STUDY ON THE ICTHYOFAUNAL DIVERSITY IN SELECTED RIVERS OF MIZORAM DRAINING INTO BARAK RIVER

By

Samuel Lalronunga

DEPARTMENT OF ENVIRONMENTAL SCIENCE
MIZORAM UNIVERSITY
AIZAWL – 796004, INDIA

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By

Samuel Lalronunga,
Department of Environmental Science

A Thesis submitted in partial fulfillment of the requirement of the degree of Doctor of Philosophy in Environmental Science of Mizoram University, Aizawl

Dedicated to my mom Vanlalruali and my dad Vanlalngena

CERTIFICATE

This is to certify that the thesis entitled "**Study on the icthyofaunal diversity in selected rivers of Mizoram draining into Barak River**" submitted to Mizoram University for the award of the degree of Doctor of Philosophy by **Samuel Lalronunga**, research scholar in the Department of Environmental Science, is a record of original research work carried out during the period from 2011-2014 under our guidance and supervision. This workhas not been submitted elsewhere for any degree.

(Prof. LALNUNTLUANGA)
Supervisor
Department of Environmental Science
Mizoram University

(Dr. LALRAMLIANA)
Joint supervisor
Department of zoology
Pachhunga University College

MIZORAM UNIVERSITY
AIZAWL-796004

26th October, 2015

DECLARATION

I, Mr. Samuel Lalronunga, hereby declare that the subject matter of this thesis entitled "**Study on the icthyofaunal diversity in selected rivers of Mizoram draining into Barak River**" is the record of work done by me, that the contents of this thesis did not form basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree in any other University/Institute.

This is being submitted to the Mizoram University for the award of the degree of Doctor of Philosophy in the Department of Environmental Science.

(SAMUEL LALRONUNGA)

(Prof. B.P. MISHRA)
Head
Department of Environmental Science
Mizoram University

(Prof. LALNUNTLUANGA)
Department of Environmental Science
Mizoram University

TABLE OF CONTENTS

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List of figures

List of tables

List of acronyms

%	:	Percentage
+	:	Plus
/	:	Per
°	:	Degree
°C	:	Degree Celsius
’	:	Minute
>	:	Greater than
<	:	Lesser than
AMSL	:	Above mean sea level
Anon.	:	Anonymous
c.	:	Around
cm	:	Centimeter
DHL	:	Dorsal head length
E	:	East
eg.	:	Example
et al.	:	And others
etc.	:	And other things
HL	:	Head length
i.e.	:	That is
IUCN	:	International Union for Conservation of Nature
kg	:	Kilograms
km	:	Kilometer
km^2	:	Square kilometer
m	:	Meter
mm	:	Millimeter
MZBM	:	Mizoram University Biodiversity Museum
N	:	North
PUCMF	:	Pachhunga University College Museum of Fishes
SL	:	Standard length
viz.	:	Namely
vs.	:	Versus
ZSI	:	Zoological Survey of India

CHAPTER 1

INTRODUCTION

1.1 General

Ichthyology (from Greek: *ikhthus* - fish; and *logos* - study) is the branch of zoology devoted to the study of fish. This includes skeletal fish (Osteichthyes), cartilaginous fish (Chondrichthyes), and jawless fish (Agnatha). Jayaram (2002) defined fish in a simple way as an aquatic cold-blooded vertebrate that have gills throughout their life and limbs, if any, in the shape of fins. Fishes occupy essentially all aquatic habitats that have liquid water throughout the year, including thermal and alkaline springs, hypersaline lakes, sunless caves, anoxic swamps, temporary ponds, torrential rivers, wave-swept coasts, high-altitude and high-latitude environments. Fish exhibit enormous diversity in their morphology, in the habitat where they occupy and in their biology. The altitudinal record is set by nemacheiline loach, *Triplophysa stolickai* that inhabit Tibetan hot springs at elevations of 5,200 m AMSL (Zhu, 1981). The record for unheated waters is Lake Titicaca in northern South America, where pupfishes of the genus *Orestias* live at an altitude of 3,812 m AMSL (Helfmen *et al*., 2009). The deepest living fishes are cusk-eels (family Ophidiidae), which occur 8,000 m down in the deep sea (Helfmen *et al*., 2009). Fish are invariable living components of water bodies.

