyth)
28) <i>Rasbora daniconius</i> (Hamilton)	88) <i>Botia dario</i> (Hamilton)
29) <i>Rasbora elonga</i> (Hamilton)	89) <i>Botia histrionica</i> Blyth
30) <i>Rasbora kobonensis</i> Chaudhuri	90) <i>Botia rostrata</i> Gunther
31) <i>Rasbora rasbora</i> (Hamilton)	91) <i>Lepidocephalus bermorei</i> (Blyth)
32) <i>Acrossocheilus hexagonolepis</i> (Mc Clelland)	92) <i>Lepidocephalus guntea</i> (Hamilton)
33) <i>Amblypharyngodon mola</i> (Hamilton)	93) <i>Lepidocephalusirrorata</i> (Hora)
34) <i>Aspidoparia jaya</i> (Hamilton)	94) <i>Lepidocephalus burmanicus</i> Rendhal
35) <i>Aspidoparia moran</i> (Hamilton)	95) <i>Lepidocephalus menoni</i> (Pillai & Yazdani)
36) <i>Catla catla</i> (Hamilton)	96) <i>Lepidocephalus goalparensis</i> (Pillai & Yazdani)
37) <i>Chagunius chagunio</i> (Hamilton)	97) <i>Neoeucirrhichthys maydelli</i> Banarescu & Nalbant
38) <i>Cirrhina mrigala</i> (Hamilton)	98) <i>Noemacheilus beavani</i> Gunther
39) <i>Cirrhina reba</i> (Hamilton)	99) <i>Noemacheilus botia</i> (Hamilton)
40) <i>Crossocheilus latius latius</i> (Hamilton)	100) <i>Noemacheilus corica</i> (Hamilton)
41) <i>Garra anandalei</i> Hora	101) <i>Noemacheilus kangjupkhulensis</i> Hora
42) <i>Garra gotyala gotyala</i> (Gray)	102) <i>Noemacheilus manipurensis</i> Chaudhuri
43) <i>Garra kempii</i> Hora	103) <i>Noemacheilus multifasciatus</i> Day
44) <i>Garra lamta</i> (Hamilton)	104) <i>Noemacheilus prashadi</i> Hora
45) <i>Garra lissorhynchus</i> (Mc Clelland)	105) <i>Noemacheilus rupecola rupecola</i> (Mc Clelland)
46) <i>Garra naganensis</i> Hora	106) <i>Noemacheilus rupecola ingisi</i> Hora
47) <i>Garra nasuta</i> (Mc Clelland)	107) <i>Noemacheilus savona</i> (Hamilton)
48) <i>Garra rupecula</i> (Mc Clelland)	108) <i>Noemacheilus scaturigina</i> (Mc Clelland)

Table 2 (Contd) : Checklist of fishes of the  
North-East India.

TABLE-2 (Contd)

Family: Cobitidae (Contd)	Superorder: Atherinomorpha
109) <i>Noemacheilus sikmaiensis</i> Hora	Order: Atheriniformes
110) <i>Noemacheilus subfusca</i> (Mc Clelland)	Suborder: Cyprinodontoides
111) <i>Noemacheilus zonalternans</i> (Blyth)	Family: Cyprinodontidae
112) <i>Noemacheilus zontus</i> (Mc Clelland)	166) <i>Orizias melastigma</i> (Mc Clelland)
113) <i>Noemacheilus vinciguerrai</i> Hora	167) <i>Aplocheilus panchax</i> (Hamilton)
114) <i>Somileptes gongota</i> (Hamilton)	Suborder: Exocoetoides
Order: Siluriformes	Family: Belontiidae
Family: Bagridae	168) <i>Xenentodon cancila</i> (Hamilton)
115) <i>Rita rita</i> (Hamilton)	Superorder: Acanthopterygii
116) <i>Batasio batasio</i> (Hamilton)	Order: Gasterosteiformes
117) <i>Batasio tengana</i> (Hamilton)	Suborder: Syngnathoides
118) <i>Chandramara chandramara</i> (Hamilton)	Family: Syngnathidae
119) <i>Mystus bleekeri</i> (Day)	169) <i>Dorichthys deqcata</i> (Hamilton)
120) <i>Mystus cavasins</i> (Hamilton)	Order: Channiformes
121) <i>Mystus menoda menoda</i> (Hamilton)	Family: Channidae
122) <i>Mystus tengara</i> (Hamilton)	170) <i>Channa barca</i> (Hamilton)
123) <i>Mystus vittatus</i> (Bloch)	171) <i>Channa marulius</i> (Hamilton)
124) <i>Aorichthys seenghala</i> (Sykes)	172) <i>Channa orientalis schneider</i>
125) <i>Aorichthys aor</i> (Hamilton)	173) <i>Channa punctata</i> (Bloch)
Family: Siluridae	174) <i>Channa striatus</i> (Bloch)
126) <i>Ompak bimaculatus</i> (Bloch)	175) <i>Channa stewartii</i> (Playfair)
127) <i>Ompak pabda</i> (Hamilton)	Order: Symbranchiformes
128) <i>Ompak pabo</i> (Hamilton)	Suborder: Symbranchoides
129) <i>Wallago attu</i> (Schneider)	Family: Symbranchidae
130) <i>Silurus cochinchinensis</i> (Valenciennes)	176) <i>Monopterus alba</i> (Zuiew)
Family: Schilbeidae	177) <i>Amphipnous cuchia</i> (Hamilton)
131) <i>Ailia coila</i> (Hamilton)	178) <i>Amphipnous hodgarti</i> (Chaudhuri)
132) <i>Pseudeutropius atherenoides</i> (Bloch)	Order: Perciformes
133) <i>Clupiosoma garua</i> (Hamilton)	Suborder: Percoidei
134) <i>Eutropichthys murius</i> (Hamilton)	Family: Scaenidae
135) <i>Eutropichthys vacha</i> (Hamilton)	179) <i>Johnius coitor</i> (Hamilton)
136) <i>Silonia silondia</i> (Hamilton)	180) <i>Pama pama</i> (Hamilton)
Family: Pangasiidae	Family: Centropomidae
137) <i>Pangasius pangasius</i> (Hamilton)	181) <i>Chanda nama</i> Hamilton
Family: Amblycipitidae	182) <i>Chanda baculis</i> Hamilton
138) <i>Amblyceps mangois</i> (Hamilton)	183) <i>Chanda ranga</i> Hamilton
Family: Sisoridae	Family: Nandidae
139) <i>Bagarius bagarius</i> (Hamilton)	184) <i>Badis badis</i> (Hamilton)
140) <i>Conta conta</i> (Hamilton)	185) <i>Nandus nandus</i> (Hamilton)
141) <i>Erethistes pussilus</i> Muller & Troschel	Suborder: Mugiloidei
142) <i>Erethistoides montana montana</i> Hora	Family: Mugilidae
143) <i>Exostoma labiatum</i> (Mc Clelland)	186) <i>Sicamugil cascasia</i> (Hamilton)
144) <i>Euchiloglanis hodgarti</i> Hora	187) <i>Rhinomugil corsula</i> (Hamilton)
145) <i>Gagata cenia</i> (Hamilton)	Suborder: Gobioides
146) <i>Gagata viridescens</i> (Hamilton)	Family: Gobiidae
147) <i>Glyptothorax annandalei</i> Hora	188) <i>Glossogobius gutum</i> (Hamilton)
148) <i>Glyptothorax cavia</i> (Hamilton)	Suborder: Anabantoides
149) <i>Glyptothorax conirostris</i> (Steindachner)	Family: Anabantidae
150) <i>Glyptothorax gracilis</i> (Gunther)	189) <i>Anabas testudineus</i> Bloch
151) <i>Glyptothorax horai</i> Shaw & Shebbeare	190) <i>Colisa sota</i> (Hamilton)
152) <i>Glyptothorax platypogoneides</i> (Bleeker)	191) <i>Colisa fasciata</i> (Schneider)
153) <i>Glyptothorax ribeiroi</i> (Hora)	192) <i>Colisa lalia</i> (Hamilton)
154) <i>Glyptothorax striatus</i> (Mc Clelland)	193) <i>Ctenops nobilis</i> Mc Clelland
155) <i>Glyptothorax telchitta</i> (Hamilton)	Order: Mastacembeliformes
156) <i>Glyptothorax trilineatus</i> Blyth.	Suborder: Mastacembeloides
157) <i>Glyptothorax sinense manipurensis</i> Menon	Family: Mastacembelidae
158) <i>Hara hara</i> (Hamilton)	194) <i>Mastacembelus armatus</i> Lacepede
159) <i>Hara jerdoni</i> Day	195) <i>Mastacembelus pancalus</i> (Hamilton)
160) <i>Pseudecheneis sulcatus</i> (Mc Clelland)	196) <i>Macrogathus aculeatus</i> (Bloch)
161) <i>Sisor rhabdophorus</i> (Hamilton)	Family: Pillaiidae
Family: Clariidae	197) <i>Pillai indica yazdani</i>
162) <i>Clarias batrachus</i> (Linnaeus)	198) <i>Pillai khajuriae</i> Talwar et al
Family: Heteropneustidae	Family: Tetraodontidae
163) <i>Heteropneustes fossilis</i> (Bloch)	199) <i>Tetraodon cutcutia</i> Hamilton
Family: Chacidae	
164) <i>Chaca chaca</i> (Hamilton)	
Family: Olyridae	
165) <i>Olyra longicaudata</i> (Mc Clelland)	

Table 3 : Relative abundances of fishes in the North-East India recorded in the present study with numbers in parentheses.

TABLE-3

Cypriniformes	= 53.8%(91)	Puntius	= 16.4%(11)
Siluriformes	= 25.4%(43)	Barilius	= 11.9%(8)
Perciformes	= 7.7%(13)	Garra	= 11.9%(8)
Channiformes	= 3.5%(6)	Labeo	= 11.9% (8)
Mastacembeliformes	= 2.4%(4)	Danio	= 8.9% (6)
Clupeiformes	= 2.4%(4)	Rasbora	= 4.5% (3)
Atheriniformes	= 1.8%(3)	Aspidoparia	= 3.0% (2)
Osteoglossiformes	= 1.2%(2)	Chela	= 3.0% (2)
Gasterosteiformes	= 0.6%(1)	Cirrhina	= 3.0% (2)
Symbranchiiformes	= 0.6%(1)	Osteobrama	= 3.0% (2)
Tetraodontiformes	= 0.6%(1)	Salmostoma	= 3.0% (2)
		Tor	= 3.0% (2)
<u>Cypriformes</u>		Acrossocheilus	= 1.5% (1)
		Amblypharyngodon	= 1.5% (1)
Cyprinidae	= 73.6%(67)	Catla	= 1.5% (1)
Cobitidae	= 20.9%(19)	Crossocheilus	= 1.5% (1)
Psilorhynchidae	= 3.3%(3)	Esomus	= 1.5% (1)
Homalopteridae	= 2.2%(2)	Oxygaster	= 1.5% (1)
		Chagunius	= 1.5% (1)
		Oreichthys	= 1.5% (1)
		Semiplotus	= 1.5% (1)
		Schizothorax	= 1.5% (1)
		Schizothoraichthys	1.5% (1)
<u>Siluriformes</u>		<u>Sisoridae</u>	
		Glyptothorax	= 41.1%(7)
Sisoridae	= 39.6%(17)	Gagata	= 11.7%(2)
Bagridae	= 23.3% (10)	Bagarius	= 5.9%(1)
Schilbeidae	= 14.0%(6)	Conta	= 5.9%(1)
Siluridae	= 9.3%(4)	Erethistes	= 5.9%(1)
Pangasiidae	= 2.3%(1)	Euchiloglanis	= 5.9%(1)
Amblycipitidae	= 2.3%(1)	Exostoma	= 5.9%(1)
Clariidae	= 2.3%(1)	Hara	= 5.9%(1)
Heteropneustidae	= 2.3%(1)	Pseudecheneis	= 5.9%(1)
Chacidae	= 2.3%(1)	Sisor	= 5.9%(1)
Olyridae	= 2.3%(1)		
<u>Perciformes</u>		<u>Anabantidae</u>	
		Colisa	= 60.0%(3)
Anabantidae	= 38.5%(5)	Anabas	= 20.0%(1)
Centropomidae	= 23.0%(3)	Ctenops	= 20.0%(1)
Nandidae	= 15.4%(2)		
Sciaenidae	= 15.4%(2)		
Gobiidae	= 7.7%(1)		

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19 species and forming 20.9%. The remaining two families, Psilorhynchidae and Homalopteridae of this order Cypriniformes were less than 5, not only in their species number but also in their percentages. The dominant family Cyprinidae had the maximum genera of 23 in numbers. They were Puntius, Barilius, Garra, Labeo, Danio, Rasbora, Aspidoparia, Chela, Cirrhina, Osteobrama, Salmostoma, Tor, Acrossocheilus, Amblypharyngodon, Catla, Crossocheilus, Esomus, Oxygaster, Chagunius, Oriechthys, Semiplotus, Schizothorax, and Schizothoraichthys.

Of these, Puntius, Barilius, Garra and Labeo were the dominant genera, with 11, 8, 8 and 8 numbers of species and 16.4%, 11.9%, 11.9% and 11.9% percentages respectively. These were followed by the genus Danio which comprised of 6 species and made up of 8.9%. All the others were represented by less than 5 species and also by less than 5%.

Next in order of dominance after Cypriniformes was Siluriformes which comprised of 10 families. The families Sisoridae and Bagridae formed the dominant families, with 17 and 10 species each and a percentage of 39.6% and 23.3% respectively. These were followed by the families Schilbeidae and Siluridae with 6 and 4 species and 14% and 9.3% respectively. The remaining families under this order Siluriformes were made up of only one species each and comprising a percentage of 2.3%. The dominant family Sisoridae was seen to be comprised of 10 genera. Of these the genus Glyptothorax formed the dominant genus with 7 species

and a relative percentage 41.1% among the genera. This was followed by the genus Gagata with only 2 species and 11.7% abundance. The remaining 8 genera were represented by only one species each.

The third in order of dominance in the present investigation was Perciformes which comprised of 5 families, Anabantidae, Centropomidae, Nandidae, Sciaenidae, and Gobiidae. Of these, Anabantidae and Centropomidae were the dominant families with 5 and 3 species each and relative percentages of 38.5% and 23.0% respectively. These were followed by the families Nandidae and Sciaenidae with 2 species each and a percentage of 15.4%. The last family Gobiidae had only one species with a percentage of 7.7%. The dominant family Anab<sup>n</sup>atidae was made up of three genera, Colisa, Anabas and Ctenops. Of these Colisa was made up of 3 species and comprised of nearly 60% while Anabas and Ctenops had one species with a percentage of 20% each.

Though these were the general observations for the whole region under consideration which was made up of 5 Political States and 2 Union Territories, interestingly enough, of a total of 169 species in the whole area only 21 species were found to be common to all the 5 states and 2 union territories. Of these again Cyprinidae formed the dominant group with 15 species followed by Channidae with only 2 species. The remaining families were Nandidae, Mastacembelidae, Cobitidae and Olyridae all with one species each (Table 5).

Table 4: Endemic fishes of the North-East India.

Table 5 : Fish species and subspecies that were collected in all the five states of North-East India in the present study.

TABLE-4

Family:	Garra naganensis Hora
Pillaiidae Yazdani	Garra rupecula (Mc Clelland)
	Glyptothorax sinense manipurensis Menon
Genera:	Lepidocephalus goalparensis (Pillai & Yazdani)
Aborichthys Chaudhuri	
Chandramara Jayaram	
Exostoma Mc Clelland	Lepidocephalus irrorata (Hora)
Neoeucirrhichthys Bararascu & Nalbant	Lepidocephalus menoni (Pillai & Yazdani)
Pillaia Yazdani	Neoeucirrhichthys maydelli Banarescu & Nalbant
Species:	Noemacheilus manipurensis Chaudhuri
Aborichthys garoensis Hora	Noemacheilus prashadi Hora
Amphiprourus hodgarti (Chaudhuri)	Noemacheilus sabfusca (Mc Clelland)
Chandramara Chandramara (Hamilton)	Pillaia indica Yazdani
Danio (Brachydanio) acuticephala Hora	Pillaia khajuriae Talwar et al
Danio (Danio) naganensis Chaudhuri	Psilorhynchus homaloptera Hora & Mukerji
Erethistoides montana montana Hora	Puntius shalynius Yazdani & Talukdar
Exostoma labiatum (Mc Clelland)	Rasbora kobonensis Chaudhuri
Garra kempfi Hora	Semiplotus gangulyi Dey
Garra lissorhynchus (Mc Clelland)	

TABLE-5

Chela cachius (Hamilton)	Puntius clavatus (Mc Clelland)
Barilius barna (Hamilton)	Puntius ticto (Hamilton)
Barilius bendelisis (Hamilton)	Tor putitora (Hamilton)
Barilius bola (Hamilton)	Tor tor (Hamilton)
Barilius vagra (Hamilton)	Noemacheilus botia (Hamilton)
Danio (Danio) aequipinnatus (Mc Clelland)	Olyra longicaudata (Mc Clelland)
Danio (Danio) dangila (Hamilton)	Badis badis (Hamilton)
Danio (Brachydanio) rerio (Hamilton)	Channa orientalis Schneider
Acrossocheilus hexagonolepsis (Mc Clelland)	Channa punctata (Bloch)
Crossocheilus latius latius (Hamilton)	Mastacembelus armatus Lacepede
	Garra gotyla gotyla (Gray)

In addition to the common occurrence of these 21 species it was observed from the present investigation that 25 species were endemic to the area irrespective of the political boundaries. Further, though they represented cosmopolitan genera for these 25 species, yet it was seen that 5 genera were endemic to the region. Finally one family erected quite recently was also endemic to the region under consideration in the present investigation (Table 4).

#### Assam

A similar analysis for the entire region above was seen for the 5 different political entities undertaken in the present investigation. When so done it was seen that Assam had 159 species comprising of 83 genera grouped into 31 families, 11 orders and five superorders of the sub class Actinopterygii (Table 6). Of these, 146 species representing 76 genera and 30 families representative of all the orders and superorders of the whole region was collected in the present investigation. Once again, the 11 orders that comprised the total fish fauna of Assam, the order Cypriniformes was seen to be the dominant order with 75 species forming 50.0%, followed by the order Siluriformes with 39 species showing a relative percentage of 26.7%. The order Perciformes with 13 species and 8.9% comes third in the order of dominance. All the other orders comprised of less than 10 species each with some having only one species and with percentages below 5% (Table 7).

TABLE - 6

S.No.	Species Name	S.No.	Species Name
Clupeidae:			
1.	Hilsa ilisha (Hamilton)	88.	Batasio batasio (Hamilton)
2.	Gadusia chapra (Hamilton)	89.	Chandramara chandramara (Hamilton)
3.	Gadusia variegata (Day)	90.	Mystus bleekeri (Day)
Engraulidae:			
4.	Setipinna phasa (Hamilton)	91.	Mystus cavasius (Hamilton)
Notopteridae:			
5.	Notopterus chitala (Hamilton)	92.	Mystus menoda menoda (Hamilton)
6.	Notopterus notopecterus (Pallas)	93.	Mystus tengara (Hamilton)
Cyprinidae:			
7.	Chela cachius (Hamilton)	94.	Mystus vittatus (Hamilton)
8.	Chela laubuca (Hamilton)	95.	Aorichthys seenghala (Hamilton)
9.	Oxygaster gora (Hamilton)	96.	Aorichthys aor (Hamilton)
10.	Salmostoma becailla (Hamilton)	Siluridae:	
11.	Salmostoma phulo phulo (Hamilton)	97.	Ompak bimaculatus (Bloch)
12.	Barilius barila (Hamilton)	98.	Ompak pabda (Hamilton)
13.	Barilius barna (Hamilton)	99.	Ompak pabo (Hamilton)
14.	Barilius bendelisis (Hamilton)	100.	Wallago attu (Schneider)
15.	Barilius bola (Hamilton)	101.	Silurus cochinchinensis Valenciennes
16.	Barilius shacra (Hamilton)	Schilbeidae:	
17.	Barilius tileo (Hamilton)	102.	Ailia coila (Hamilton)
18.	Barilius vagra (Hamilton)	103.	Pseudeutropius atherinoides (Bloch)
19.	Danio (Danio) aequipinnatus (Mc Clelland)	104.	Clupiosoma garua (Hamilton)
20.	Danio (Danio) dangila (Hamilton)	105.	Eutropichthys murius (Hamilton)
21.	Danio (Brachydanio) rerio (Hamilton)	106.	Eutropichthys vacha (Hamilton)
22.	Danio (Danio) devario (Hamilton)	107.	Silonia silondia (Hamilton)
23.	Esomus danricus (Hamilton)	Pangasiidae:	
24.	Rasbora daniconius (Hamilton)	108.	Pangasius pangasius (Hamilton)
25.	Rasbora elonga (Hamilton)	Amblycipitidae:	
26.	Rasbora rasbora (Hamilton)	109.	Amblyceps mangoia (Hamilton)
27.	Acrossocheilus hexagonolepis (Mc Clelland)	Sisoridae:	
28.	Amblypharyngodon mola (Hamilton)	110.	Bagarius bagarius (Hamilton)
29.	Aspidoparia jaya (Hamilton)	111.	Conta conta (Hamilton)
30.	Aspidoparia morar (Hamilton)	112.	Erethistes pusillus Muller & Troschel
31.	Catla catla (Hamilton)	113.	Erethistoides montana montana Hora
32.	Chagunius chagunio (Hamilton)	114.	Exostoma labiatum (Mc Clelland)
33.	Cirrhina mrigala (Hamilton)	115.	Gagata cenla (Hamilton)
34.	Cirrhina reba (Hamilton)	116.	Gagata viridescens (Hamilton)
35.	Crossocheilus latius latius (Hamilton)	117.	Glyptothorax cavia (Hamilton)
36.	Gerra annandalei Hora	118.	Glyptothorax gracilis (Günther)
37.	Gerra gotyla gotyla (Gray)	119.	Glyptothorax horai Shaw & Shabbeare
38.	Gerra lamta (Hamilton)	120.	Glyptothorax striatus (Mc Clelland)
39.	Gerra lissorhynchus (Mc Clelland)	121.	Hara hara (Hamilton)
40.	Gerra nasuta (Mc Clelland)	122.	Hara jerdoni Day
41.	Labeo bata (Hamilton)	123.	Pseudecheneis sulcatus (Mc Clelland)
42.	Labeo boga (Hamilton)	124.	Sisor rabdophorus Hamilton
43.	Labeo calbasu (Hamilton)	Clariidae:	
44.	Labeo dero (Hamilton)	125.	Clarias batrachus (Linnaeus)
45.	Labeo gonius (Hamilton)	Heteropneustidae:	
46.	Labeo pangusia (Hamilton)	126.	Heteropneustes fossilis (Bloch)
47.	Labeo nandina (Hamilton)	Chacidae:	
48.	Labeo rohita (Hamilton)	127.	Chaca chaca (Hamilton)
49.	Oreochromis mossambicus (Hamilton)	Olyridae:	
50.	Osteobrama cotio cotio (Hamilton)	128.	Olyra longicaudata (Mc Clelland)
51.	Puntius chola (Hamilton)	Cyprinodontidae:	
52.	Puntius clavatus (Mc Clelland)	129.	Orizias melastigma (Mc Clelland)
53.	Puntius conchonus (Hamilton)	130.	Aplocheilichthys panchax (Hamilton)
54.	Puntius gelius (Hamilton)	Belontiidae:	
55.	Puntius guganio (Hamilton)	131.	Xenentodon cancila (Hamilton)
56.	Puntius sophore (Hamilton)	Syngnathidae:	
57.	Puntius sarana sarana (Hamilton)	132.	Dorichthys deocata (Hamilton)
58.	Puntius terio (Hamilton)	Channidae:	
59.	Puntius ticto (Hamilton)	133.	Channa barca (Hamilton)
60.	Puntius phutunio (Hamilton)	134.	Channa marulius (Hamilton)
61.	Semiplotus semiplotus (Mc Clelland)	135.	Channa orientalis Schneider
62.	Semiplotus gangulyi Day	136.	Channa punctata (Bloch)
63.	Tor putitora (Hamilton)	137.	Channa stewartii (Playfair)
64.	Tor tor (Hamilton)	138.	Channa striatus (Bloch)
Pailorhynchidae:			
65.	Pailorhynchus balitora (Hamilton)	Symbranchidae:	
Hamalopteridae:			
66.	Balitora brucei Gray	139.	Amphipneus cuchia (Hamilton)
67.	Balitora maculata Gray	Sclaeinidae:	
Cobitidae:			
68.	Aborichthys elongatus Hora	140.	Johnius coitor (Hamilton)
69.	Botia dario (Hamilton)	141.	Pama pama (Hamilton)
70.	Botia histriónica Blyth	Centropomidae:	
71.	Botia rostrata Günther	142.	Chanda baculis Hamilton
72.	Lepidocephalus berdmorei (Blyth)	143.	Chanda nama Hamilton
73.	Lepidocephalus guntea (Hamilton)	144.	Chanda ranga Hamilton
74.	Lepidocephalus goalparensis (Pillai & Yazdani)	Nandidae:	
75.	Lepidocephalus irrorata (Hora)	145.	Badis badis (Hamilton)
76.	Neoeucirrhichthys maydelli Banarescu & Nalbant	146.	Nandus nandus (Hamilton)
77.	Noemacheilus beavani Günther	Mugilidae:	
78.	Noemacheilus botia (Hamilton)	147.	Sicamugil cascasia (Hamilton)
79.	Noemacheilus corica (Hamilton)	148.	Rhinomugil corsula (Hamilton)
80.	Noemacheilus rupecola rupecola (Mc Clelland)	Gobiidae:	
81.	Noemacheilus rupecola inglisii Hora	149.	Glossogobius gutum (Hamilton)
82.	Noemacheilus savona (Hamilton)	Anabantidae:	
83.	Noemacheilus scaturigina (Mc Clelland)	150.	Anabas testudineus Bloch
84.	Noemacheilus zonatus (Mc Clelland)	151.	Colisa fasciata (Schneider)
85.	Somileptes gonogata (Hamilton)	152.	Colisa lalia (Hamilton)
Bagridae:			
86.	Rita rita (Hamilton)	153.	Colisa sota (Hamilton)
87.	Batasio tengana (Hamilton)	154.	Ctenops nobilis Mc Clelland
Mastacembelidae:			
155.	Mastacembelus armatus Lacepede	Pillaiidae:	
156.	Mastacembelus pancalus (Hamilton)	158.	Pillaiia khajuriai Talwar et al
157.	Macroglyptothorax aculeatus (Bloch)	Tetraodontidae:	
Pillaiidae:			
158.	Pillaiia khajuriai Talwar et al	159.	Tetraodon cutcutia Hamilton

Table 7 : Relative abundances of fishes in Assam state recorded in the present study with numbers in parentheses.

TABLE-7

Cypriniformes	= 50.0% (73)	<u>Cyprinidae</u>	
Siluriformes	= 26.7% (39)	Puntius	= 17.6%(10)
Perciformes	= 8.9% (13)	Labeo	= 14.1%(8)
Channiformes	= 4.1% (6)	Barilius	= 12.4%(7)
Clupeiformes	= 2.7% (4)	Garra	= 8.9%(5)
Atheriniformes	= 2.1% (3)	Danio	= 7.1%(4)
Mastacembeliformes	= 2.1% (3)	Rasbora	= 5.4%(3)
Osteoglossiformes	= 1.3% (2)	Chela	= 3.5%(2)
Gasterosteiformes	= 0.7% (1)	Salmostoma	= 3.5%(2)
Symbranchiformes	= 0.7% (1)	Aspidoparia	= 3.5%(2)
Tetraodontiformes	= 0.7% (1)	Cirrhhina	= 3.5%(2)
		Tor	= 3.5%(2)
<u>Cypriniformes</u>		Oxygaster	= 1.7%(1)
Cyprinidae	= 78.1% (57)	Esomus	= 1.7%(1)
Cobitidae	= 17.8% (13)	Acrossocheilus	= 1.7%(1)
Homalopteridae	= 2.8% (2)	Amblypharyngodon	= 1.7%(1)
Psilorhynchidae	= 1.4% (1)	Catla	= 1.7%(1)
		Crossocheilus	= 1.7%(1)
		Osteobrama	= 1.7%(1)
		Oreochthys	= 1.7%(1)
		Semiplotus	= 1.7%(1)
		Chagunius	= 1.7%(1)
<u>Siluriformes</u>		<u>Sisoridae</u>	
Sisoridae	= 33.3% (13)	Glyptothorax	= 30.7%(4)
Bagridae	= 25.6% (10)	Gagata	= 15.4%(2)
Schilbidae	= 15.3% (6)	Bagarius	= 7.7%(1)
Siluridae	= 10.2% (4)	Conta	= 7.7%(1)
Pangasiidae	= 2.6%(1)	Exostoma	= 7.7%(1)
Ablycipitidae	= 2.6% (1)	Erethistes	= 7.7%(1)
Clariidae	= 2.6% (1)	Hara	= 7.7%(1)
Heteropneustidae	= 2.6% (1)	Pseudecheneis	= 7.7%(1)
Chacidae	= 2.6% (1)	Sisor	= 7.7% (1)
Olyridae	= 2.6% (1)		

## Endemic genus:

Neoeucirrhichthys Banarescu &amp; Nalbant

## Endemic species/subspecies:

Semiplotus gangulyi Dey

Lepidocephalus goalparensis (Pillai &amp; Yazdani)

Neoeucirrhichthys maydelli Banarescu &amp; Nalbant

Erethistoides montana montana Hora

Under this dominant order Cypriniformes in Assam, the family Cyprinidae was the dominant, with 57 species and a relative percentage of 78.1%. This was followed by the family Cobitidae which had 13 species and forming 17.8%. The other two families, Homalopteridae and Psilorhynchidae were both less than 3 in their number of species and percentages. The family Cyprinidae was observed to contain the maximum genera of 21. They were Puntius, Labeo, Barilius, Garra, Danio, Rasbora, Chela, Salmostoma, Aspidoparia, Cirrhina, Tor, Oxygaster, Esomus, Acrossocheilus, Amblypharyngodon, Catla, Crossocheilus, Osteobrama, Oreochthys, Semiplotus and Chagunius. Of these, Puntius, Labeo, Barilius and Garra comprised of 11, 8, 7 and 5 numbers of species and with 17.6%, 14.1%, 12.4% and 8.9% as percentages respectively of the genera of the family Cyprinidae. These were followed by Danio and Rasbora with 4 and 3 numbers of species, 7.1% and 5.4% respectively. All the other genera were represented by less than 3 species and less than 5%.

The next order dominant, after Cypriniformes was Siluriformes, comprising of 10 families. Of these families, Sisoridae and Bagridae were found to be dominant families, with 13 and 10 species each and a percentage of 33.3% and 25.6% respectively. These were followed by the families Schilbeidae and Siluridae with 6 and 4 species and 15.3% and 10.2%, respectively. The remaining six families Pangasiidae, Amblycipitidae, Clariidae, Heteropneustidae, Chacidae and

Olysiidae, were made up of only one species each with a percentage of 2.6%. The dominant family Sisoridae, was seen to be comprised of 9 genera. Of these the genus Glyptothorax formed the dominant genus with 4 species and a relative percentage of 30.7%, followed by the genus Gagata with 2 species and 15.4%. The remaining 7 genera were represented by only one species each with a relative percentage of 7.7%.

Of the 146 species in the state of Assam it was observed that 4 species were endemic to this state, and also the genus Neoeucirrhichthys.

#### Arunachal Pradesh

Arunachal Pradesh fish fauna comprised of 68 species representing 37 genera, 15 families, 6 orders and 2 superorders under the sub-class Actinopterygii. However, of these, 49 species comprising of 27 genera, 11 families and 5 orders of the same number of superorders and of the same sub class were in our collections. The orders that represented the fish fauna of Arunachal Pradesh were Cypriniformes, Siluriformes, Channiformes, Perciformes and Mastacembeliformes (Table 8).

Of these, the order Cypriniformes comprised of 36 species forming 73.5% followed by Siluriformes with 8 species and with a percentage of 16.4%. The third important order was Channiformes with only 3 species and only 6.1%. The other two orders Perciformes and Mastacembeliformes were represented by only one species each with a percentage of 2.% (Table 9).

Table 8 : Checklist of fishes of Arunachal Pradesh.

TABLE-8

S.No.	Species Name	S.No	Species Name
	<b>Cyprinidae:</b>	42.	Noemacheilus corica (Hamilton)
1.	Chela cachius (Hamilton)	43.	Noemacheilus rupecola rupecola (Mc Clelland)
2.	Barilius barna (Hamilton)	44.	Noemacheilus savona (Hamilton)
3.	Barilius bendelisis (Hamilton)	45.	Noemacheilus scaturigina (Mc Clelland)
4.	Barilius bola (Hamilton)	46.	Noemacheilus zonatus (Mc Clelland)
5.	Barilius tileo (Hamilton)	47.	Somileptes gongota (Hamilton)
6.	Barilius vagra (Hamilton)		<b>Bagridae:</b>
7.	Danio (Danio) aequipinnatus (Mc Clelland)	48.	Mystus cavasius (Hamilton)
8.	Danio (Danio) dangila (Hamilton)		<b>Amblycipitidae:</b>
9.	Danio (Brachydanio) rerio (Hamilton)	49.	Amblyceps mangois (Hamilton)
10.	Rasbora kobonensis Chaudhuri		<b>Sisoridae:</b>
11.	Chagunius chagunio (Hamilton)	50.	Conta conta (Hamilton)
12.	Acrossocheilus hexagonolepis	51.	Euchiloglanis hodgarti (Hora)
13.	Crossocheilus latius latius (Hamilton)	52.	Exostoma labiatum (Mc Clelland)
14.	Garra annandalei Hora.	53.	Glyptothorax annandalei Hora
15.	Garra gotyla gotyla (Gray)	54.	Glyptothorax cavia (Hamilton)
16.	Garra lamta (Hamilton)	55.	Glyptothorax gracilis (Gunther)
17.	Garra nasuta (Mc Clelland)	56.	Glyptothorax ribeiroi (Hora)
18.	Garra rupecula (Mc Clelland)	57.	Pseudecheneis sulcatus (Mc Clelland)
19.	Labeo boga (Hamilton)		<b>Clariidae:</b>
20.	Labeo dero (Hamilton)	58.	Clarias batrachus (Linnaeus)
21.	Labeo gonius (Hamilton)		<b>Olyridae:</b>
22.	Labeo pangusia (Hamilton)	59.	Olyra longicaudata (Mc Clelland)
23.	Puntius clavatus (Mc Clelland)		<b>Channidae:</b>
24.	Puntius conchonus (Hamilton)	60.	Channa barca (Hamilton)
25.	Puntius phutunio (Hamilton)	61.	Channa orientalis Schneider
26.	Puntius ticto (Hamilton)	62.	Channa punctata (Bloch)
27.	Schizothorax richardsoni (Gray)		<b>Symbranchidae:</b>
28.	Schizothoraichthys progastus (Mc Clelland)	63.	Amphipnous hodgarti (Chaudhuri)
29.	Semiplotus semiplotus (Mc Clelland)		<b>Nandidae:</b>
30.	Tor putitora (Hamilton)	64.	Badis badis (Hamilton)
31.	Tor tor (Hamilton)		<b>Gobiidae:</b>
	<b>Psilorhynchidae:</b>	65.	Glossogobius gutum (Hamilton)
32.	Psilorhynchus balitora (Hamilton)		<b>Anabantidae:</b>
33.	Psilorhynchus sucatio (Hamilton)	66.	Anabas testudineus Bloch
34.	Balitora maculata Gray	67.	Colisa fasciata (Schneider)
	<b>Cobitidae:</b>		<b>Mastacembelidae:</b>
35.	Aborichthys elongatus Hora.	68.	Mastacembelus armatus Lacepede
36.	Aborichthys kempfi Chaudhuri		
37.	Botia dario (Hamilton)		
38.	Botia rostrata Gunther		
39.	Lepidocephalus guntea (Hamilton)		
40.	Noemacheilus beavani Gunther		
41.	Noemacheilus botia (Hamilton)		

Table 9 : Relative abundances of fishes in Arunachal Pradesh recorded in the present study with numbers in parentheses.

TABLE-9

Cypriniformes	= 73.5% (36)
Siluriformes	= 16.4% (8)
Channiformes	= 6.1% (3)
Perciformes	= 2.0% (1)
Mastacembeliformes	= 2.0% (1)

Cypriniformes

Cyprinidae	= 77.8% (28)
Cobitidae	= 13.9% (5)
Psilorhynchidae	= 5.6% (2)
Homalopteridae	= 2.7% (1)

Siluriformes

Sisoridae	= 62.5% (5)
Amblycipitidae	= 12.5% (1)
Olyridae	= 12.5% (1)
Bagridae	= 12.5% (1)

Endemic species:

Rasbora kobonensis Chaudhuri  
 Amphipnous hodgarti (Chaudhuri)

Cyprinidae

Barilius	= 17.7% (5)
Garra	= 14.3% (4)
Labeo	= 14.3% (4)
Puntius	= 10.7% (3)
Danio	= 10.7% (3)
Tor	= 7.1% (2)
Chela	= 3.6% (1)
Chagunius	= 3.6% (1)
Acrossocheilus	= 3.6% (1)
Crossocheilus	= 3.6% (1)
Schizothorax	= 3.6% (1)
Schizothoraichthys	= 3.6% (1)
Semiplotus	= 3.6% (1)

Sisoridae

Clyptothorax	= 60.0% (3)
Euchiloglanis	= 20.0% (1)
Pseudechmeis	= 20.0% (1)

Within the dominant order Cypriniformes, the family Cyprinidae was dominant with the largest number of species, and comprised of 77.8% of all the families, in this order. This was followed by the family Cobitidae with 5 species and forming 13.9%. The remaining two families Psilorhynchidae and Homalopteridae were represented by 2 and 1 species forming relative percentages of 5.6% and 2.7% respectively. Among the family Cyprinidae, which was dominant, it was observed that a total of 13 genera were represented. They were Barilius, Garra, Labeo, Puntius, Danio, Tor, Chela, Chagunius, Acrossocheilus, Crossocheilus, Schizothorax, Schizothoraichthys and Semiplotus. Of these Barilius, Garra, and Labeo comprised of 5, 4 and 4 species and 17.7%, 14.3% and 14.3% respectively. These were followed by Puntius, Danio and Tor with 3, 3 and 2 species with relative percentages of 10.7%, 10.7% and 7.1% respectively. All the other 7 genera were represented by only one species each with a relative percentage of 3.6% only.

The next order which was dominant after Cypriniformes was Siluriformes which comprised of 4 families only. The family Sisoridae with 5 species was dominant with a relative percentage of 62.5% among the families of this order. All the other three families were represented by a single species each with a relative percentage of 12.5%. The dominant family Sisoridae comprised of only three genera. Glyptothorax formed the dominant genus of the family with 3 species and formed a relative percentage of 60.0%, while the other two genera

Euchiloglanis and Pseudecheneis were represented by only one species each with a relative percentage of 20.0%. Of these 68 species only 2 species were found to be endemic to this Union Territory.

### Meghalaya

The fish fauna of Meghalaya comprised of 86 species under 43 genera, 21 families, 7 orders and 4 superorders of the sub class Actinopterygii. Our collections comprised of 82 species representing all the genera, families, orders and superorders (Table 10). The orders of the present investigation as well as reported earlier were Cypriniformes, Siluriformes, Perciformes, Channiformes, Mastacembeliformes, Atheriniformes and Osteoglossiformes. Of these, the order Cypriniformes comprised of 51 species forming 62.3% followed by Siluriformes with only 17 species and comprising 20.7%. The third important order was Perciformes with 5 species forming only 6.1%. The remaining orders all were comprised of less than 5 species each both in number of species and their relative percentages (Table 11).

Since Cypriniformes formed the dominant order it is only justifiable to see the dominant families under this order, and when so done the family Cyprinidae was observed to be dominant with 39 species and with a relative percentage of 76.4% followed by Cobitidae with only 10 species forming a relative percentage of 19.6% of all the families under the order Cypriniformes. The

Table 10 : Checklist of fishes of Meghalaya state.

TABLE-10

S.No.	Species Name	S.No.	Species Name
	<b>Notopteridae:</b>	48.	<i>Botia rostrata</i> Gunther
1.	<i>Notopterus chitala</i> (Hamilton)	49.	<i>Lepidocephalus berdmorei</i> (Blyth)
	<b>Cyprinidae:</b>	50.	<i>Lepidocephalus quntea</i> (Hamilton)
2.	<i>Chela cachius</i> (Hamilton)	51.	<i>Lepidocephalus menoni</i> (Pillai & Yazdani)
3.	<i>Chela laubuca</i> (Hamilton)	52.	<i>Noemacheilus botia</i> (Hamilton)
4.	<i>Barilius barila</i> (Hamilton)	53.	<i>Noemacheilus corica</i> (Hamilton)
5.	<i>Barilius barna</i> (Hamilton)	54.	<i>Noemacheilus rupecola rupecola</i> (Mc Clelland)
6.	<i>Barilius bendelisis</i> (Hamilton)	55.	<i>Somileptes gongota</i> (Hamilton)
7.	<i>Barilius bola</i> (Hamilton)		<b>Bagridae:</b>
8.	<i>Barilius shacra</i> (Hamilton)	56.	<i>Batasio tengana</i> (Hamilton)
9.	<i>Barilius vagra</i> (Hamilton)	57.	<i>Mystus bleekeri</i> (Day)
10.	<i>Danio</i> ( <i>Danio</i> ) <i>aequipinnatus</i> (Mc Clelland)	58.	<i>Mystus vittatus</i> (Bloch)
11.	<i>Danio</i> ( <i>Danio</i> ) <i>dangila</i> (Hamilton)	59.	<i>Aorichthys seenghala</i> (Sykes)
12.	<i>Danio</i> ( <i>Danio</i> ) <i>devario</i> (Hamilton)		<b>Siluridae:</b>
13.	<i>Danio</i> ( <i>Brachydanio</i> ) <i>rerio</i> (Hamilton)	60.	<i>Ompak pabda</i> (Hamilton)
14.	<i>Acrossocheilus hexagonolepis</i> (Mc Clelland)	61.	<i>Ompak pabo</i> (Hamilton)
15.	<i>Amblypharyngodon mola</i> (Hamilton)		<b>Schilbeidae:</b>
16.	<i>Catla catla</i> (Hamilton)	62.	<i>Clupiosoma garua</i> (Hamilton)
17.	<i>Chagunius chagunio</i> (Hamilton)	63.	<i>Eutropiichthys vacha</i> (Hamilton)
18.	<i>Cirrhina mrigala</i> (Hamilton)		<b>Amblycipitidae:</b>
19.	<i>Cirrhina reba</i> (Hamilton)	64.	<i>Amblyceps mangois</i> (Hamilton)
20.	<i>Crossocheilus latius latius</i> (Hamilton)		<b>Sisoridae:</b>
21.	<i>Garra gotyla gotyla</i> (Gray)	65.	<i>Glyptothorax cavia</i> (Hamilton)
22.	<i>Garra lamta</i> (Hamilton)	66.	<i>Glyptothorax striatus</i> (Mc Clelland)
23.	<i>Garra lissorhynchus</i> (Mc Clelland)	67.	<i>Glyptothorax telchitta</i> (Hamilton)
24.	<i>Garra nasuta</i> (Mc Clelland)	68.	<i>Pseudecheneis sulcatus</i> (Mc Clelland)
25.	<i>Garra rupecula</i> (Mc Clelland)		<b>Clariidae:</b>
26.	<i>Labeo bata</i> (Hamilton)	69.	<i>Clarias batrachus</i> (Linnaeus)
27.	<i>Labeo calbasu</i> (Hamilton)		<b>Heteropneustidae:</b>
28.	<i>Labeo dero</i> (Hamilton)	70.	<i>Heteropneustes fossilis</i> (Bloch)
29.	<i>Labeo gonius</i> (Hamilton)		<b>Chacidae:</b>
30.	<i>Labeo nandina</i> (Hamilton)	71.	<i>Chaca chaca</i> (Hamilton)
31.	<i>Labeo pangusia</i> (Hamilton)		<b>Olyridae:</b>
32.	<i>Puntius clavatus</i> (Mc Clelland)	72.	<i>Olyra longicaudata</i> (Mc Clelland)
33.	<i>Puntius conchonus</i> (Hamilton)		<b>Belonidae:</b>
34.	<i>Puntius phutunio</i> (Hamilton)	73.	<i>Xenentodon cancila</i> (Hamilton)
35.	<i>Puntius sarana sarana</i> (Hamilton)		<b>Channidae:</b>
36.	<i>Puntius shalynius</i> Yazdani & Talukdar	74.	<i>Channa orientalis</i> Schneider
37.	<i>Puntius sophore</i> (Hamilton)	75.	<i>Channa punctata</i> (Bloch)
38.	<i>Puntius ticto</i> (Hamilton)	76.	<i>Channa stewartii</i> (Playfair)
39.	<i>Tor putitora</i> (Hamilton)	77.	<i>Channa striatus</i> (Bloch)
40.	<i>Tor tor</i> (Hamilton)		<b>Nandidae:</b>
	<b>Psilorhynchidae:</b>	78.	<i>Badis badis</i> (Hamilton)
41.	<i>Psilorhynchus balitora</i> (Hamilton)	79.	<i>Nandus nandus</i> (Hamilton)
42.	<i>Psilorhynchus sucatio</i> (Hamilton)		<b>Gobiidae:</b>
	<b>Homalopteridae:</b>	80.	<i>Glossogobius gutum</i> (Hamilton)
43.	<i>Balitora brucei</i> Gray		<b>Anabantidae:</b>
	<b>Cobitidae:</b>	81.	<i>Anabas testudineus</i> Bloch
44.	<i>Aborichthys garoensis</i> Hora	82.	<i>Colisa fasciata</i> (Schneider)
45.	<i>Aborichthys kempii</i> Chaudhuri		<b>Mastacembelidae:</b>
46.	<i>Botia dario</i> (Hamilton)	83.	<i>Mastacembelus armatus</i> Lacepede
47.	<i>Botia histrionica</i> Blyth	84.	<i>Mastacembelus pancalus</i> (Hamilton)
			<b>Pillaiidae:</b>
		85.	<i>Pillaia indica</i> Yazdani
		86.	<i>Pillaia khajuriai</i> Talwar et al

Table 11 : Relative abundances of fishes in Meghalaya state recorded in the present study with numbers in parentheses.