Variation in body length ranges more than 1000fold. The world’s smallest fishes and vertebrates mature at around 7-8 mm and include an Indonesian minnow, *Paedocypris progenetica* which matures at 7.9 mm (Kottelat *et al.*, 2005) and two gobioids, *Trimmatom nanus* from the Indian Ocean which matures at 8 mm (Winterbottom & Emery, 1981) and *Schindleria brevipinguis* from Australia’s Great Barrier Reef in which males mature at 7 mm, although females are 10 times that length (Watson & Walker, 2004). The world’s longest cartilaginous fish is the 12 m long (or longer) whale shark, *Rhincodon typus*, whereas the longest bony fish is the 8 m long (or longer) oarfish, *Regalecus glesne* (Helfmen *et al*., 2009). Body masses top out at 34,000 kg for whale shark and 2,300 kg for the ocean sunfish, *Mola mola* (Helfmen *et al*., 2009). Diversity in form includes relatively fishlike shapes such as minnows, trouts, perches, basses, and tunas, but also such unexpected shapes as boxlike trunkfishes (family Ostraciidae), elongate eels (order Anguilliformes) and catfishes (Siluriformes), globose lumpsuckers (family Cyclopteridae) and frogfishes (family Antennariidae), rectangular ocean sunfish, *Mola mola*; question-mark-shaped seahorses (*Hippocampus* spp.), flattened and circular flatfishes (order Pleuronectiformes) and batfishes (family Ephippidae) ignoring the exceptionally bizarre fishes of the deep sea.

1.2 Global diversity

Freshwater biodiversity constitutes a vitally important component of the planet, with a species richness that is relatively higher compared to both terrestrial and marine ecosystems (Gleick, 1996). The freshwater ecosystem supports various orders of animals, plants and fungi, contributing to a quarter of vertebrate diversity and almost as much of invertebrate diversity described to date (Darwall *et al*., 2008). While freshwater habitats cover less than 1% of the world's surface (Gleick, 1996), they provide a home for 7% (1,26,000 species) of the estimated 1.8 million described species (Balian *et al*., 2008), including a quarter of the estimated 60,000 vertebrates. Fishes constitute almost half the total number of 55,000 vertebrates recognized in the world over (Helfmen *et al*., 2009). Comprising approximately 25% of all vertebrates, freshwater fishes are an important component of global biodiversity (Reid *et al*., 2013). The number of valid species is placed at 27,977 under 515 families and 4,498 genera (Nelson, 2006). Of these, 108 are jawless fishes (70 hagfishes and 38 lampreys); 970 are cartilaginous sharks (403), skates and rays (534), and chimaeras

(33); and the remaining 26,000+ species are bony fishes; many others remain to be formally described (Helfmen *et al*., 2009).

1.3 Definition of freshwater fish

Freshwater fishes are defined as “those that spend all or a critical part of their life cycle in freshwaters”. There are an estimated 13,000 freshwater fish species in the world (Lévêque *et al*., 2008). Ichthyologists used to distinguish three major groups of freshwater fish according to their tolerance to saltwater and their hypothesised ability to disperse across marine barriers (Myers, 1949): the primary division fish being strictly intolerant of salt water; the secondary division able occasionally to cross narrow sea barriers; and the peripheral division including representatives of predominantly marine families that have colonised inland waters from the sea. This classification scheme has been challenged partly because of the subjectivity in distinguishing between divisions (Lévêque *et al.*, 2008). However, the scheme is still widely used by many fish biogeographers and has the advantage of common usage. The popular internet site FishBase (Froese & Pauly, 2015) adheres to a slightly different classification with fresh and brackishwater fish species falling into three categories: (1) exclusively freshwater, (2) occurring in fresh and brackishwaters, (3) or in fresh, brackish and marine waters. The first category covers more or less the primary and secondary divisions of Myers (1949), while categories 2 and 3 cover the peripheral division.

1.4 Importance of freshwater fishes

1.4.1 Economic and nutritional value

Fishes are important food resource and fishing remains the largest extractive use of wildlife in the world. Fish forms the most important wetland product on a global scale, and is certainly the most utilized wetland resource. In 2010, the annual capture, combining both wild capture and aquaculture, was 149 million tonnes (FAO, 2012). About 94% of all freshwater fisheries occur in developing countries (FAO, 2007). Asia accounts for 63% of total fish production and fish accounts for 30% of the typical diet across Asia as a whole (Briones *et al.*, 2004). They provide food and a livelihood for millions of the world's poorest people, and also contribute to the overall economic well being by means of export commodity trade, tourism and recreation (Worldfish Center, 2002). In the Mekong River basin alone, some 55.3 million people depend on freshwater fish for nutrition and livelihoods, with an estimated average fish consumption of 56.6 kg/person/year (Baran *et al.*, 2007). It is estimated that freshwater fishes make up more than 6% of the world's annual animal protein supplies for humans (FAO, 2007). In Bangladesh, Indonesia and the Philippines freshwater fishes comprise 50% of animal protein intake, while in Thailand and Vietnam its share is 40%. It is the major and often the only source of animal protein for low income families (Briones *et al.*, 2004). There are serious threats to this valuable resource with most wild fisheries near maximum sustainable exploitation levels (Delgado *et al.*, 2003). Fishing provides a lasting vestige of utilizing the resources of a global commons, which are often part of maintaining traditional and cultural customs (Clausen & York, 2008).

1.4.2 Ecosystem-services value

Fishes are good indicators of the ecological health of the waters they inhabit. It is estimated that the global values of ecosystem goods (e.g. fish as food and fresh water to drink), ecosystem regulation (e.g. creation of climate and rain through the hydrological cycle), ecosystem support (e.g. nutrient recycling), and cultural considerations (e.g. recreation), yields a value measured in trillions of dollars (Reid *et al*., 2013).

1.4.3 Fish as bioindicators

Due to feeding and living in the aquatic environments fish are particularly vulnerable and heavily exposed to pollution because they cannot escape from the detrimental effects of pollutants (Yarsan & Yipel, 2013; Mahboob *et al*., 2014; Saleh & Marie, 2014). Fish, in comparison with invertebrates, are more sensitive to many toxicants and are a convenient test subject for indication of ecosystem health (Adam & Ryon, 1994; Whitfield & Elliott, 2002).

1.4.4 Scientific value

Due to the size and abundance of fish they are easily sampled research objects that provide information crucial for management and our understanding of freshwater ecosystems (Holmlund & Hammer, 1999). They are excellent research models in areas such as phylogenetics, evolutionary biogeography and ecology. Due to the fact that the African cichlid fish radiations are the most diverse extant animal radiations, they provide a unique system to test predictions of speciation and adaptive radiation theory (Seehausen, 2006).

The present fish fauna is living witness to climatic changes in the past, a fact that gives us information about past climate. For example, the distribution of Arctic char (*Salvelinus alpinus*) in Scandinavian lakes reveals a climatic pattern of a maximum water temperature of 16°C from the most recent glaciation period 10,000 years ago to today (Holmlund& Hammer, 1999). Scientists have been able to extract antifreeze proteins form pond smelts (*Hypomesus nipponensis*) that can be used to protect the internal structure of products containing water, e.g. meat, vegetables, processed foods, blood, cells, tissues and organs (Mahapatra *et al*., 2015)

1.4.5 Fish in medicine

Fish are used in management to mitigate vector borne diseases like schistosomiasis and malaria. Due to bioaccumulation, predatory species have also been used as sentinels for the presence of toxic chemicals in waterways (Holmlund & Hammer, 1999). Perhaps because of their fecundity, small size, and economical maintenance and use, fish models are becoming well established in many laboratories. In fact, it is said that the facility that does not house at least one colony of zebrafish, medaka, or other fish species is probably not at the forefront of biomedical research (McHugh, 2003).