TABLE-11

Cypriniformes	= 62.3%(51)	<u>Cyprinidae:</u>	
Siluriformes	= 20.7%(17)	Puntius	= 17.9% (7)
Perciformes	= 6.1% (5)	Labeo	= 15.4% (6)
Channiformes	= 4.9% (4)	Barilius	= 15.4% (6)
Mastacembeliformes	= 3.6% (3)	Garra	= 12.8% (5)
Atheriniformes	= 1.2% (1)	Danio	= 10.2% (4)
Osteoglossiformes	= 1.2% (1)	Chela	= 5.1% (2)
<u>Cypriniformes:</u>		Tor	= 5.1% (2)
Cyprinidae	= 76.4% (39)	Amblypharyngodon	= 2.6% (1)
Cobitidae	= 19.6% (10)	Acrossocheilus	= 2.6% (1)
Psilirhynchidae	= 2.0% (1)	Catla	= 2.6% (1)
Homalopteridae	= 2.0% (1)	Chagunius	= 2.6% (1)
		Crossocheilus	= 2.6% (1)
<u>Siluriformes:</u>		<u>Bagridae:</u>	
Bagridae	= 23.5% (4)	Mystus	= 50.0% (2)
Sisoridae	= 23.5% (4)	Aorichthys	= 25.0% (1)
Siluridae	= 11.7% (2)	Batasio	= 25.0% (1)
Schilbeidae	= 11.7% (2)	Sisoridae:	
Amblycipitidae	= 5.9% (1)	Glyptothorax	= 75.0% (3)
Heteropneustidae	= 5.9% (1)	Pseudecheneis	= 25.0% (1)
Chacidae	= 5.9% (1)		
Olyridae	= 5.9% (1)		

Endemic species:

Aborichthys garoensis Hora  
 Lepidocephalus menoni (Pillai & Yazdani)  
 Pillaia indica Yazdani  
 Puntius shalynius Yazdani & Talukdar.

two other families Psilorhynchidae and Homalopteridae were represented by only one species each comprising a percentage of only 2.0%. In the dominant family Cyprinidae, it was observed that the maximum number of genera, 13 were observed. They were Puntius, Labeo, Barilius, Garra, Danio, Chela, Cirrhina, Tor, Acrossocheilus, Amblypharyngodon, Catla, Chagunius, and Crossocheilus. Of these Puntius, Labeo and Barilius comprised of 7, 6 and 6 numbers of species and with 17.9%, 15.4% and 15.4% percentages respectively. These were followed by Garra and Danio with 5 and 4 species forming relative percentages of 12.8% and 10.2% respectively of all the genera of the family Cyprinidae. All the other 8 genera were represented by less than 4 species each and relative percentages of less than 6.0%.

The next order which was dominant in Meghalaya after Cypriniformes was Siluriformes comprising of 9 families of which the families Bagridae and Sisoridae were dominant. They comprised of 4 species each and with a relative percentage of 23.5%. These were followed by Siluridae and Schilbeidae with 2 species each and formed 11.7%. All the other 5 families were represented by a single species and made up of a relative percentage of 5.9% only. The dominant families Bagridae and Sisoridae comprised of 3 and 2 genera respectively, while the genus Mystus with 2 species formed 50.0% being the dominant genus in the family Bagridae. The genus Glyptothorax with 3 species formed the dominant genus in the family Sisoridae with a relative percentage of 75.0%. All the other genera in both

the families were represented by only one species each and formed a relative percentage of 25.0%. Of the 86 species, 4 species belonging to 3 genera were endemic to this state.

### Mizoram

Fish fauna of Mizoram was represented by 53 species under 34 genera, 18 families, 8 orders and 4 superorders of the sub class Actinopterygii (Table 12). Of these, 50 species representing 31 genera, 16 families and 7 orders and the same number of superorders were observed in the present investigation. The orders in the present investigation as well as those of other works, were Cypriniformes, Siluriformes, Perciformes, Channiformes, Mastacembeliformes, Atheriniformes and Osteoglossiformes. Of these the order Cypriniformes comprised of 28 species, forming a relative percentage of 56.0%, followed by Siluriformes with 7 species and made up of 14.0%. The third order in importance was Perciformes with 6 species formed only 12% of all the orders. All the other 4 orders were represented by less than 5 species each and relative percentages of less than 10.0% (Table 13).

The dominant family Cyprinidae with 24 species formed a relative percentage of 85.7% of all the families of the order Cypriniformes, followed by the family Cobitidae comprising of 3 species and forming a percentage of 10.7%. The last family Psilorhynchidae was represented by only one species, with a relative percentage of only 3.6%. Among the family Cyprinidae,

Table 12 : Checklist of fishes of Mizoram.

TABLE-12

S.No.	Species Name	S.No.	Species Name
Notopteridae:		Bagridae:	
1.	<i>Notopterus chitala</i> (Hamilton)	32.	<i>Mystus tengara</i> (Hamilton)
2.	<i>Notopterus notopterus</i> (Pallas)	Schilbeidae:	
Cyprinidae:		33.	<i>Clupiosoma garua</i> (Hamilton)
3.	<i>Chela cachius</i> (Hamilton)	Sisoridae:	
4.	<i>Barilius barna</i> (Hamilton)	34.	<i>Exostoma labiatum</i> (Mc Clelland)
5.	<i>Barilius barila</i> (Hamilton)	35.	<i>Glyptothorax telchitta</i> (Hamilton)
6.	<i>Barilius bendelisis</i> (Hamilton)	Clariidae:	
7.	<i>Barilius bola</i> (Hamilton)	36.	<i>Clarias batrachus</i> (Linnaeus)
8.	<i>Barilius vagra</i> (Hamilton)	Heteropneustidae:	
9.	<i>Danio</i> ( <i>Danio</i> ) <i>aequipinnatus</i> (Mc Clelland)	37.	<i>Heteropneustes fossilis</i> (Bloch)
10.	<i>Danio</i> ( <i>Danio</i> ) <i>dangila</i> (Hamilton)	Olyridae:	
11.	<i>Danio</i> ( <i>Brachydanio</i> ) <i>rerio</i> (Hamilton)	38.	<i>Olyra longicaudata</i> (Mc Clelland)
12.	<i>Acrossocheilus hexagonolepis</i> (Mc Clelland)	Cyprinodontidae:	
13.	<i>Amblypharyngodon mola</i> (Hamilton)	39.	<i>Orizias melastigma</i> (Mc Clelland)
14.	<i>Crossocheilus latius latius</i> (Hamilton)	Belonidae:	
15.	<i>Garra gotyla gotyla</i> (Gray)	40.	<i>Xenentodon cancila</i> (Hamilton)
16.	<i>Garra lamta</i> (Hamilton)	Channidae:	
17.	<i>Garra nasuta</i> (Mc Clelland)	41.	<i>Channa orientalis</i> Schneider.
18.	<i>Labeo bata</i> (Hamilton)	42.	<i>Channa punctata</i> (Bloch)
19.	<i>Labeo dero</i> (Hamilton)	43.	<i>Channa striatus</i> (Bloch)
20.	<i>Puntius chola</i> (Hamilton)	Symbranchidae:	
21.	<i>Puntius clavatus</i> (Mc Clelland)	44.	<i>Monopterus alba</i> (Zuiew)
22.	<i>Puntius phutunio</i> (Hamilton)	Nandidae:	
23.	<i>Puntius ticto</i> (Hamilton)	45.	<i>Badis badis</i> (Hamilton)
24.	<i>Semiplotus semiplotus</i> (Mc Clelland)	46.	<i>Nandus nandus</i> (Hamilton)
25.	<i>Tor putitora</i> (Hamilton)	Gobiidae:	
26.	<i>Tor tor</i> (Hamilton)	47.	<i>Glossogobius gutum</i> (Hamilton)
Psilorhynchidae:		Anabantidae:	
27.	<i>Psilorhynchus balitora</i> (Hamilton)	48.	<i>Anabas testudineus</i> Bloch
Cobitidae:		49.	<i>Colisa fasciata</i> (Schneider)
28.	<i>Botia dario</i> (Hamilton)	50.	<i>Colisa laia</i> (Hamilton)
29.	<i>Lepidocephalus guntea</i> (Hamilton)	Mastacembelidae:	
30.	<i>Noemacheilus botia</i> (Hamilton)	51.	<i>Mastacembelus armatus</i> Lacepede
31.	<i>Noemacheilus rupecola rupecola</i> (Mc Clelland)	52.	<i>Mastacembelus puncalus</i> (Hamilton)
		53.	<i>Macrognathus aculeatus</i> (Bloch)

Table 13 : Relative abundances of fishes in Mizoram recorded in the present study with numbers in parentheses.

TABLE-13

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Cypriniformes	=56.0%(28)	<u>Cyprinidae:</u>	
Siluriformes	=14.0%(7)	Barilius	= 20.8%(5)
Perciformes	=12.0% (6)	Puntius	= 16.7%(4)
Channiformes	= 6.0% (3)	Danio	= 12.5%(3)
Mastacembeliformes	= 6.0% (3)	Garra	= 12.5%(3)
Atheriniformes	= 4.0% (2)	Labeo	= 8.3%(2)
Osteoglossiformes	= 2.0% (1)	Tor	= 8.3%(2)
		Chela	= 4.2% (1)
<u>Cypriniformes</u>		Acrossocheilus	= 4.2% (1)
Cyprinidae	=85.7%(24)	Amblypharyngodon	= 4.2% (1)
Cobitidae	=10.7%( 3)	Crossocheilus	= 4.2% (1)
Psilorhynchidae	= 3.6% (1)	Semiplotus	= 4.2% (1)
<u>Siluriformes:</u>		<u>Sisoridae:</u>	
Sisoridae	= 28.5% (2)	Exostoma	= 50.0%(1)
Bagridae	= 14.3% (1)	Glyptothorax	= 50.0%(1)
Clariidae	= 14.3% (1)		
Heteropneustidae	= 14.3% (1)		
Schilbeidae	= 14.3% (1)		
Olyridae	= 14.3% (1)		

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it was observed that the maximum genera of 11 in numbers occurred. They were Barilius, Puntius, Danio, Garra, Labeo, Tor, Chela, Acrossocheilus, Amblypharyngodon, Crossocheilus and Semiplotus. Of these Barilius and Puntius comprised of the dominant genera with 5 and 4 species and 20.8% and 16.7% respectively, followed by Danio and Garra with 3 species each, comprising of a relative abundance of 12.5%. All the other genera were represented by less than 3 species and their percentages were also less than 10%.

The next order which was dominant after Cypriniformes was Siluriformes which comprised of 6 families, of which the family Sisoridae formed the dominant family with only 2 species and with a relative percentage of 28.5%. All the other 5 families comprised of a single species each and with a relative percentage of 14.3% only. The dominant family Sisoridae when further broken down composed of only 2 genera, Glyptothorax and Exostoma, both were represented by only a single species. The present investigation did not record any endemic species of fish from the Union Territory of Mizoram.

#### Nagaland

Nagaland's fish fauna comprised of 90 species, representing 46 genera, 20 families, 8 orders and 4 superorders of the sub class Actinopterygii. However, our collections consisted of 85 species and 45 genera representing all the families, orders and superorders (Table 14). The orders that were representative

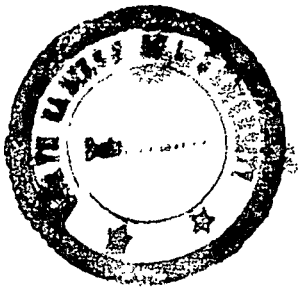


Table 14 : Checklist of fishes of Nagaland state.

TABLE-14

S.No.	Species name	S.No.	Species name
<b>Notopteridae:</b>			
1.	<i>Notopterus chitala</i> (Hamilton)	51.	<i>Noemacheilus manipurensis</i> Chaudhuri
2.	<i>Notopterus notopterus</i> (Pallas)	52.	<i>Noemacheilus prashadi</i> Hora
<b>Cyprinidae:</b>		53.	<i>Noemacheilus rupecola rupecola</i> (Hamilton)
3.	<i>Chela cachius</i> (Hamilton)	54.	<i>Noemacheilus rupecola inglisi</i> Hora
4.	<i>Chela laubuca</i> (Hamilton)	55.	<i>Noemacheilus sikmaiensis</i> Hora
5.	<i>Barilius barila</i> (Hamilton)	56.	<i>Noemacheilus subfusca</i> (Mc Clelland)
6.	<i>Barilius barna</i> (Hamilton)	57.	<i>Noemacheilus zonalternans</i> (Blyth)
7.	<i>Barilius bendelis</i> (Hamilton)	58.	<i>Somleptes gongota</i> (Hamilton)
8.	<i>Barilius bola</i> (Hamilton)	<b>Bagridae:</b>	
9.	<i>Barilius guttatus</i> (Day)	59.	<i>Batasio tengana</i> (Hamilton)
10.	<i>Barilius shacra</i> (Hamilton)	60.	<i>Mystus bleekeri</i> (Day)
11.	<i>Barilius vagra</i> (Hamilton)	61.	<i>Mystus cavasius</i> (Hamilton)
12.	<i>Danio</i> ( <i>Danio</i> ) <i>aequipinnatus</i> (Mc Clelland)	<b>Siluridae:</b>	
13.	<i>Danio</i> ( <i>Danio</i> ) <i>dangila</i> (Hamilton)	62.	<i>Ompak bimaculatus</i> (Bloch)
14.	<i>Danio</i> ( <i>Danio</i> ) <i>naganensis</i> Chaudhuri	63.	<i>Ompak pabo</i> (Hamilton)
15.	<i>Danio</i> ( <i>Brachydanio</i> ) <i>dangila</i> (Hamilton)	64.	<i>Ompak pabda</i> (Hamilton)
16.	<i>Danio</i> ( <i>Brachydanio</i> ) <i>rerio</i> (Hamilton)	65.	<i>Silurus cochinchinensis</i> Valenciennes
17.	<i>Esomus danricus</i> (Hamilton)	<b>Amblycepididae:</b>	
18.	<i>Rasbora rasbora</i> (Hamilton)	66.	<i>Amblyceps mangois</i> (Hamilton)
19.	<i>Acrossocheilus hexagonolepis</i> (Mc Clelland)	<b>Sisoridae:</b>	
20.	<i>Chagunius chagunio</i> (Hamilton)	67.	<i>Conta conta</i> (Hamilton)
21.	<i>Crossocheilus latius latius</i> (Hamilton)	68.	<i>Euchiloglanis hodgarti</i> (Hora)
22.	<i>Garra gotyla gotyla</i> (Gray)	69.	<i>Exostoma labiatum</i> (Mc Clelland)
23.	<i>Garra kempfi</i> Hora	70.	<i>Glyptothorax cavia</i> (Hamilton)
24.	<i>Garra lissorhynchus</i> (Mc Clelland)	71.	<i>Glyptothorax platypogonoides</i> (Bleek)
25.	<i>Garra naganensis</i> Hora	72.	<i>Glyptothorax trilineatus</i> Blyth
26.	<i>Garra nasuta</i> (Mc Clelland)	73.	<i>Pseudecheneis sulcatus</i> (Mc Clelland)
27.	<i>Garra rupecula</i> (Mc Clelland)	<b>Clariidae:</b>	
28.	<i>Labeo boqa</i> (Hamilton)	74.	<i>Clarias batrachus</i> (Linnaeus)
29.	<i>Labeo gonius</i> (Hamilton)	<b>Heteropneustidae:</b>	
30.	<i>Labeo calbasu</i> (Hamilton)	75.	<i>Heteropneustes fossilis</i> (Bloch)
31.	<i>Osteobrama belangeri</i> (Valenciennes)	<b>Chacidae:</b>	
32.	<i>Puntius clavatus</i> (Mc Clelland)	76.	<i>Chaca chaca</i> (Hamilton)
33.	<i>Puntius conchonus</i> (Hamilton)	<b>Olyridae:</b>	
34.	<i>Puntius phutunio</i> (Hamilton)	77.	<i>Olyra longicaudata</i> (Mc Clelland)
35.	<i>Puntius sarana sarana</i> (Hamilton)	<b>Belonidae:</b>	
36.	<i>Puntius ticto</i> (Hamilton)	78.	<i>Xenentodon cancila</i> (Hamilton)
37.	<i>Schizothorax richardsonii</i> (Gray)	<b>Channidae:</b>	
38.	<i>Semiplotus semiplotus</i> (Mc Clelland)	79.	<i>Channa orientalis</i> Schneider
39.	<i>Tor putitora</i> (Hamilton)	80.	<i>Channa punctata</i> (Bloch)
40.	<i>Tor tor</i> (Hamilton)	81.	<i>Channa striatus</i> (Bloch)
<b>Psilorhynchidae:</b>		<b>Symbranchidae:</b>	
41.	<i>Psilorhynchus balitora</i> (Hamilton)	82.	<i>Amphipnous cuchia</i> (Hamilton)
42.	<i>Psilorhynchus homaloptera</i> Hora & Mukerji	<b>Nandidae:</b>	
43.	<i>Psilorhynchus sucatio</i> (Hamilton)	83.	<i>Badis badis</i> (Hamilton)
<b>Homalopteridae:</b>		<b>Gobiidae:</b>	
44.	<i>Balitora brucei</i> Gray	84.	<i>Glossogobius gutum</i> (Hamilton)
<b>Cobitidae:</b>		<b>Anabantidae:</b>	
45.	<i>Acanthopthalmus pangia</i> (Hamilton)	85.	<i>Anabas testudineus</i> Bloch
46.	<i>Botia berdmorei</i> (Blyth)	86.	<i>Colisa fasciata</i> (Schneider)
47.	<i>Botia histrionica</i> Blyth	87.	<i>Colisa sota</i> (Hamilton)
48.	<i>Lepidocephalus berdmorei</i> Blyth	<b>Mastacembelidae:</b>	
49.	<i>Noemacheilus botia</i> (Hamilton)	88.	<i>Mastacembelus armatus</i> Lacepede.
50.	<i>Noemacheilus kangjupkhulensis</i> Hora	89.	<i>Mastacembelus puncalus</i> (Hamilton)
		90.	<i>Macrognaathus aculeatus</i> (Bloch)

of the fish fauna of Nagaland were Cypriniformes, Siluriformes, Perciformes, Channiformes, Mastacembeliformes, Osteoglossiformes, Symbranchiiformes and Atheriniformes. Of these the order Cypriniformes comprised of 52 species forming 61.2% followed by Siluriformes with only 18 species and formed a relative percentage of 21.2% among all the orders. Perciformes came next in the order of dominance with only 5 species and formed 5.9%. All the other 5 orders were comprised of less than 4 species each and some with only one species and moreover their percentages were all below 5% (Table 15).

Since Cypriniformes formed the dominant order it is only reasonable to see the dominant families under this order, and when so done the family Cyprinidae was made up of the largest number of species, 37, and made up of 71.1% of all the families. This was followed by the family Cobitidae representing 11 species and forming 21.2% of all the families of the order Cypriniformes, while Psilorhynchidae comprised of 3 species showed a relative percentage of 5.8%. The fourth family Homalopteridae with only one species made up of only 1.9%. The family Cyprinidae, which was dominant under the order Cypriniformes comprised of a maximum of 14 genera. They were Barilius, Garra, Danio, Puntius, Labeo, Chela, Tor, Esomus, Rasbora, Acrossocheilus, Chagunius, Crossocheilus, Osteobrama and Semiplotus. Of these Barilius, Garra, Danio and Puntius comprised of the dominant genera with 7, 6, 5 and 5 numbers of species and 18.9%, 16.2%, 13.6% and 13.6% respectively. These

Table 15 : Relative abundances of fishes in Nagaland state recorded in the present study with numbers in Parentheses.

TABLE - 15

Cypriniformes	= 61.2% (52)	Cyprinidae:	
Siluriformes	= 21.2% (18)	Barilius	= 18.9% (7)
Perciformes	= 5.9% (5)	Garra	= 16.2% (6)
Channiformes	= 3.5% (3)	Danio	= 13.6% (5)
Mastacembeliformes	= 3.5% (3)	Puntius	= 13.6% (5)
Osteoglossiformes	= 2.3% (2)	Labeo	= 8.1% (3)
Symbranchiformes	= 1.2% (1)	Chela	= 5.4% (2)
Atheriniformes	= 1.2% (1)	Tor	= 5.4% (2)
		Acrossocheilus	= 2.7% (1)
<u>Cypriniformes:</u>		<b>Chagunius</b>	= 2.7% (1)
<u>Cyprinidae</u>	= 71.1% (37)	Crossocheilus	= 2.7% (1)
Cobitidae	= 21.2% (11)	Esomus	= 2.7% (1)
Psilorhynchidae	= 5.8% (13)	Rasbora	= 2.7% (1)
Homalopteridae	= 1.9% (1)	Osteobrama	= 2.7% (1)
		Semiplotus	= 2.7% (1)

Siluriformes:

Sisoridae	= 33.3% (6)
Siluridae	= 22.2% (4)
Bagridae	= 16.5% (3)
Clariidae	= 5.6% (1)
Heteropneustidae	= 5.6% (1)
Chacidae	= 5.6% (1)
Olyridae	= 5.6% (1)

Sisoridae:

Glyptothorax	= 33.2% (2)
Conta	= 16.7% (1)
Euchiloglanis	= 16.7% (1)
Exostoma	= 16.7% (1)
Pseudocheneis	= 16.7% (1)

## Endemic species:

Danio (Brachydanio) acuticephala Hora  
 Danio (Danio) naganensis Chaudhuri  
 Garra naganensis Hora  
 Psilorhynchus homaloptera Hora & Mukerji.

were followed by the 10 other genera which were represented by less than 5 species and also less than 6.0%.

The next order which was dominant after Cypriniformes was Siluriformes which comprised of 8 families of which the family Sisoridae formed the dominant family, with 6 species and a relative percentage of 33.3% of all the families. This was followed by the families Siluridae and Bagridae comprising 4 and 3 species and made up of 22.2% and 16.5% respectively. All the other 5 families were represented by only one species each and their relative percentages were only 5.6%. The dominant family Sisoridae comprised of 5 genera. They were Glyptothorax, Euchiloglanis, Conta, Exostoma and Pseudecheneis. Of these the genus Glyptothorax was dominant, with only 2 species and a relative percentage of 33.2%, followed by all the other 4 genera which comprised of only a single species each and formed only 16.7%. Only four species of fishes belonging to 3 genera were found to be endemic to the state of Nagaland though many of the forms of the state had confined to Naga Hills and Manipur state only.

#### Patterns of Distribution

After a detailed analysis of the above and with the help of a checklist and updating from our present collection, the presence and absence of species for the whole North East, it was felt to look at the distribution of fishes without any consideration to the political boundaries. It was felt, therefore, best for such an analysis to map the occurrence of species, their

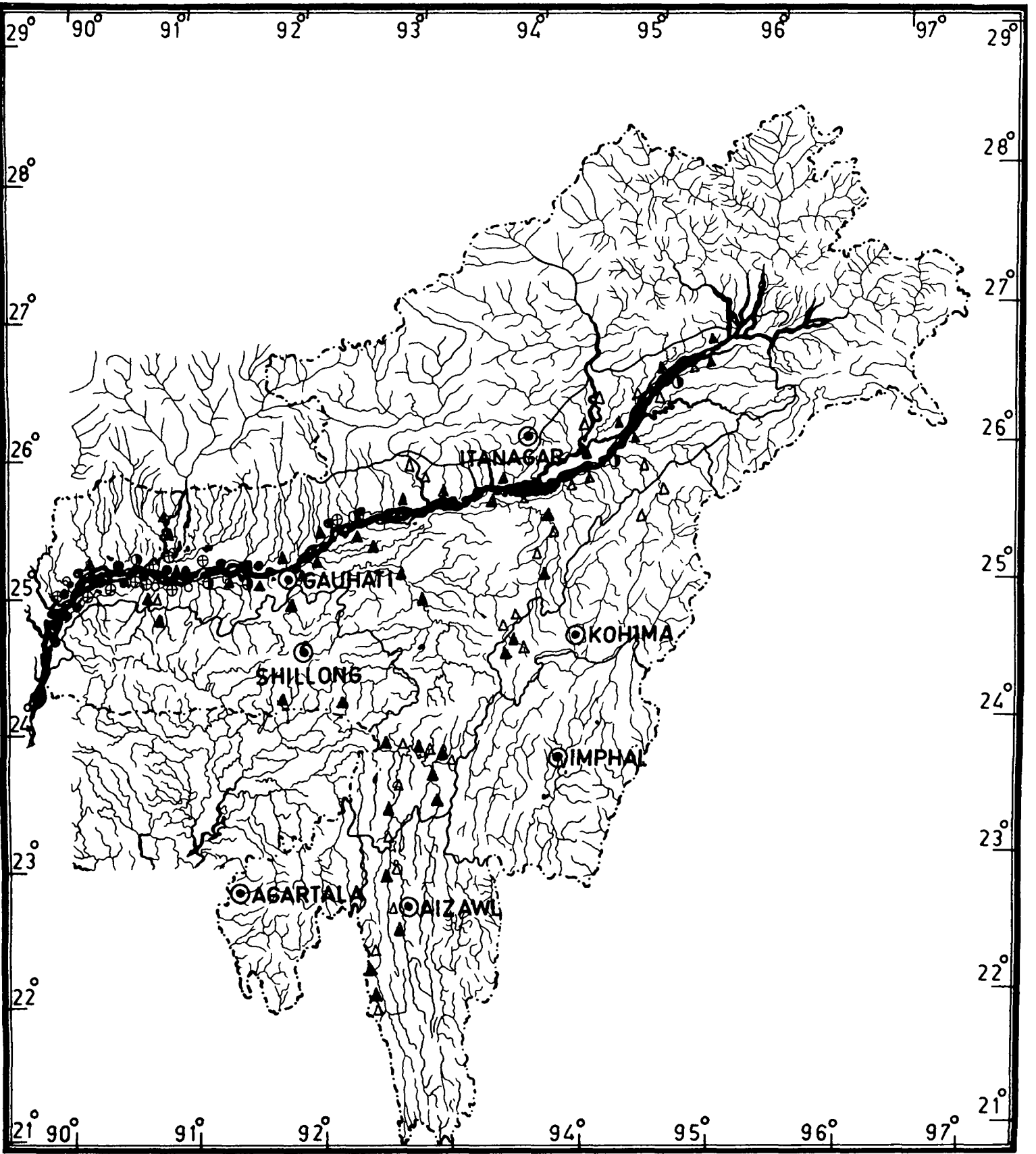
genera and orders based primarily on the drainage pattern of the study area undertaken. When so done it was seen that though an analogy could be formed between the earlier analysis with the political entities, yet the distribution is best understood for a detailed discussion on the watershed and the drainage in the individual States/Union Territories which would merge within each other without any clearcut boundary demarcation. The distribution in the present investigation is shown in the different drainage maps. Map II shows 4 genera, Hilsa, Gadusia, Setipinna and Notopterus and their three families, along with six species. The genera Chela, Oxygaster, Salmostoma under the family Cyprinidae are represented with their 5 species in Map IIIa, while the genus Barilius with 9 species in Map IIIb and the genus Danio with its 6 species is shown in Map IIIc. Similarly Map III d shows the distribution of 9 Cyprinid genera. They are Esomus, Rasbora, Acrossocheilus, Amblypharyngodon, Aspidoparia, Catla, Chagnius, Cirrhina and Crossocheilus with their 14 species while the genera Garra and Labeo with 8 species each are represented in the Maps IIIe & III f respectively. The distribution of Orêichthys, Osteobrama and Puntius genera are shown in the Map IIIg, with their 15 species. The last group of Cyprinid genera comprising of Schizothorax, Schizothraichthys, Semiplotus and Tor with 6 species are represented in Map IIIh. Psilorhynchus and Balitora, belonging to the families Psilorhynchidae and Homalopteridae respectively with 3 and 2 species are shown in Map IV. Maps Va and Vb show the distribution of 6 cobitid genera, 3 each, with 8 species in each map in

Map II: Distributional map of

- : *Hilsa ilisha* (Hamilton)
- ⊕ : *Gadusia chapra* (Hamilton)
- : *Gadusia variegata* (Day)
- ⊙ : *Setipinna phasa* (Hamilton)
- ▲ : *Notopterus chitala* (Hamilton)
- △ : *Notopterus notopterus* (Pallas)

in North-East India.

II

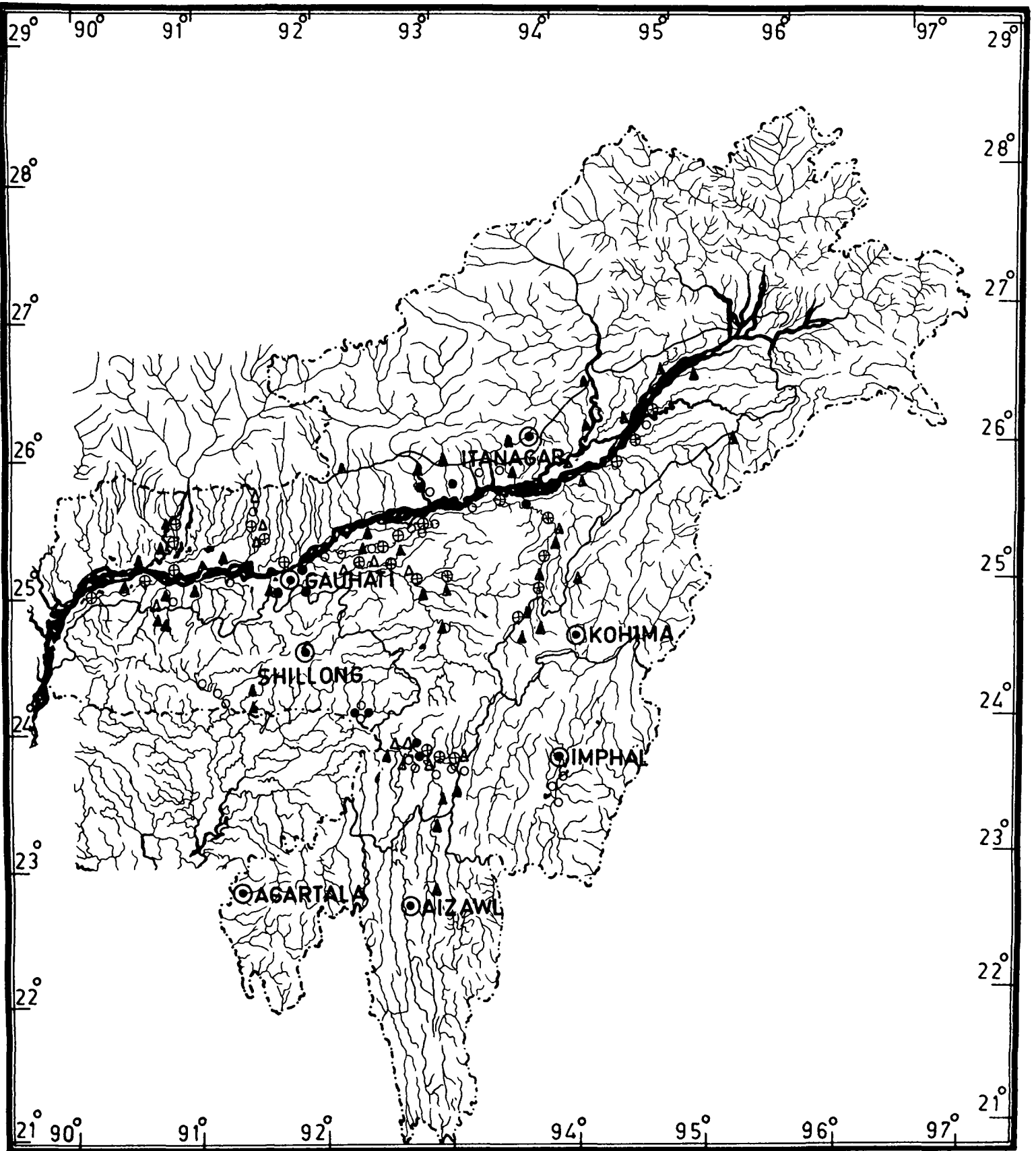


Map IIIa: Distributional map of

- ▲ : *Chela cachius* (Hamilton)
- : *Chela laubuca* (Hamilton)
- : *Oxygaster gora* (Hamilton)
- ⊕ : *Salmostoma bacaila* (Hamilton)
- Δ : *Salmostoma phulo phulo* (Hamilton)

in North-East India.

III a

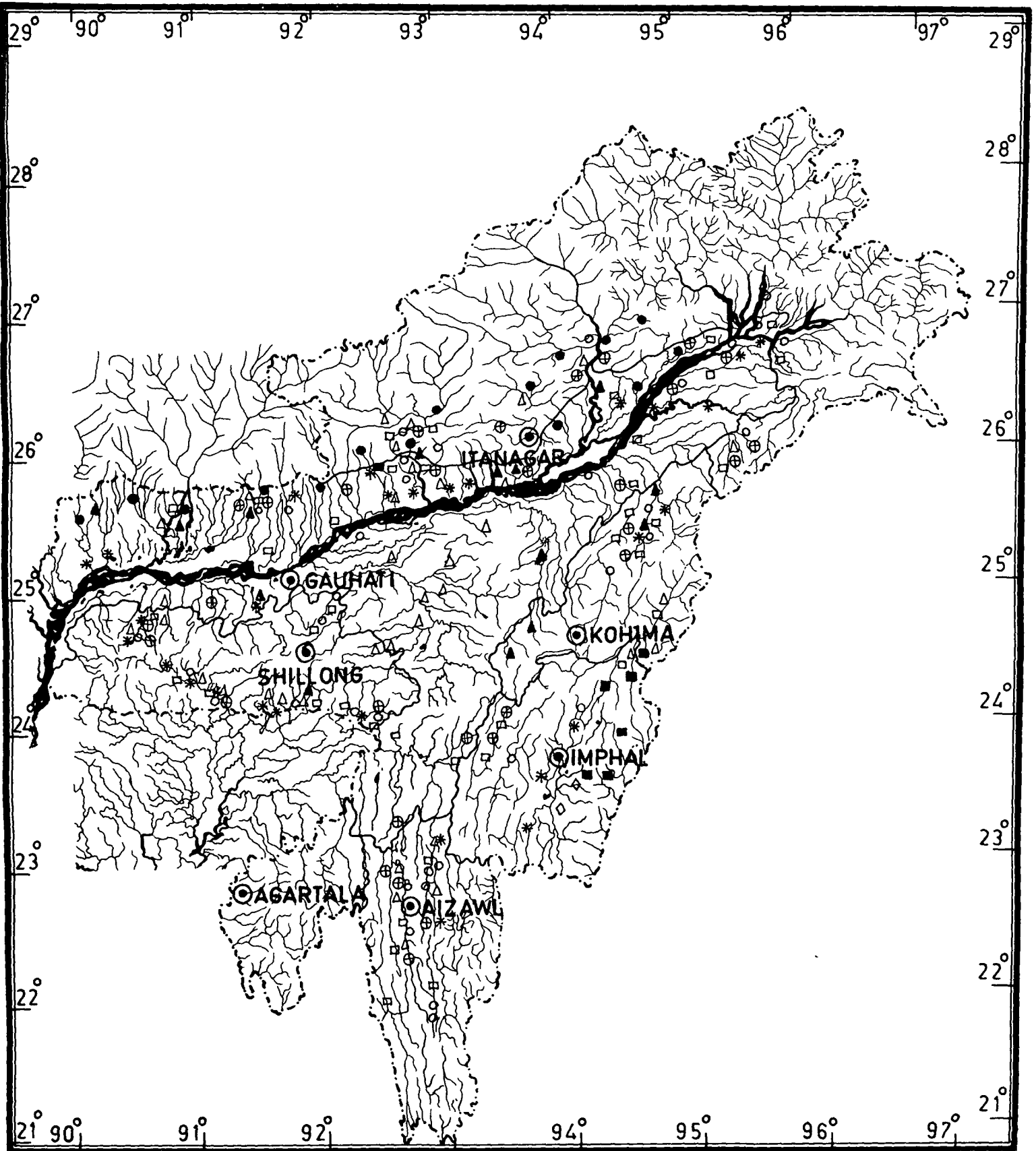


Map IIIb: Distributional map of

- \* : *Barilius barila* (Hamilton)
- Δ : *Barilius barna* (Hamilton)
- : *Barilius bola* (Hamilton)
- ◻ : *Barilius bendelisis* (Hamilton)
- ◇ : *Barilius dogarsinghi* Hora
- : *Barilius guttatus* (Day)
- ▲ : *Barilius shacra* (Hamilton)
- : *Barilius tileo* (Hamilton)
- ⊕ : *Barilius vagra* (Hamilton)

in North-East India.

III b

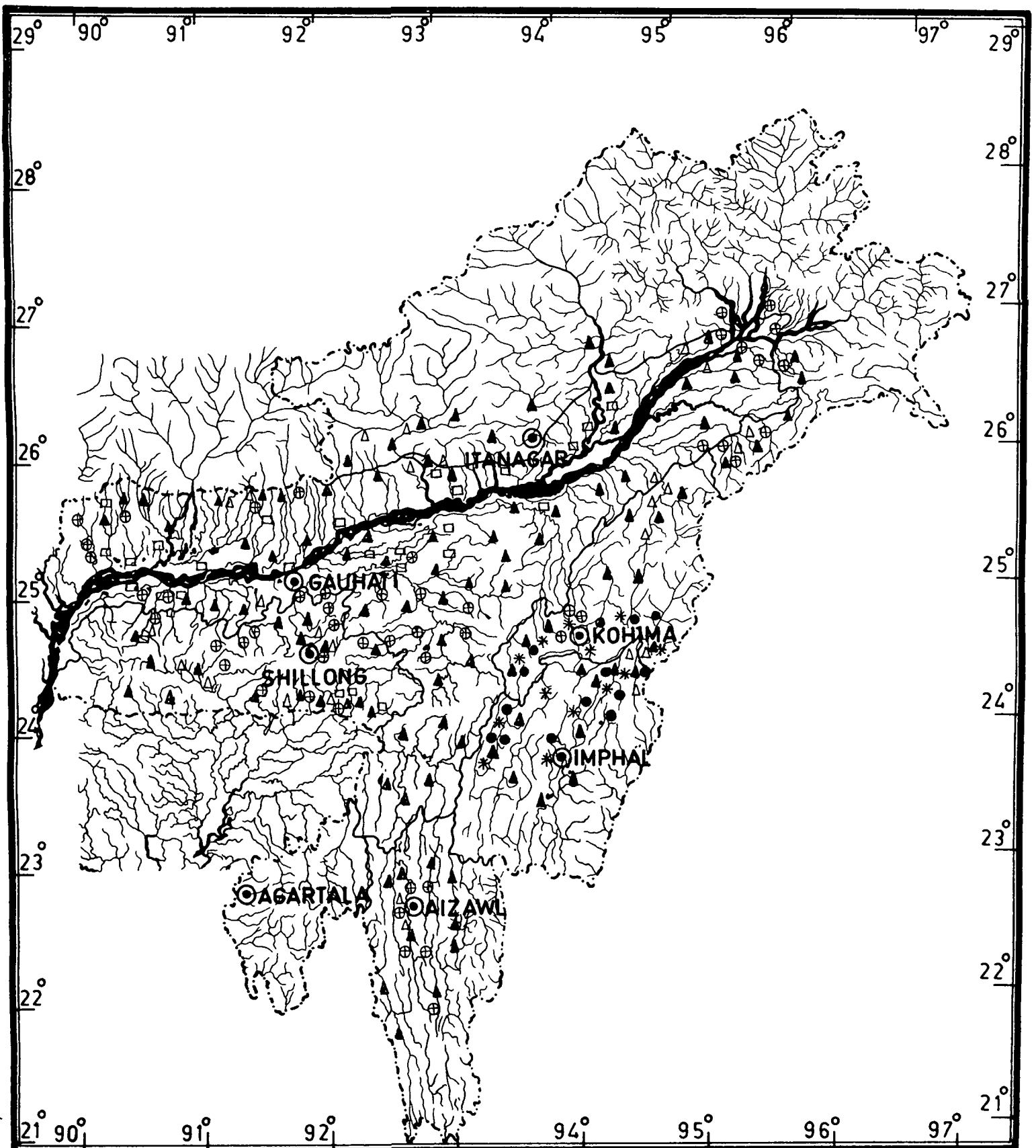


Map IIIc: Distributional map of

- ▲ : Danio (Danio) aequipinnatus  
(Mc Clelland)
- ⊙ : Danio (Danio) dangila (Hamilton)
- ◻ : Danio (Danio) devario (Hamilton)
- \* : Danio (Danio) naganensis Chaudhuri
- ⊕ : Danio (Brachydanio) rerio (Hamilton)
- : Danio (Brachydanio) acuticephala Hora

in North-East India.

III c

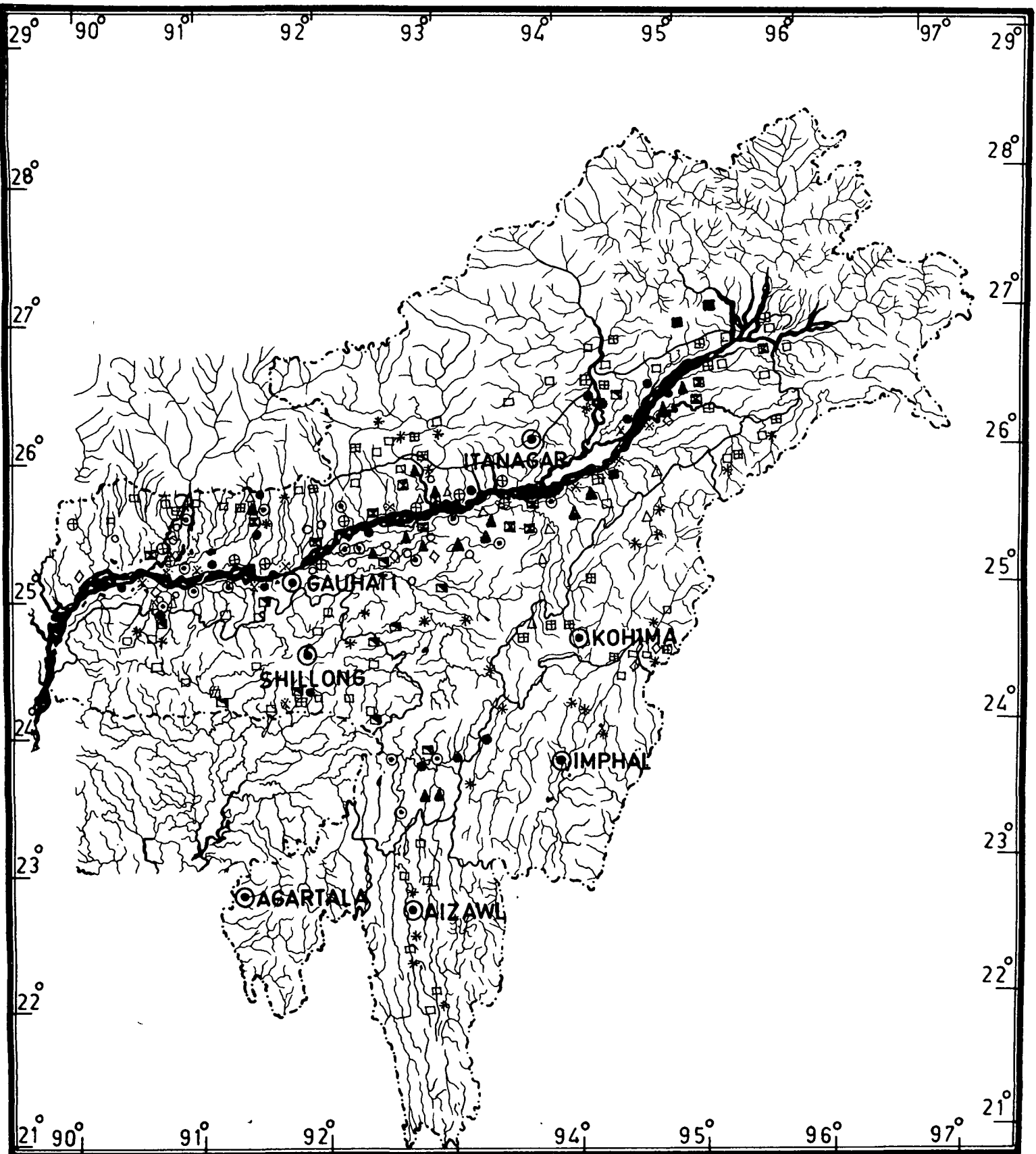


Map IIIId: Distributional map of

- △ : *Esomus danricus* (Hamilton)
- : *Rasbora daniconius* (Hamilton)
- ▲ : *Rasbora elonga* (Hamilton)
- : *Rasbora kobonensis* Chaudhuri
- ◇ : *Rasbora rasbora* (Hamilton)
- : *Acrossocheilus hexagonolepis*  
(Mc Clelland)
- ⊙ : *Amblypharyngodon mola* (Hamilton)
- ⊕ : *Aspidoparia jaya* (Hamilton)
- ⊞ : *Aspidoparia morar* (Hamilton)
- \* : *Catla catla* (Hamilton)
- ⊞ : *Chagunius chagunio* (Hamilton)
- : *Cirrhina mrigala* (Hamilton)
- ◻ : *Cirrhina reba* (Hamilton)
- \* : *Crossocheilus latius latius* (Hamilton)

in North-East India.