1.4.6 Control of vectors

Various species of mosquito transmits diseases like malaria, dengue, chikungunya, yellow fever, encephalitis, West Nile virus, filarial (elephantiasis), etc. Worldwide, malaria is a leading cause of premature mortality, particularly in children under the age of five, with an estimated 207 million cases and more than half a million deaths in 2012 (WHO, 2013). Several species of fresh water fishes feed on mosquito larvae and are of considerable value in controlling mosquito population (Chandra *et al*., 2008).

1.5 Major threats to freshwater fishes

Freshwater fishes may now be the most threatened group of vertebrates, based on more than 5,000 species assessed, to date, by the IUCN (Reid *et al*., 2013). Freshwater biodiversity is being threatened by a number of key impacts including overexploitation, water pollution, flow modification including water abstraction, destruction or degradation of habitat and invasion by invasive alien species (Dudgeon *et al*., 2006; Millennium Ecosystem Assessment, 2005). Compounding these threats are the predicted global impacts of climate change leading to temperature changes and shifts in precipitation and runoff patterns (Dudgeon *et al.*, 2006). Often species, or biodiversity, declines in response to more than one category of threat, and the real 'threat' is the combined or synergistic impact of changes brought about by human activities. FishBase (Froese & Pauly, 2015) listed 217 fishes in India as threatened. IUCN Red List assessment of freshwater fishes of the Eastern Himalaya shows that about 2% of fishes of the region are at high risk of extinction (Allen *et al*., 2010).

Major threats to freshwater fishes and other freshwater biodiversity include: habitat modification, fragmentation, and destruction; invasive species; overfishing; environmental pollution; forestry practice and climate change.

1.5.1 Habitat modification, fragmentation and destruction

The amount of water impounded behind dams has quadrupled since 1960, and three to six times more water is held in reservoirs than in natural rivers (Millennium Ecosystem Assessment, 2005). Water withdrawals from rivers and lakes have doubled since 1960, and 70% of all water used worldwide is for agriculture (Millennium Ecosystem Assessment, 2005). This has taken a heavy toll on the world's freshwater biota in general causing many species of freshwater fish to become endangered (Revenga & Kura, 2003). General habitat loss is, for example, closely associated with the decline of Asiatic arowana (*Scleropages formosus*) in Thailand (Ismail, 1989). The consequences of damming are disruption of fish migration routes and breeding patterns, changes to flow regimes, increased sedimentation within reservoirs, and indirect impacts associated with development near to new reservoirs (Nilsson *et al.*, 2005) and increased human settlement (Smakhtin & Anputhas, 2006). A large amount of freshwater fish species are also being threatened by degradation, reduction or even loss of floodplains by damming, agriculture practices, urban development, rivers dredging and geomorphological modifications (Dudgeon *et al*., 2006).

1.5.2 Invasive species

Alien (non-indigenous) species are species that occur outside of their natural ranges as a result of human activity (Primack, 2004). Of these species, many are considered invasive, because they increase in abundance at the expense of native species (Davis, 2003). Invasive species may displace native species through competition for limited recourses, prey upon native species to the point of extinction or alter the habitat and make persistence for natives impossible (Primack, 2004). Some species have been introduced intentionally from several motivations such as aquaculture, sport fishing/ angling, improvement in species composition, biological control (Welcomme, 1988; Panov *et al*., 2009) whereas others were brought either accidentally, usually as a contamination of stocking material, released by aquarists, or due to the range expansion after liquidation of geographic barriers, facilitated by water transport and human alteration in the environment (Grabowska *et al*., 2010).

1.5.3 Overfishing

Overfishing is the principle cause of the decline of many fish, shellfish, and other living marine resources around the world (Pauly *et al*., 2002). In many developing countries human population growth is driving a greater need for protein sources and freshwater fishes are often the most accessible resource. About 1 billion people, largely in developing countries rely on fish as their primary animal protein source (Allan *et al*., 2005). Overexploitation (unsustainable fishing) poses a serious threat to fish and aquatic biodiversity and also to the livelihoods of people in riverine and lake communities.Several taxa are facing a major decline in population, especially high value food fish: Murray cod (*Maccullochella peelii*), Sutchi catfish (*Pangasianodon hypophthalmus*), giant barb (*Catlocarpio siamensis*), the freshwater whipray

(*Himantura chaophraya*), Mekong giant catfish (*Pangasianodon gigas*), etc. (Allan *et al*., 2005).

1.5.4 Environmental pollution

Environmental pollutants, such as metals, pesticides, and other organics, pose serious risks to many aquatic organisms (Scott & Sloman, 2004). Modern agricultural practices, eventhough contributed to enhance the crop production, also widely polluted the aquatic environment (Pandey *et al*., 2000). The industrial effluents and urban sewage released into rivers directly after little or no treatment have added to the problem (Pandey, 2000). Increasing pollution of rivers and other water bodies has become a matter of great concern in recent years (Dikshith *et al*., 1990). Environmental pollutants have adverse impacts on development, growth, behavior and reproduction of fishes (Scott & Sloman, 2004)

1.5.5 Forestry practice

The alteration of the terrestrial ecosystem is reflected in the productivity and structure of the aquatic ecosystem in many ways (Vannote *et al*., 1980). Forest management measures, e.g. logging and drainage, have caused substantial changes to the water quality and sediment loading of streams and to the spawning and nursery habitats of fishes (Heikurainen *et al*., 1978; Everest *et al*., 1987; Ahtiainen, 1988). Such impacts affect the food supply, growth, survival and reproduction of fishes in a stream (Condore & Kelley, 1961; Cooper, 1965; Holtby & Hartman, 1982; Murphy *et al*., 1986; Wilzbach & Cummins, 1986). The construction of forest roads on mountainous slopes has had similar effects (Beschta, 1978; Fahey & Coker, 1992; Clarke & Scruton, 1997). Clear cuttings have led to changes in seasonal and diurnal patterns of water temperatures thus having impacts on the state of the streamdwelling fish stocks (Brown, 1970; Hartman *et al*., 1984; Beschta *et al*., 1987; Holtby, 1988).

1.5.6 Climate change

All freshwater fishes are exotherms that cannot regulate their body temperature through physiological means (Moyle & Cech, 2004) and whose body temperatures are virtually identical to their environmental temperatures. These fishes may thermoregulate behaviorally, by selecting thermally heterogeneous microhabitats (Brett, 1971; Nevermann & Wurtsbaugh, 1994; Nielsen*et al*., 1994; Brio, 1998), but they are constrained by the range of temperatures available in the environment. Biochemical reaction rates vary as a function of body temperature, all aspects of fish physiology; including growth, reproduction, and activity are directly influenced by changes in temperature (Wohlschlag*et al*., 1968; Schmidt-Nielsen, 1990; Franklin *et al*., 1995). Therefore, increasing global temperatures can affect individual fish by altering physiological functions such as thermal tolerance, growth, metabolism, food consumption, reproductive success, and the ability to maintain internal homeostasis in the face of a variable external environment (Fry, 1971).

1.6 Ichthyology in India

India is one of the megabiodiversity countries in the World (Mittermeier and Mittermeier, 1997). In Indian region (including Bangladesh, Nepal, Bhutan, and Myanmar) alone there are 2500 species of which 930 are inhabitants of freshwater and the rest live in the sea (Jayaram, 1999). Out of a total of 2,500 species of fish in India, 930 are in fresh waters and belong to 326 genera, 99 families and 20 orders (Talwar & Jhingran, 1991). The most updated report on freshwater fish diversity of India is 890 species, of which 24 introduced and 192 are endemic species (Froese & Pauly, 2015). However, the rich biodiversity of the freshwater fish of the Indian region has been rapidly dwindling because of increasing degradation of inland water (Bagra *et al*., 2009). Conservation International (CI) recognizes thirty-four (34) biodiversity hotspots in the world (Mittermeier *et al.*, 2005); these hotspots once covered 15.7 percent of the planet, but already 86 percent of the hotspots has been destroyed and they now cover just 2.3 percent of the planet (Laverty *et al.*, 2008). Three of these biodiversity hotspots: Western Ghats, Himalaya and Indo-Burma are located within India (Mittermeier *et al.*, 2005). The three Indian fish biodiversity hotspots Western Ghats, North East India and the Himalayas are still unexplored with respect to number of endemic fish species from these regions. The North-Eastern region of India is composed of eight states *viz.* Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura.