III d

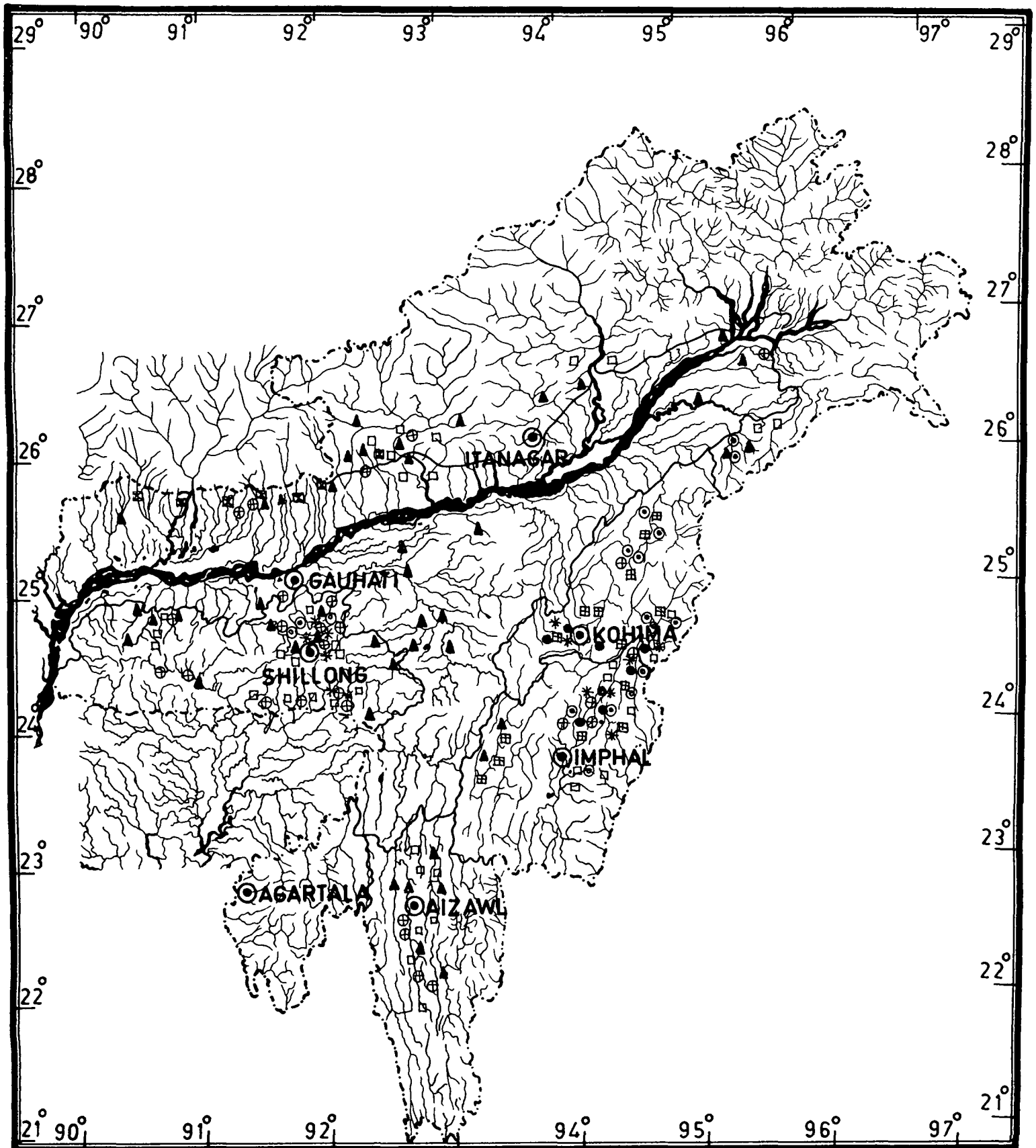


Map IIIe: Distributional map of

- : *Garra annandalei* Hora
- ⊕ : *Garra gotyla gotyla* (Gray)
- : *Garra kempfi* Hora
- \* : *Garra lissorhynchus* (Mc Clelland)
- △ : *Garra lamta* (Hamilton)
- ⊞ : *Garra naganensis* Hora.
- : *Garra nasuta* (Mc Clelland)
- ⊙ : *Garra rupecula* (Mc Clelland)

in North-East India.

III e

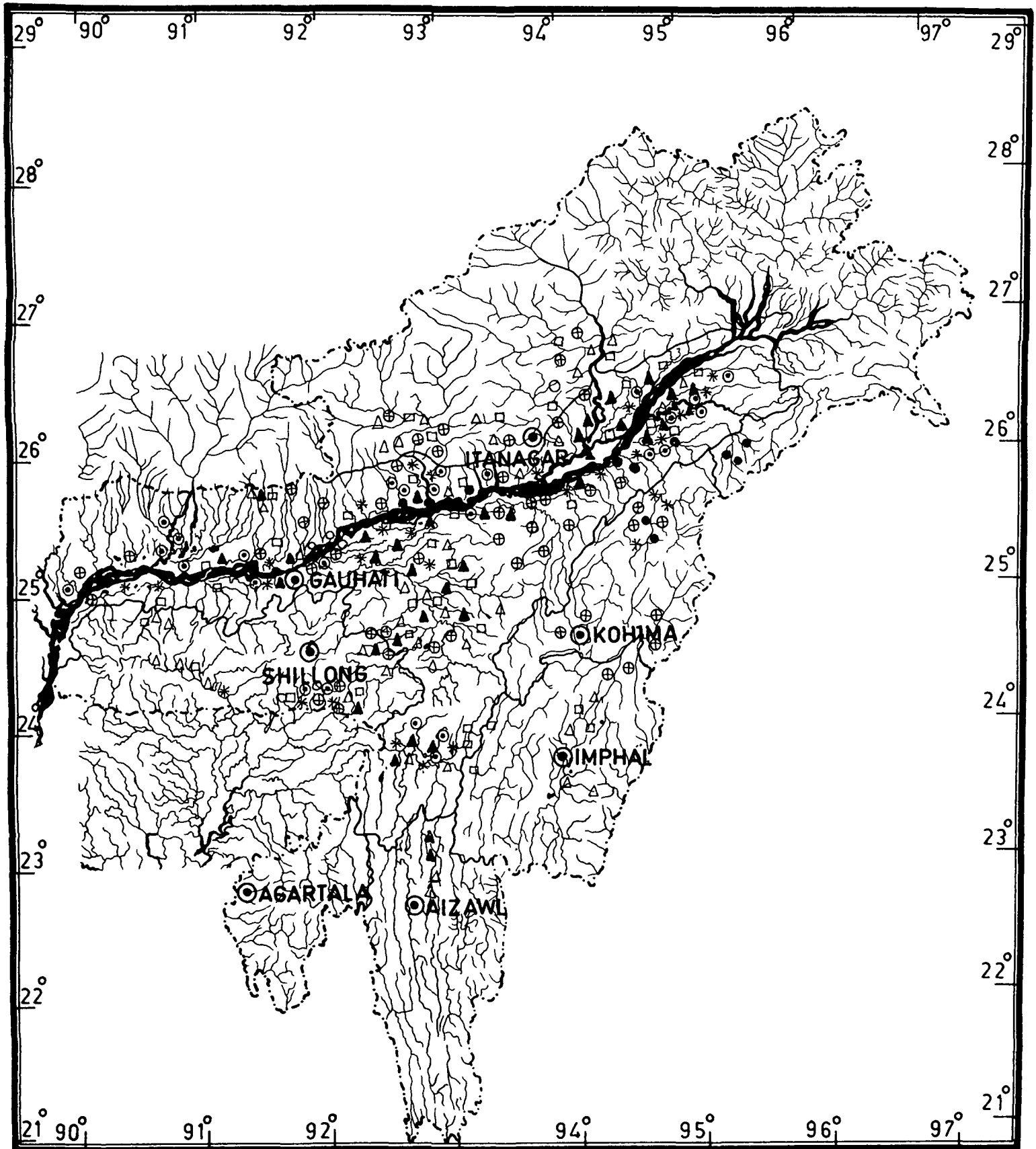


Map IIIf: Distributional map of

- ▲ : Labeo bata (Hamilton)
- : Labeo boga (Hamilton)
- \* : Labeo calbasu (Hamilton)
- △ : Labeo dero (Hamilton)
- ⊙ : Labeo gonius (Hamilton)
- : Labeo pangusia (Hamilton)
- : Labeo nandina (Hamilton)
- ◉ : Labeo rohita (Hamilton)

in North-East India.

III f

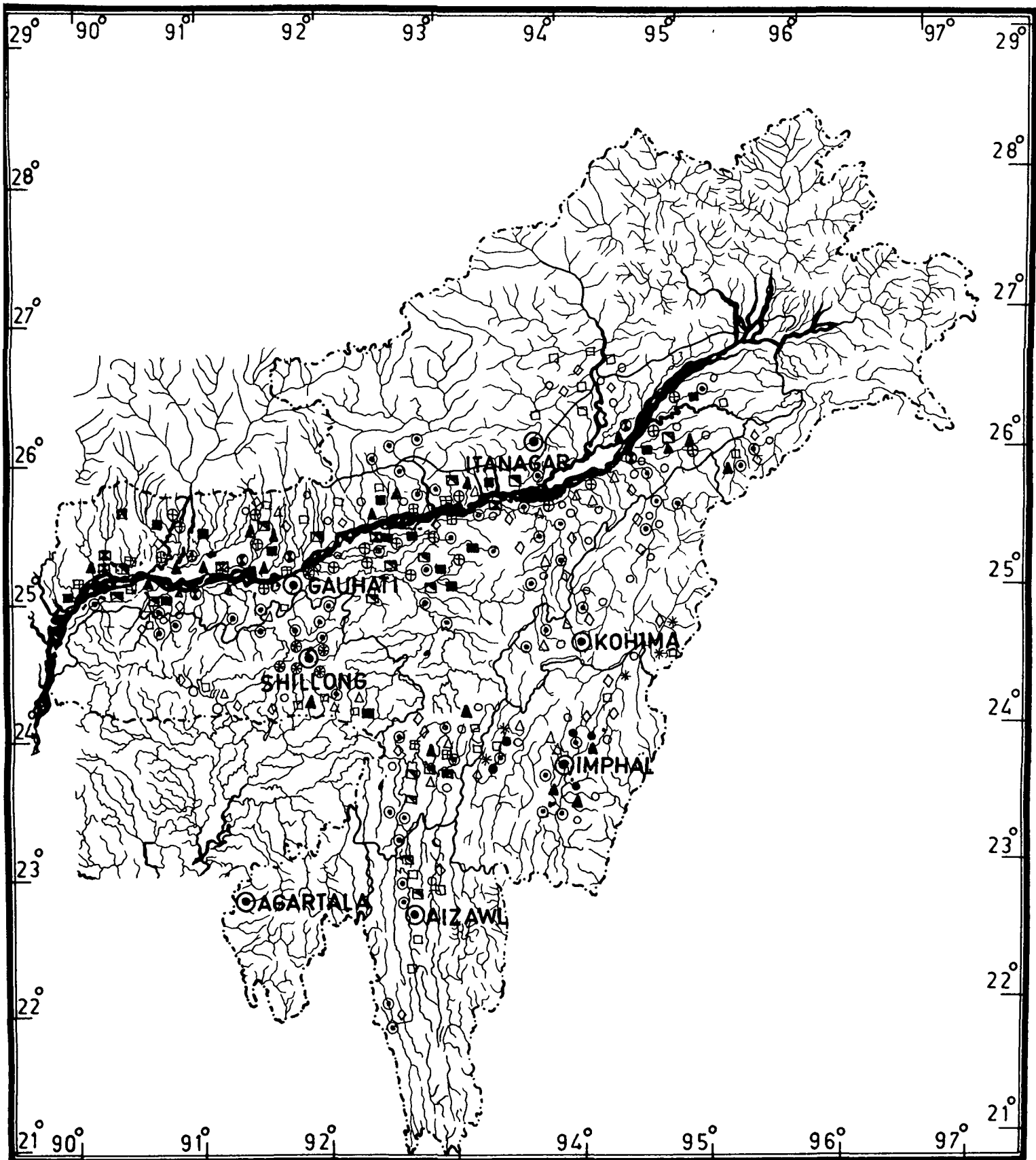


Map IIIg: Distributional map of

- ▣ : *Oreochthys cosuatis* (Hamilton)
- ⊕ : *Osteobrama cotio cotio* (Hamilton)
- : *Osteobrama cotio sunma* (Day)
- \* : *Osteobrama belangeri* (Valenciennes)
- ▣ : *Puntius cholā* (Hamilton)
- ▲ : *Puntius conchonus* (Hamilton)
- : *Puntius clavatus* (Mc Clelland)
- ▣ : *Puntius gelius* (Hamilton)
- ⊕ : *Puntius guganio* (Hamilton)
- ⊙ : *Puntius phutunio* (Hamilton)
- △ : *Puntius sarana sarana* (Hamilton)
- ⊕ : *Puntius shalynius* Yazdani & Talukdar
- : *Puntius sophore* (Hamilton)
- ◇ : *Puntius terio* (Hamilton)
- : *Puntius ticto* (Hamilton)

in North-East India.

III g

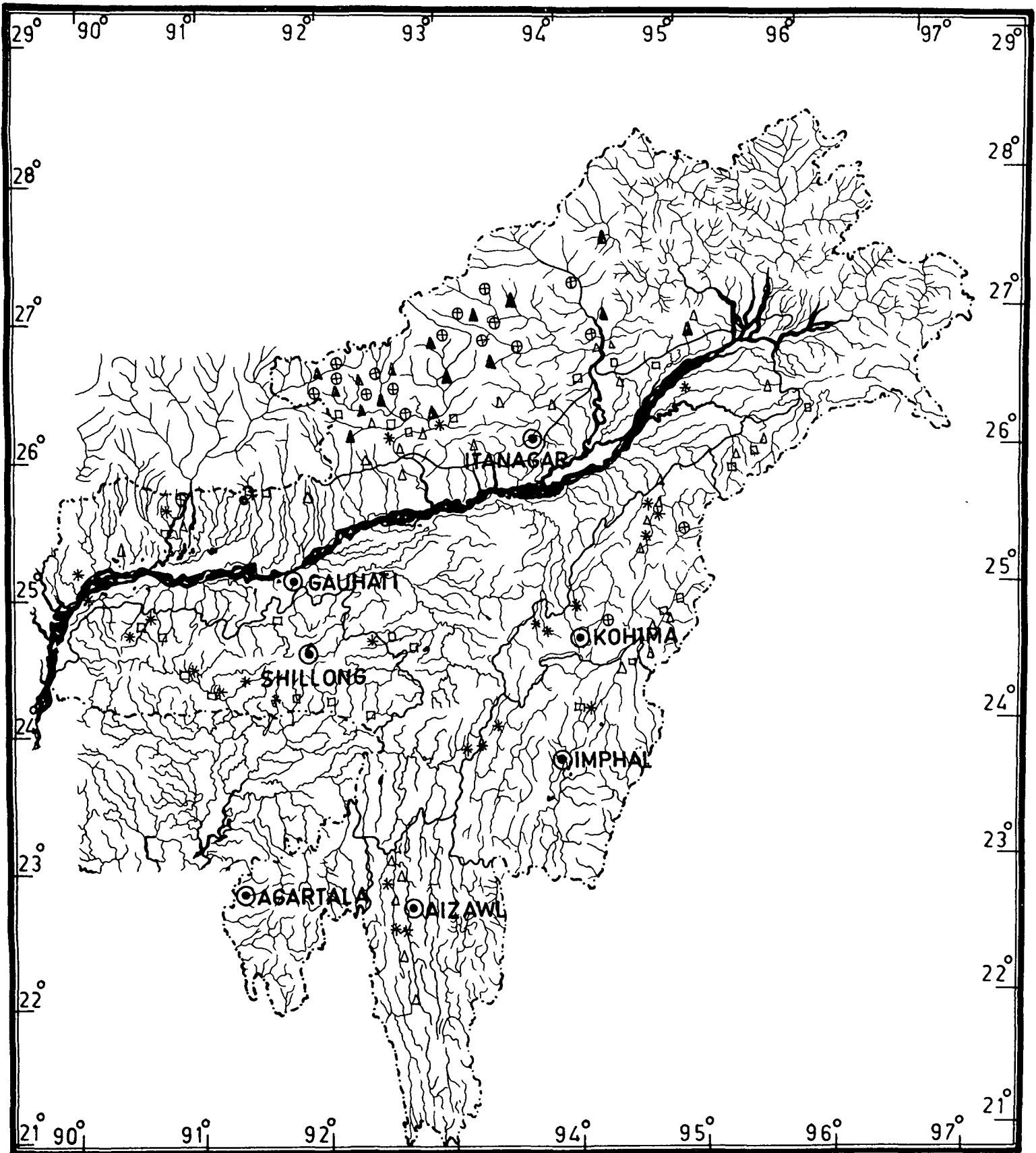


Map IIIh: Distributional map of

- ⊕ : Schizothorax richardsonii (Gray)
- ▲ : Schizothoraichthys progastus (Mc Clelland)
- △ : Semiplotus semiplotus (Mc Clelland)
- : Semiplotus gangulyi Dey
- \* : Tor putitora (Hamilton)
- : Tor tor (Hamilton)

in North-East India.

III h

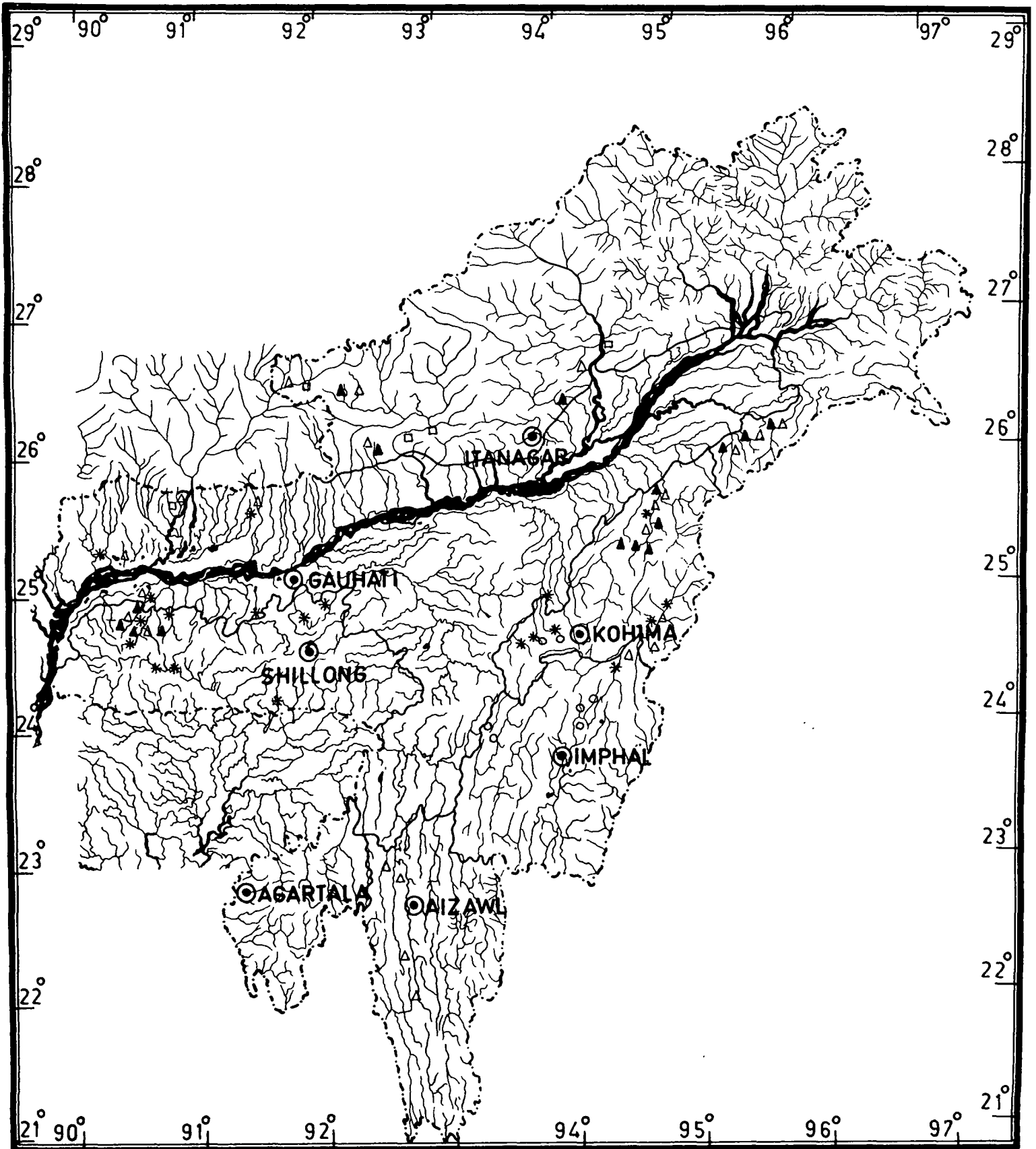


Map IV: Distributional map of ,

- ▲ : *Psilorhynchus balitora* (Hamilton)
- : *Psilorhynchus homaloptera* Hora & Mukerji
- △ : *Psilorhynchus sucatio* (Hamilton)
- \* : *Balitora brucei* Gray
- : *Balitora maculata* Gray

in North-East India.

IV

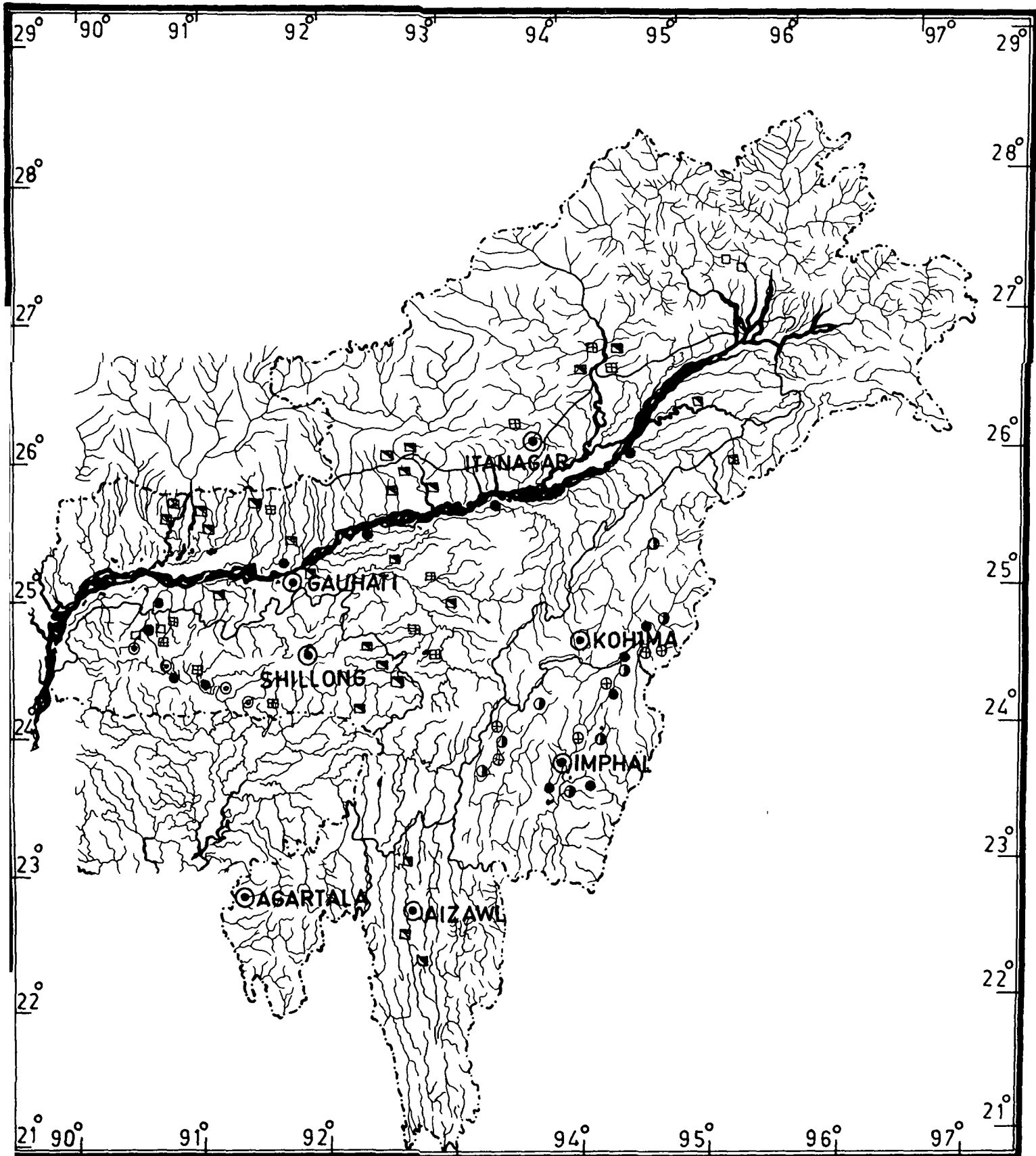


Map Va: Distributional map of

- : *Aborichthys elongatus* Hora
- : *Aborichthys garoensis* Hora
- : *Aborichthys kempfi* Chaudhuri
- : *Acanthopthalmus pangia* (Hamilton)
- ⊕ : *Botia berdmorei* (Blyth)
- : *Botia dario* (Hamilton)
- : *Botia histrionica* Blyth
- ⊞ : *Botia rostrata* Gunther

in North-East India.

Va

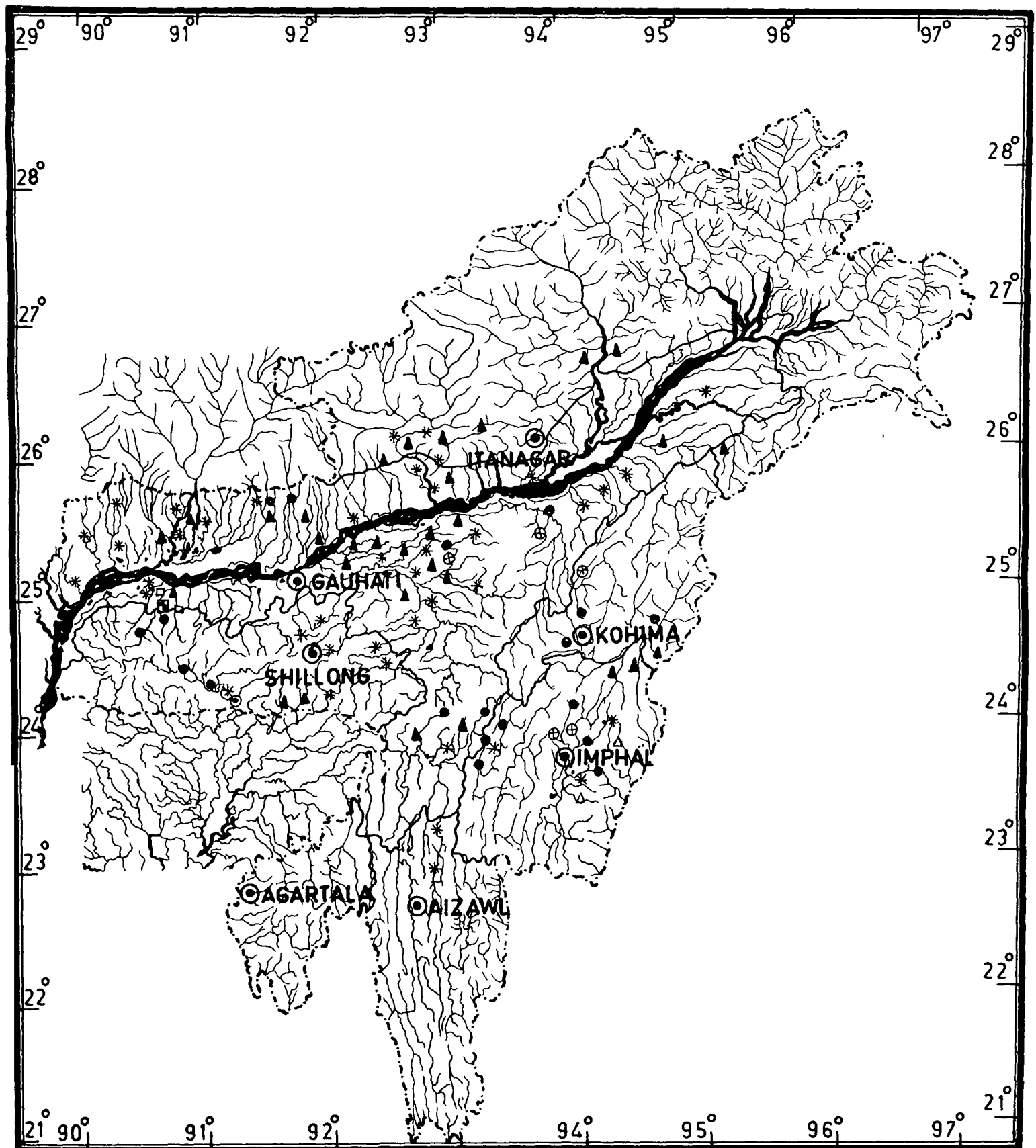


Map Vb: Distributional map of

- : *Lepidocephalus berdmorei* (Blyth)
- \* : *Lepidocephalus guntea* (Hamilton)
- ⊕ : *Lepidocephalus irrorata* (Hora)
- ⊙ : *Lepidocephalus menoni* (Pillai & Yazdani)
- : *Lepidocephalus goalparensis* (Pillai & Yazdani)
- △ : *Lepidocephalus burmanicus* Rendahl
- : *Neoeucirrhichthys maydelli* Banarescu & Nalbant
- ▲ : *Somileptes gongota* (Hamilton)

in North-East India.

Vb



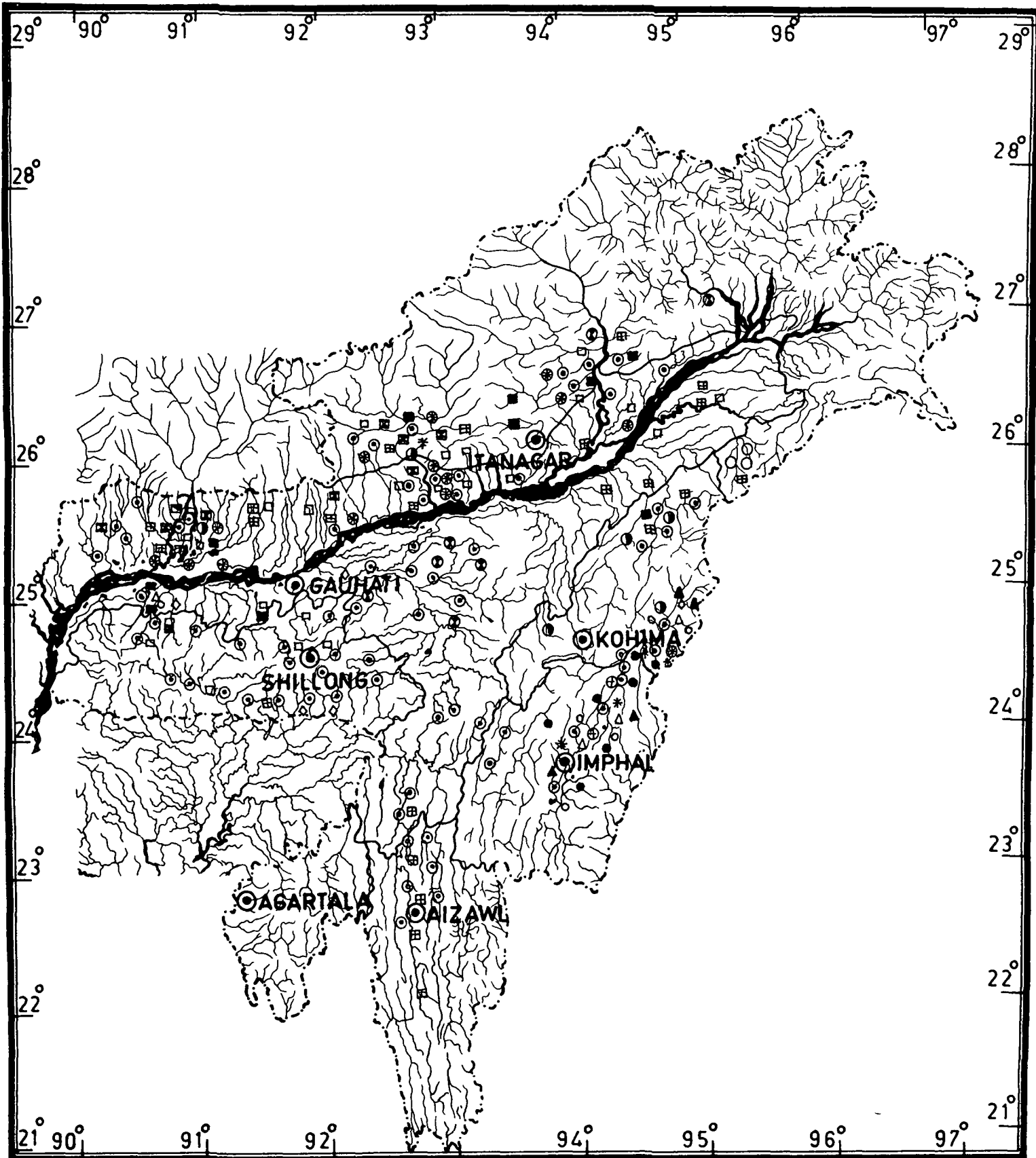
various drainages of North-East India while Vc represents the distribution of a single cobitid genus, Noemacheilus with its 16 species in various drainages of North-East India. Map VI shows the distribution of 4 genera belonging to the family Bagridae viz., Rita, Batasio, Mystus and Aorichthys with 11 species, while Map VII represents the distributional pattern of 8 genera, of which Ompak, Wallago and Silurus belong to the family Siluridae while Ailia, Pseudeutropius, Clupiosoma, Eutropiichthys and Silonia belong to the family Schilbeidae, with 10 species. 6 genera belonging to six families and with six species are shown in the Map VIII comprising of Pangasius, Amblyceps, Clarias, Heteropneustes, Chaca and Olyra. Map IXa shows the distribution of Bagarius, Conta, Erethistis, Erethistoides, Euchiloglanis, Exostoma, Hara, Pseudechneis and Sisor genera of Sisoridae with their 10 species, while 13 species of Sisorid fishes representing Glyptothorax and Gagata genera are shown in Map IXb. Cyprinodontid genera Aplocheilus and Orizias, Belonid genus Xenentodon, Syngnathid genus Dorichthys and Channid genus Channa with their 10 species are shown in the Map X. Distribution of Amphipnous and Monopterus genera of Symbranchidae, Johnius and Pama genera of Sciaenidae, genus Chanda of Centropomidae and two genera, Badis and Nandus of Nandidae with 10 species is shown in the Map XI. Map XII shows the distribution of 6 genera viz., Sicamugil, Rhinomugil, Glossogobius, Anabas, Colisa and Ctenops with their 8 species, while the distribution of two genera Mastacembelus and Macragnathus of Mastacembelidae, Pillaia of Pillaiidae and Tetraodon of Tetraodontidae with their 6 species are shown in the Map XIII.

## Map Vc: Distributional map of

- : *Noemacheilus beavani* Gunther
- ⊙ : *Noemacheilus botia* (Hamilton)
- : *Noemacheilus corica* (Hamilton)
- ⊕ : *Noemacheilus kangjupkhulensis* Hora
- : *Noemacheilus manipurensis* Chaudhuri
- ▣ : *Noemacheilus multifasciatus* Day
- \* : *Noemacheilus prashadi* Hora
- ⊙ : *Noemacheilus rupecola inglisi* Hora
- ⊕ : *Noemacheilus rupecola rupecola* (Mc Clelland)
- : *Noemacheilus savona* (Hamilton)
- ⊕ : *Noemacheilus scaturigina* (Mc Clelland)
- △ : *Noemacheilus sikmaiensis* Hora
- : *Noemacheilus subfusca* (Mc Clelland)
- ▲ : *Noemacheilus vinciguerrai* Hora
- ◇ : *Noemacheilus zonalternans* (Blyth)
- ⊙ : *Noemacheilus zonatus* (Mc Clelland)

in North-East India.

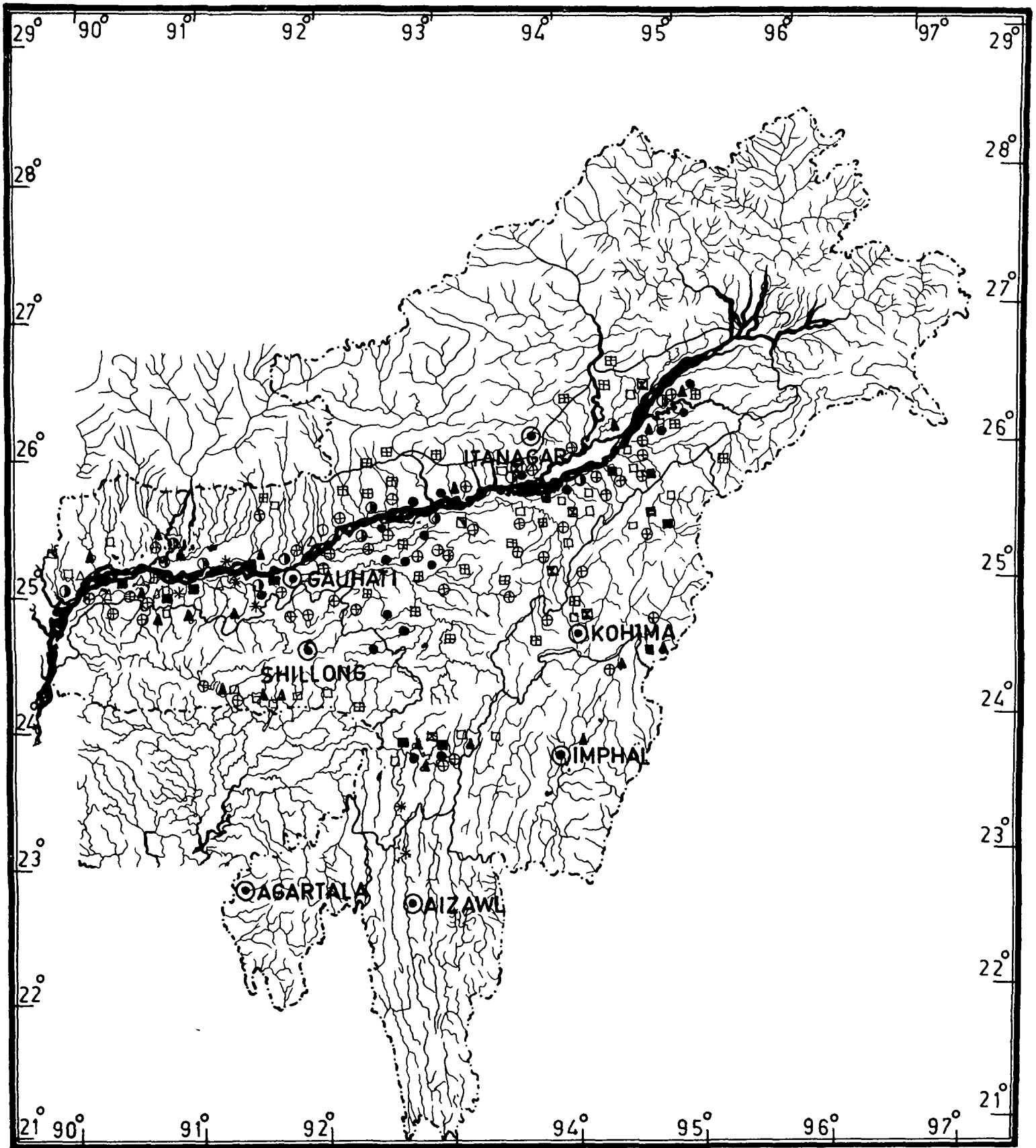
V c



Map VI: Distributional map of

- : *Rita rita* (Hamilton)
- △ : *Batasio batasio* (Hamilton)
- : *Batasio tengana* (Hamilton)
- ▣ : *Chandramara chandramara* (Hamilton)
- ▲ : *Mystus bleekeri* (Day)
- ▤ : *Mystus cavasius* (Hamilton)
- : *Mystus menoda menoda* (Hamilton)
- \* : *Mystus tengara* (Hamilton)
- ⊕ : *Mystus vittatus* (Bloch)
- ▥ : *Aorichthys aor* (Hamilton)
- : *Aorichthys seenghala* (Sykes)

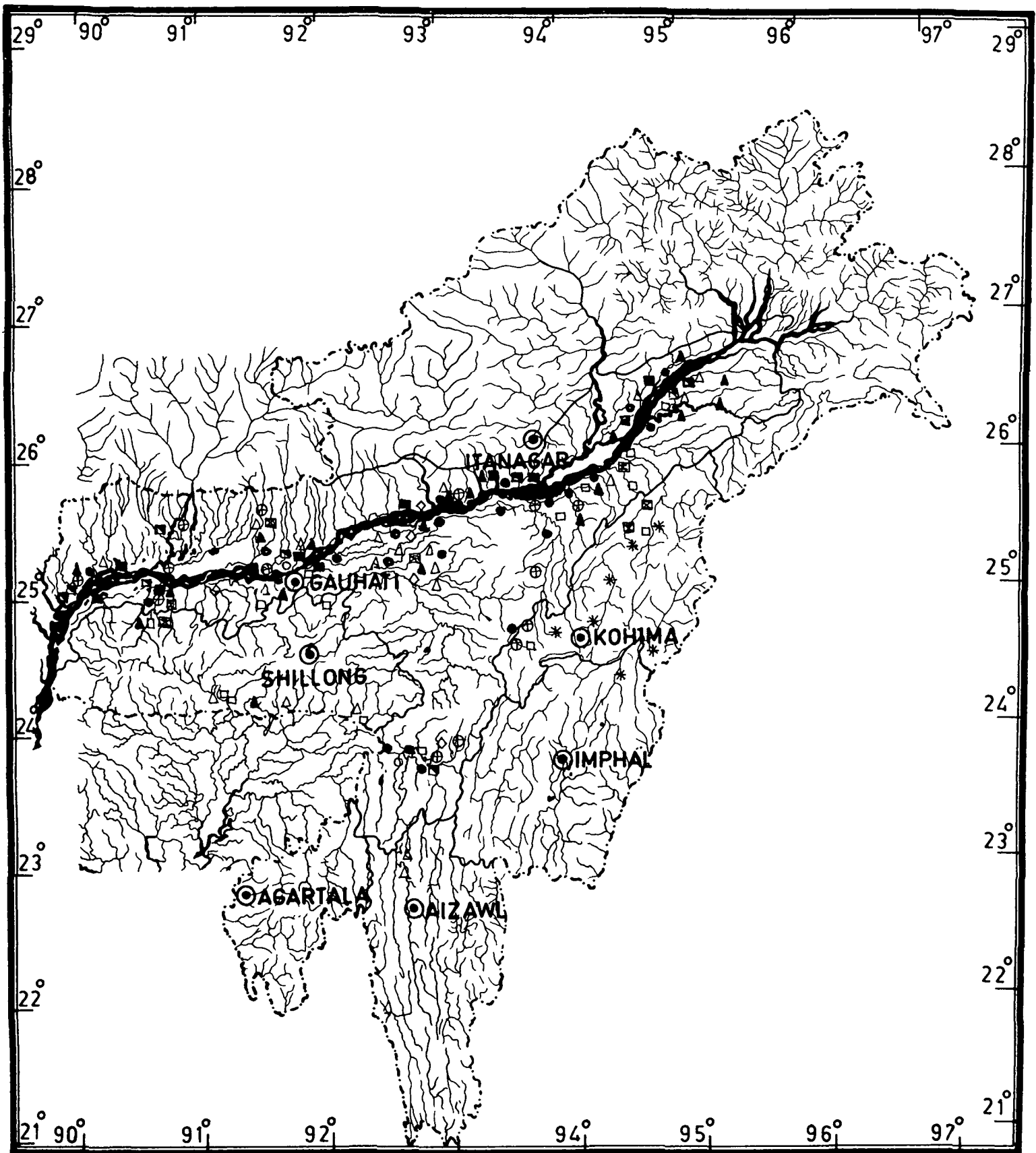
in North-East India.