Ichthyological research in the northeast region started with the pioneering works of Hamilton (1822), followed by Day (1878). Hora made tremendous contribution to the ichthyology of the region till the middle of 20th century. However, works on the Burmese forms became almost standstill after Hora’s (1941a) report on the Vernay-Hopwood Upper Chindwin expedition. Apart from these explorations, works on the freshwater fish fauna of North East India is very scanty and neglected. But in the later part of the 20th century and in the beginning of the 21st century, scientists from all over the world have focused their research on the ichthyofaunal exploration in south-east Asia. Many new species have been discovered and many taxa have been reviewed. More than 75 research papers have been published and as many as 139 species of fishes have been described new from the region (Vishwanath*et al*., 2007).

Abell *et al.* (2008) presented a global map of 426 freshwater ecoregions based on the distributions and compositions of freshwater fish species. According to this classification, Mizoram lies in the Chin Hills-Arakan Coastecoregion. Abell *et al.* (2008) states that the region has a species richness consisting of around 500 fish species, and estimated 28-40 species to be endemic. Diversity of fishes in northeast India are threatened by various factors such as pollution, habitat alteration, over-exploitation, loss of habitat, invasive species (Vishwanath *et al*., 2010).

Though Mizoram is rich in floral and faunal diversity, research and documentation is very poor. Efforts of biodiversity conservation are made easier by taxonomy through the understanding of the basic units of biodiversity, ie. species, and their relationships. Proper documentation of biological resources through taxonomy is a need of the hour as the knowledge of the identity of an organism increases the effectiveness of conservation. The work on the fishes of northeast India particularly Mizoram is still in juvenile stage. This was due to lack of extensive survey works by researchers from outside Mizoram, particularly in the interiors of hills, because of difficult topography and lack of proper language communication.Considering the fact that freshwater fishes are the most threatened large taxon in the world (Carrizo *et al*., 2013) and the Eastern Himalaya aquatic biodiversity hotspot, home to many endemic freshwater fish species (Vishwanath *et al*., 2010) is highly threatened (Allen *et al*., 2010), a proper documentation of freshwater fishes of Mizoram is a need of the hour.

The major objectives of the study envisage the followings:

1. To carry out taxonomic study on the ichthyofauna in the selected rivers of Barak drainage of Mizoram.
2. To study the ichthyofaunal diversity and distribution in the selected rivers of Barak drainage of Mizoram.
3. To identify threats to freshwater fishes in the selected rivers of Barak drainage of Mizoram.

CHAPTER 2

REVIEW OF LITERATURE

2.1 Freshwater fish diversity

Fish are the largest group among vertebrates and make up more than half of the 55,000 exant species of vertebrates (Helfman *et al*., 2009). Nelson (2006) estimated 27,977 valid species of fishes under 62 orders, 515 families and 4,494 genera. The eventual number of extant fish species may be projected to be close to 32,500 (Nelson, 2006). Of these, 108 are jawless fishes (70 hagfishes and 38 lampreys); 970 are cartilaginous sharks (403), skates and rays (534), and chimaeras (33); and the remaining 26,000+ species are bony fishes; many others remain to be formally described (Helfman *et al*., 2009). About 11,952 species or 42.72%, normally live in freshwater lakes and rivers that cover only 1% of the earth's surface and account for a little less than 0.01% of its water (Nelson, 2006). The secondary freshwater species numbers 12,457 and the remaining 3568 species are exclusively marine (Nelson, 2006). Approximately 26,000 species are bony fishes, 10,100 are entirely freshwater and 2,500 move between the sea and freshwater during their life cycles (Helfman *et al.*, 1997). In terms of area, freshwater ecosystems occupy only 0.8% of Earth's surface, but they are estimated to harbor at least 100,000 species, or nearly 6% of all described species (Dudgeon *et al.*, 2006). Each year, new freshwater species are described. For South America alone, about 465 new freshwater fish species have been described in the last five years which that corresponds to a new species every four days (Abell *et al*., 2008). The presence of species confined to small ranges is also unusually high in freshwater ecosystems; for example, 632 animal species have been recorded as endemic to Lake Tanganyika (Groombridge & Jenkins, 1998).