## Map VII: Distributional map of

- ⊕ : *Ompak bimaculatus* (Bloch)
- : *Ompak pabda* (Hamilton)
- : *Ompak pabo* (Hamilton)
- : *Wallago attu* (Schneider)
- \* : *Silurus cochinchinensis* (Valenciennes)
- : *Ailia coila* (Hamilton)
- ◇ : *Pseudeutropius atherenoides* (Bloch)
- △ : *Clupiosoma garua* (Hamilton)
- ▲ : *Eutropiichthys vacha* (Hamilton)
- : *Eutropiichthys murius* (Hamilton)
- : *Silonia silondia* (Hamilton)

in North-East India.

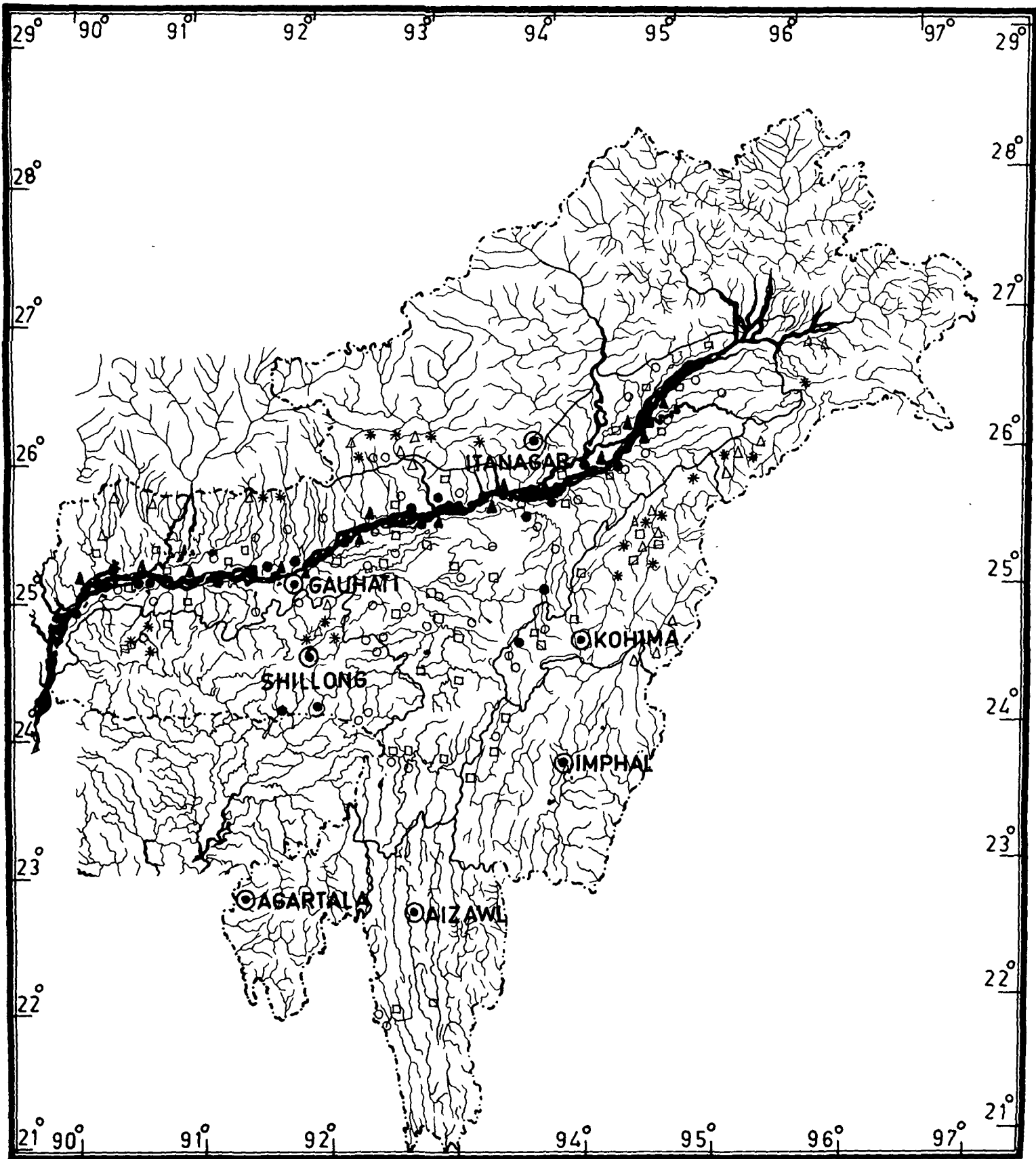


## Map VIII: Distributional map of

- ▲ : *Pangasius pangasius* (Hamilton)
- △ : *Amblyceps mangois* (Hamilton)
- : *Clarias batrachus* (Linnaeus)
- : *Heteropneustes fossilis* (Bloch)
- : *Chaca chaca* (Hamilton Bloch)
- \* : *Olyra longicaudata* (Mc Clelland)

/ in North-East India.

VIII

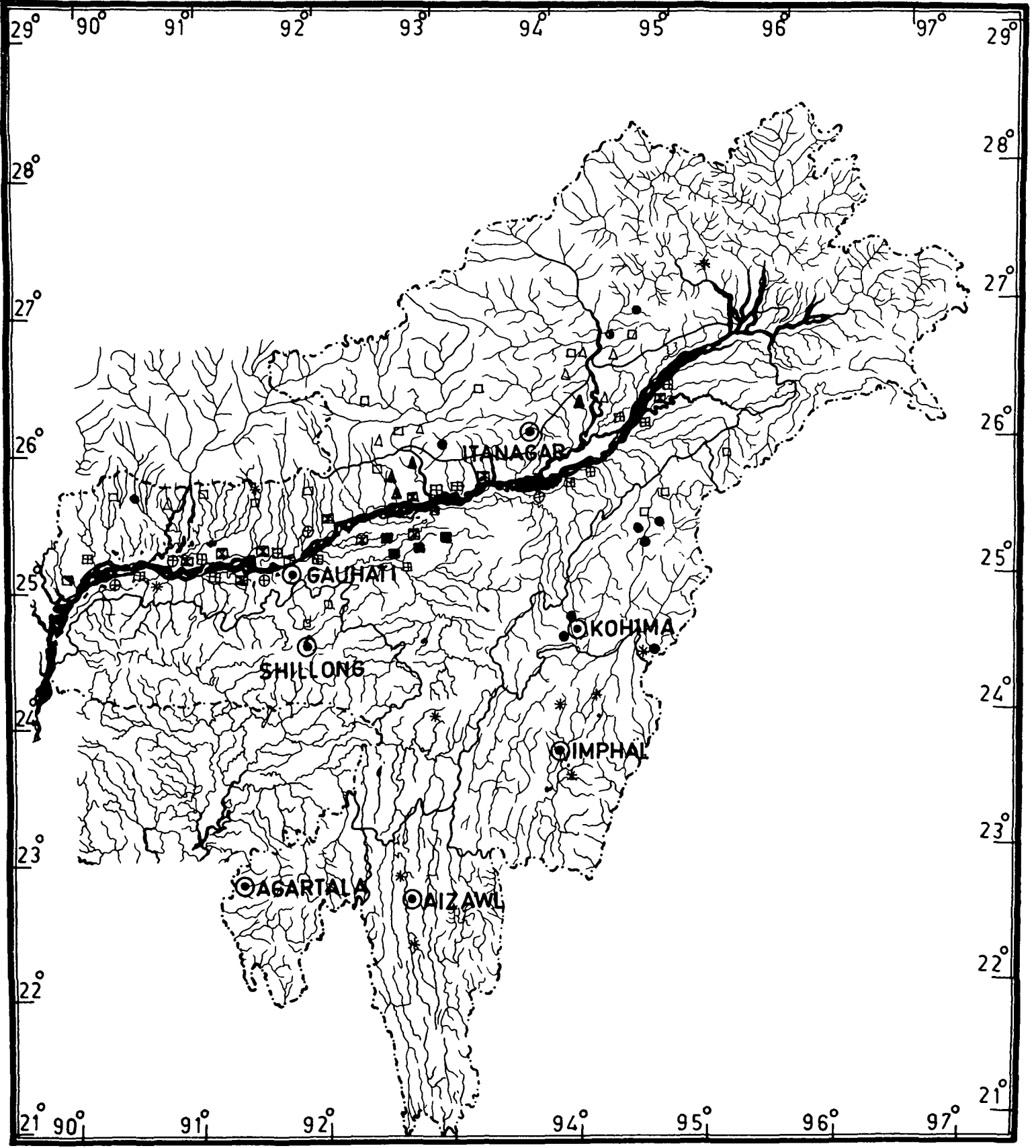


## Map IXa : Distributional map of

- ▣ : *Bagarius bagarius* (Hamilton)
- △ : *Contá conta* (Hamilton)
- : *Erethistes pussilis* Muller & Troschel
- ▲ : *Erethistoides montana montana* Hora
- : *Euchiloglanis hodgarti* (Hora)
- \* : *Exostoma labiatum* (Mc Clelland)
- ▣ : *Hara hara* (Hamilton)
- ⊙ : *Hara jerdoni* Day
- : *Pseudécheneis sulcatus* (Mc Clelland)
- ▣ : *Sisor rabdophorus* Hamilton

in North-East India.

IX a

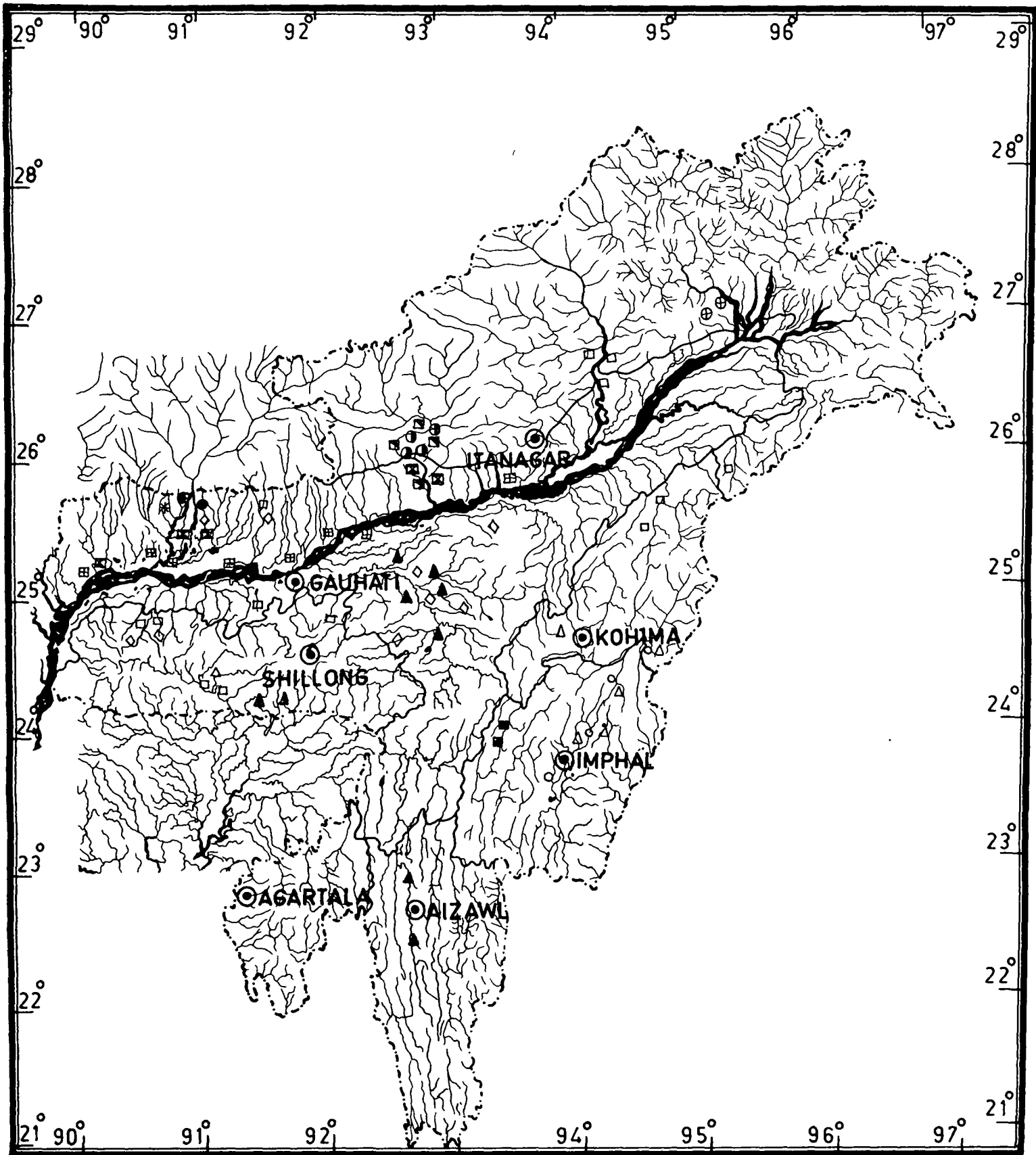


## Map IXb: Distributional map of

- : *Gagata cenia* (Hamilton)
- : *Gagata viridescens* (Hamilton)
- ⊙ : *Glyptothorax annandalei* Hora
- : *Glyptothorax cavia* (Hamilton)
- \* : *Glyptothorax conirostris* (Steindachner)
- : *Glyptothorax gracilis* (Gunther)
- : *Glyptothorax horai* Shaw & Shebbeare
- △ : *Glyptothorax platypogonoides* (Bleeker)
- : *Glyptothorax ribeiroi* (Hora)
- ◇ : *Glyptothorax striatus* (Mc Clelland)
- ▲ : *Glyptothorax telchitta* (Hamilton)
- : *Glyptothorax trilineatus* Blyth
- : *Glyptothorax sinense manipurensis* Menon

in North-East India.

IX b

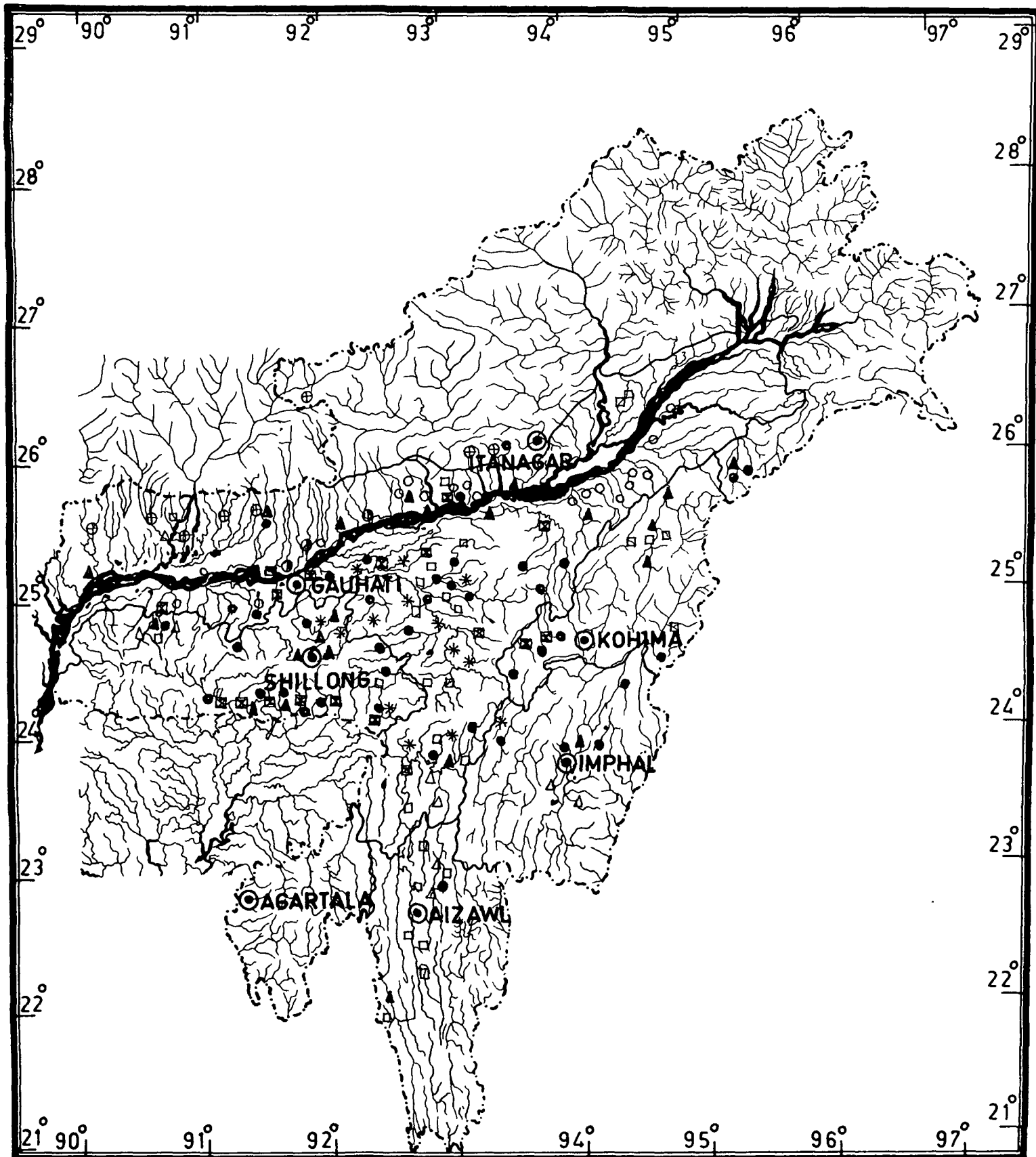


Map X : Distributional map of

- : *Aplocheilus panchax* (Hamilton)
- △ : *Orizias melastigma* (Mc Clelland)
- : *Xenentodon cancila* (Hamilton)
- ▣ : *Dorichthys deocata* (Hamilton)
- ⊕ : *Channa barca* (Hamilton)
- : *Channa marulius* (Hamilton)
- ▲ : *Channa orientalis* Schneider
- : *Channa punctata* (Bloch)
- \* : *Channa stewartii* (Playfair)
- : *Channa striatus* (Bloch)

in North-East India.

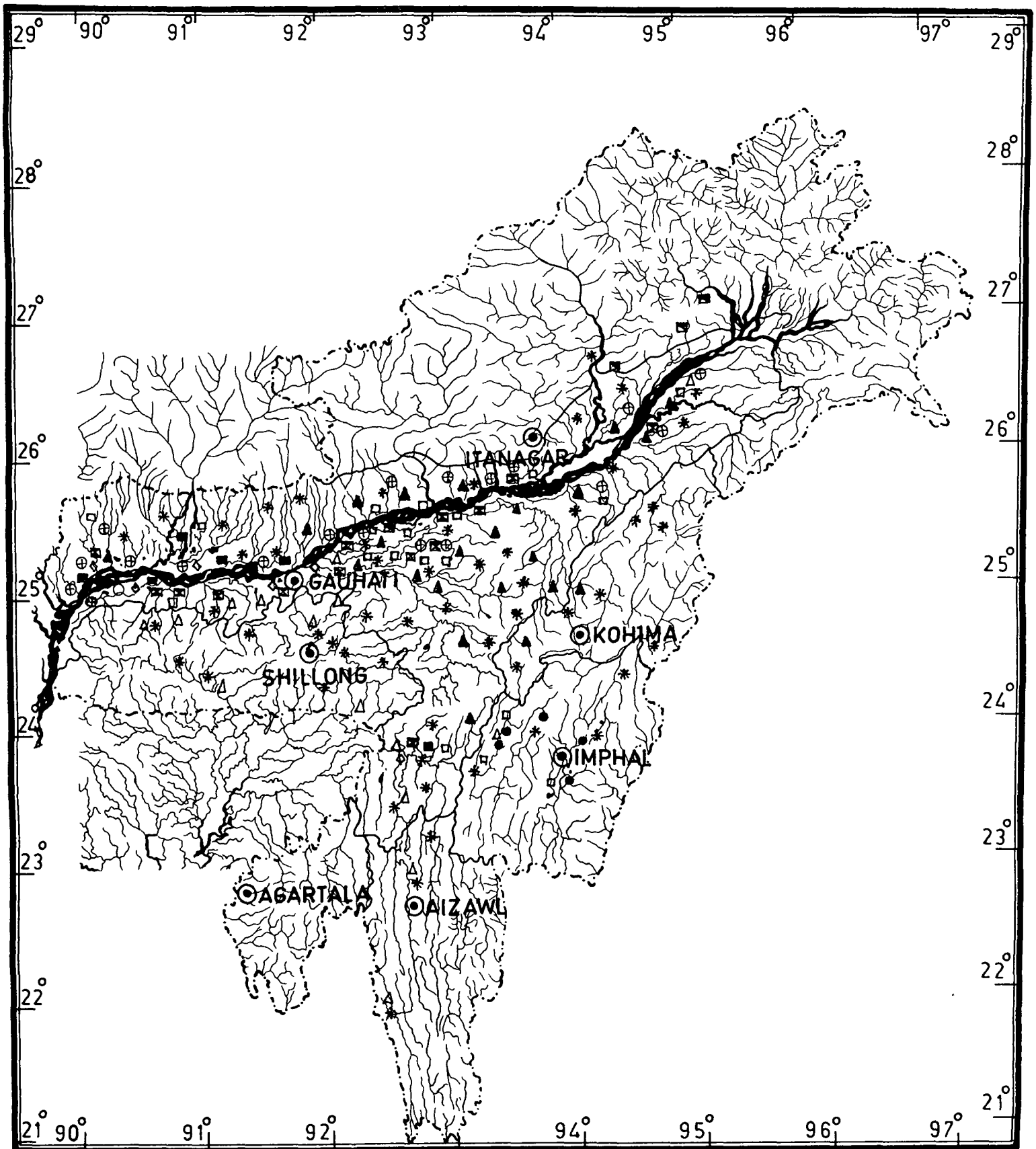
X



## Map XI: Distributional map of

- : *Monopterus alba* (Zuiew)
- ▲ : *Amphipnous cuchia* (Hamilton)
- : *Amphipnous hodgarti* (Chaudhuri)
- ◇ : *Johnius coitor* (Hamilton)
- : *Pama pama* (Hamilton)
- : *Chanda baculis* Hamilton.
- ⊕ : *Chanda nama* Hamilton
- : *Chanda ranga* Hamilton
- \* : *Badis badis* (Hamilton)
- △ : *Nandus nandus* (Hamilton)

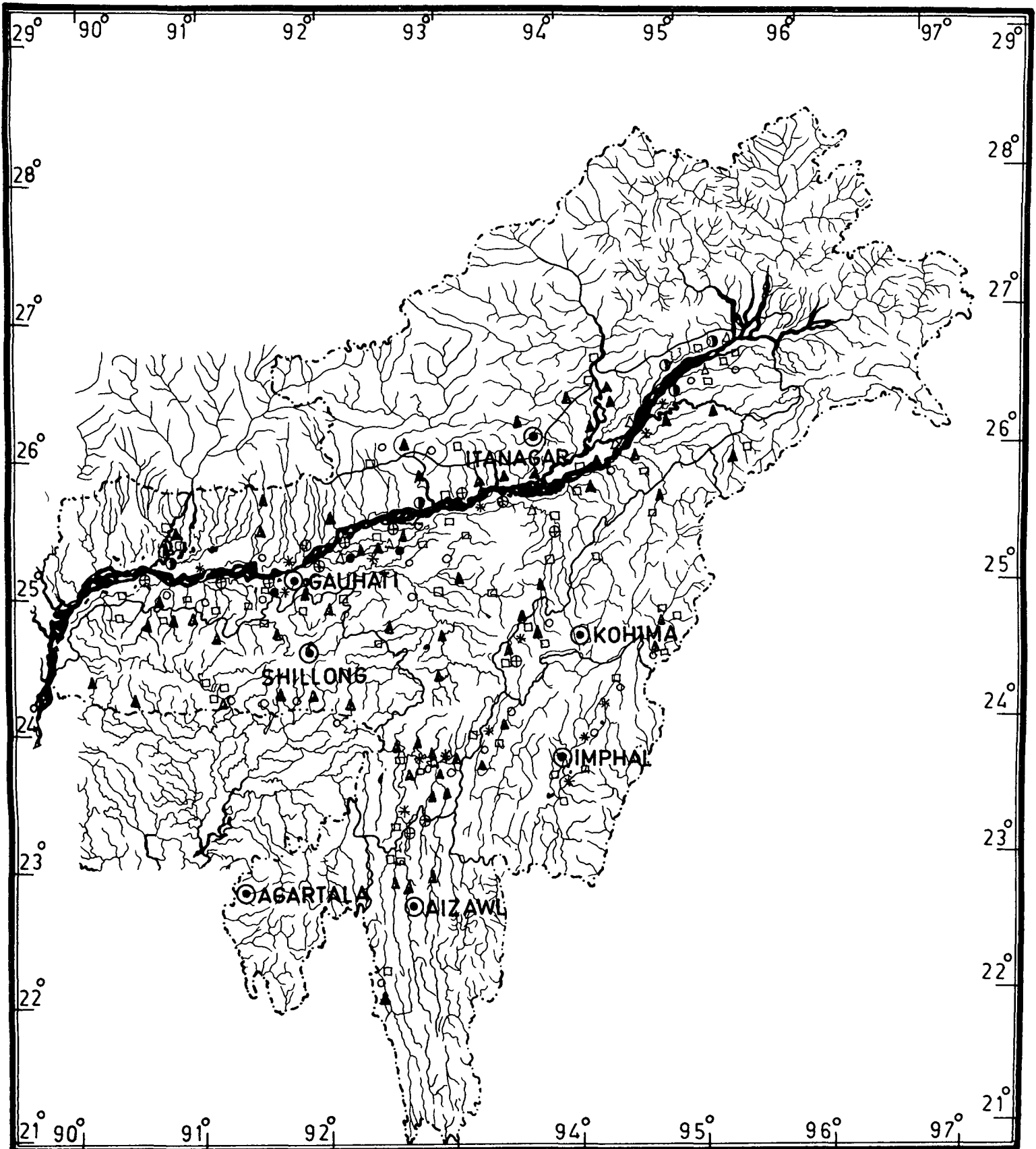
in North-East India.



## Map XII: Distributional map of

- Δ : *Sicamugil cascasia* (Hamilton)
- : *Rhinomugil corsula* (Hamilton)
- ▲ : *Glossogobius gutum* (Hamilton)
- : *Anabas testudineus* Bloch
- : *Colisa fasciata* Schneider
- ⊕ : *Colisa lalia* (Hamilton)
- \* : *Colisa sota* (Hamilton)
- : *Ctenops nobilis* Mc Clelland

in North-East India.

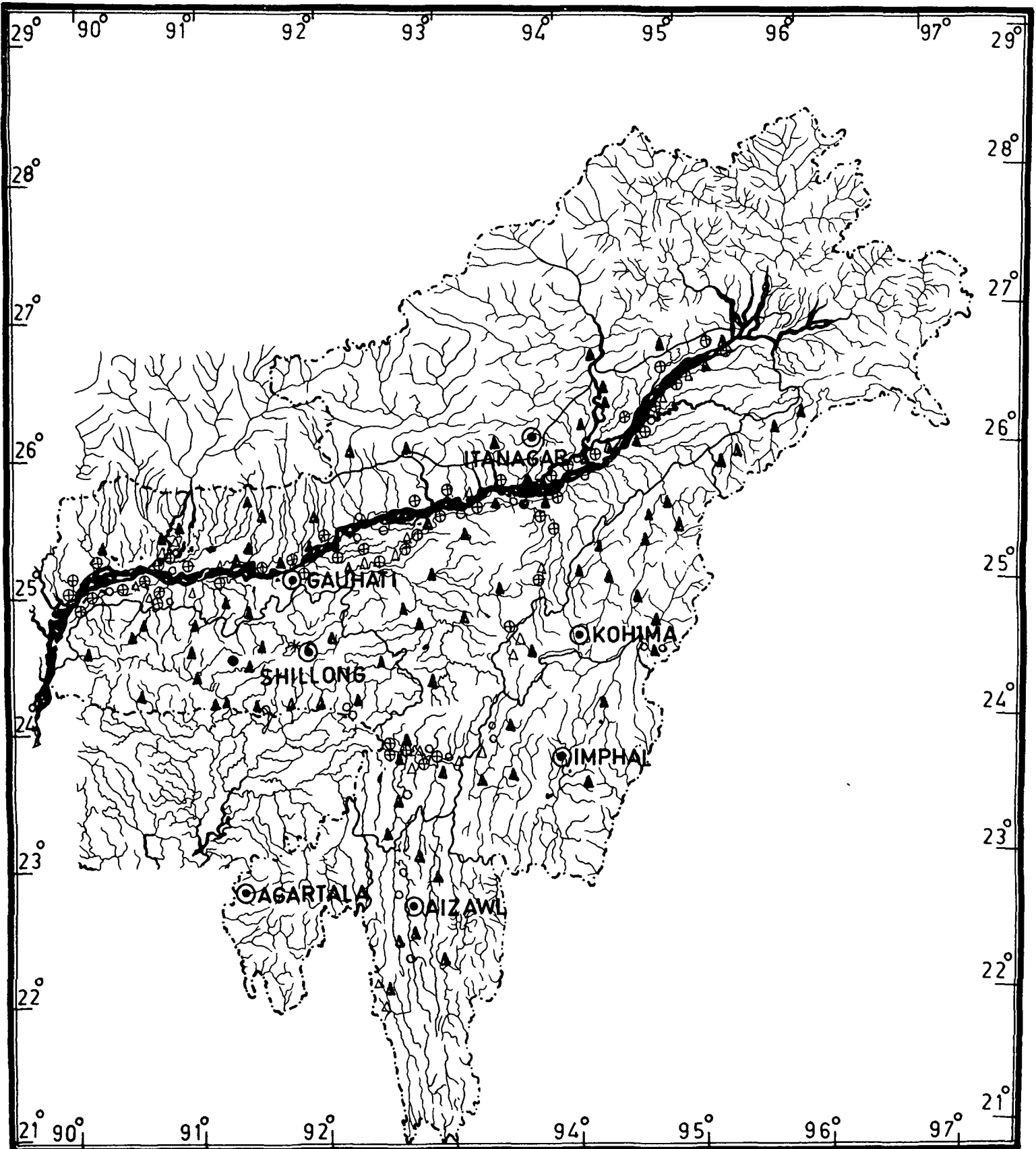


Map XIII: Distributional map of

- ▲ : Mastacembelus armatus Lacepede
- : Mastacembelus pancalus (Hamilton)
- △ : Macrognathus aculeatus (Bloch)
- \* : Pillaia indica Yazdani
- : Pillaia khajuriae Talwar et al.
- ⊕ : Tetraodon cutcutia Hamilton

in North-East India.

XIII



Though it was worthwhile to show the distribution of the fish species collected in the present investigation it was felt that records both from earlier collections and present investigation should give a better and ideal picture on the occurrence and non-occurrence of species based on the primary habitat - the different aquatic systems making up the drainage pattern. For this, the habitat was broadly divided into 7 major categories, Low land, Upland, Montane, Big river, Small river/stream, Creek, Bheels, Ponds and Paddy fields, and the different species were indicated for their presence or absence accordingly. Further, the region was made up of three major drainages of which the Brahmaputra was the dominant followed by Meghna and Chindwin. The Brahmaputra drainage was made up of 12 major rivers inclusive of the River Brahmaputra, while the Meghna with 8 major lotic systems and the Chindwin only 2 (Table 16).

This analysis was seen to be useful as it was indicative of the number of species inhabiting a particular habitat or a lotic system. Among the habitats it was seen that the Upland forms were dominant with 153 species followed by Low land with 128 species, while only 77 species were Montane dwellers. Small riverine forms were highest with 181 species inhabiting small rivers and streams. These were followed by Big river, Creeks and Bheels/Paddy fields/Ponds with 115, 93 and 68 species respectively. Among the lotic systems it was seen that the Brahmaputra drainage in general and the rivers Brahmaputra,

TABLE-16 Fish species/subspecies of North-East Indian drainages and their general habitat

Habitat			
A=	Low land	42=	<i>Garra gotyla gotyla</i> (Gray)
B=	Upland	43=	<i>Garra kempfi</i> Hora
C=	Montane	44=	<i>Garra lamta</i> (Hamilton)
D=	Big river	45=	<i>Garra lissorhynchus</i> (Mc Clelland)
E=	Stream/small river	46=	<i>Garra naganensis</i> Hora
F=	Creek	47=	<i>Garra nasuta</i> (Mc Clelland)
G=	Sheels/Ponds/Paddy Fields	48=	<i>Garra rupecula</i> (Mc Clelland)
		49=	<i>Labeo bata</i> (Hamilton)
H=	Brahmaputra	50=	<i>Labeo boga</i> (Hamilton)
I=	Subhansiri	51=	<i>Labeo calbasu</i> (Hamilton)
J=	Jia Bharali	52=	<i>Labeo gonius</i> (Hamilton)
K=	Pagladiya	53=	<i>Labeo dero</i> (Hamilton)
L=	Manas	54=	<i>Labeo pangusia</i> (Hamilton)
M=	Dikhu	55=	<i>Labeo mandina</i> (Hamilton)
N=	South Dhansiri	56=	<i>Labeo rohita</i> (Hamilton)
O=	Kallong	57=	<i>Oreochthys cosuatis</i> (Hamilton)
P=	Digaru	58=	<i>Osteobrama cotio cotio</i> (Hamilton)
Q=	Kulsi	59=	<i>Osteobrama cotio cunna</i> (Day)
R=	Dudhnai	60=	<i>Osteobrama belangeri</i> (Valenciennes)
S=	Krishnai	61=	<i>Puntius chola</i> (Hamilton)
		62=	<i>Puntius clavatus</i> (Mc Clelland)
T=	Barak	63=	<i>Puntius conchonus</i> (Hamilton)
U=	Lubha	64=	<i>Puntius gelius</i> (Hamilton)
V=	Tlwang	65=	<i>Puntius guganio</i> (Hamilton)
W=	Tuirial	66=	<i>Puntius phutunio</i> (Hamilton)
X=	Myndtu	67=	<i>Puntius sophore</i> (Hamilton)
Y=	Umngi	68=	<i>Puntius sarana sarana</i> (Hamilton)
Z=	Mahadeo	69=	<i>Puntius terio</i> (Hamilton)
a=	Simsong	70=	<i>Puntius ticto</i> (Hamilton)
		71=	<i>Puntius shalynius</i> Yazdani & Talukdar
b=	Imphal	72=	<i>Schizothorax richardsonii</i> (Gray)
c=	Tizu	73=	<i>Schizothoracichthys progastus</i> (Mc Clelland)
		74=	<i>Semiplotus semiplotus</i> (Mc Clelland)
1=	<i>Hilsa Ilisha</i> (Hamilton)	75=	<i>Semiplotus gangulyi</i> Dey
2=	<i>Gadusia chapra</i> (Hamilton)	76=	<i>Tor putitora</i> (Hamilton)
3=	<i>Gadusia variegata</i> (Day)	77=	<i>Tor tor</i> (Hamilton)
4=	<i>Setipinna phasa</i> (Hamilton)	78=	<i>Psilorhynchus balitora</i> (Hamilton)
5=	<i>Notopterus chitala</i> (Hamilton)	79=	<i>Psilorhynchus homaloptera</i> Hora & Mukerji
6=	<i>Notopterus notopterus</i> (Pallas)	80=	<i>Psilorhynchus sucatio</i> (Hamilton)
7=	<i>Chela cachius</i> (Hamilton)	81=	<i>Balitora brucei</i> Gray
8=	<i>Chela laubuca</i> (Hamilton)	82=	<i>Balitora maculata</i> Gray
9=	<i>Oxygaster gora</i> (Hamilton)	83=	<i>Aborichthys elongatus</i> Hora
10=	<i>Salmostoma bacaila</i> (Hamilton)	84=	<i>Aborichthys garoensis</i> Hora
11=	<i>Salmostoma phulo phulo</i> (Hamilton)	85=	<i>Aborichthys kempfi</i> Chaudhuri
12=	<i>Barilius barila</i> (Hamilton)	86=	<i>Acanthopthalmus pangia</i> (Hamilton)
13=	<i>Barilius barna</i> (Hamilton)	87=	<i>Botia berdmorei</i> (Blyth)
14=	<i>Barilius bendelisis</i> (Hamilton)	88=	<i>Botia dario</i> (Hamilton)
15=	<i>Barilius bola</i> (Hamilton)	89=	<i>Botia histrionica</i> Blyth
16=	<i>Barilius shacra</i> (Hamilton)	90=	<i>Botia rostrata</i> Gunther
17=	<i>Barilius dogarsinghi</i> Hora	91=	<i>Lepidocephalus berdmorei</i> (Blyth)
18=	<i>Barilius tileo</i> (Hamilton)	92=	<i>Lepidocephalus guntea</i> (Hamilton)
19=	<i>Barilius vagra</i> (Hamilton)	93=	<i>Lepidocephalus irrorata</i> (Hora)
20=	<i>Barilius guttatus</i> (Day)	94=	<i>Lepidocephalus burmanicus</i> Rendahl
21=	<i>Danio (Danio) aequipinnatus</i> (Mc Clelland)	95=	<i>Lepidocephalus menoni</i> (Pillai & Yazdani)
22=	<i>Danio (Brachydanio) rerio</i> (Hamilton)	96=	<i>Lepidocephalus goalparensis</i> (Pillai & Yazdani)
23=	<i>Danio (Danio) dangila</i> (Hamilton)	97=	<i>Neoeucirrhichthys maydelli</i> Banarese & Nalbant
24=	<i>Danio (Brachydanio) acuticephala</i> Hora		
25=	<i>Danio (Danio) devario</i> (Hamilton)	98=	<i>Noemacheilus beavani</i> Gunther
26=	<i>Danio (Danio) naganensis</i> Chaudhuri	99=	<i>Noemacheilus botia</i> (Hamilton)
27=	<i>Esomus danricus</i> (Hamilton)	100=	<i>Noemacheilus corica</i> (Hamilton)
28=	<i>Rasbora daniconius</i> (Hamilton)	101=	<i>Noemacheilus kangjupkhulensis</i> Hora
29=	<i>Rasbora elonga</i> (Hamilton)	102=	<i>Noemacheilus manipurensis</i> Chaudhuri
30=	<i>Rasbora kobonensis</i> Chaudhuri	103=	<i>Noemacheilus multifasciatus</i> Day
31=	<i>Rasbora rasbora</i> (Hamilton)	104=	<i>Noemacheilus prashadi</i> Hora
32=	<i>Acrossocheilus hexagonolepis</i> (Mc Clelland)	105=	<i>Noemacheilus rupecola rupecola</i> (Mc Clelland)
33=	<i>Amblypharyngodon mola</i> (Hamilton)	106=	<i>Noemacheilus rupecola inglisi</i> Hora
34=	<i>Aspidoparia jaya</i> (Hamilton)	107=	<i>Noemacheilus savona</i> (Hamilton)
35=	<i>Aspidoparia mola</i> (Hamilton)	108=	<i>Noemacheilus scaturigina</i> (Mc Clelland)
36=	<i>Catla catla</i> (Hamilton)	109=	<i>Noemacheilus sikkimensis</i> Hora
37=	<i>Chagunius chagunio</i> (Hamilton)	110=	<i>Noemacheilus subfusca</i> (Mc Clelland)
38=	<i>Cirrhina mrigala</i> (Hamilton)	111=	<i>Noemacheilus zonalternans</i> (Blyth)
39=	<i>Cirrhina reba</i> (Hamilton)	112=	<i>Noemacheilus zonatus</i> (Mc Clelland)
40=	<i>Crossocheilus latius latius</i> (Hamilton)	113=	<i>Noemacheilus vinciguerrai</i> Hora
41=	<i>Garra annandalei</i> Hora	114=	<i>Somdileptes gongota</i> (Hamilton)



TABLE-16 (Contd.)

Habitat		
A= Lowland		142= <i>Erethistoides montana montana</i> Hora
B= Upland		143= <i>Euchiloglenis hodgarti</i> Hora
C= Montane		144= <i>Exostoma labiatum</i> (Mc Clelland)
D= Big river		145= <i>Gagata cenia</i> (Hamilton)
E= Stream/small river		146= <i>Gagata viridescens</i> (Hamilton)
F= Creek		147= <i>Glyptothorax annandalei</i> Hora
G= Bheels/Ponds/Paddy Fields		148= <i>Glyptothorax cavia</i> (Hamilton)
		149= <i>Glyptothorax conirostris</i> (Steindachner)
H= Brahmaputra		150= <i>Glyptothorax gracilis</i> (Gunther)
I= Subhansiri		151= <i>Glyptothorax horai</i> Shaw & Shebbeare
J= Jia Bharali		152= <i>Glyptothorax platypogoneides</i> (Bleeker)
K= Pagladiya		153= <i>Glyptothorax ribeiroi</i> (Hora)
L= Manas		154= <i>Glyptothorax striatus</i> (Mc Clelland)
M= Dikhu		155= <i>Glyptothorax telchitta</i> (Hamilton)
N= South Dhansiri		156= <i>Glyptothorax trilineatus</i> Blyth
O= Kallong		157= <i>Glyptothorax sinense manipurensis</i> Menon
P= Digaru		158= <i>Hara hara</i> (Hamilton)
Q= Kulsi		159= <i>Hara jerdoni</i> Day
R= Dudhnai		160= <i>Pseudecheneis sulcatus</i> (Mc Clelland)
S= Krishnai		161= <i>Sisor rabdophorus</i> Hamilton
		162= <i>Clarias batrachus</i> (Linnaeus)
T= Barak		163= <i>Heteropneustes fossilis</i> (Bloch)
U= Lubha		164= <i>Chaca chaca</i> (Hamilton)
V= Tiwang		165= <i>Olyra longicaudata</i> (Mc Clelland)
W= Tuirial		166= <i>Orizias melastigma</i> (Mc Clelland)
X= Myndtu		167= <i>Aplocheilus panchax</i> (Hamilton)
Y= Umngi		168= <i>Xenentodon cancila</i> (Hamilton)
Z= Mahadeo		169= <i>Dorichthys deocata</i> (Hamilton)
a= Simsong		170= <i>Channa barca</i> (Hamilton)
		171= <i>Channa marulius</i> (Hamilton)
b= Imphal		172= <i>Channa orientalis</i> Schneider
c= Tizu		173= <i>Channa punctata</i> (Bloch)
		174= <i>Channa stewartii</i> (Playfair)
115= <i>Rita rita</i> (Hamilton)		175= <i>Channa striatus</i> (Bloch)
116= <i>Batosio batasio</i> (Hamilton)		176= <i>Monopterus alba</i> (Zuiew)
117= <i>Batasio tengana</i> (Hamilton)		177= <i>Amphipnous cuchia</i> (Hamilton)
118= <i>Chandramara chandramara</i> (Hamilton)		178= <i>Amphipnous hodgarti</i> (Chaudhuri)
119= <i>Mystus bleekeri</i> (day)		179= <i>Johnius coitor</i> (Hamilton)
120= <i>Mystus cavasins</i> (Hamilton)		180= <i>Pama pama</i> (Hamilton)
121= <i>Mystus menoda menoda</i> (Hamilton)		181= <i>Chanda baculis</i> Hamilton
122= <i>Mystus tengara</i> (Hamilton)		182= <i>Chanda nama</i> Hamilton
123= <i>Mystus vittatus</i> (Bloch)		183= <i>Chanda ranga</i> Hamilton
124= <i>Aorichthys seenghala</i> (Sykes)		184= <i>Badis badis</i> (Hamilton)
125= <i>Aorichthys aor</i> (Hamilton)		185= <i>Nandus nandus</i> (Hamilton)
126= <i>Ompak bimaculatus</i> (Bloch)		186= <i>Sicamugil Cascasia</i> (Hamilton)
127= <i>Ompak pabda</i> (Hamilton)		187= <i>Rhinomugil corsula</i> (Hamilton)
128= <i>Ompak pabo</i> (Hamilton)		188= <i>Glossogobius gutum</i> (Hamilton)
129= <i>Wallago attu</i> (Schneider)		189= <i>Anabas testudineus</i> Bloch
130= <i>Silurus cochinchinensis</i> (Valenciennes)		190= <i>Colisa sota</i> (Hamilton)
131= <i>Ailia coila</i> (Hamilton)		191= <i>Colisa fasciata</i> (Schneider)
132= <i>Pseudeutropius atherenoides</i> (Bloch)		192= <i>Colisa lalia</i> (Hamilton)
133= <i>Clupiosoma garua</i> (Hamilton)		193= <i>Ctenops nobilis</i> Mc Clelland
134= <i>Eutropiichthys murius</i> (Hamilton)		194= <i>Mastacembelus armatus</i> Lacepede
135= <i>Eutropiichthys vacha</i> (Hamilton)		195= <i>Mastacembelus puncalus</i> (Hamilton)
136= <i>Silonia silondia</i> (Hamilton)		196= <i>Macrogathus aculeatus</i> (Bloch)
137= <i>Pangasius pangasius</i> (Hamilton)		197= <i>Pillaia indica</i> yezdani
138= <i>Amblyceps mangois</i> (Hamilton)		198= <i>Pillaia khajuria</i> Talwar et al
139= <i>Bagarius bagarius</i> (Hamilton)		199= <i>Tetrodon cutcutia</i> Hamilton
140= <i>Conta conta</i> (Hamilton)		
141= <i>Erethistes pussilus</i> Muller & Troschel		



Pagladiya, Krishnai comprised of largest number of species with 118, 70, and 87 number of species respectively. In addition only the river Barak of the Meghna drainage seemed to be habitable for a large number of species 79. In all the other cases they were between the ranges of 20 and 60 species.

The next analysis done during the present investigation was to place these lotic systems into a gradient category indicative of the nature, and geomorphology of these rivers (Table 17). This was then compared for each river/lotic system according to the categories for the total fish fauna represented in that particular area or zone in that lotic system. It was seen that in the River Brahmaputra, the Lowland/Upland category comprised of the largest number of species of 55 and made up of 46.61% of the different categories. However the River Barak for the same Lowland/Upland category though had only 39 species comprised of nearly 49.37% and similarly for Krishnai for the same category where 38 species were present the percentage was 43.68. Further, it was observed that the River Brahmaputra in the lowland category possessed 36 species forming 30.51%. The only other river in the Brahmaputra drainage which showed remarkable relative percentage of 50.79% and having only 32 species was Kallong. Similarly the rivers Kulsi and Duhnai for the same Lowland/Upland category also showed 50% each though possessing only 20 and 12 species respectively. All other categories irrespective of the river showed lesser percentages in this category. However, the river Jia Bharali of the

Table 17 : Number of fish species and subspecies tabulated by rivers/drainages (percentages in parentheses), inhabiting various gradient categories of the North-East Indian rivers/drainages, and the Average Gradient Index for the fauna of each river/drainage.

AFGI: Average Faunal Gradient Index of river/drainage.

TABLE-17

	Lowland	Lowland/ Upland	Lowland/ Upland/ Montane	Upland	Upland/ Montane	Montane	AFGI
Brahmaputra	36 (30.51)	55 (46.61)	9 (7.63)	1 (0.85)	17 (14.40)	-	2.22
Subhansiri	1 ( 2.13)	16 (34.04)	6 (12.77)	2 (4.26)	17 (36.17)	5 (10.63)	3.70
Jia Bharali	1 ( 1.96)	14 (27.45)	7 (13.73)	1 (1.96)	24 (47.06)	4 (47.06)	3.88
Pagladiya	10 (14.28)	25 (35.71)	14 (20.00)	3 (4.29)	15 (21.43)	3 ( 4.29)	2.96
Manas	11 (17.18)	23 (35.93)	6 ( 9.38)	2 (3.13)	19 (29.69)	3 ( 4.69)	3.06
Dikhu	1 ( 2.27)	19 (43.18)	5 (11.36)	2 (4.55)	13 (29.55)	4 ( 9.09)	3.43
South Dhansiri	9 (19.56)	22 (47.83)	4 ( 8.70)	-	10 (21.74)	1 ( 2.17)	2.63
Kallong	13 (20.63)	32 (50.79)	9 (14.22)	1 (1.59)	8 (12.70)	-	2.35
Digaru	3 ( 7.31)	15 (36.59)	8 (19.51)	1 (2.44)	12 (29.27)	2 (4.88)	3.24
Kulsi	5 (12.50)	20 (50.00)	7 (17.50)	-	7 (17.50)	1 (2.50)	2.63
Dudhnai	4 (16.67)	12 (50.00)	4 (16.67)	-	3 (12.50)	1 (4.17)	2.54
Krishnai	14 (16.09)	38 (43.68)	13 (14.94)	1 (1.15)	18 (20.69)	3 (3.45)	2.77
<hr/>							
Barak	19 (24.05)	39 (49.37)	7 ( 8.86)	2 (2.53)	12 (15.19)	-	2.35
Lubha	5 (16.13)	13 (41.94)	6 (19.35)	1 (3.23)	6 (19.35)	-	2.68
Tlwang	2 ( 5.41)	15 (40.54)	7 (18.91)	2 (5.41)	11 (29.73)	-	3.14
Tuirial	1 ( 4.55)	10 (45.45)	7 (31.82)	1 (4.55)	3 (13.63)	-	2.77
Myndtu	1 ( 4.35)	7 (30.43)	5 (21.74)	-	10 (43.48)	-	3.48
Umnung	3 ( 7.32)	18 (43.90)	7 (17.07)	1 (2.44)	11 (26.83)	1 (2.44)	3.05
Mahadeo	4 (13.79)	11 (37.93)	8 (27.59)	1 (3.45)	5 (17.24)	-	2.72
Simsong	5 (10.42)	21 (43.75)	8 (16.67)	1 (2.08)	12 (25.00)	1 (2.08)	2.94
<hr/>							
Imphal	6 (10.71)	15 (26.79)	10 (17.86)	5 (8.93)	20 (35.71)	-	3.32
Tizu	2 ( 3.51)	18 (31.58)	6 (10.53)	4 (7.02)	25 (43.85)	2 (3.51)	3.67

Brahmaputra drainage, Myntdu of the Meghna drainage, and Tizu of the Chindwin drainage having 24, 10 and 25 species respectively in the Upland/Montane category showed percentages of 47.06%, 43.48% and 43.85% respectively. All other categories showed much less numbers and percentages and on a general observation it was seen that the abundant numbers and their percentages indicative of them irrespective of the rivers or their drainage system revealed a maximum abundance in the Lowland/Upland category. In contrast the Upland/Montane categories were seen to be least habitable. In addition an Average Faunal Gradient Index when prepared was seen to be highest ( $> 3$ ), in the case of the rivers Subhansiri, Jia Bharali, Manas, Dikhu, Digaru of the Brahmaputra drainage, Tiwang, Myntdu, and Umning of the Meghna drainage and the two rivers Imphal and Tizu of the Chindwin drainage.

However, it was felt best to identify the families and the number of species occurring in similar categories. A near to a similar picture was obtained like the above in that the Lowland/Upland category formed the major occupation by species irrespective of the families (Table 18). This of course was made up in part by the family Cyprinidae and to some extent the families Cobitidae and Bagridae, as the other families were more or less distributed in the different categories evenly. In addition to family Cyprinidae, Cobitidae and Sisoridae had more species than the other families in the Upland/Montane category which on a total was only second to the Lowland/Upland category

Table 18 : Gradients inhabited by fishes of the North-East Indian rivers/drainages and Average Gradient Index for each family.

AGI: Average Gradient Index.



in terms of the number of species present. This was followed by the Lowland category, which, though for all the families were more or less the same yet formed nearly 38 in total of the number of species with 19.1%. The least was the Montane category where most of the families were not represented except for 4, the Cyprinidae, Psilorhynchidae, Homalopteridae with 2 each and Sisoridae only one.

In addition to these categorizations it was felt best to observe the number of species according to a permutation combination of two or more of these categories. When so done, it was observed that the Lowland, Lowland/Upland, Lowland/Upland/Montane, Upland and Upland/Montane, comprise the largest number of 139 species with a relative percentage of 69.85%. This was followed by 128 species of 64.32%, when Lowland, Lowland/Upland and Lowland/Upland/Montane were brought together. When the Lowland, Lowland/Upland were together combined they formed 110 species with a percentage of nearly 55%, all the other combination were less than 100 species and less than 50%.

For these families also an Average Gradient Index was prepared which would indicate whether the species of that family were confined to only one category or evenly distributed. The maximum was 6 as seen for the family Homalopteridae followed by 5.6 for Psilorhynchidae and 5 for Olyridae and Amblycipitidae. All the others were  $2 \pm 1$ .

Further to get a clear understanding of the commonly occurring species in the different rivers of the three major drainages an Average Faunal Resemblance Index indicative of the number of shared fishes between one lotic system in relation to

the others. This becomes all the more important since the actual number of species shared by the lotic systems do not give a true picture of the real sharing which the Index is capable of. In the present investigation the maximum index obtained between any two systems was around  $60\% \pm 5\%$ . This is seen in the case of Kailong and the Brahmaputra, Krishnai and Brahmaputra, Barak and Brahmaputra with 52, 62 and 60 shared species of fishes with an Index of 63.3, 61.9 and 63.4 respectively. Similarly, it was seen in the case of Subhansiri and Jia Bharali where 30 were shared with an Index of 61.3% and Krishnai and Simsang where 43 common species with an Index of 69.5%, Umning and Myntdu where only 18 were shared however with an Index of 61.1% and Tizu and Imphal where 36 were common with an Index of 63.7%. In all the other combinations the Index was around 50 or below that, however, in no case reaching below an index of 15 eventhough shared species were up to 6 (Table 19).

The distribution as seen in the results reveal that only the Brahmaputra drainage occupied not only the major groups and their numbers but also the maximum record of species in the present investigation. Moreover it was confined to the river Brahmaputra itself. Therefore it was felt that out of the 199 recorded species in this area whether the barrier created by the Brahmaputra river had an effect on the isolation of species. It was seen that 26 species occurring on the southern side were not found on the north and similarly 16 species on the northern side were not recorded on the south (Table 20).

Table 19 : Numbers of shared fishes and Average Faunal Resemblance Indices (below) of (selected) the North-East Indian rivers/drainages.



Table 20 : Fishes distributed on the southern  
and the northern sides of the  
Brahmaputra River.

TABLE-20

Southern side	Northern side
Barilius dogarsinghi Hora Barilius guttatus (Day) Danio (Brachydanio) acuticephala Hora	Barilius tileo (Hamilton) Rasbora kobonensis Chaudhuri Garra annandalei Hora Schizothoraichthys progastus
Danio (Danio) naganensis Chaudhuri	(Mc Clelland)
Garra naganensis Hora Garra lissorhynchus (Mc Clelland) Osteobrama cotio cunma (Day) Osteobrama belangari (Valenciennes)	Semiplotus gangulyi Dey Balitora maculata Gray Aborichthys elongatus Hora Noemacheilus beavani Gunther Noemacheilus multifasciatus Day Noemacheilus scaturigina (Mc Clelland)
Puntius shalynius Yazdani & Talukdar	Glyptothorax annandalei Hora Glyptothorax gracilis Gunther Glyptothorax horai Shaw & Shebbeare
Aborichthys garoensis Hora Lepidocephalus irrorata (Hora) Lepidocephalus burmanicus Rendahl	Glyptothorax ribeiroi (Hora) Channa barca (Hamilton)
Lepidocephalus goalparensis (Pillai & Yazdani)	Amphipnous hodgarti (Chaudhuri)
Lepidocephalus menoni (Pillai & Yazdani)	
Neoeucirrhichthys maycolli Banarescu & Nalbant	
Noemacheilus kangjupkhulensis Hora	
Noemacheilus manipurensis Chaudhuri	
Noemacheilus prashadi Hora	
Noemacheilus sikmaiensis Hora	
Noemacheilus vinciguerrai Hora	
Noemacheilus zonalternans (Blyth)	
Glyptothorax trilineatus (Blyth) Glyptothorax sincense manipurensis Menon	
Monopterus alba (Zuiew)	
Pillaia indica Yazdani	
Pillaia khajuriai Talwar et al	

### Population Dynamics

After the general analysis of the distribution of species in the region, 5 major lotic systems were chosen with 4 stations each, to be as far as possible representative of the entire system for a population analysis over seasons. As the number of species involved were numerous, groupings into families were done and represented in histograms. In all the 5 lotic systems, irrespective of the stations or the months of collection the dominant family seemed to be Cyprinidae with just two exceptions in the streams Umkhrach and Sumer, where the winter months of November, December and January, were dominated by the family Cobitidae. In addition, the stream Sumer, in the third station was dominated throughout the period of investigation by the families Pillaiidae, and Channidae; which were represented in less numbers in other stations in the same stream. This order of dominance of Cyprinidae, Cobitidae and Channidae in that order were true for most of the rivers. All other families formed percentages much less than these three and seemed to effect the seasonal dynamics to a negligible extent. The only observation from this seasonal study of the population dynamics of the families of fishes in this region was seen to be a dominance of Cyprinidae during summer with the fall in winter replaced as a rise in population by the Cobitidae. The family Channidae in all the rivers revealed their maximum peaks of abundance during the autumn months of August to October (Figs. 2-6).

Fig. 2 : Seasonal fluctuations in the relative abundances of different families of fishes in all four stations of Umkhran stream during the present study.

Stn. I        = Station I  
Stn. II      = Station II  
Stn. III     = Station III  
Stn. IV      = Station IV



Fig. 3 : Seasonal fluctuations in the relative abundances of different families of fishes in all four stations of Sumer stream during the present study.

Stn. I	=	Station I
Stn. II	=	Station II
Stn. III	=	Station III
Stn. IV	=	Station IV

□ CYPRINIDAE  
 ■ COBITIDAE  
 ▨ NANDIDAE

◻ Sisoridae  
 ▩ CHANNIDAE  
 ◐ OLYRIDAE

△ PILLAIIDAE  
 ⊠ AMBLYCIPITIDAE

STN. I

STN. II

STN. III

STN. IV

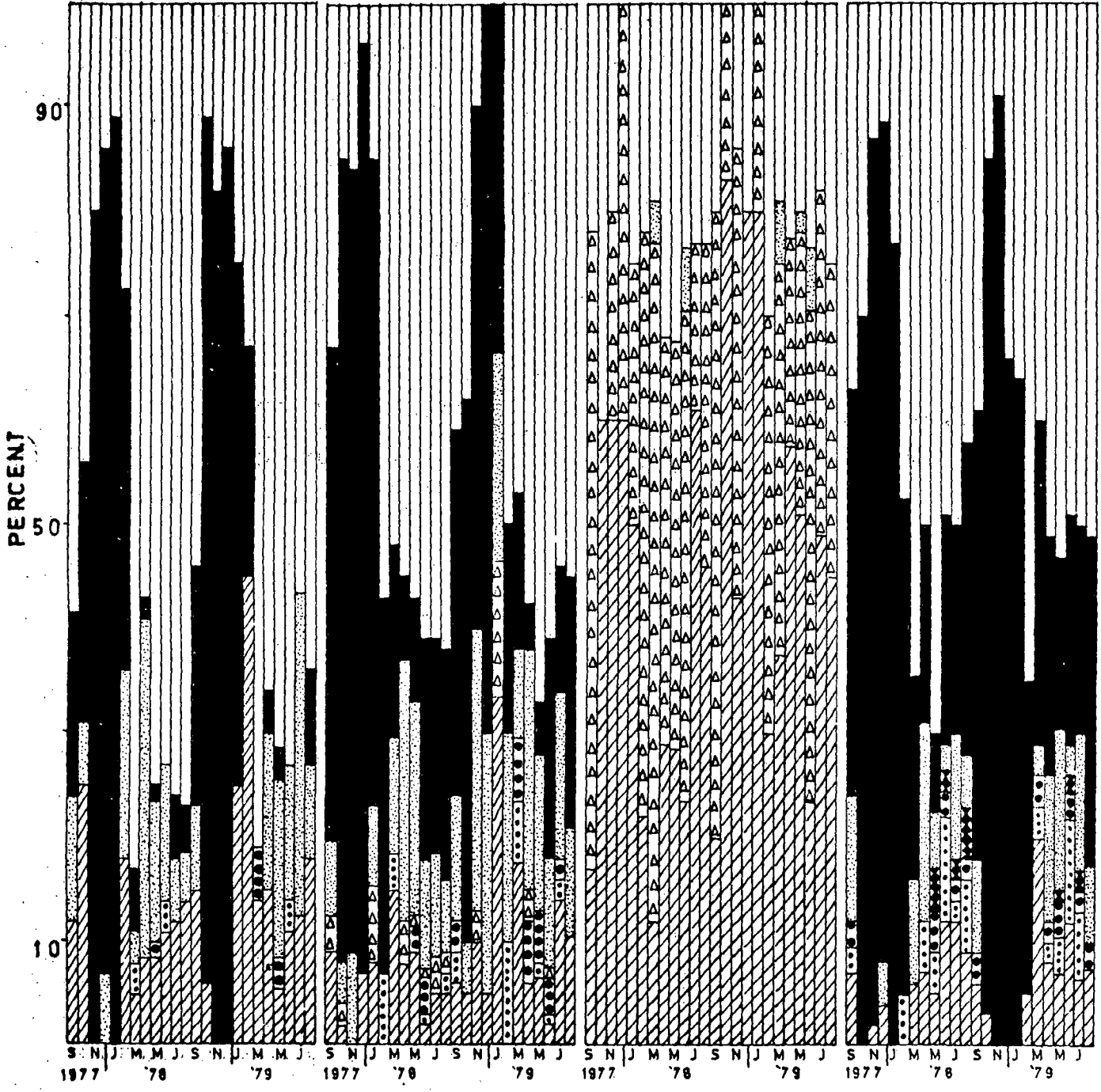


Fig. 4 : Seasonal fluctuations in the relative abundances of different families of fishes in all four stations of Simsong river during the present study.

Stn. I	=	Station I
Stn. II	=	Station II
Stn. III	=	Station III
Stn. IV	=	Station IV

- |              |                    |             |
|--------------|--------------------|-------------|
| □ CYPRINIDAE | ⊗ HOMALOPTERIDAE   |             |
| ■ COBITIDAE  | ▨ ANABANTIDAE      | ▧ CHANNIDAE |
| ▤ NANDIDAE   | ▩ HETEROPNEUSTIDAE | ▨ SILURIDAE |
| ⊞ SISORIDAE  | ▲ MASTACEMBELIDAE  | ⊙ BELONIDAE |

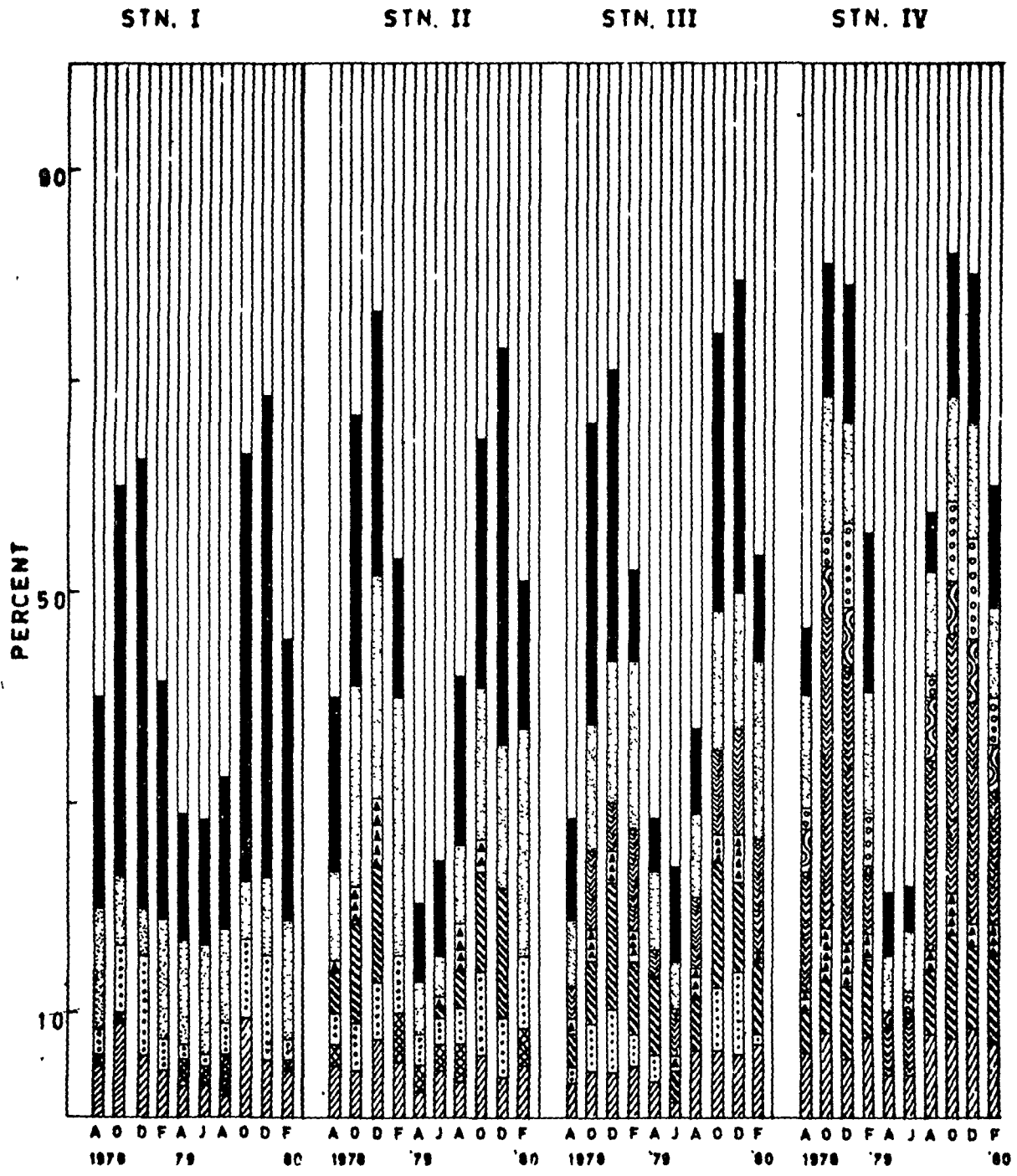


Fig. 5 : Seasonal fluctuations in the relative abundances of different families of fishes in all four stations of Damrang river during the present study.

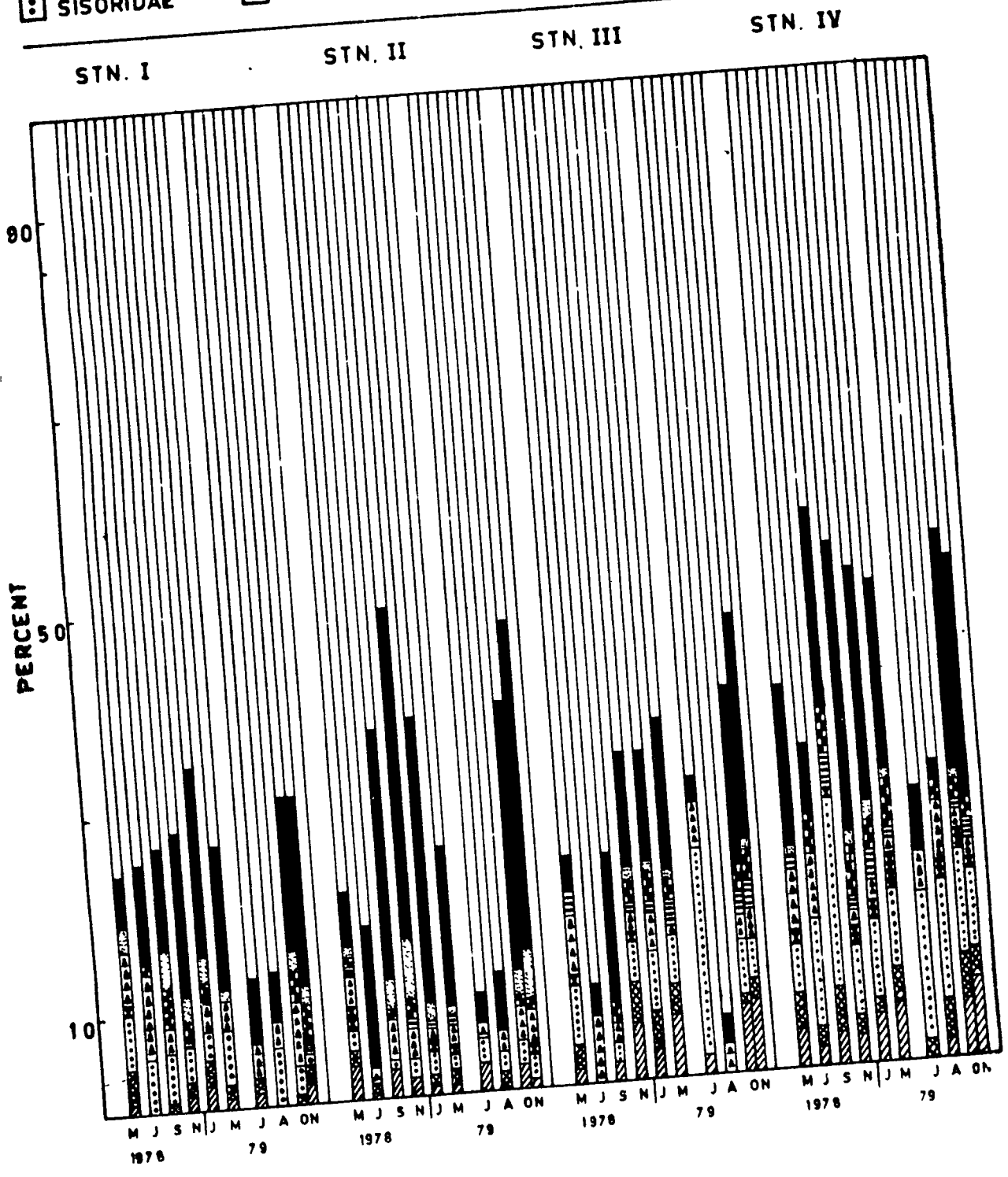
Stn. I	=	Station I
Stn. II	=	Station II
Stn. III	=	Station III
Stn. IV	=	Station IV



Fig. 6 : Seasonal fluctuations in the relative abundances of different families of fishes in all four stations of Pagladiya river during the present study.

Stn. I	=	Station I
Stn. II	=	Station II
Stn. III	=	Station III
Stn. IV	=	Station IV

- CYPRINIDAE
- COBITIDAE
- ▨ NANDIDAE
- ⊞ SISORIDAE
- ▩ HOMALOPTERIDAE
- ▣ PSILORHYNCHIDAE
- ▨ GOBIIDAE
- ▤ MASTACEMBELIDAE
- ▧ CHANNIDAE
- ⊞ AMBLYCIPITIDAE



Community Analysis

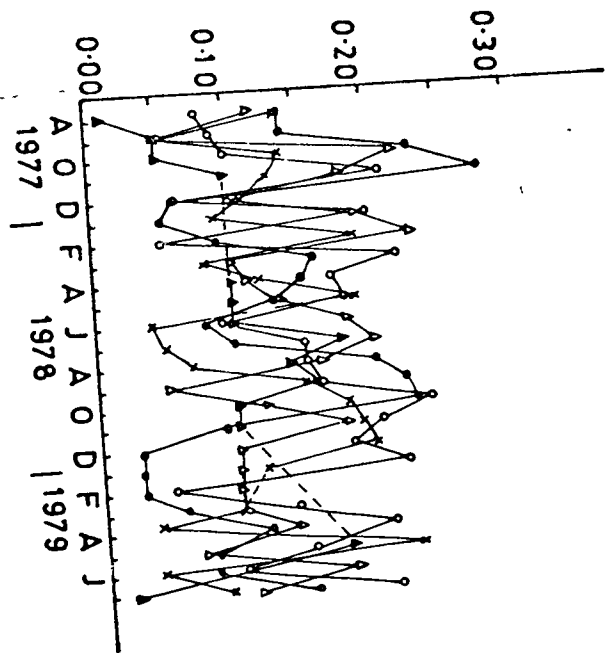
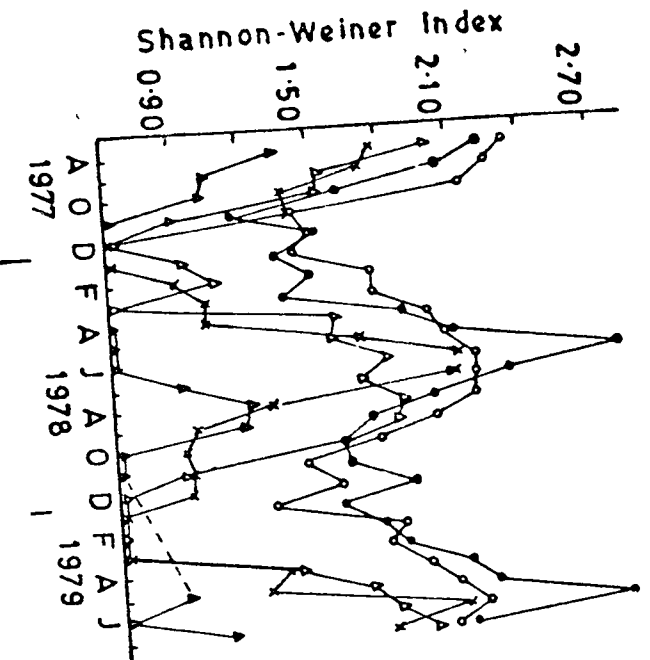
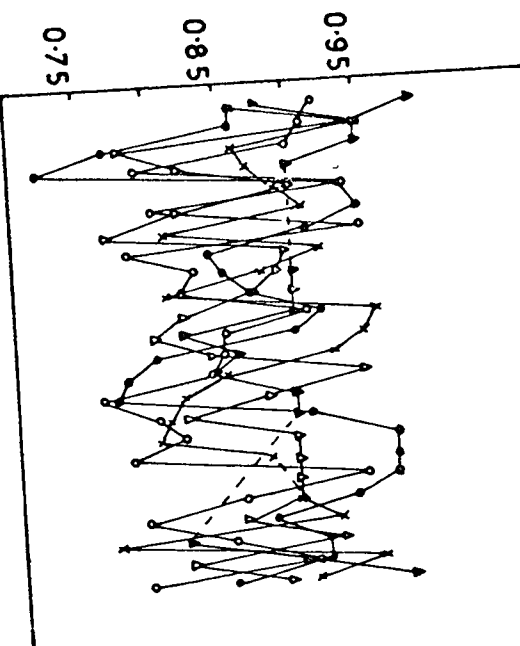
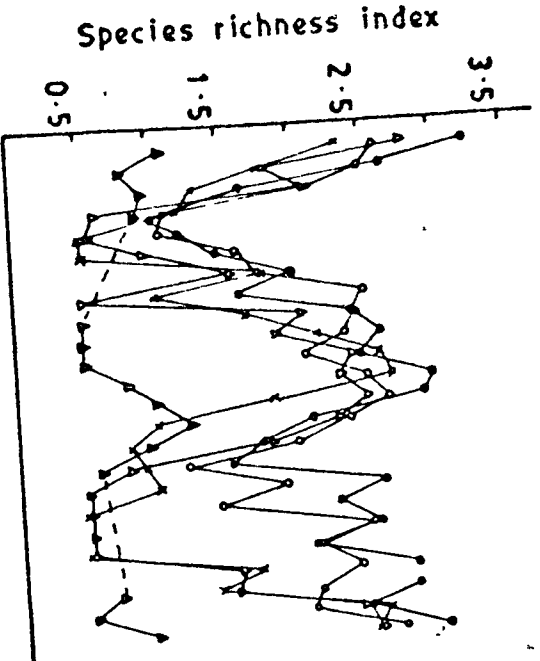
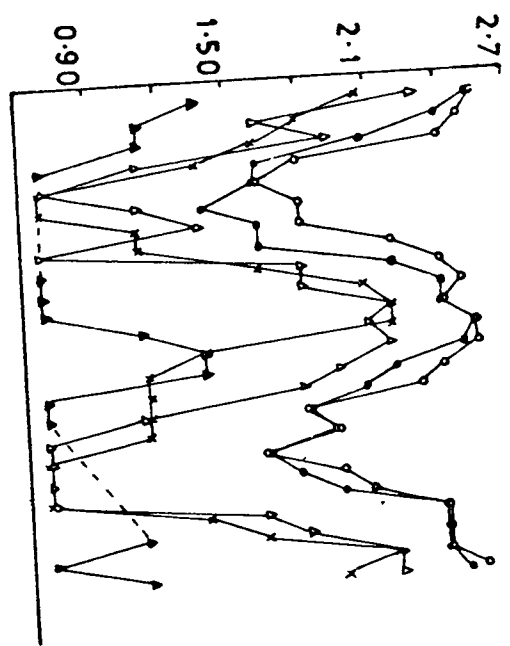
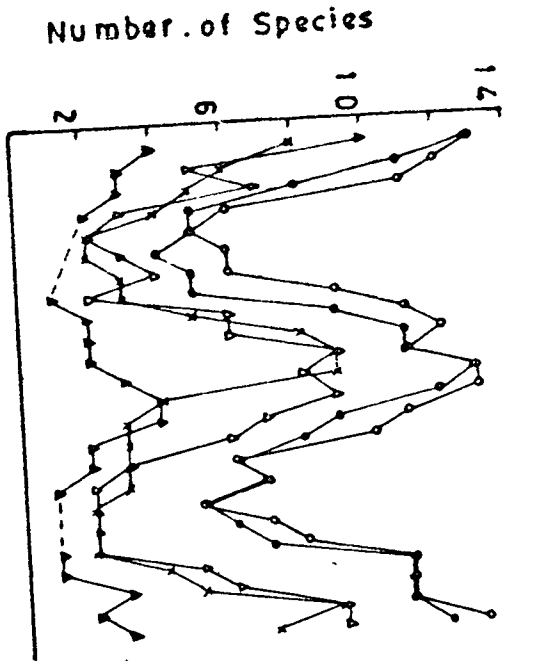
With the observation of the seasonal fluctuations of the families in the 5 rivers undertaken for detailed investigation the number of species and their fluctuation in the different stations and also the total rivers were plotted to see if there was a particular trend of fluctuation in the species numbers. Of the 4 rivers/streams of Meghalaya, the number of species in Sumer and Umkhrak during the summer months of May, June revealed peaks of abundance not only in the four different stations undertaken but as well as when the total rivers were considered. However, in Simsang the peaks were obtained in the winter months of December, January, February with a drop in summer. Here, too, it was the same picture of a fluctuating trend when the total lotic system was considered. In the fourth lotic system of Meghalaya present in Garo Hills, the trend was similar to Simsang. This trend of fluctuation in the seasonal abundance of the number of species as seen for Simsang and Damrang was also true for the river Pagladiya in Assam. In addition to the individual rivers and their stations the rivers of Meghalaya were further combined together to enable a picture of the general trend of fluctuations for the lotic systems in that state. When so done, it was observed that during the first annual cycle there seemed to be an increase during the early spring months while the subsequent annual cycle revealed a rise and drop in every month alternatively more or less (Fig. 7-11).

Though the number of species and their fluctuations were observed, a better understanding in the number of species

Fig. 7 : Seasonal fluctuations of species number, species richness index, Shannon-Weiner Index,  $H_{max.}$ , evenness index(J) and Redundance values(R) in the Umkhras stream during the present study.

○—○ : Total stream  
▲—▲ : Station I  
△—△ : Station II  
x---x : Station III  
●—● : Station IV

UMKRAH



Redundance (R)

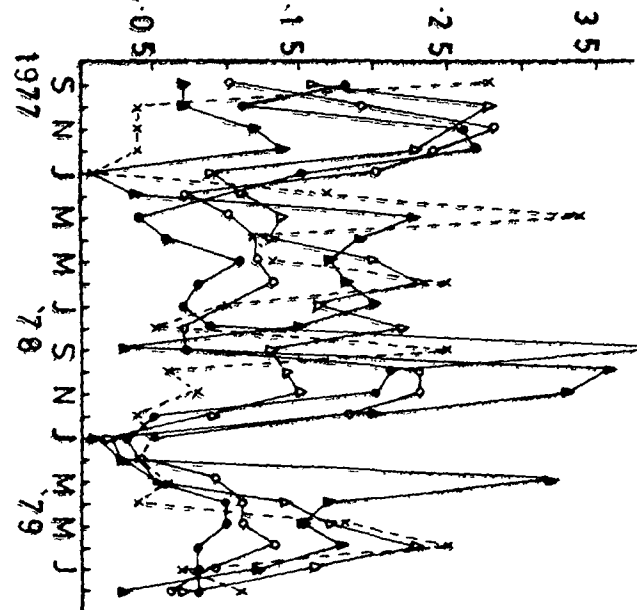
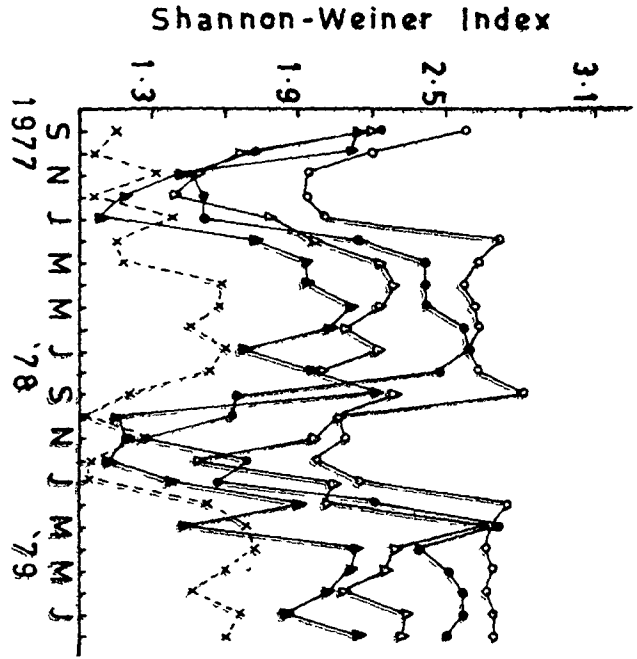
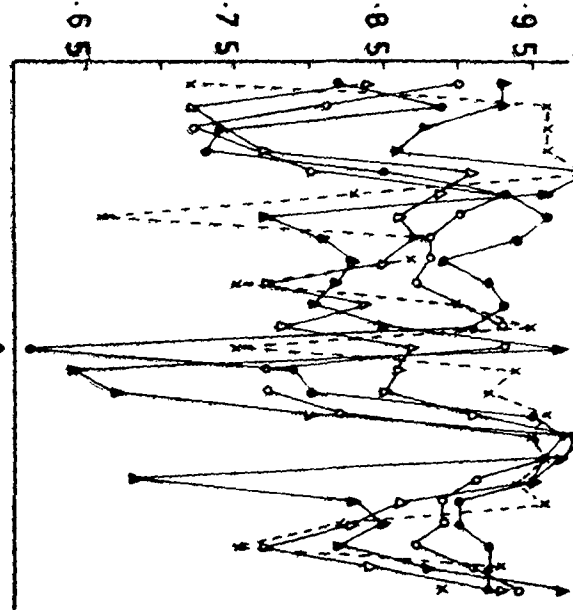
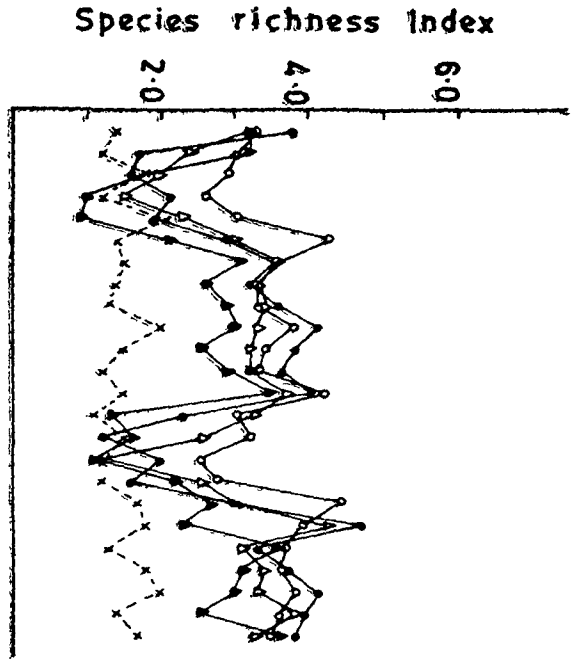
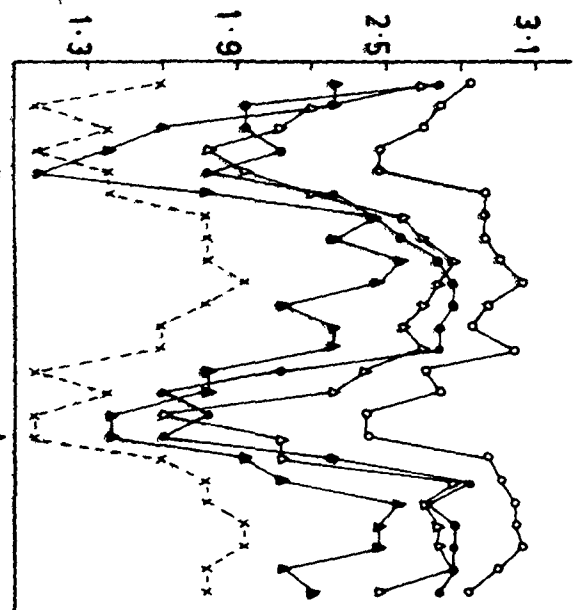
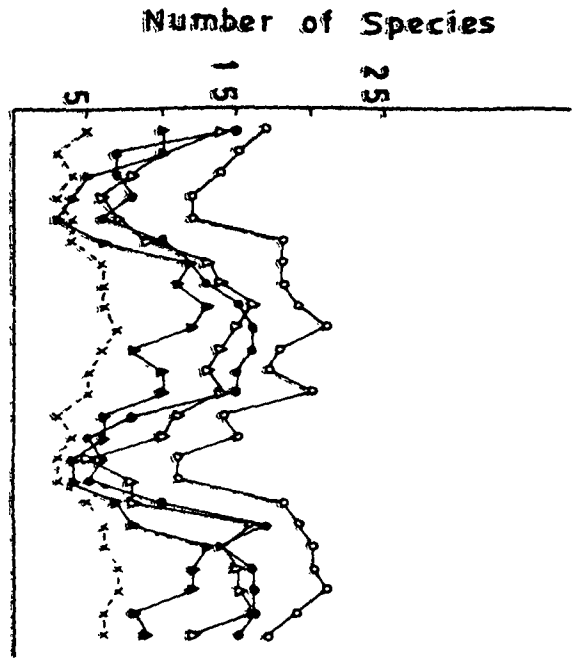
Evenness Index (J)

H' max.

Fig. 8 : Seasonal fluctuations of species number, species richness index, Shannon-Weiner Index, Hmax., evenness index(J) and Redundance values(R) in the Sumer stream during the present study.

○—○ : Total stream  
▲—▲ : Station I  
△—△ : Station II  
×—× : Station III  
●—● : Station IV

SUMER



$H_{max}$

Evenness Index (J)

Redundance (R)

Fig. 9 : Seasonal fluctuations of species number, species richness index, Shannon-Weiner Index,  $H_{max.}$ , evenness index( $J$ ) and Redundance values( $R$ ) in Simsong river during the present study.