2.1.1 Global Status

The largest number of species occurs in the tropics and the diversity of fishes, in general, increases from the poles to the tropics (Helfman *et al.*, 2009). South America, Africa and Southeast Asia, in that order, contain the most freshwater fishes (Berra, 2007; Lévêque *et al*., 2008). In many arctic lakes there is only one species, the Arctic charr, *Salvelinus alpinus* (Johnson, 1983) compared to Lake Malawi which has at least 500 species of Cichlidae alone (Craig, 1992). Freshwater fishes are one of the most important groups zoogeographically because they are more or less confined to drainage systems which are in bordered by a saltwater barrier (Helfman *et al.*, 2009). Six freshwater zoogeographic regions are normally recognized (Berra, 2007; Helfman *et al.*, 2009) *viz.* i) Nearctic (North America except tropical Mexico); ii) Neotropical (Middle and South America, including tropical Mexico); iii) Palearctic (Europe and Asia north of the Himalayan Mountains); iv) African (or Ethiopian); v) Oriental (Indian subcontinent, Southeast Asia, the Philippines, and most of Indonesia); and vi) Australian (Australia, New Guinea, Tasmania, New Zealand, Celebes and nearby islands to the east).

Lévêque *et al.* (2008) gave the number of species and genera (species/Genus) per zoogeographic region for strictly freshwater fishes: Palaearctic (1888/380); Nearctic (1411/298); Neotropical (4035/705); Africa (2938/390); Oriental (2345/440) and Australian (261/94).

2.1.2 Palearctic region

The Palearctic region of northern Europe and Asia contains only 15, 2 and 13 families of primary, secondary and peripheral freshwater fishes respectively (Berra, 2007). Since the European continent experienced periods of late glaciation, there is less diversity of European freshwater fish than tropical fish. Since the 19th Century, standard books have typically listed between 160 and 270 species of freshwater fishes in Europe, depending on taxonomic and geographical definitions (Freyhof & Brooks, 2011). Europe itself was historically thought to be relatively depauperate in freshwater fishes, but recent reanalysis suggests Europe has a rich fauna of 579 species under 118 genus and 35 families from 24 European countries (Kottelat & Freyhof, 2007). Among these, 546 species are native and 33 species are introduced (of which 28 are well established to their new environment). Subsequently, Freyhof & Brooks (2011) assessed the conservation status of 531 species of native freshwater fish from Europe and 381 species from 27 Member States of the European Union.

The Mediterranean region of Europe has only been recognized as a hotspot of freshwater fish diversity in the last 20 years and many new species have been described from this region (Freyhof & Brooks, 2011). Smith & Darwall (2006) recorded 253 species of endemic freshwater fish from this region alone. The majority of Europe’s freshwater fish species belongs to one of the following two taxonomic groups: The warm-water adapted Cypriniforms (280 species), such as carps, chubs, dace and loaches, have their highest level of species diversity in the southern and temperate parts of Europe, whereas the Salmoniforms (102 species), such as salmon, trout, grayling and whitefish, are most abundant and diverse in mountainous regions and in northern Europe (Freyhof & Brooks, 2011). Both groups are well known for including many local endemics at species level. Over 80% (426 of 531 species) of all European freshwater fish species are endemic to Europe and many of these species are range restricted, only found in one or few rivers or lakes (Freyhof & Brooks, 2011). The killifish family Valenciidae is the only fish family endemic to Europe and the Mediterranean basin (Freyhof *et al*., 2014). About 5-10 new species of freshwater fish are described every year across Europe. Currently it has been accepted that 18 of the 564 native European species are undescribed, however the undescribed species are expected to be discovered over the coming years. In the future, the total number of native European freshwater fishes is most likely to stabilise around 700-800 species.