○—○ : Total river  
▲—▲ : Station I  
△—△ : Station II  
×---× : Station III  
●—● : Station IV

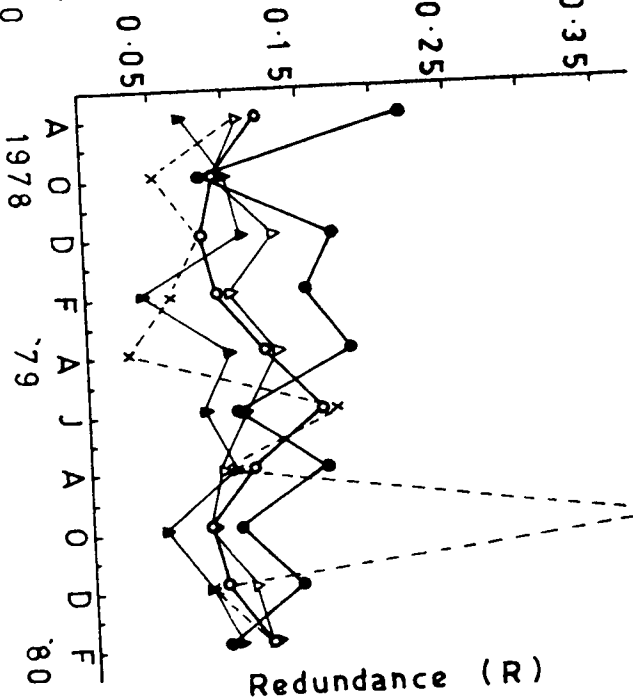
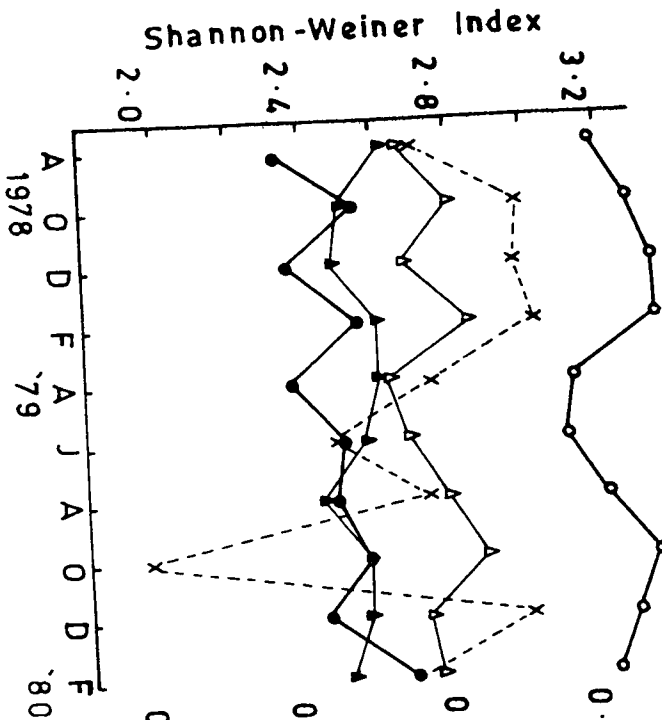
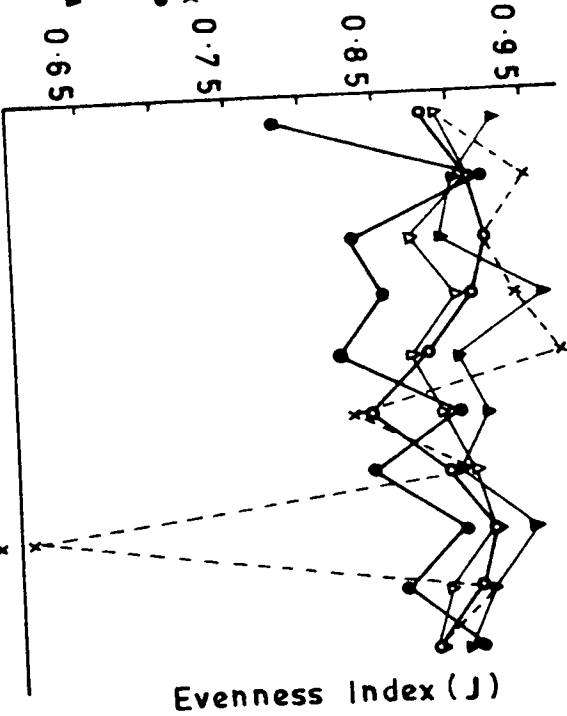
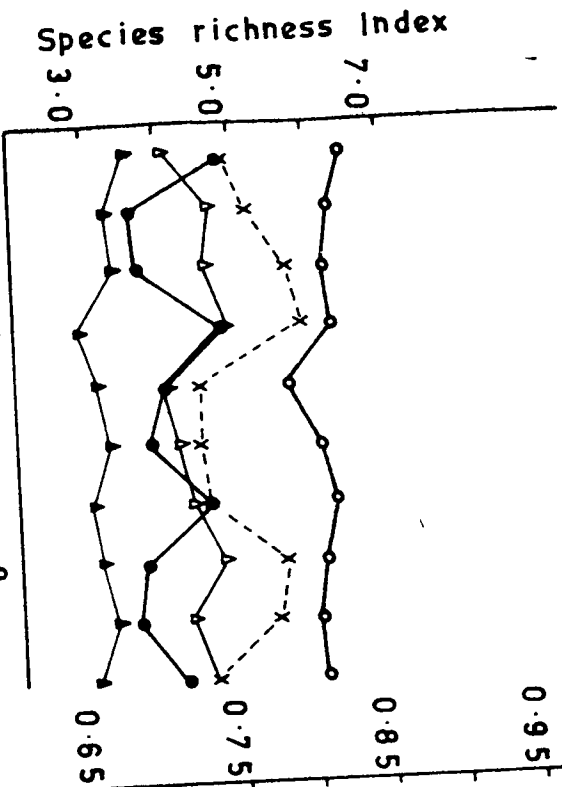
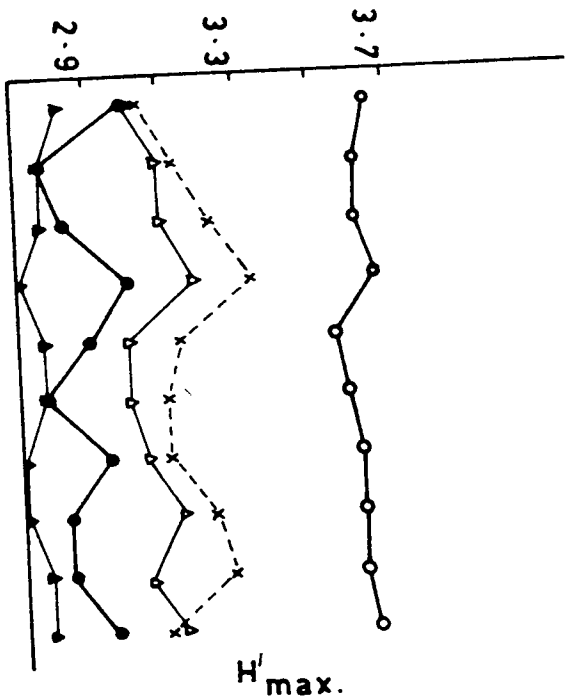
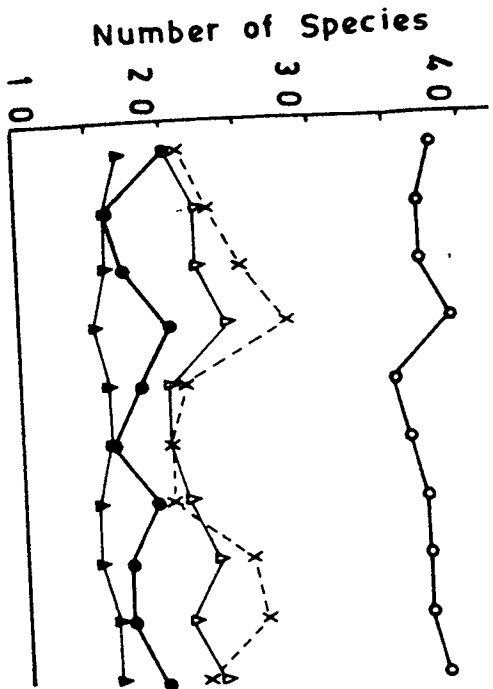


Fig. 10 : Seasonal fluctuations of species number, species richness index, Shannon-Weiner Index, Hmax., evenness index(J) and Redundance Values(R) in Damrang river during the present study.

- : Total river
- ▲—▲ : Station I
- △—△ : Station II
- x--x : Station III
- : Station IV

DAMRANG

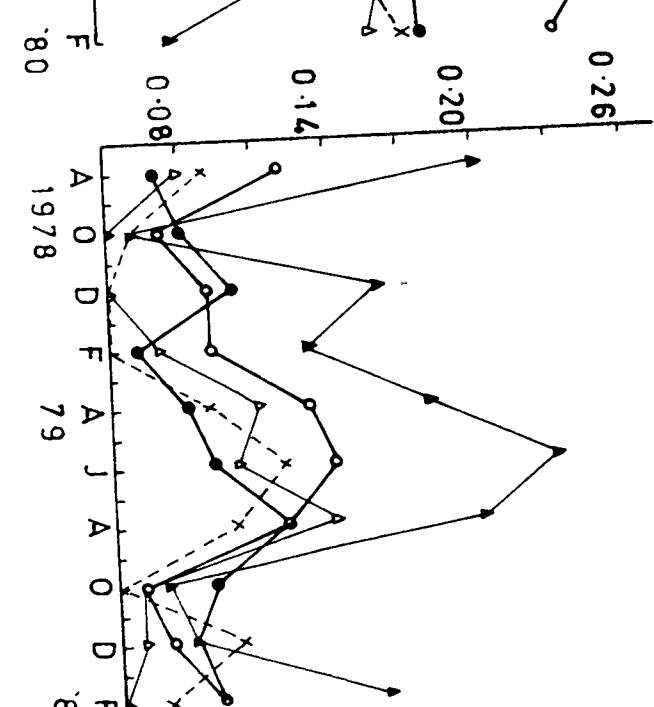
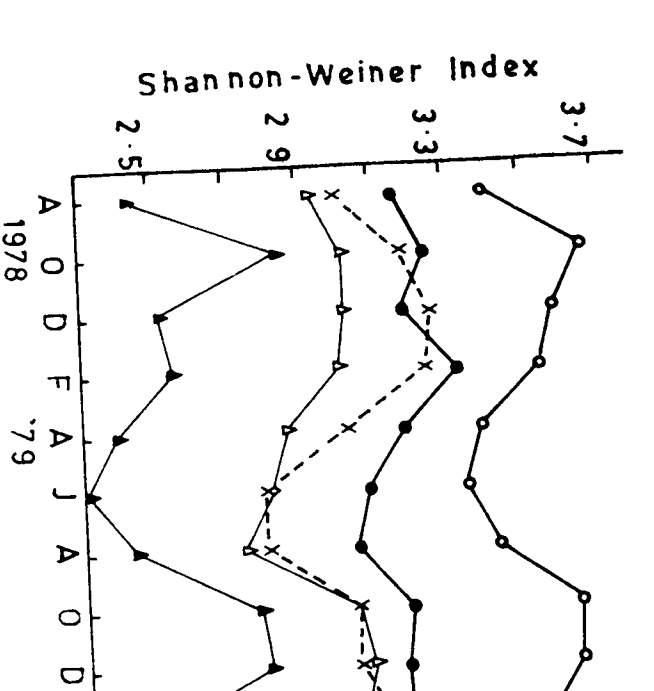
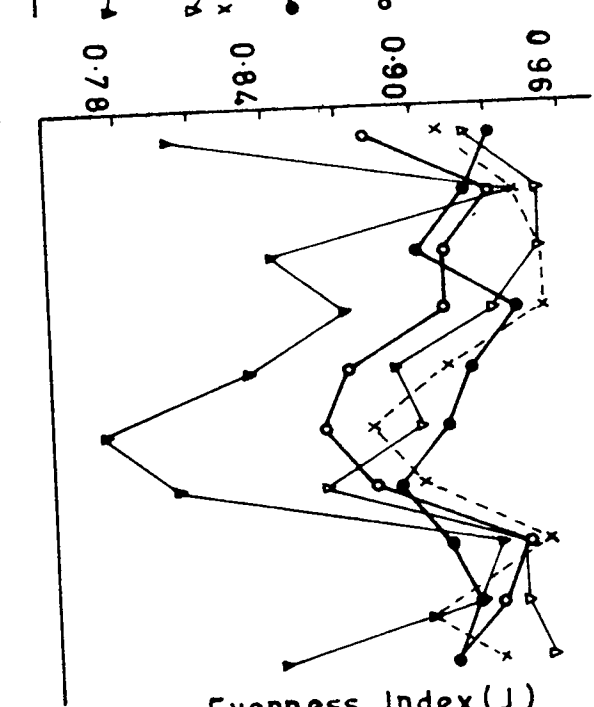
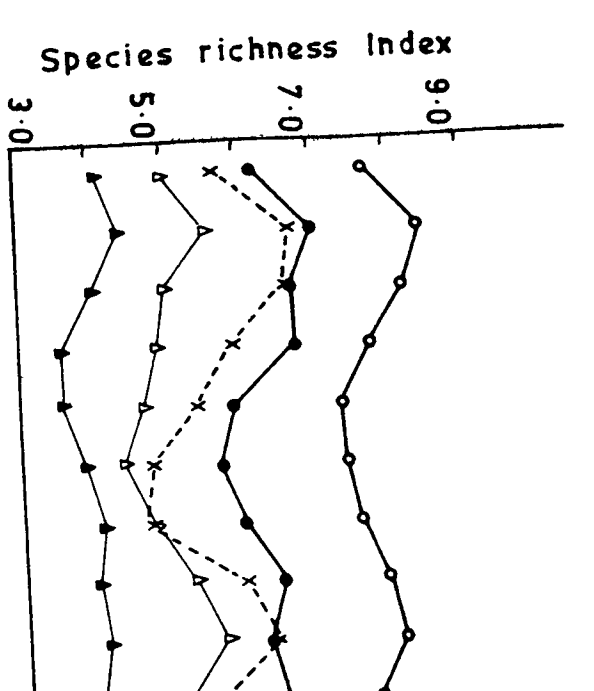
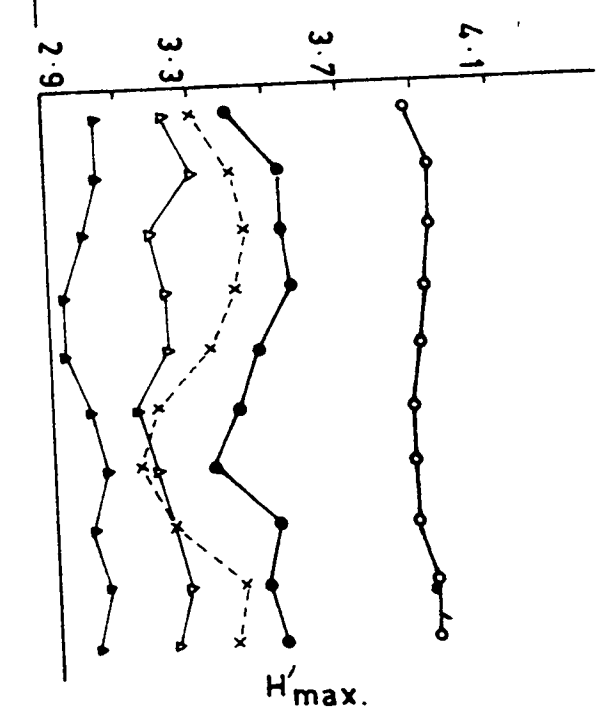
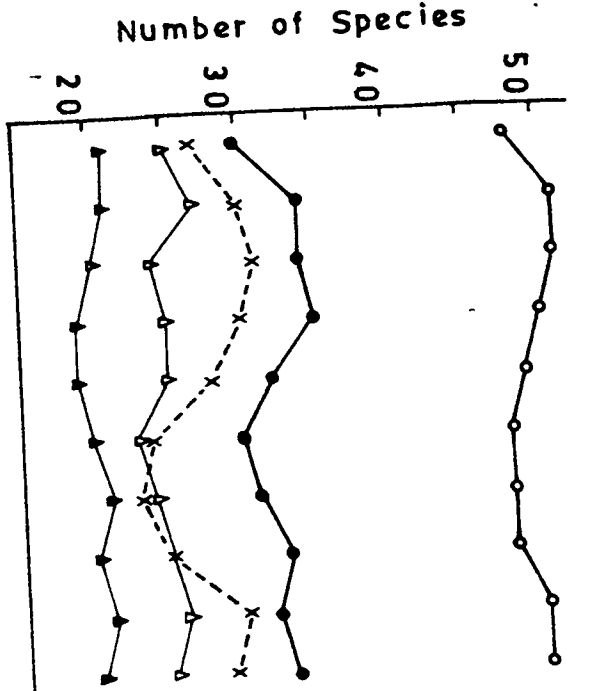
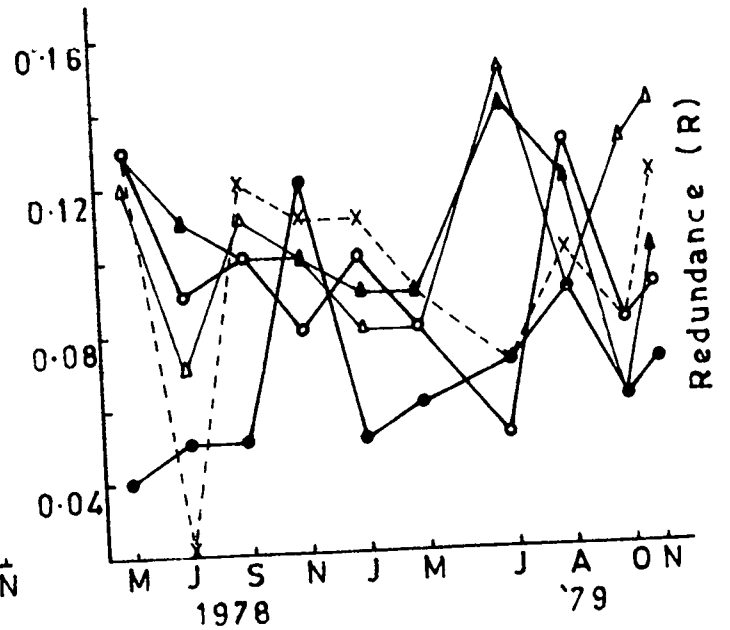
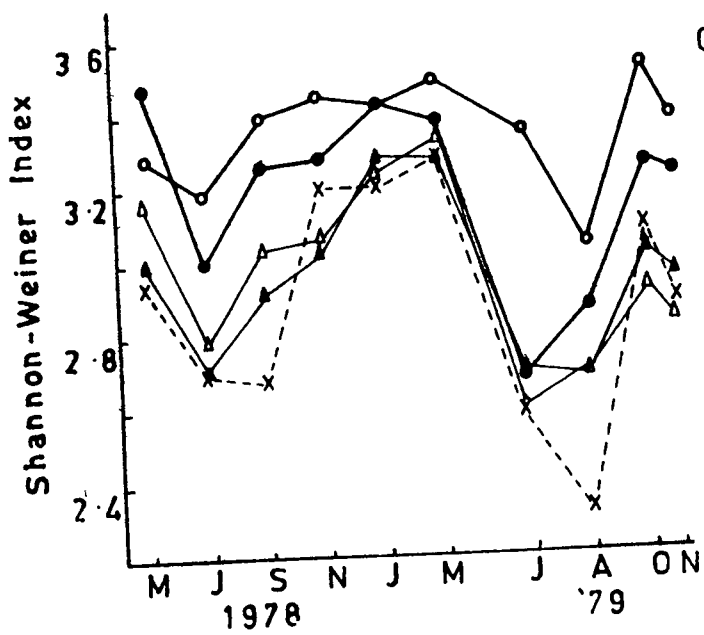
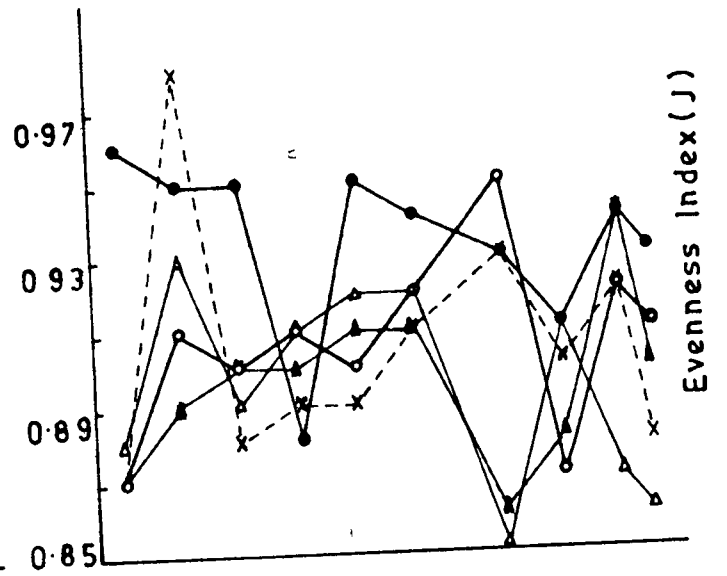
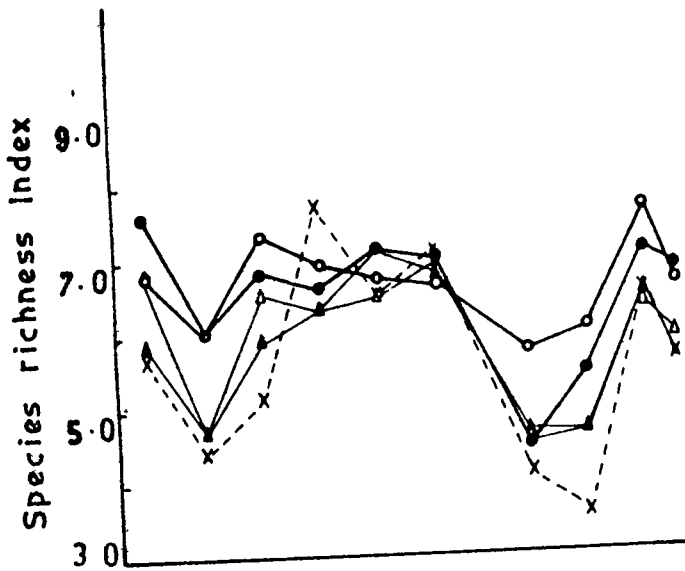
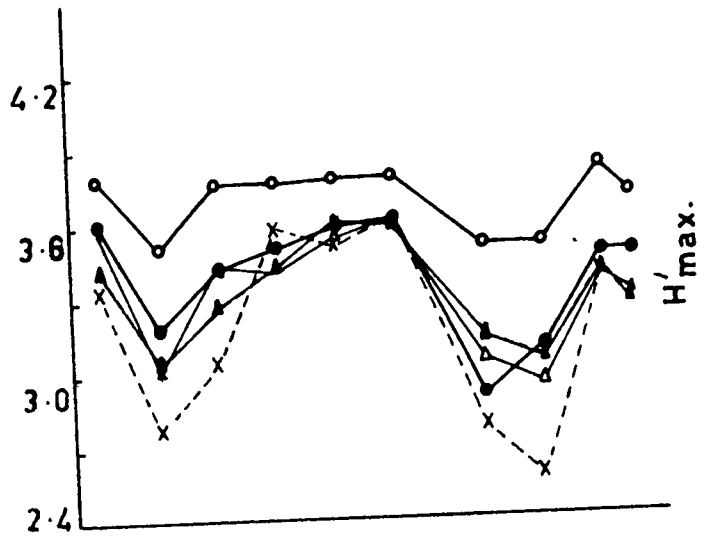
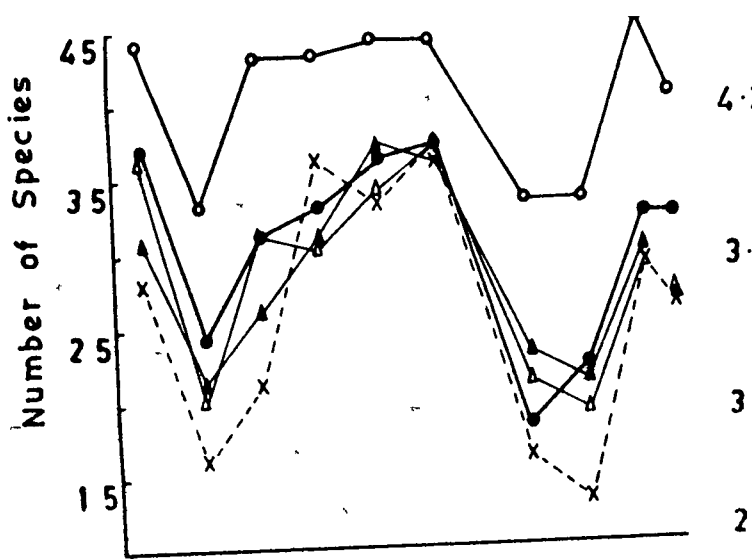


Fig. 11 : Seasonal fluctuations of species number, species richness index, Shannon-Weiner Index,  $H_{max.}$ , evenness index( $J$ ) and Redundance values( $R$ ) in the Pagladiya river during the present study.

○—○ : Total river  
▲—▲ : Station I  
△—△ : Station II  
x---x : Station III  
●—● : Station IV

PAGLADIYA



inclusive of the individuals present in each species could be achieved by a community analysis using the Species Richness Index of Margalef, the Shannon-Weiner Index, the maximum possible diversity index ( $H'_{max.}$ ) of the number of species and their individuals, the evenness index ( $J$ ) and their redundancy ( $R$ ) value. For the 4 rivers of Meghalaya it was observed that the Species Richness Index, the Shannon-Weiner Index, the  $H'_{max.}$  values and the evenness index all followed a more or less similar seasonal trend of fluctuation in relation to the stations and total system as seen for the trend of fluctuation in the number of species. The only exception to the contrary was the Shannon-Weiner Index for station III at the river Simsong which though had the usual winter maxima, revealed a drastic drop to a very low level during the autumn months of September and October, and that too observed only for the second annual cycle of study. This was true also for the evenness index for the same station and the same river. The redundancy values in all the 4 rivers of Meghalaya understandably revealed a mirror image of the evenness values. The river Pagladiya of Assam followed a similar pattern as the rivers of Meghalaya in that the Species Richness Index, Shannon-Weiner Index,  $H'_{max.}$  values and the evenness index followed a more or less similar trend of fluctuation as that of the number of species. However, the evenness index slightly deviated from this trend especially for the III station which showed a <sup>reverse</sup> trend in the river during both the annual cycles and station IV though possessing the usual peaks of abundance revealed a drop during the month of November of the first annual

cycle when it should have been on an increasing trend. Further, the total river, station I and II during the first annual cycle from May to July showed increased values in contrast to all the other indices when they decreased. In this river also the redundancy values possessed a mirror image of the evenness index. For the rivers of Meghalaya when the same indices were seen, a trend of fluctuation similar to the number of species was also present for the Species Richness Index, Shannon-Weiner Index and the  $H_{max}$ . In case of the evenness index during the late autumn months and early winter months of October, November there was a drastic fall from the oscillating trend of fluctuation which revealed a drop during spring and a rise during summer. As usual the redundancy values revealed an opposite picture to that of the evenness index. Though these were the general trends of fluctuations, the actual numbers and the values of indices varied from station to station and from river to river.

m In case of Umkhrach the maximum number of species present during the peak of abundance was 13 in July and August for the total river, and 13 in August in station IV, 9 in the months of June and July in the first annual cycle and July in the second annual cycle in station III, 10 in the month of August in the first annual cycle in station II and only 4 in the months of August in first annual cycle and August and September in the second annual cycle in station I. The lowest number of species 5 were recorded in the months of December for the total system in both the annual cycles, 4 in station IV in the month of January

in the first annual cycle, nil in the months of February in the second annual cycle in station III, 2 in the months of December and March in the first annual cycle and December to March in the second annual cycle in station II, and nil in the months of November to February and December to March in the first and second annual cycles respectively in Station I.

In Sumer the maximum number of species abundance 21 was recorded in the month of June in both the annual cycles for the total system, 17 in station IV in the months of March in second annual cycle, 7 in station III in June in first annual cycle and in the months of May and June in second annual cycle, 16 in station II in the months of May in the first annual cycle and March and July in the second annual cycle, and 13 in the month of May in first annual cycle and April in the second annual cycle at station I. The minimum observed was 11 in the months of December and January in the second annual cycle for total river, 5 in station IV in November and January in second annual cycle, 3 in station III in October and during December and October, December and January in the first and second annual cycles respectively. Station II showed a minimum abundance of 5 in December in the second annual cycle while station I in January of first annual cycle with 3.

In Simseng the maximum abundance of 39 was recorded in February in the first annual cycle for the total system, and 20 in station IV, 8 in station III, and 24 in station II in the

month of February in the first annual cycle while station I recorded a maximum of 17 in August in the first annual cycle. The minimum abundance of species number of 35 was observed in April for total river, 15 in station IV in October and August in first and second annual cycles respectively. Station III recorded a minimum of 20 species in June and August in the first and second annual cycles, station II also 20 in August, April and June of first annual cycle and in station I the minimum of 15 was observed in February in first annual cycle and August and October in second annual cycle. In Damrang maximum abundance of species number of 51 was recorded in October and December in the first annual cycle for the total system, 35 in station IV in February, 31 in station III in December and 27 in station II in October in the first annual cycle while 21 was recorded in station I in August and October in the first annual cycle and August and December in the second. Minimum abundance of 48 in the months of August and June in the first annual cycle and August and October in the second was recorded for total system, while it was August and June with 20 in station IV in the first annual cycle. Station III showed minimum in August with 23 in the second annual cycle and for station II was observed in June with 23 in the first annual cycle. Station I recorded minimum in the months of February and April in the first annual cycle with a species number of 19.

Pagladiya system recorded a maximum abundance of 45 species in October in the second annual cycle for total system,

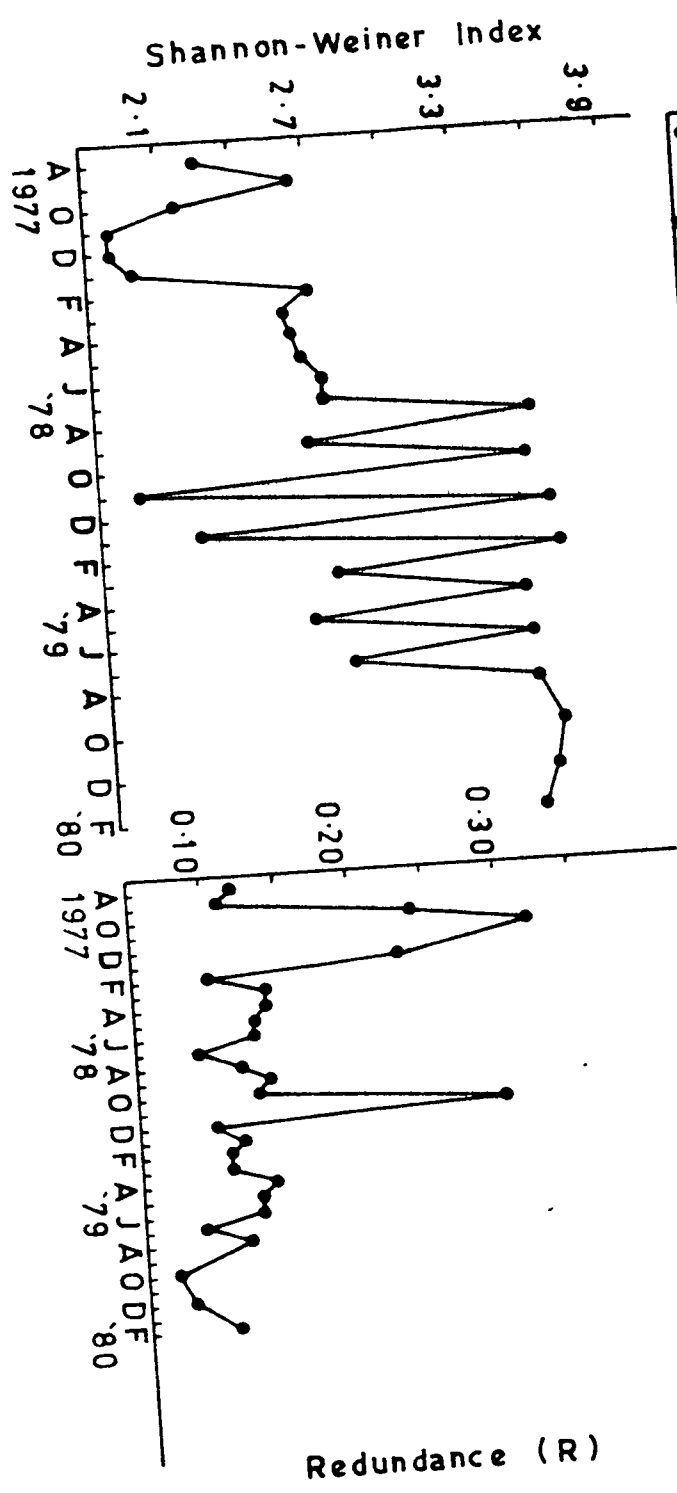
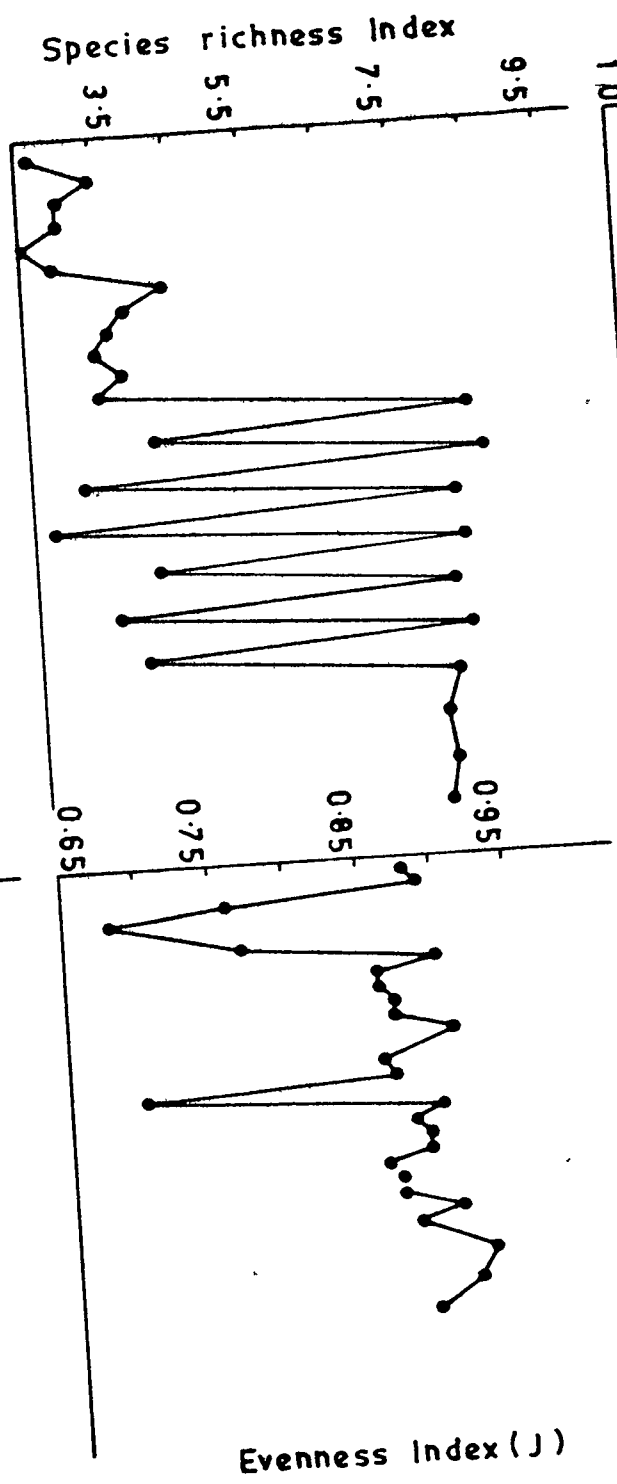
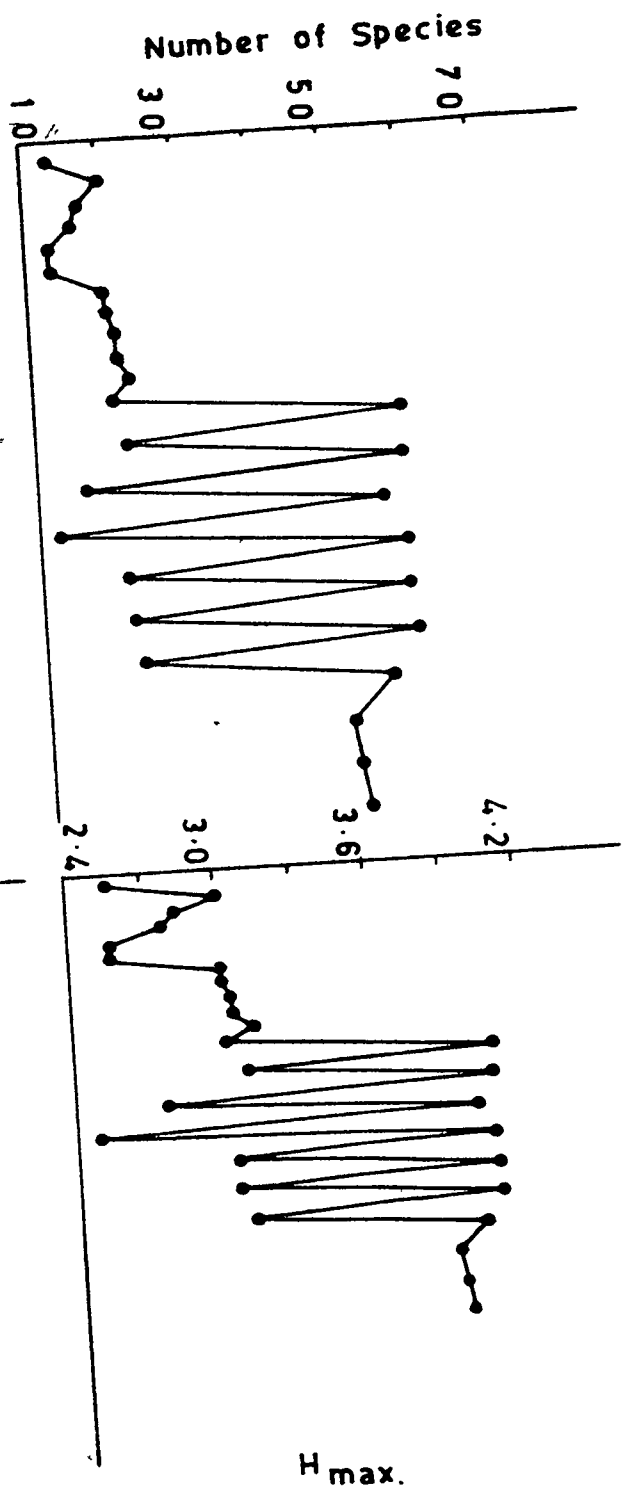
while in station IV the maximum was in the months of May and March with 37 species in the first annual cycle. Stations III and II the maximum was recorded in March, and station I in January with the same number in the first annual cycle. The minimum abundance of species number for the total system was observed in the months of July in the first, and June and August in the second annual cycles with 33 number of species. Station IV, III, and II recorded numbers of 18, 13, 19 in June, August and August respectively in the second annual cycle while station I showed a minimum of 21 in July and August of the first and second annual cycles respectively.

Total Meghalayan water systems showed a maximum abundance of species number of 60 in June of 1979 while the minimum with 12 numbers were recorded in January of 1979 (Fig. 12).

The maximum values of Species Richness Index in Umkhrah system was recorded in July in the second annual cycle for total system (2.70), August for stations IV (3.25) and II (2.64) and July for station III (2.72) in the first annual cycle. Station I showed maximum (1.25) in September in the second annual cycle. The minimum values (1.07) for total river was in December, for station IV (1.01) in November, for station III (0.49) in December and January, and station I in April to June (0.47) in the first annual cycle while for station II in December and March (0.49) in the first annual cycle and December to March in the second annual cycle.

Fig.12: Seasonal fluctuations of species number, species richness index, Shannon-Weiner Index, Hmas., evenness index(J) and Redundance values (R) in total Meghalayan systems during present study.

MEGHALAYA



The peak values for Species Richness Index in Sumer system was observed for total system in February, 4.37), for station IV (4.70) in March, for station II (4.25) in March and for station I (3.14) in April in second annual cycle while it was in January (2.16) in the first annual cycle for station III. The lowest values for the same index was observed in December for the total system (2.54), November (1.23) for station IV, December (1.33) for station II and October (1.12) for station III in the second annual cycle, while it was observed in January (0.91) in first annual cycle in station I.

Maximum values of the same index in Simsong river was observed for total river (6.53) and station I (3.65) in August, for station IV (4.80) in August and February, for station III (5.90) and station II (4.90) in February in the first annual cycle, while the minimum values (5.68) were recorded in April for total river and station II (4.04) in February (2.88) for station I, April and June for station III (4.52) in the first annual cycle. Station IV recorded minimum values (3.63) in October and December months of first and second annual cycles respectively.

Highest values of Species Richness Index in Dangrang river was recorded for total river (8.46) and stations IV and III and I (7.05, 6.70 and 4.48) in October, in the first annual cycle and for station II (5.67) in December of the second annual cycle. The minimum values of the index were observed for

total river (7.37) in April, for stations IV and II (5.72 and 4.40) in June and for station I (3.53) in February and April, of first annual cycle and for station III (4.73) in August of the second annual cycle.

Peak values of the Species Richness Index in Pagladiya system was noticed for total river (7.60) in October in the second annual cycle, while for stations I, II, III and IV (7.13, 6.85, 7.67 and 7.57) the highest values were recorded in January, March, November and May in the first annual cycle respectively. The lowest values were observed in June for total river (5.66) stations IV and II (4.42 and 4.53) and for stations I and II (4.56 and 3.50) in the second annual cycle.

The total lotic systems of Meghalaya recorded the highest value (8.62) of Species Richness Index in October 1978, and the lowest value (2.53) in December 1977.

Shannon-Weiner Index values of Umkhras system recorded highest (2.35) for total system in August and similarly for station I (1.36) in the first annual cycle, while for stations IV (2.79) it was in June, station II (2.01) August and for station III (2.12) in June in the first annual cycle. The lowest recorded values for total river (1.26) were in January of second annual cycle while station IV (1.15) recorded lowest in November, of first annual cycle. In station III lowest (zero) values observed were in February of second annual cycle, station II in December and March in first annual cycle and December to March in

second annual cycle (zero). Zero values were recorded from December to March in first and December to April in second annual cycles in station I.

Sumer system showed maximum values of Shannon-Weiner Index for total system (2.80) and station I (2.25) in September, stations IV and II (2.70 and 2.65) in March and station III (1.73) in April of the second annual cycle, while the lowest values for total river (1.88) and station II (1.39) in December and station I (0.91) in January in the first annual cycle. The lowest values for station IV (1.28) was observed in November and station III (1.03) in October of the second annual cycle.

In Simesong river the highest Shannon-Weiner Index (3.12) values were in February for total system and station III (3.33) and in August (2.63) for station I in the first annual cycle while in stations IV and II (2.69 and 2.75) the highest values were observed in February and October in the second annual cycle. The lowest values (3.10) for the total system was recorded in June, for station IV (2.33) in August and station II (2.62) in April of the first annual cycle while the lowest values for station I and III (2.44 and 1.97) were recorded in August and October of the second annual cycle.

In Damrang river system the peak values of Shannon-Weiner Index was observed for total river (3.66) and station I (2.85) in October, for station IV (3.33) in February and for

station III (3.25) in December of the first annual cycle while it was (3.08) in December in second annual cycle for station II. The lowest was observed in June for total river (3.33) and station I (2.32) of first annual cycle, August for stations II and IV (2.75 and 3.03) of second annual cycle and in June and August for station III (1.80) of first and second annual cycles.

Pagladiya river system showed highest Shannon-Weiner Index values for total river (3.51) in October of the second annual cycle while station I, II, III and IV (3.28, 3.32, 3.28 and 3.48) showed highest in the months of January and March, March, March and May in first annual cycle respectively. The lowest values were recorded for total system (3.03) and for stations III and I (2.31 and 2.67) in August of second annual cycle, while stations IV and II (2.67 and 2.60) recorded lowest in June of the second annual cycle.

Total lotic systems of Meghalaya showed highest (3.65) Shannon-Weiner Index value in February of 1979 and lowest (1.88) in November and December of 1977.

Maximum diversity ( $H'_{max}$ ) values were observed highest in the Umkhras system in August and July in the two annual cycles, for total system, (2.56), and minimum (1.61), in December of the first annual cycle. For station IV the maximum value (2.56) was in July and August of first annual cycle, for station III maximum (2.20) in June, July of first and in June of second annual cycles. For station II the maximum value

(2.30) was recorded in August of first annual cycle while it was highest (1.39) in August of both annual cycles and September in the second annual cycle. The minimum value for station IV (1.39) was observed in January of first annual cycle and for station III (zero value) in February in second annual cycle. For station II minimum values (0.69) were observed in December and March of first annual cycle and December to March in the second while station I showed (zero values) from December to March and December to April in first and second annual cycles respectively.  $H_{\max}$  values of Sumer showed highest values for total system (3.04) in June, minimum (2.40) in December and January of first and second annual cycles respectively. For station IV maximum (2.83) in March and minimum (1.61) in November and January both in the second annual cycle, for station III maximum (1.94) in June and minimum (1.10) in October and December of first annual cycle, October, December and January in the second annual cycle, for station II maximum (2.77) in May of first annual cycle and March and May of second annual cycle, and for station I maximum (2.56) in May and April of first and second annual cycles respectively and minimum (1.10) in January of the first annual cycle.

In Simsong  $H_{\max}$ , values were highest for the total river (3.66), for stations III (3.33) and station II (3.18) in February of first annual cycle, and for station IV (3.00) in August and February, for station I in August of the first annual cycle. The lowest values (3.55) for total system was observed in April of the first annual cycle whereas in station IV (2.77)

it was in August and June of first annual cycle. Station III showed minimum (3.04) in August of first annual cycle while station II recorded lowest values in August, April and June of first annual cycle. Station I showed its lowest values in the months of February in first annual cycle and August and October in the second annual cycle.

In Damarang the peak values of  $H_{max}$ . for total system (3.93) was observed in October and December while the lowest (3.87) was in August and June, and August and October of first and second annual cycles respectively. Highest values for station IV (3.55) and station III (3.43) were observed in February and December respectively in the first annual cycle while lowest for station IV (3.33) and station III (3.13) was recorded in August of second annual cycle. Station II showed highest value (3.30) in October and lowest (3.13) in June of the first annual cycle and station I recorded maximum value (3.04) in August and October, and August, December of first and second annual cycles with lowest value (2.94) in February and April of first annual cycle.

Pagladiya river system recorded highest  $H_{max}$ . value (3.81) for total system in October in second annual cycle, lowest (3.50) in July of first and June and August of the second annual cycles respectively. In station IV the highest values (3.61) were recorded in May and March of first annual cycle with lowest (2.89) in June of second annual cycle. Stations II and III recorded high values (3.61) in the month of March and first

annual cycle with lowest values for station III (2.56) and station II (2.94) in August of second annual cycle. Station I recorded high value (3.61) in the month of January and lowest (3.04) in the month of August of the first and July of second annual cycles respectively.

Meghalayan lotic systems showed maximum  $H_{max}$  value (4.21) in June of 1979 and minimum (2.48) in January of 1979.

Evenness Index (J) and Redundance (R) values of Umkhrach showed maximum values (0.95 and 0.24) for total system in February, and October in both the annual cycles and in the second cycle the minimum values (0.76 and .05) were in the reverse way. In station IV the maximum was (0.97 and 0.28) from December to February of the second annual cycle and in November of the first, and the minimum (0.72 and 0.3) in the reverse way. In station III maximum of J value (0.96) in June, minimum (zero) in February of second while the R values maximum (0.23) in May and minimum (zero) in February of second annual cycle. In station II the maximum J value, (0.95) was in September and minimum (0.77) in February of first annual cycle while maximum R value was (0.23) in February of first annual cycle and minimum (.05) in the reverse months. In station I maximum J value (.99) was in August of first annual cycle and minimum (0.82) was in July and May of first and second annual cycles. Maximum R value (0.18) and minimum value (0.01) in the reverse way were recorded.

In Sumer system the peak values of evenness index (J) and Redundance (R) were recorded for total system (0.96) in

February and (0.28) November of second and first annual cycles while the minimum values (0.72 and 0.04) in the reverse months. The maximum J and R values in station IV (0.97 and 0.39) were in January and September of second annual cycle, while the minimum (0.61 and 0.03) in the opposite way, while in station III maximum (0.99 and 0.34) in January and March of first annual cycle, the minimum (0.66 and 0.01) in the reverse months of the first annual cycle. Station II showed maximum (0.98 and 0.28) in January and October and November of second and first annual cycles while the minimum (0.72 and 0.02) were in the reverse months. Station I recorded highest values of J and R (0.64 and 0.01) in the opposite.

The maximum J and R values were recorded for total system (0.92 and 0.16) of Simsang river in December and October of first and second annual cycles and in June of second annual cycle respectively, while the minimum values (0.84 and 0.08) vice versa. Station IV recorded highest values (0.92 and 0.22) in October and August of first cycle and the minimum (0.78 and 0.08) vice versa, while station III showed maximum (0.97 and 0.39) values in April and October of first and second annual cycles and minimum (0.61 and 0.03) vice versa. Station II recorded highest values of J and R (0.92 and 0.13) in October, and December and April of second and first annual cycles respectively the minimum values (0.87 and 0.08) vice versa whereas the highest values (0.96 and

0.11) were recorded in station I during February and December months of first annual cycle and the minimum (0.89 and 0.04) in the opposite.

Damrang river showed maximum values of J and R for total system (0.94 and 0.14) in the months of October and June of second and first annual cycles respectively and the minimum values (0.86 and 0.06) in the reverse way, while in station IV maximum was recorded (0.94 and 0.12) in February and August of first and second annual cycles respectively and minimum (0.88 and 0.06) in the reverse months. In station III the maximum values (0.95 and 0.10) were observed in February and April, and in August of first and second annual cycles, the minimum (0.90 and 0.05) in the reverse way; while in station II the maximum values (0.95 and 0.14) were in October and December of first, and August of second annual cycles respectively, with minimum (0.86 and 0.05) in the opposite. Station I recorded maximum values (0.94 and 0.23) in October and June of first annual cycle with minimum values (0.77 and 0.06) in the opposite months.

In Pagladiya river the highest values both for J and R were recorded for total system (0.95 and 0.13) in June and May and August of second, first and second annual cycles respectively with minimum (0.87 and 0.05) in reverse way. Station IV showed maximum (0.96 and 0.12) values in May and November of first cycle with minimum (0.88 and 0.04) in the reverse, while station III the maximum (0.98 and 0.13) were in July and May of first

annual cycle with minimum (0.87 and 0.02) in the reverse. Station II recorded highest (0.92 and 0.15) in January and March of first and June of second annual cycles with minimum (0.85 and 0.08) in the reverse. In station I the maximum (0.94 and 0.14) were recorded in October and June of first annual cycle with minimum (0.86 and 0.06) in the opposite months respectively.

Total lotic systems of Meghalaya recorded maximum J and R values (0.93 and 0.32) in October, 1979, and in November 1977 respectively, while the minimum values (0.68 and 0.07) were recorded in the same months but in the opposite way.

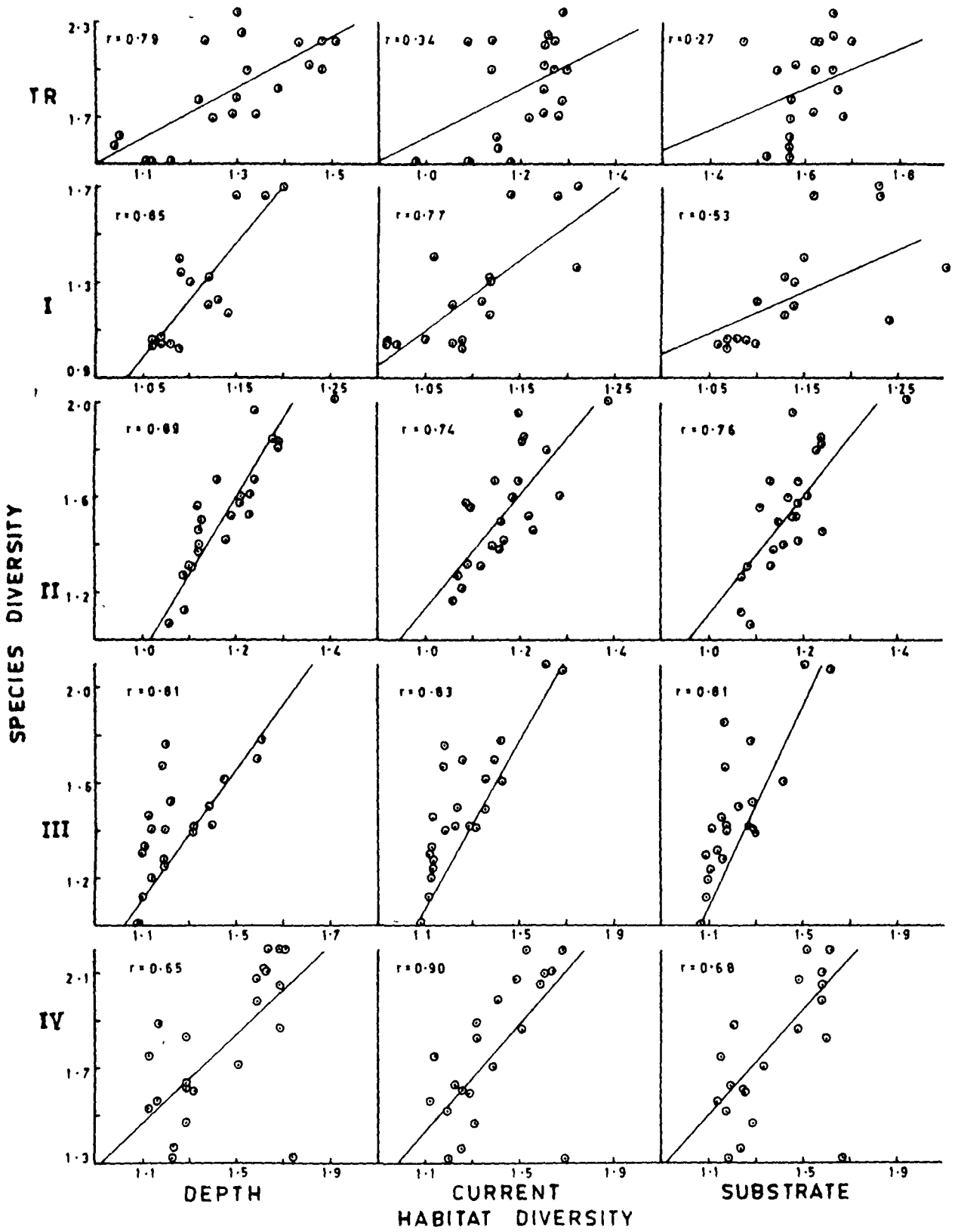
#### Ecosystem Analysis and Correlation

In addition to the general fluctuating trends of various indices the investigation was carried out to observe if these trends and especially the diversity of species was affected by their habitat diversity. For this, three different habitats, the depth, current and substrate were undertaken and their diversity indices calculated and plotted as a regression coefficient with species diversity for the different stations and for the total system to enable a picture of relationship between habitat diversity and species diversity. The river Umkhrah for all the stations revealed a highly positive correlation and significant for all the habitat diversity in relation to its species diversity ( $r = .53$  to  $.89$ ) and for depth alone for the total river ( $r = .79$ ) (Fig. 13). In the case of Simsong the correlations were not significant and in most of the

Fig. 13: Regressions ( $r$ ) of fish species diversity against habitat diversity for total stream and stations I, II, III and IV in the Umkhrah stream during the present study.

TR : Total stream  
I : Station I  
II : Station II  
III : Station III  
IV : Station IV

UMKHRAH



cases they revealed a trend in the negative with only station II ( $r = .31$ ) and the total river ( $r = .37$ ) showed a positive relationship for substrate diversity and species diversity relationship (Fig. 14). In addition those which did reveal a positive nature were not very significant. Sumer like Umkhrak though revealed a positive trend for most of the habitats was not very highly significant as in the latter ( $r = .06$  to  $.7$ ). Further, a negative correlation existed between current diversity and species diversity at station II ( $r = - .15$ ). In addition, in station III the relationship between depth diversity and species diversity was not ordinarily possible to be plotted as in the case with others as the calculated 'Y' values differed in their fourth decimal places and that too by only .0001 (Fig. 15).

In Damrang a totally different picture was obtained from the other rivers considered, in that the depth diversity for the total river and all the stations except the fourth revealed a negative correlation while the IV station was positive ( $r = .32$ ) (Fig. 16). Similarly, between current diversity and species diversity the trend was predominantly negative and even in those cases where they were positive as for station II ( $r = .07$ ) and the total river ( $r = .07$ ) the values were so low to be non significant. The only relationship which was positive though not highly significant was seen between substrate diversity and species diversity for all the stations as well as for the total river ( $r = .23$  to  $.6$ ). The river Pagladiya of Assam also like

Fig. 14: Regressions ( $r$ ) of fish species diversity against habitat diversity for total river and stations I, II, III and IV in the Sinsong river during the present study.

TR : Total river  
I : Station I  
II : Station II  
III : Station III  
IV : Station IV

SIMSONG

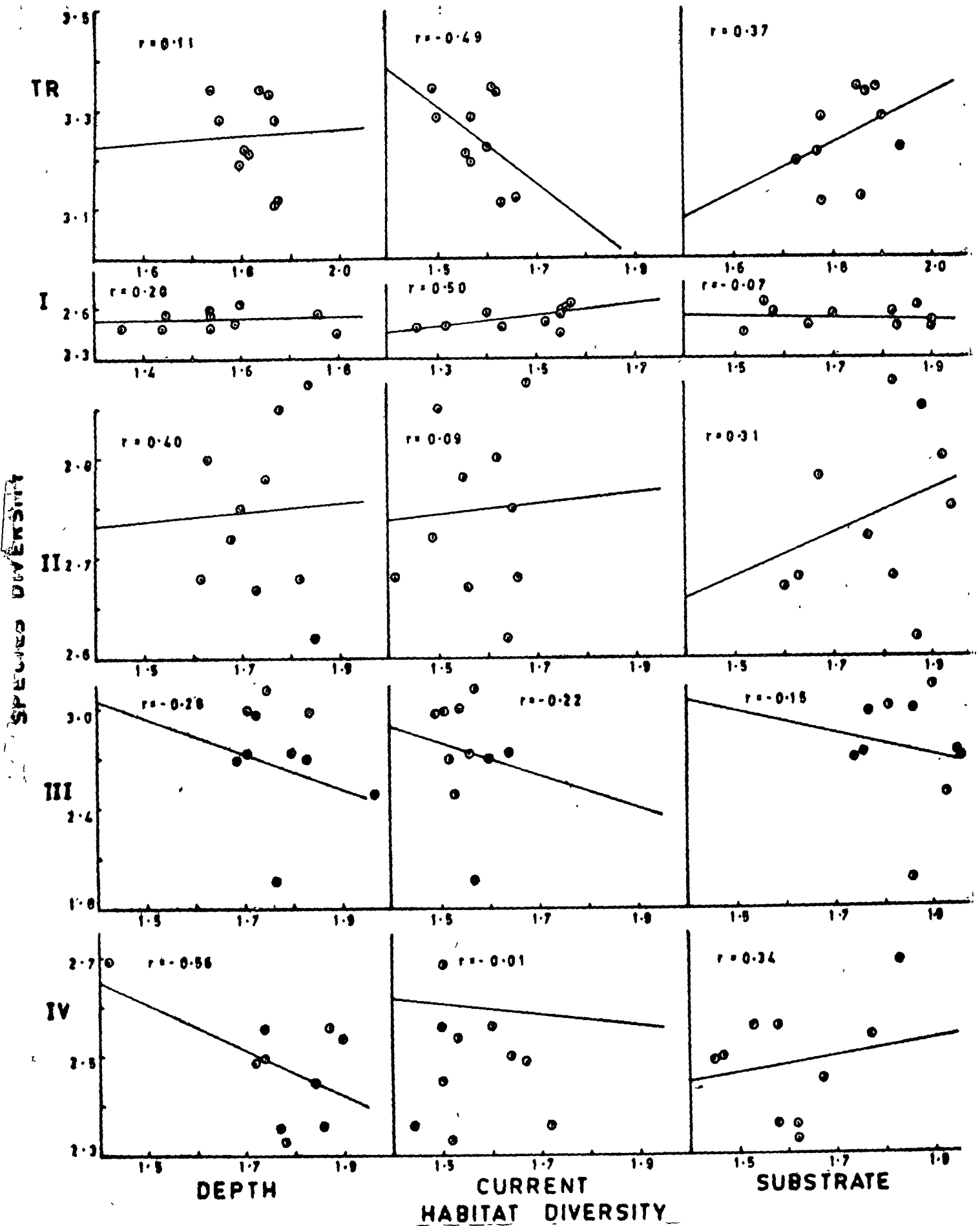


Fig. 15: Regressions ( $r$ ) of fish species diversity against habitat diversity for total stream and stations I, II, III and IV in the Sumer stream during the present study.

TR : Total stream  
I : Station I  
II : Station II  
III : Station III  
IV : Station IV

SUMER

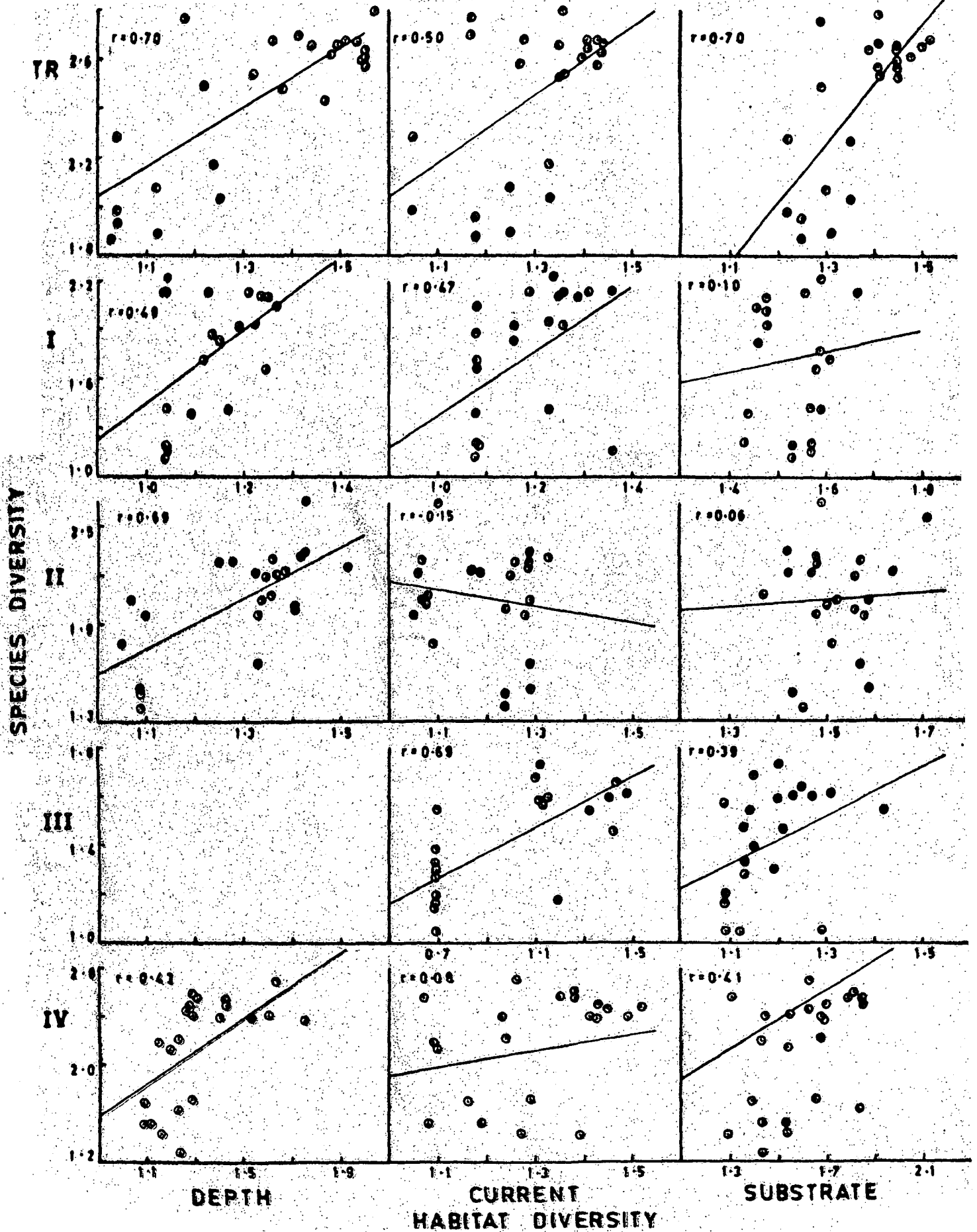
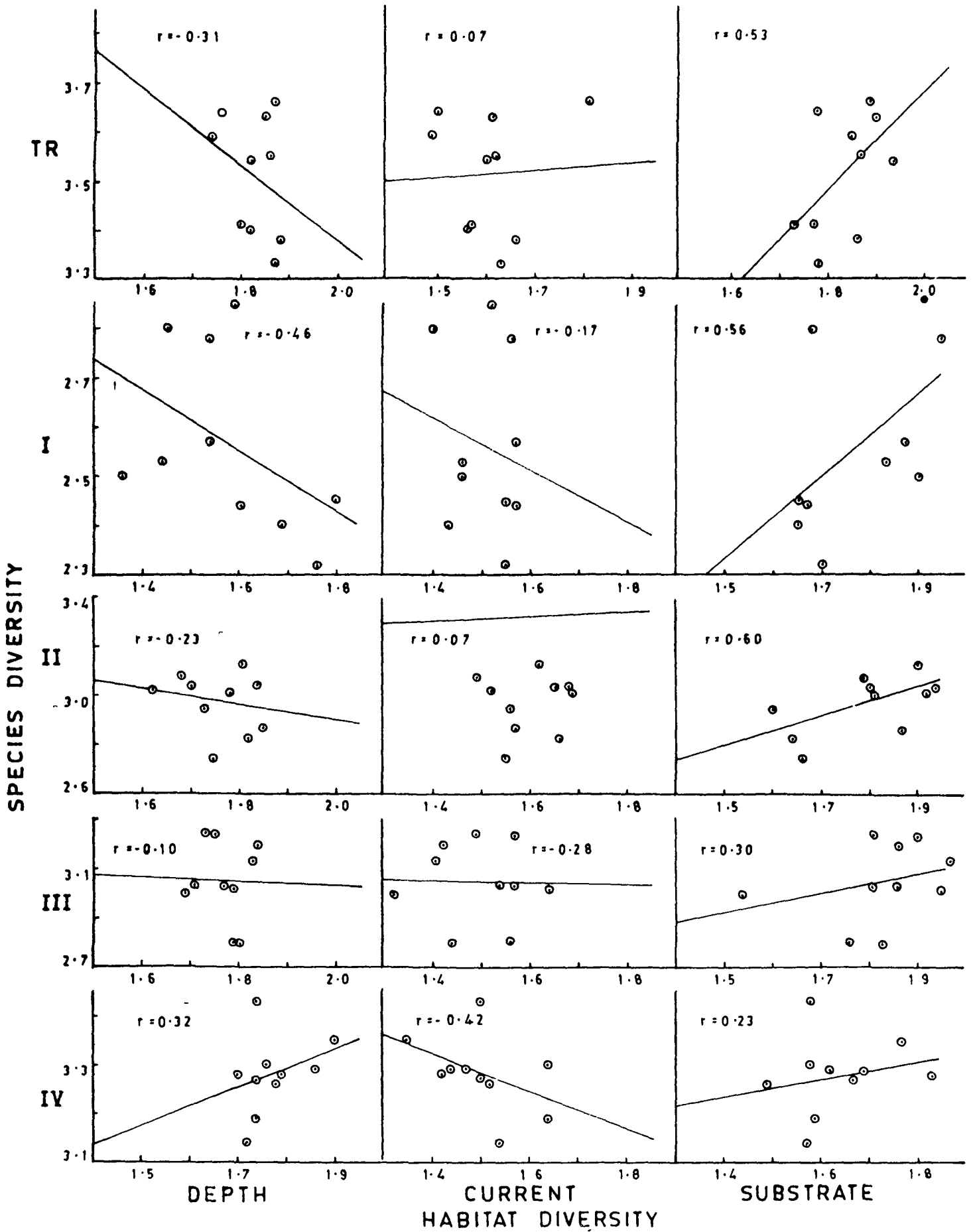


Fig. 16: Regression ( $r$ ) of fish species diversity against habitat diversity for total river and stations I, II, III and IV in the Damrang river during the present study.

TR : Total river  
I : Station I  
II : Station II  
III : Station III  
IV : Station IV

DAMRANG



Damrang did not possess a common relationship between habitat diversity and species diversity (Fig. 17). In this river the positive relationship was seen for all the habitats when the total river ( $r = .41$  to  $.9$ ) was considered and as well as for station III ( $r = .35$  to  $.76$ ) between substrate diversity and species diversity and in station IV between depth diversity and species diversity ( $r = .63$ ). The rest revealed a negative relationship and in some cases quite significant.

A similar analysis when done for all the lotic systems of Meghalaya, they revealed a highly positive significant relationship between all the habitats undertaken and their species ( $r = .89$  to  $.93$ ) (Fig. 18).

#### Frequency of distribution

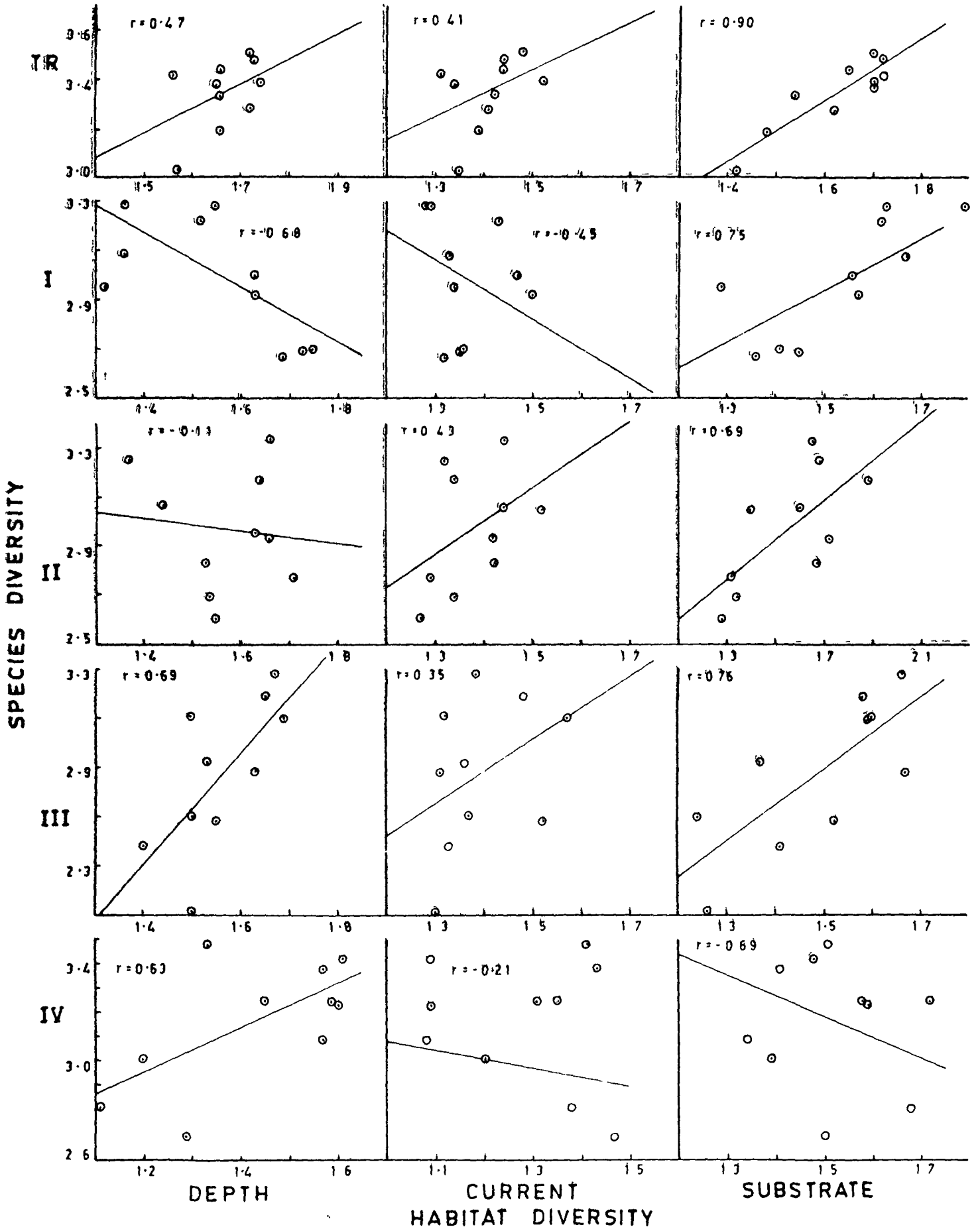
Though the significant differences emerged between the habitat diversity and species diversity in that habitat it was however necessary to find the distribution of the dominant species independent of the habitats to identify their random or non-random and their aggregate behaviour. In addition the clumpiness of the dominant species was also worked out. These were the poisson distribution and Morisita's Index.

In case of Morisita's Index though the  $N$  value for these dominant species in the present investigation did not lie between a large range and confined between  $120 \pm 20$ , yet the index varied to a large extent in the second decimal place. The maximum index

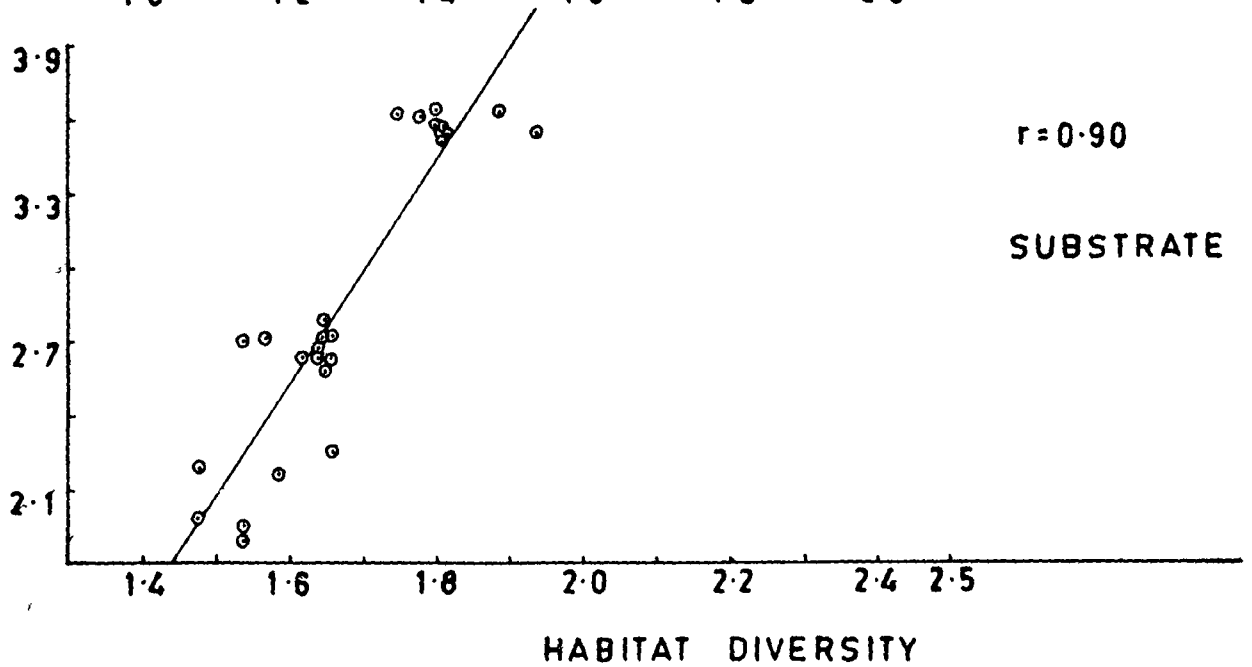
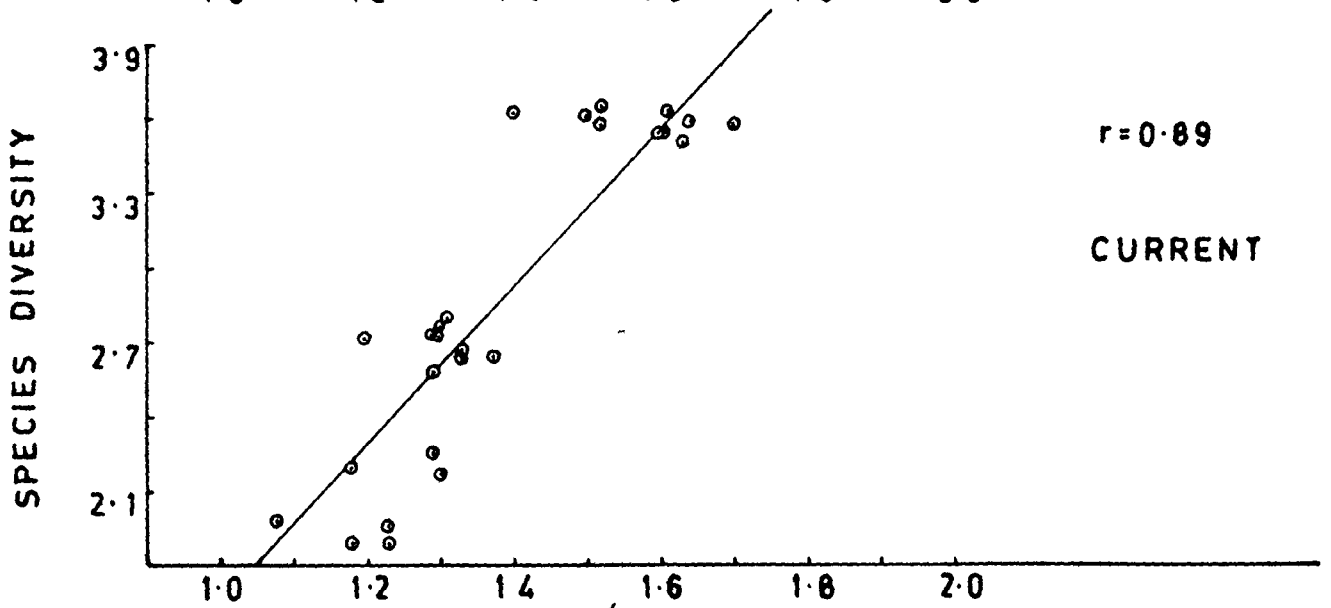
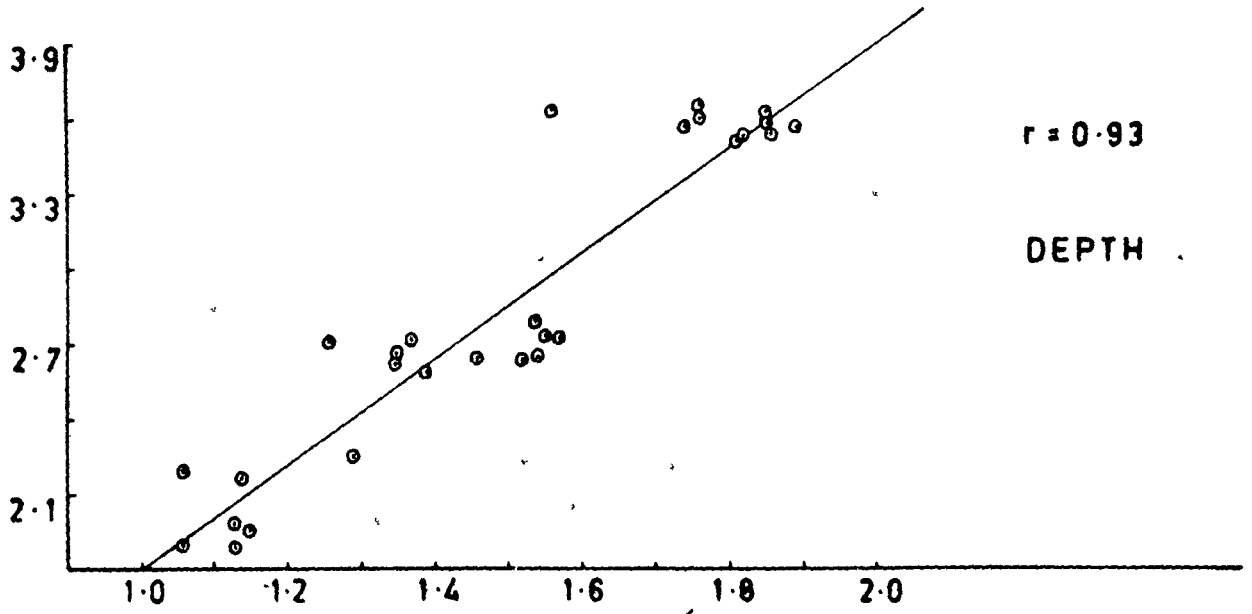
Fig. 17: Regressions (r) of fish species diversity against habitat diversity for total river and stations I, II, III and IV in the Pagladiya river during the present study.

TR : Total river  
I : Station I  
II : Station II  
III : Station III  
IV : Station IV

PAGLADIYA



MEGHALAYA



recorded was in the case of Mystus vittatus being 1.440 followed by Mastacembelus armatus with 1.342 even though the  $n_1(n_1-1)$  were nearly the lowest. This shows that these species were greatly aggregated in contrast to all the other species where the Morisita's Index though did reveal more than 1 was more or less around the unity value. The lowest index observed was in the case of Balitora brucei with 1.104, Acrossocheilus hexagonolepis having an index of 1.109, and Pillaia indica 1.107. Of these the N values though lower for the first and the third yet in the second species it was near the maximum and yet showed very little aggregation. The F values when calculated predicted the percent chance of occurrence of the aggregated behaviour in these dominant species (Table 21).

In the poisson distribution the observed frequency and the expected frequency along with chi square were analysed. It was seen that the maximum number of individuals observed were 631, 603, 616, 684 for Puntius shalynius, Lepidocephalus guntea, Neomacheilus botia and Channa punctata. In addition to these totals the others were between 400 to 500 only. Of these except only Balitora brucei, all the other species showed significant results either at 1% or 5% level (Table 22). The frequency occurrences were largest among those occurring 2, 3, 4 and 5 among the various species. This was true for all the dominant groups. However, in certain cases like 1 frequency for Labeo pungusia, Tor putitora, Xenentodon cancila, Mastacembelus armatus and Pillaia indica, they were around a maximum number of

Table 21 : Morisita's Index ( $I_0$ ) and the 'F' values for different fish species of the North-East India from different waterbodies during the present study.

TABLE-21

Species name	ni (ni-1)	N	n(n-1)	$I_0$	F
Barilius bendelisis	2594	141	19740	1.152	1.611
Danio (Danio) aequipinnatus	2704	141	19740	1.151	1.621
Acrossocheilus hexagonolepis	1590	139	19182	1.109	1.351
Garra gotyla gotyla	1520	139	19182	1.242	1.722
Labeo pangusia	1580	139	19182	1.163	1.514
Puntius shalynius	3326	141	19740	1.180	1.809
Puntius clavatus	1922	139	19182	1.120	1.423
Semiplotus semiplotus	1806	129	16502	1.153	1.537
Tor putitora	1332	132	17292	1.165	1.488
Balitora brucei	714	126	15750	1.104	1.237
Botia dario	2312	140	19460	1.282	2.018
Lepidocephalus guntea	3090	141	19740	1.200	1.861
Noemacheilus botia	3194	141	19740	1.189	1.829
Mystus vittatus	1944	123	15006	1.440	2.468
Ompak pabca	1202	123	15006	1.197	1.566
Amblyceps mangois	2284	132	17292	1.233	1.879
Glyptothorax cavia	1166	123	15006	1.181	1.516
Olyra longicaudata	2436	132	17292	1.244	1.945
Heteropneustes fossilis	2492	140	19460	1.259	1.979
Xenentodon cancila	2022	141	19740	1.230	1.789
Channa punctata	3906	140	19460	1.171	1.838
Chanda range	2348	132	17292	1.252	1.957
Glossogobius gutum	1512	132	17292	1.173	1.544
Colisa fasciata	1576	126	15750	1.139	1.465
Mastacembelus armatus	1928	140	19460	1.342	2.102
Pillaia indica	2442	129	16502	1.107	1.445

Table 22 : Poisson Distribution - The observed and expected frequencies of fish species per site in the North-East Indian waterbodies.

TABLE 22

Species Name	0	1	2	3	4	5	6	7	8	9	10	TOTAL
<i>Berillius bendelisis</i>	O 5	22	19	21	20	16	14	9	5	6	4	564
	E 2.58	10.33	20.66	27.55	27.55	20.04	14.69	8.39	4.20	1.87	0.75	
	(O-E) <sup>2</sup> /E 1.17	6.11	0.15	2.04	2.85	2.28	0.03	0.04	0.13	2.84	2.64	x <sup>2</sup> =20.36**
<i>Danio (Danio) aequipinnatus</i>	O 4	21	20	22	19	15	15	8	6	6	5	576
	E 2.36	9.65	19.74	26.91	27.52	22.51	15.34	8.97	4.58	2.08	0.85	
	(O-E) <sup>2</sup> /E 0.67	6.13	0.01	1.09	3.82	3.76	0.007	0.12	0.34	2.56	3.44	x <sup>2</sup> =21.94*
<i>Acrossocheilus hexagonolepis</i>	O 9	29	21	19	22	15	15	6	3	..	..	447
	E 5.44	17.63	28.57	30.86	24.99	16.20	8.75	4.05	1.64	..	..	
	(O-E) <sup>2</sup> /E 1.41	4.46	2.73	7.40	0.41	0.10	2.60	0.63	0.62	..	..	x <sup>2</sup> =20.36**
<i>Garra gotyla gotyla</i>	O 21	31	15	14	14	19	16	9	..	..	..	413
	E 7.13	2.18	31.45	31.14	23.12	13.73	6.80	2.88	..	..	..	
	(O-E) <sup>2</sup> /E 9.16	26.79	18.04	20.98	5.94	1.46	5.29	4.16	..	..	..	x <sup>2</sup> =97.8*
<i>Labeo pangusia</i>	O 17	25	19	18	17	18	15	10	..	..	..	435
	E 6.08	19.02	29.77	31.06	24.30	15.21	7.94	3.55	..	..	..	
	(O-E) <sup>2</sup> /E 7.01	1.43	6.10	9.48	3.13	0.43	3.32	4.16	..	..	..	x <sup>2</sup> =35.06*
<i>Puntius thalynius</i>	O 4	21	19	17	18	13	9	13	11	9	7	631
	E 1.60	7.16	16.04	23.95	26.81	24.03	17.94	11.48	6.43	3.20	1.43	
	(O-E) <sup>2</sup> /E 1.44	9.12	0.46	2.84	4.31	9.36	8.88	0.17	1.90	3.74	4.43	x <sup>2</sup> =46.65*
<i>Puntius clavatus</i>	O 11	19	21	21	24	14	12	9	8	..	..	489
	E 4.11	14.48	25.49	29.91	26.32	18.53	10.87	5.47	2.41	..	..	
	(O-E) <sup>2</sup> /E 4.32	20.43	0.96	3.78	0.22	1.47	0.11	1.38	3.91	..	..	x <sup>2</sup> =18.39**
<i>Tor putitora</i>	O 18	23	21	22	16	12	13	8	..	..	..	389
	E 6.91	20.38	30.06	29.56	21.80	12.86	6.32	2.67	..	..	..	
	(O-E) <sup>2</sup> /E 6.83	0.30	3.91	2.60	2.10	0.06	3.43	3.55	..	..	..	x <sup>2</sup> =22.78*
<i>Balitora brucei</i>	O 19	29	19	17	17	8	6	..	..	..	..	286
	E 13.02	33.54	29.55	25.38	14.40	6.54	2.47	..	..	..	..	
	(O-E) <sup>2</sup> /E 1.88	0.71	0.09	2.14	0.39	0.27	2.08	..	..	..	..	x <sup>2</sup> =7.56
<i>Botia dario</i>	O 18	20	19	18	12	20	16	3	4	6	4	503
	E 3.86	13.87	24.90	30.41	26.74	19.20	11.49	5.89	2.64	1.05	0.38	
	(O-E) <sup>2</sup> /E 11.11	1.88	1.83	8.56	18.11	0.03	1.27	2.78	0.46	4.08	3.38	x <sup>2</sup> =58.46*
<i>Lepidocephalus guntea</i>	O 5	24	19	17	16	14	11	9	12	9	5	603
	E 1.95	8.35	17.88	25.50	27.29	23.36	16.66	10.19	5.45	2.59	1.11	
	(O-E) <sup>2</sup> /E 1.86	10.21	0.07	4.35	7.97	8.26	2.97	0.16	3.38	4.37	3.07	x <sup>2</sup> =44.91*
<i>Noemacheilus botia</i>	O 7	22	16	14	18	16	13	10	11	8	6	616
	E 1.78	7.80	17.03	24.81	27.11	23.69	17.25	10.77	5.88	2.86	1.25	
	(O-E) <sup>2</sup> /E 3.89	9.17	0.07	8.35	4.61	3.70	1.39	0.06	2.38	3.30	3.76	x <sup>2</sup> =40.68*
<i>Mystus vittatus</i>	O 28	19	12	10	9	9	13	11	9	3	..	408
	E 4.47	14.76	24.51	27.12	22.51	14.95	8.27	3.92	1.63	0.60	..	
	(O-E) <sup>2</sup> /E 19.77	0.95	13.04	29.31	20.28	8.93	1.72	4.56	6.04	1.92	..	x <sup>2</sup> =101.52*
<i>Ompak pabda</i>	O 19	19	22	19	14	12	10	8	..	..	..	352
	E 7.04	20.15	28.81	27.46	19.64	11.23	5.35	2.19	..	..	..	
	(O-E) <sup>2</sup> /E 7.53	0.07	3.11	3.77	2.27	0.05	2.16	4.22	..	..	..	x <sup>2</sup> =22.18*
<i>Amblycepa mangois</i>	O 16	18	16	14	16	19	7	12	9	4	1	495
	E 3.10	11.64	21.83	27.28	25.58	19.18	11.99	6.42	3.01	1.25	0.47	
	(O-E) <sup>2</sup> /E 10.40	2.25	2.12	12.60	4.83	0.002	3.56	2.59	3.99	1.89	0.28	x <sup>2</sup> =44.51*
<i>Glyptothorax cavia</i>	O 19	19	21	20	15	13	9	7	..	..	..	349
	E 7.19	20.41	28.98	27.44	19.48	11.06	5.24	2.12	..	..	..	
	(O-E) <sup>2</sup> /E 7.34	0.10	3.03	2.77	1.34	0.29	1.57	2.40	..	..	..	x <sup>2</sup> =19.81*
<i>Olyra longicaudata</i>	O 13	21	15	16	14	18	8	11	9	3	4	509
	E 2.78	10.73	20.72	6.66	25.72	19.86	12.76	7.04	3.40	1.46	0.56	
	(O-E) <sup>2</sup> /E 8.03	5.02	2.18	7.10	9.81	0.19	2.83	1.43	3.48	0.79	2.96	x <sup>2</sup> =43.82*
<i>Heteroncheilus fossilis</i>	O 9	16	19	15	16	19	9	11	8	6	2	527
	E 3.26	12.26	23.04	28.88	27.15	20.41	12.79	6.87	3.23	1.35	0.51	
	(O-E) <sup>2</sup> /E 3.66	0.87	0.86	12.84	7.77	0.10	1.60	1.55	2.84	3.66	1.11	x <sup>2</sup> =36.8*
<i>Xenentodon cancila</i>	O 12	26	21	23	17	11	13	8	4	4	2	482
	E 4.61	15.77	26.97	30.75	26.29	17.98	10.25	5.00	2.14	0.81	0.28	
	(O-E) <sup>2</sup> /E 4.55	4.03	1.70	2.61	5.08	4.43	0.58	1.13	0.86	2.54	1.48	x <sup>2</sup> =28.99*
<i>Channa punctata</i>	O 4	18	17	14	16	15	12	7	16	8	13	684
	E 1.05	5.15	12.59	20.51	25.09	24.54	20.00	13.97	9.67	4.64	2.27	
	(O-E) <sup>2</sup> /E 2.18	9.17	1.14	3.03	5.16	6.07	5.33	6.94	5.72	1.41	14.31	x <sup>2</sup> =60.44*
<i>Chanda ranga</i>	O 13	21	16	17	18	11	12	9	7	4	4	498
	E 3.04	11.47	21.62	27.17	25.61	19.31	12.13	6.53	3.03	1.29	0.49	
	(O-E) <sup>2</sup> /E 7.63	4.32	1.97	6.08	3.22	6.28	0.001	0.68	2.19	1.84	3.08	x <sup>2</sup> =37.29*
<i>Glossogobius gutta</i>	O 21	18	14	22	16	19	12	10	..	..	..	413
	E 5.77	18.06	28.27	29.49	23.08	14.45	7.54	3.37	..	..	..	
	(O-E) <sup>2</sup> /E 11.05	0.06	14.55	2.55	3.13	1.09	1.66	4.39	..	..	..	x <sup>2</sup> =18.42*
<i>Colisa fasciata</i>	O 12	21	18	19	15	17	12	9	3	..	..	418
	E 4.56	15.12	25.10	27.79	23.06	15.31	8.47	4.02	1.67	..	..	
	(O-E) <sup>2</sup> /E 4.61	1.65	2.80	4.07	4.33	0.17	1.04	2.76	0.59	..	..	x <sup>2</sup> =22.02*
<i>Mastacembelus armatus</i>	O 19	26	21	19	17	12	8	6	5	0.56	2	449
	E 5.65	18.14	29.13	31.15	24.99	16.05	8.59	3.94	1.58	0.56	0.18	
	(O-E) <sup>2</sup> /E 9.38	2.38	3.13	7.77	3.76	1.37	0.04	0.71	1.46	4.93	1.66	x <sup>2</sup> =36.59*
<i>Pillala indica</i>	O 3	22	12	19	16	19	13	16	2	4	3	534
	E 2.05	8.50	17.60	24.29	28.14	20.82	14.36	8.50	4.39	2.02	0.84	
	(O-E) <sup>2</sup> /E 0.30	8.28	2.61	1.47	4.39	0.17	0.14	3.52	2.86	0.98	1.56	x <sup>2</sup> =26.28

\*\* significant at 1% level. \* significant at 5% level.

20  $\pm$  5. The frequency categories of 0, 7, 8, 9 and 10 were observed to be the least for most of the dominant species and in certain species totally absent. Of these the significance was seen in Semiplotus semiplotus at 5% level, others at 1%. (Table 22).

In addition Sørensen's coefficient of similarity (Q/S) was done within the stations of the river and also between the rivers (Table 23). It was seen that the river Pagladiya between their stations showed the coefficient of similarity very high, indicative of the commonness between each site. They ranged between nearly 90% and 100%. These high values of more than 90% was also seen in the case of I, II station; I, III station and II, IV station in case of Sumer. In Umkhras similarly a 100% similarity between II, III stations and 96% similarities between II, IV and III, IV. Umkhras also showed for the other stations values above 70% as also was seen for stations I and II and for II and III in case of Simsong. In the other cases it was below nearly 60% with the lowest of 27% observed as in the case of Simsong between station I and IV. This Sørensen's coefficient of similarity when seen between the rivers, the maximum of nearly 87% was seen between Simsong and Damrang followed by nearly 69% between Sumer and Umkhras. In addition nearly 50% values were obtained between Simsong, Pagladiya, and Damrang, Pagladiya. All other values were below 40% with the lowest record being 17% between Pagladiya and Umkhras.

Table 23 : Sørensen's Quotient of Similarity (Q/S)  
within the stations of the rivers/  
streams and between rivers/streams.

I : Station I  
II : Station II  
III : Station III  
IV : Station IV

TABLE-23

SIMSONG				DAMRANG				PAGLADIYA				SUMER				UMKHAH			
I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
	74.4	47.8	27.0		79.2	40.7	32.8		93.0	98.9	96.6		92.7	46.1	92.7		73.7	73.7	70.0
		72.7	30.4			60.0	43.8			91.8	89.7		48.3	95.5				100.0	96.0
			62.2				62.9				95.4				41.4				96.0
				86.7(37)				51.8(22)				32.8(10)				23.1(6)			
								49.5(24)				38.4(14)				25.0(8)			
												38.2(13)				16.9(5)			
																68.6(12)			

The present work is an account of the ecological biogeography of the fishes of the North-Eastern Regions of India. The baseline data gathered during the present investigation revealed the occurrence of 169 species in the area under consideration, eventhough earlier records had shown nearly 199 species. The lack of a record of these 30 species in the present work cannot be explained; eventhough the present regions and the areas were not only more extensively covered but also intensive seasonal analyses were made. However, all the earlier reported 5 superorders, 11 orders, 31 families and 88 genera were representated in our collections. The largest group was the Cypriniformes with Cyprinidae dominating. Though this was followed by Siluriformes and Perciformes both at the family level and at the generic levels they were far less. This trend of dominance was also seen when the entire region of North-East India was looked at in the form of its political entities.

Of a total of these 169 species, only 21 species were found to be occurring commonly in the different states and Union Territories. Once again the largest group among these commonly occurring 21 species, was dominated by the family Cyprinidae with 15 species and the others with only one or two.

The present study further revealed that in these regions of North-East in general, 1 family, 5 genera and 22 species were found to be endemic. The endemicity of these species were more or less equally distributed in the political states and union territories

Of a total of these 169 species in the present work it was seen that the state of Assam had 146 species. This was the maximum in contrast to other states and Union territories, inclusive of the common occurrence and endemicity. This was followed by Nagaland and Meghalaya with 85 and 82 species respectively. The Union Territory of Mizoram follows with 50 and finally Arunachal Pradesh the least with 49 species.

From the list of species at their generic level, as seen in the present work, of the 88 genera, 57 were found to be primary freshwater fishes. With this phenomenon of nearly 75% of the recorded genera being primary freshwater fishes, it was only understandable that a clearer picture would emerge if the watershed and the drainage system in this region was looked at for its distributional pattern. As seen from the results, the region was broadly categorized into three major drainages, the Brahmaputra, the Meghna and the Chindwin. The major rivers which make up these drainages were more in number in the Brahmaputra, followed by Meghna and the least in Chindwin. Therefore, as more ecological habitats were provided it was seen that the Brahmaputra had 162, the Meghna 111 and the Chindwin 67 species. The Meghna and the Chindwin drainages are southern to the Brahmaputra drainage, and therefore the primary habitat of the fishes was best seen by a categorization according to the gradients. From the results it was very obvious that though the major portions of these lotic systems lie within the region under consideration, the lowland/upland category, irrespective of these

drainages occupied the largest number of species. This was true, based either on the individual lotic systems or from a similar analysis of the families recorded in the present investigation. The decrease in the number of species in the southern two drainages, the Meghna and the Chindwin could possibly be due to the fact that lesser number of lotic systems were available within that study area unlike the Brahmaputra drainage. The latter, more or less occupied in total an area of the other two drainages, and in addition possessed great variations and additions in their lotic systems either in Bangladesh or in Burma. Moreover, while dealing not only the Brahmaputra drainage in general but the River Brahmaputra in particular it was necessary to see whether a decrease of species in the southern latitudes existed. However, from the present investigation it showed a trend of increase in the rivers on the southern side of the Brahmaputra. There were larger number of species (26) in contrast to the northern side where only 16 were recorded.

In the three drainages the possibility of sharing of these fishes were next analysed to indicate the dispersal pattern within these lotic systems. A percentage of 60 and above was seen with the River Brahmaputra and two of the rivers in its own drainage, Kallong and Krishnai, and with only the Barak river of the Meghna drainage. A similar phenomenon like the Brahmaputra and the Barak was seen between the Krishnai and Singsong of the Brahmaputra and Meghna drainages respectively with nearly 70%. In the other cases where the Average Faunal Resemblance Indices were above 60%, it was confined within the respective drainages

like Subhansiri and Jia Bharali of the Brahmaputra, Umning and Myntdu of the Meghna and the two rivers, Imphal and Tizu in Chindwin drainage.

The fishes belonging to the families Clupeidae, Engraulidae and Notopteridae showed their preference to big rivers except the Notopterus genus which was distributed in fairly big hill streams also. The genus Notopterus was observed to inhabit the Brahmaputra and Meghna drainages only. It was not recorded from the Chindwin drainage of the North-East India.

The sub-family Ambramidinae was mainly distributed in the Brahmaputra valley of Assam and the Barak river of the Meghna drainage. Except for Oxygaster gora and Chela cachius which is present not only here but also in other rivers, the rest of the recorded species under this sub-family were confined to Assam only. Chindwin drainage does not contain any of the fishes of this sub-family, whereas the genus Barilius of the sub-family Rasborinae showed ubiquitous distribution, while some individual species showed isolated or patchy distribution with only Barilius bendelisis in all the state. The genus Danio had two species D. (D) naganensis and D. (B) acuticephala confined to Nagaland and Manipur i.e. dominantly Chindwin species, while D. (D) aequipinnatus was distributed practically through all types of habitats and places. Esomus danricus, Rasbora, Aspidoparia and Amblypharyngodon were mostly confined to the slow flowing low lands of Assam, while Acrossocheilus hexagonolepis, Chagunius chagunio, Crossocheilus latius latius

were commonly distributed in all the hill streams and fast flowing rivers. Catla catla and Cirrhina were also recorded from big rivers and lowlands of Assam and Meghalaya.

The genus Garra of the sub-family Cyprinidae had none of its species distributed uniformly throughout the region, Garra lissorhynchus occurred in Meghalaya, Nagaland and Manipur, G. naganensis and G. kempfi in Nagaland and Manipur, while G. gotyla gotyla was recorded from Mizoram, Assam and Meghalaya. The genus is very much adapted to hill and fast flowing upland streams. The genus Labeo has both lowland/upland distribution, L. gonius, L. pangusia and L. dero were mostly confined to the fast flowing streams while L. rohita, L. calbasu, L. nandina, L. bata and L. boga were distributed in all the lowland drainages of the region.

The largest genus found in North-East India, Puntius, was distributed throughout the region with P. shalynius and P. clavatus inhabiting the fast flowing streams while the rest confined to the lowland areas. P. shalynius occurred only in the hill streams of Khasi and Jaintia Hills as an endemic form. Osteobrama distributed in the lowlands of Assam and the Chindwin tributaries in Nagaland and Manipur while Oreochthys cosuatis inhabits the lowlands and flood plains of Assam only. Schizothorax richardsonii and Schizothoraichthys progastus were recorded in the high altitude streams of Arunachal Pradesh only. Tor sps. showed a remarkable habitat specialization, in that they harboured in the hill streams and fast flowing clean streams of

uplands of the region, while Semiplotus semiplotus showed a patchy distribution, that was recorded mainly from northern side of Brahmaputra in Assam, Nagaland and Mizoram. It was also selective to fast flowing hilly and uplands streams and rivers.

The families Psilorhynchidae and Homalopteridae had one of the highly specialized forms for hill stream adaptations. Their distribution also represents clearly their habitat selection in the hill streams with their patchy distributional nature.

Family Cobitidae had the maximum number of species adapted to hill streams in this region. Many species were endemic to their locality. Their distribution was peculiar with many isolated distributional patches in this region.

Neoeucirrhichthys maydelli was one of them. Only Lepidocephalus guntea, Noemacheilus corica were with fairly wide distribution in the region, while the rest were confined to one or two places in their respective drainages.

Most of the Bagrid species were lowland and flood-plain forms. They preferred large rivers, small streams of the plains with uniform distribution, except like Chandramara which was confined to a few places. Batasio species occurred in the upland streams of Assam and Nagaland while the general Mystus and Aorichthys preferred lowland areas only.

Siluridae and Schilbeidae showed a lowland distribution with few species occurring in fast streams like Silurus cochinchinensis. They were all distributed mainly in the Assam Valley of Brahmaputra and few places of Nagaland. Pangusius pangusius was distributed in Assam of Brahmaputra drainage only. Chaca chaca was recorded from the Brahmaputra and Meghna drainages of Assam and Meghalaya respectively. Olyra longicaudata and Amblyceps mangois were confined to the hill streams and clear streams of upland areas of Nagaland, Assam and Meghalaya while Clarias batrachus and Heteropneustes fossilis distributed throughout the plains and big rivers of the region except Arunachal Pradesh.

Of the Sisord catfishes Bagarius bagarius, Sisor rabdophorus, Conta conta and Gagata were confined to lowland streams and rivers of Assam while Erethistis pussilis, Euchiloglanis hodgarti, Exostoma labiatum, Hara sps. and Pseudecheneis sulcatus preferred the fast high altitude/upland streams. Glyptothorax was the only genus with a wide distribution in the region. Like Cobitids, this family also showed a great degree of isolation and patchy distribution.

The genus Channa was distributed in all the states of North-East India with Channa barca only on the northern side of the Brahmaputra river. The other species were distributed in all habitats with C. punctata and C. orientalis dominating in the region. Xenentodon cancila was distributed throughout lowland

clear waters of the region while Dorichthys deocata occurred in the Brahmaputra only. Aplocheilius panchax and Orizias melastigma were very much confined to the lowland paddy fields, small streams, bheels and ponds of the region. Sciaenid fishes Pama pama and Johnius coitor were recorded from Assam only while Amphipnous cuchia was recorded from the floodplains shallow parts of the rivers of Assam and Nagaland, Chanda species were predominantly in large, lowland riverine forms with Assam as their mainland of distribution. Badis badis was distributed throughout in all the habitats of the region while Nandus nandus preferred the lowland bheels and ponds of Assam and Meghalaya.

Colisa sota, C. lalia and Ctenops nobilis were mainly confined to the valleys of Assam and lowlands, while C. fasciata was distributed widely in the region followed by Anabas testudineus. Glossogobius gutum was recorded from almost all the parts of the North-East from lowlands. Pillala indica was distributed in Meghalaya only, while Tetraodon cutcutia was observed in Assam. Mastacembelus armatus was one of the two species which were widely distributed in all habitats of N.E. India, while the other two species of the family, M. pancalus and Macrognaathus aculeatus were confined to the lowlands of Assam, Meghalaya, Nagaland and Mizoram.

For the detailed analysis on the dispersal patterns and distribution of the present day species, based on the geomorphology, the five lotic systems undertaken revealed one

constant feature in their seasonality phenomena. Irrespective of the stations under consideration in the different rivers or streams, Cyprinidae dominated throughout and its peak values recorded during the summer months. The only exception to this was the replacement in the two hill streams of Umkhrach and Sumer where the family Cobitidae took over as the dominant, especially during the winter months. This phenomenon of the species under Cyprinidae being dominant as revealed by the number of species present was also true when the Species Richness Index and the Shannon-Weiner Index were observed. In all the lotic systems undertaken for this detailed study not only were these values true for the complete system but also when seen at the individual stations of each river or stream. The analysis of Hmax. values and evenness index revealed more or less a similar trend of fluctuation.

These analyses revealed a common feature, as it was confined only to the analysis of fish without any consideration to the ecological habit. The stations chosen in the different rivers and streams, and total rivers and streams by themselves were the best representations of the lotic systems in the North-Eastern Region. The analysis in the system helped not only to identify the number of species occupying in a certain habitat but also revealed whether there were any particular longitudinal zonations in these lotic systems, and identified the possible role of the habitat.

The only river, which showed significant correlations between the different habitats and its species in all the stations and as a whole was Umkhrak. In contrast the river Singsong not only showed no correlation but even negative correlations in certain stations and in the whole river. This negative correlation at that station was due to the substrate diversity. Sumer, like Umkhrak, was more or less similar, in that station II a negative correlation existed between current diversity and species diversity. The river Damrang was consistent in its negative relationship with depth diversity in more or less all the stations and the total river. This was also true for current diversity and where positive, it was insignificant. However, substrate and species diversity were positively correlated, though not very high. The river Pagladiya was more or less similar to Damrang. This relationship revealed that the species diversity of fishes irrespective of the divisions in the major river could be seen to be very well adapted. This explains that substrate, current and depth have been major factors in the control of species abundance and distribution. Further, the lotic systems undertaken in the present study and their stations whether at the head waters or the flood plains, have enabled the establishment of species to maximum utilization of all the ecological niches available, even though confined to the one largest group of Cyprinidae.

Though the above does reveal a true ecological inter-relationship between the environment and the fauna under consideration, a further analysis on the distribution of

dominant species was done independent of their habitat, for their occurrence either randomly or non-randomly and for their aggregate and non-aggregate behaviour. Most of the species undertaken were seen to be occurring randomly with an aggregate behaviour of more than 500 individuals irrespective of their predatory or non-predatory behaviour. This behavioural pattern was highly significant. This significance is further proved by the fact that frequency of occurrence was also confined to the higher categories beyond 7 to 10 and that too, was highly significant. This confirms the fact that there was present a random distribution in a particular aggregated form. Though this aggregate behaviour was seen in general for all the dominant species, a further insight into the individual species by the use of Morisita's Index finally confirmed the fact that there was not only aggregation in general, but there existed a marked clumped or clumpyness as the values worked out were always higher than unity.

Though aggregatedness and clumpyness were seen in these major lotic systems undertaken, it was left to see whether a similarity existed between the stations and between the rivers. In most cases irrespective of the station and the rivers a very high Coefficient of Similarity as seen by Sørensen's Index was observed. This was very true between the stations in the individual rivers and also between the lotic systems themselves. The lowest, however, as can be anticipated was between the hill-stream Umkhras of Meghalaya and the river Pagladiya of Assam.

The factors operating in the abundance and distribution of species in particular fish in lotic ecosystems have yet to be clearly identified. From the present results the analysis revealed that some individual species did change one habitat type to another, especially as seen from the clear aggregation of Cyprinids and Cobitids, with the former mostly occupying the plains and valleys while the latter in the hill streams and fast flowing upland streams. The study therefore revealed a phenomenon between these two major groups of separation based on their architectural choices (Robinson, 1981). Comparisons between such populations could, therefore, be attributed to the degree of evolutionary rather than ecological specialization (Scriber, 1973). This is very well seen in the present study when a comparison of a frequency distribution and the 'Similarity Index' were analysed, when the three different drainages showed clearly a closer affinity of lotic systems in and between them, rather than between the drainages. This fact possibly proved that every taxon has a geographical range which fluctuates through time and becomes discontinuous, and though individuals are distributed within the range at various points at a given time they may not be available at the same points at a second time. This is the basic concept of dispersal, a process by which organisms are able to spread from their place of origin to other localities (Udvardy, 1969). This phenomenon is more conspicuous with advanced species which are capable of dispersal rapidly in contrast to primitive ones.

The present investigation indicates that within each zoogeographic unit of the larger North-East India the clustering of samples of species was more or less similar, proving a common ecological and evolutionary history. Therefore presumably, factors to and other than biogeographic history are important in influencing community structure. The present study revealed that rare species were habitat specialists while the more abundant ones were generalists (Lovejoy, 1975; Wiens, 1975), involving a complex mosaic of environmental factors and biotic responses in the process of any community development. This is all the more true in lotic environments which exhibit continuity over time. Though climatic and geological processes affect many changes in streams and rivers major drainage patterns persist, making these systems most stable, long-lasting freshwater environments. Due to extreme environmental stresses like drought, floods or temperature extremes, species can be eliminated from a lotic system but the loss is only temporary as aquatic life has evolved mechanisms to re-invade decimated areas (Karr & Dudley, 1978). The species then are equally capable of invading space when it becomes available, irrespective of which species was in that site before. They also have the capability to hold the space eventhough surrounded by neighbours of other species, for a sufficient time to reach breeding sites (Sale, 1978). This therefore, allows the fish to get its offspring into sites in which they can live, and by adapting this strategy of breeding frequently and dispersing its offspring widely, it increases its own chances of survival. The complexity and diversity of these

adaptation implies a long history of evolution in the environment that determine which species becomes successful at a given time in a given location. This consequently determined the local makeup of the community. Therefore the final structure of the community is the result of stochastic processes of colonization combined with deterministic aspects of adaptation. If the North-Eastern Regions are looked at from these angles it was seen from the present study that there was a general trend for fish distribution with addition of species with increasing stream order. This was all the more since the low-order streams are subject to freezing-up and are repopulated during rainy season in these regions, primarily because of the movement of the fishes in the higher-order streams during these wet periods. This became very clear as in the present study that the smaller streams also tend to be populated with species that occur in larger streams or rivers within that drainage system (Whiteside & Mc Natt, 1972).

Though, ordinarily, in a community these are the possible explanations when looked only qualitatively, but in a situation of habitat specificity it is ideal to consider the number of species and their individuals in the assemblage or the degree of heterogeneity. This is most useful especially in comparing the evenly distributing assemblages where one could predict the change in the distribution of individuals among the species. From the present study it was quite obvious that a change in the species composition in the different lotic systems

and their drainages, seasonally or otherwise, greater intra-assemblage variation was constituted rather than a change in the distribution of individuals among the species. This aspect was very clear in the present study where the head waters taken as station I for all 5 lotic systems studied, the assemblage of Cyprinids and Cobitids alternate with each other in summer and winter respectively. A similar phenomenon was the species richness, which was important because the distributional phenomenon becomes sensitive to changes in near interval samples while still not affecting the overall sample. It was this index which transmits real information making possible an indepth analysis of the assemblage rather than the diversity index. However, in the present study where both the indices were used it was seen that they not only complemented each other but were also of a similar nature to the simpler fluctuating trend of mechanism in the number of species over the seasons.

The intra-assemblages of species and in particular their seasonal occupation of different positions is a common phenomenon of range in any species. This is generally associated with the occupation of two distinct regions one for their breeding and the other for their non-breeding ranges. This was clear from the present study, where certain groups of species during particular seasons extended their range eventhough primarily confined or adapted to sections of streams. Therefore, in any evolutionary time, just as

happenings over the seasons in the present day, the assembled fauna is not in a true equilibrium but rather in a quasi-equilibrium (Wilson & Taylor, 1967). It would therefore seem that the rate of species extinction would appear to equal the rate of species immigration. However, the determinant would be the environmental stability, which becomes decisive whether the time scale is expanded or not.

The present investigation further revealed that both richness and diversity in the region under consideration increased from the Upland/Montane to the Montane/Lowland. In other words, the flood plains, paddy fields and the valleys revealed higher indices than the mountainous regions. This variation in regional diversity both on a local scale or for the general landmass, as the three drainages or the entire North-East respectively, exists for other regional fauna also (Aho, 1978). This attribution of diversity indices falls short because it is primarily of a theoretical interest and cannot be used to understand the feedback mechanisms, except however, for a concrete understanding of the environmental stability, maturity, productivity, predation pressure and spatial heterogeneity. In this case from the present study and its results, when interpreted in terms of the total picture of the environment, revealed patches forming environmental mosaics and the sequence of patches encountered move through the habitat. The idea of a homogenous habitat moving into heterogeneous one inclusive of the random properties subject

to the condition of long-term frequency was very well established from the present work. One could, therefore, draw a conclusion that many species could become differentiated within the same geographic region and speciation may be referred to as quasi-sympatric. Therefore, a single species rarely or never forms continuous belt as also seen in the present study where breaks in continuity exist, in stretches of areas which are probably unsuitable, even within a particular drainage (Pielou, 1978). Such a concept when confined to localization in one particular lotic system as a transition from the small head-water areas to major rivers referred to as stream continuum can also be extended to the present study that many species have partially filled the functional gap left by the decline or loss of species, as was obvious from different stations in the five lotic systems undertaken for detailed study. Hence any fish population structure or its community, indicative of the species number, richness or heterogeneity index would not be distributed as a continuous longitudinal gradient but more across ecotones such as stream order boundaries. It is here that the indices are useful or the number of unshared species between any two stations to detect differences in multispecific complexes or community groups across these boundaries (Margalef, 1958a). This again was very obvious from the present study where the last station in all the five lotic systems undertaken had revealed to a small extent the replacement of upland species but to a larger extent to the addition of lowland species, all with a very high

number. The same concept was not feasible when extended to head-waters.

It is, however, better to get a clearer understanding when the assemblage of communities are looked at from the habitats that they occupied. The head-streams where current is one major criteria to be reckoned with, was seen, that except for the two hill-streams Umkhrah and Sumer all the other rivers showed negative correlation. However, substrate revealed a very prominent positive correlation especially in the mid river or streams though all the three habitats when looked at together showed a more or less positive relationship to the diversity of species present in that station. The colonization except for the patch takes place in smaller substratum and slower current conditions (Rabeni & Minshall, 1977). Moreover, several trends were discernable along the stream elevation gradient and species richness decreased with increased elevation and though some were wider in their range yet most were restricted in terms of altitude. The faunal diversity in the present study, revealed a distinct relationship between stations while substratum, depth or current did not bring conclusive evidences. Probably, the longitudinal zonation in any location may be a faunal characteristic rather than a substratum characteristic. This may be explained by the fact, that measures of species diversity usually fail to distinguish within and between-habitat diversity but in the present investigation this was

overcome by the incorporation of both. Possibly the explanation therefore would lie in the study of partitioned species with micro-habitat diversities in addition to the habitats undertaken in the present study (Allan, 1975). It is possible that a correlation in the stream channel sinuosity and variability of stream depth and velocity could be the major attributes (Zimmer & Bachman, 1976; Menzels & Fierstine, 1976). From the present study this phenomenon was clear as there was a direct relationship and highly significant, between habitat diversity in the smaller hill-streams of Umkhrah and Sumer in Meghalaya rather than the other three major lotic systems considered.

General distributional pattern of the North-East Indian fish fauna was governed by the geomorphological history of the water bodies or drainages concerned and the changing ecological characters that have been part of the biogeographical evolution of the region. The history of the fish of the region should in reality be considered as an inseparable part of the history of the origin of the streams that cut across in all directions ranging from the hill streams of Meghalaya, Arunachal Pradesh, Nagaland and Mizoram to the meandering slow rivers of Assam. The distributional maps clearly shows that the higher altitudes harboured highly specialized hill-stream fishes like Garra, Psilorhynchus, Balitora, Pseudecheneis, Glyptothorax, Semiplotus, etc., which are very well adapted to inhabit the highly oxygenated, fast flowing streams of the region.

Schizothorax and Schizothoraichthys were confined to near alpine streams of Arunachal Pradesh where the water temperature goes down to freezing point showing their limited range of adaptability in distribution. Universal species like Danio, Barilius, Badis, Mastacembelus and Puntius were seen to have distributed upto moderately high elevations with varied ecological requirements. On the other hand most of the species of Bagridae, Cyprinidae, Channidae and Anabantidae were observed to prefer the lowlands, while the Cobitids showed an enormous range of adaptability in their distribution with universal species like Lepidocephalus guntea and Noemacheilus botia. The species which showed remarkable patchyness in their distribution were Neoeucirrhichthys, Noemacheilus kangjupkhulensis, N. sikmaiensis, N. subfusca, L. goalparensis and L. menoni with discontinuous forms like L. irrolata. Others are Pillaia indica with very narrow distributional range and P. khajuriae with discontinuity. So the hills and the valleys had a unique combination of species with increasing in diversity from top to bottom with a north-south delimitation of ranges of some species.

The Brahmaputra with its mosaic of water bodies harboured the maximum number of fish species and also acted as a barrier for some, resulting in many discontinuities and patches in the distribution and at the same time as a limit in their distribution. Meghna drainage does not possess a unique fauna of its own but harboured some species that were

obstructed by the Brahmaputra. The Chindwin drainage contained quite a few endemic forms in Naga Hills and Manipur, while Mizo Hills did not possess a unique fish fauna but had all the general hill stream fishes with poor representation of species.

As the North-East India (earlier greater Assam) has been a gateway rather than an amphitheatre of faunal radiation, its transitional nature is unquestionable (Mani, 1974f). The fish fauna also shows their predominantly South Asian nature followed by East Asian and High Asian nature (Table 24). They have Ethiopian faunal similarity at generic level to some extent and family level similarities with Nearctic and Holarctic regions. The North-East Indian fauna represented predominantly South Asian with few endemics and high degree of speciation due to the high orogenic nature of the region. The richness of the species composition in North-East and its importance in the migrational routes of species was mainly due to the changing nature of region with the eruption of Himalayas and the destruction of North-Western gateways for faunal introductions (Davis, 1979).

Powell et al. (1981) was of the opinion that India, particularly the North-East Regions was in close contact with Sundaland about 65 m.y. ago (the beginning of the Cenozoic) and have been sliding along it for most of the Cenozoic for faunal exchange between the then Indian block and its eastern counterpart, and might have given rise to the

Table 24 : North-East Indian fish species/sub-species and their relationships.

- A : Peninsular India
- B : Rest of India
- C : South Asian Subregion
- D : East Asian Subregion
- E : West Asian Subregion
- F : High Asian Subregion
- G : Holarctic Region
- H : Ethiopian Region
- I : Madagascan Region
- J : Nearctic Region
- K : Australian Region
- L : New Zealand Region
- M : South-West Pacific Region

TABLE - 24

S.No.	Species Name	A	B	C	D	E	F	G	H	I	J	K	L	M	Status	S.No.	Species Name	A	B	C	D	E	F	G	H	I	J	K	L	M	Status
Clupeidae																															
1.	<i>Hilsa ilisha</i> (Hamilton)	+	+	+	-	+	-	-	-	-	-	-	-	-	? South Asian	59.	<i>Osteobrama cotio cunna</i> (Day)	-	-	+	-	-	-	-	-	-	-	-	-	South Asian	
2.	<i>Gadusia chapra</i> (Hamilton)	+	+	+	-	-	-	-	-	-	-	-	-	-	+	South Asian	60.	<i>Osteobrama belangeri</i> (Valenciennes)	-	-	+	-	-	-	-	-	-	-	-	East Asian	
3.	<i>Gadusia variegata</i> (Day)	-	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	61.	<i>Puntius chola</i> (Hamilton)	+	+	+	-	-	-	-	-	-	-	-	South Asian	
Engraulidae:																															
4.	<i>Setipinna phasa</i> (Hamilton)	+	+	+	-	-	-	-	-	-	-	-	-	-	-	Oriental	62.	<i>Puntius elevatus</i> (Mc Clelland)	+	+	+	-	-	-	-	-	-	-	-	South Asian	
Notopteridae:																															
5.	<i>Notopterus chitala</i> (Hamilton)	-	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	63.	<i>Puntius conchonus</i> (Hamilton)	+	+	+	-	-	-	-	-	-	-	-	South Asian	
6.	<i>Notopterus notopterus</i> (Pallas)	+	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	64.	<i>Puntius gelius</i> (Hamilton)	+	+	+	-	-	-	-	-	-	-	-	South Asian	
Cyprinidae:																															
7.	<i>Chala cachius</i> (Hamilton)	+	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	65.	<i>Puntius gunganio</i> (Hamilton)	+	+	+	-	-	-	-	-	-	-	-	South Asian	
8.	<i>Chala laubuca</i> (Hamilton)	+	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	66.	<i>Puntius phuturio</i> (Hamilton)	+	+	+	-	-	-	-	-	-	-	-	South Asian	
9.	<i>Oxygaster gora</i> (Hamilton)	+	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	67.	<i>Puntius sarana sarana</i> (Hamilton)	+	+	+	-	-	-	-	-	-	-	-	South Asian	
10.	<i>Salmostoma bacalla</i> (Hamilton)	+	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	68.	<i>Puntius shalynius</i> Yazdani & Talukdar	+	+	+	-	-	-	-	-	-	-	-	Endemic	
11.	<i>Salmostoma phulo phulo</i> (Hamilton)	-	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	69.	<i>Puntius sophore</i> (Hamilton)	+	+	+	-	-	-	-	-	-	-	-	South Asian	
12.	<i>Barilius barila</i> (Hamilton)	-	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	70.	<i>Puntius terio</i> (Hamilton)	+	+	+	-	-	-	-	-	-	-	-	South Asian	
13.	<i>Barilius barna</i> (Hamilton)	-	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	71.	<i>Puntius ticto</i> (Hamilton)	+	+	+	-	-	-	-	-	-	-	-	South Asian	
14.	<i>Barilius bendelisis</i> (Hamilton)	+	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	72.	<i>Schizothorax richardsonii</i> (Gray)	-	+	+	-	-	-	-	-	-	-	-	High Asian	
15.	<i>Barilius bola</i> (Hamilton)	+	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	73.	<i>Schizothorax richardsonii</i> (Mc Clelland)	-	+	+	-	-	-	-	-	-	-	-	High Asian	
16.	<i>Barilius dogarsinghi</i> Hora	-	+	+	-	-	-	-	-	-	-	-	-	-	-	Endemic	74.	<i>Semiplotus semiplotus</i> (Mc Clelland)	-	+	+	-	-	-	-	-	-	-	-	South Asian	
17.	<i>Barilius guttatus</i> (Day)	-	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	75.	<i>Semiplotus gangulyi</i> Dey	-	+	+	-	-	-	-	-	-	-	-	Endemic	
18.	<i>Barilius shacra</i> (Hamilton)	-	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	76.	<i>Tor putitora</i> (Hamilton)	-	+	+	-	-	-	-	-	-	-	-	South Asian	
19.	<i>Barilius tileo</i> (Hamilton)	-	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	77.	<i>Tor tor</i> (Hamilton)	-	+	+	-	-	-	-	-	-	-	-	South Asian	
20.	<i>Barilius vagra</i> (Hamilton)	-	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	Pailorhynchidae:														
21.	<i>Danio (Danio) aequipinnatus</i> (Mc Clelland)	+	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	78.	<i>Pailorhynchus balitora</i> (Hamilton)	-	+	+	-	-	-	-	-	-	-	-	South Asian	
22.	<i>Danio (Danio) danjila</i> (Hamilton)	-	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	79.	<i>Pailorhynchus homaloptera</i> Hora & Mukerji	-	+	+	-	-	-	-	-	-	-	-	South Asian	
23.	<i>Danio (Danio) devario</i> (Hamilton)	-	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	80.	<i>Pailorhynchus sucatio</i> (Hamilton)	-	+	+	-	-	-	-	-	-	-	-	South Asian	
24.	<i>Danio (Danio) naganensis</i> Chaudhuri	-	+	+	-	-	-	-	-	-	-	-	-	-	-	Endemic	Homalopteridae:														
25.	<i>Danio (Brachydanio) acuticephala</i> Hora	-	+	+	-	-	-	-	-	-	-	-	-	-	-	Endemic	81.	<i>Balitora brucei</i> Gray	-	+	+	-	-	-	-	-	-	-	-	South Asian	
26.	<i>Danio (Brachydanio) rerio</i> (Hamilton)	+	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	82.	<i>Balitora maculata</i> Gray	-	+	+	-	-	-	-	-	-	-	-	South Asian	
27.	<i>Saornis danricus</i> (Hamilton)	-	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	Cobitidae:														
28.	<i>Rasbora daniconius</i> (Hamilton)	+	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	83.	<i>Aborichthys elongatus</i> Hora	-	+	+	-	-	-	-	-	-	-	-	South Asian	
29.	<i>Rasbora elonga</i> (Hamilton)	+	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	84.	<i>Aborichthys garoensis</i> Hora	-	+	+	-	-	-	-	-	-	-	-	Endemic	
30.	<i>Rasbora kobonensis</i> Chaudhuri	-	+	+	-	-	-	-	-	-	-	-	-	-	-	Endemic	85.	<i>Aborichthys kempii</i> Chaudhuri	-	+	+	-	-	-	-	-	-	-	-	South Asian	
31.	<i>Rasbora rasbora</i> (Hamilton)	-	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	86.	<i>Acanthopthalmus pangia</i> (Hamilton)	-	+	+	-	-	-	-	-	-	-	-	South Asian	
32.	<i>Acrossocheilus hexagonolepis</i> (Mc Clelland)	-	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	87.	<i>Botia berdmorei</i> (Blyth)	-	+	+	-	-	-	-	-	-	-	-	South Asian	
33.	<i>Amblypharyngodon mola</i> (Hamilton)	+	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	88.	<i>Botia dario</i> (Hamilton)	-	+	+	-	-	-	-	-	-	-	-	South Asian	
34.	<i>Aspidoparia jaya</i> (Hamilton)	-	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	89.	<i>Botia histriónica</i> Blyth	-	+	+	-	-	-	-	-	-	-	-	South Asian	
35.	<i>Aspidoparia rorar</i> (Hamilton)	-	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	90.	<i>Botia rostrata</i> Gunther	-	+	+	-	-	-	-	-	-	-	-	South Asian	
36.	<i>Catla catla</i> (Hamilton)	+	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	91.	<i>Lepidocephalus berdmorei</i> (Blyth)	-	+	+	-	-	-	-	-	-	-	-	South Asian	
37.	<i>Chagunius chagunio</i> (Hamilton)	-	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	92.	<i>Lepidocephalus guntea</i> (Hamilton)	-	+	+	-	-	-	-	-	-	-	-	South Asian	
38.	<i>Cirrhina mirgala</i> (Hamilton)	+	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	93.	<i>Lepidocephalus irrerata</i> (Hora)	-	+	+	-	-	-	-	-	-	-	-	Endemic	
39.	<i>Cirrhina reba</i> (Hamilton)	+	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	94.	<i>Lepidocephalus burmanicus</i> Rendahl	-	+	+	-	-	-	-	-	-	-	-	South Asian	
40.	<i>Crossocheilus latus latus</i> (Hamilton)	+	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	95.	<i>Lepidocephalus manoni</i> (Pillai & Yazdani)	-	+	+	-	-	-	-	-	-	-	-	Endemic	
41.	<i>Garra anandalei</i> Hora	-	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	96.	<i>Lepidocephalus goalparensis</i> (Pillai & Yazdani)	-	+	+	-	-	-	-	-	-	-	-	Endemic	
42.	<i>Garra gotyia gotyia</i> (Gray)	+	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	97.	<i>Neoeucirrhichthys maydelli</i> Baparescu & Halbant	-	+	+	-	-	-	-	-	-	-	-	Endemic	
43.	<i>Garra kempii</i> Hora	-	+	+	-	-	-	-	-	-	-	-	-	-	-	Endemic	98.	<i>Noemacheilus beavani</i> Gunther	-	+	+	-	-	-	-	-	-	-	-	South Asian	
44.	<i>Garra lamta</i> (Hamilton)	-	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	99.	<i>Noemacheilus botia</i> (Hamilton)	-	+	+	-	-	-	-	-	-	-	-	South Asian	
45.	<i>Garra lissohynchus</i> (Mc Clelland)	-	+	+	-	-	-	-	-	-	-	-	-	-	-	Endemic	100.	<i>Noemacheilus corica</i> (Hamilton)	-	+	+	-	-	-	-	-	-	-	-	South Asian	
46.	<i>Garra naganensis</i> Hora	-	+	+	-	-	-	-	-	-	-	-	-	-	-	Endemic	101.	<i>Noemacheilus kangjupkhulensis</i> Hora	-	+	+	-	-	-	-	-	-	-	-	South Asian	
47.	<i>Garra rupecula</i> (Mc Clelland)	-	+	+	-	-	-	-	-	-	-	-	-	-	-	Endemic	102.	<i>Noemacheilus manipurensis</i> Chaudhuri	-	+	+	-	-	-	-	-	-	-	-	Endemic	
48.	<i>Garra usuta</i> (Mc Clelland)	-	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	103.	<i>Noemacheilus multifaeciatius</i> Dey	-	+	+	-	-	-	-	-	-	-	-	South Asian	
49.	<i>Lebeo beta</i> (Hamilton)	+	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	104.	<i>Noemacheilus prashadi</i> Hora	-	+	+	-	-	-	-	-	-	-	-	Endemic	
50.	<i>Lebeo boge</i> (Hamilton)	+	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	105.	<i>Noemacheilus rupecola rupecola</i> (Mc Clelland)	-	+	+	-	-	-	-	-	-	-	-	South Asian	
51.	<i>Lebeo calbagu</i> (Hamilton)	+	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	106.	<i>Noemacheilus rupecola inglii</i> Hora	-	+	+	-	-	-	-	-	-	-	-	South Asian	
52.	<i>Lebeo dero</i> (Hamilton)	+	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	107.	<i>Noemacheilus savona</i> (Hamilton)	-	+	+	-	-	-	-	-	-	-	-	South Asian	
53.	<i>Lebeo gonius</i> (Hamilton)	-	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	108.	<i>Noemacheilus scaturigina</i> (Mc Clelland)	-	+	+	-	-	-	-	-	-	-	-	South Asian	
54.	<i>Lebeo mendina</i> (Hamilton)	-	+	+	-	-	-	-	-	-	-	-	-	-	-	South Asian	109.	<i>Noemacheilus sikkimensis</i> Hora	+	+	+	-	-	-	-						

Table 24 (Contd) : North-East Indian fish species/  
subspecies and their relationships.

- A : Peninsular India
- B : Rest of India
- C : South Asian Subregion
- D : East Asian Suoregion
- E : West Asian Subregion
- F : High Asian Subregion
- G : Holarctic Region
- H : Ethiopian Region
- I : Madagascan Region
- J : Nearctic Region
- K : Australian Region
- L : New Zealand Region
- M : South-West Pacific Region



establishment of the present-day fauna. South Asian origin of North-East fish fauna was clearer from the present study also as no other fish fauna had as high percentage of North-East Ostariophysan fishes as the South Asian sub-region and their possible spreading might have occurred through Assam gateway (Briggs, 1979). Overwhelming geological evidence amassed over the recent years indicates that the surface of the earth has been in constant motion since about the Mesozoic (Cracraft, 1974) and has been a force for faunal disintegration and destruction. The Great Assam earthquake of 1950 affected the Brahmaputra system and shifted its channel course, pattern and raised its bed by depositing sediments which might have caused the present day discontinuities (Anon, 1979) as has been observed by Smith (1972), and Hartman (1973). The role of the Brahmaputra river with its everchanging pattern has been affecting the life of this region. On geological consideration the Brahmaputra's ancestors were developed during Miocene-Pliocene as evidenced by the continental sediments in Tipam Sandstone (Neogene) etc., This river was flowing probably east of Shillong Plateau and Mikir Hills. During that period the area west of  $94^{\circ}$  longg. (west of Jorhat and Lakhimpur) was Upland and had a river system in its foredeep. Thus the river Brahmaputra's role in North-East aquatic life was significant from the geological period, to create, and to some extent preserve the varied ecological niches that have been harbouring highly diversified fish fauna. Of these, the hill stream fishes and their migration to Peninsula attracted many workers

like Hora (1937h) who proposed Satpura Hypothesis to account for their migration via the Garo-Rajmahal Gap. His hypothesis was based on the following conceptions.

1. Continuity of Vindhya-Satpura trend of mountains with the Assam Himalayas in the east and Western Ghats in the west.
2. 1000 to 2000 m elevation of the Vindhya-Satpura ranges and the northern section of the Western Ghats.
3. Continuity of ecological belt of mountains with rainfall about 250 cm or above and consequently tropical evergreen forests between the Assam Himalayas and the mountains of Ceylon via Vindhya-Satpura trend.
4. The Garo-Rajmahal Gap is a very recent feature in the physiography of India.

Though the Hypothesis lacked geological evidence (Menon, 1980) it aroused interest in other workers (Mani, 1974g; Kurup, 1974). The former proposed alternative routes of fish migration through Monghyr and Rajmahal Hills on the south and Darjeeling Hills on Eastern Nepal on the North of the proposed route.

North-East fauna, fishes no exception, has been an admixture due mainly to migrations through the region to Peninsula from the east and vice versa. Finally the North-East Indian fish fauna has been in a continuous dynamic pattern because of the everchanging pattern of the Brahmaputra and its

tributaries, high seismic activity through geological periods and also due to continuous migrations, though they were primarily South Asian.

Dispersal is only one of the several mechanisms by which organisms deal with environmental variability, others include dormancy and iteroparity. The evolution of such strategies involve both density and frequency dependents, and hence it is only in a limited sense of evolutionary stable strategies. It is for these reasons that historical evolution and biogeography provide descriptive information about the development of the diversity. The process of natural selection accounts for the adaptations of individual species to their particular environments. However, the capacity of the environment to support species is an ecological property, which is determined ultimately by the physical environment. More proximally the capacity of the environment to support species depends on how essential resources are apportioned among species. Each individual species therefore plays a unique role in the ecosystem as a whole; it potentially influences every other species through its interspecific interactions and its effects on the physical environments.

This is not to say that history is unimportant. Geological and climatic changes have had major, longlasting effects on the composition and diversity of biotas. However, as mentioned earlier it is easier to understand the effects of

historical perturbations from a conceptual framework that assumes eventual equilibrium of rates of origination (Colonization or speciation) and extinction. The assumption of such an equilibrium is not unrealistic when applied to much of the earth's present biota. Given a long period of geologic and climatic stability (say 10 or 100 million years) most ecologists would probably expect to find pretty much the same general patterns of diversity as at the present. The Arctic tundra, salt marshes, hot springs, desert oases and small oceanic islands would still support many fewer species than the Amazon rain-forest, the Great barrier reef or even for that matter the North-East Hill Regions of India.

Though ecologically and geologically the present work can be understood in terms of resource allocation and co-existence of species, the patterns of geographic ranges have two other important consequences for community ecologists which should be noted in passing. Most species have much broader ranges than the study area of ecologists and these wide ranges appear to be important in enabling the species to persist over evolutionary time. Also, since the sizes of geographic ranges vary, particular species must co-exist with different combinations of other species to form different communities in different parts of their geographic range. Ecological communities are perhaps the most complex of biological structures. Who ever thought it would be easy to find out why there are so many species ?

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