Lévêque *et al*. (2008) modified the ichthyological regions defined by Reyjol *et al*. (2007) based on species lists for 233 species from 406 basins to define seven European provinces *viz.* i) Ponto-Caspian Province with 98 species of which 36.7% are endemic; ii) Northern Europe Province with 42 species of which 9.5% are endemic; iii) Western Europe Province with 47 species of which 6.4% are endemic; iv) Central Europe Province with 57 species of which 1.8% are endemic; v) Central Peri-Mediterranean Province with 93 species of which 64.5% are endemic; vi) Eastern Peri-Mediterranean Province with 64 species of which 31.2% are endemic; and vii) Iberian Peninsula Province with 50 species of which 60% are endemic.

2.1.3 Nearctic region

The Nearctic region consists of North America south to the Mexican plateau. The North American freshwater fish fauna is the best known and has been mapped by Lee *et al*. (1980) and discussed thoroughly by Hocutt & Wiley (1986). There are 14 families of primary freshwater fishes and a total of about 950 species of fishes in the region. The most speciose families include three families of ostariophysans; the Cyprinidae, Catostomidae, and Ictaluridae (the only North American family of recent catfishes) plus two percoid families; the Percidae (especially the darters) and the Centrarchidae. The ranges of five Nearctic families; the Cyprinidae, Catostomidae, Ictaluridae, Percidae, and Centrarchidae extend south well into Middle America. Included in this area are the Southern Appalachian river drainages, with about 350 species, the richest diversity of temperate freshwater fishes of any continent (Lydeard & Mayden, 1995).

This region can be divided into 10 provinces based mainly on distribution data for freshwater fishes, mussels, and crayfish (Abell *et al*., 2000, as modified by Lévêque *et al*., 2008) *viz.* i) Pacific Coastal province with about 40 endemic fish species; ii) Great Basin Province with about 50 species, about 80% of which are endemic (Miller, 1958); iii) Colorado province with about 32 species of freshwater fishes, 75% of which are endemic, with many species threatened by dams, water extraction, and introduced species (Helfman *et al.*, 2009); iv) Rio Grande province with 154 species of which about 80 species are endemic (Helfman *et al.*, 2009; Lévêque *et al.*, 2008); v) Mississippi province with about 375 species of which about 130 species are endemic (Lévêque *et al.*, 2008); vi) Atlantic province in which the northern part has a relatively high proportion of anadromous fishes, while the southern portion has numbers of secondary fishes that have invaded from marine waters (Helfman *et al.*, 2009). About 65 species of fish are endemic to this province (Lévêque *et al.*, 2008); vii) St. Lawrence province with atleast 3 species of endemic fish (Helfman *et al.*, 2009); viii) Hudson Bay Province with about 100 species (Crossman & McAllister, 1986); ix) Arctic province with 66 freshwater species (Lindsey & McPhail, 1986) of which more than half belong to diadromous families, one-third are primary freshwater species, and 11% belong to marine families (Helfman *et al.*, 2009). Four species are endemic to this province (Lévêque *et al.*, 2008); and x) Mexican Transition Bioregion with about 200 endemic species (Lévêque *et al.*, 2008).

2.1.4 Neotropical region

The Neotropical region consists of South America and Middle America, into which some North American species have moved. The Neotropical region represents by far the largest geographical hotspot, containing as many as 8000 species (53%) of all freshwater fishes (Reid, 2013). Reis *et al.* (2003) reported the occurrence of 4475 valid described species under 32 families and the number almost doubled within a span of only 10 years. There are no minnows or suckers in South America, but their ecological equivalents may be in the eight families of characins with over 1200 species. Other ostariophysans include 13 families of catfishes with about 1300 species, and six families of Gymnotiformes. Cichlids (about 150 species) are the most speciose perciform group. Representatives of many marine families have also invaded South America: freshwater stingrays (Potamotrygoninae), which are endemic to South America; herrings (Clupeidae); toadfishes (Batrachoididae); needlefishes (Belonidae, three endemic genera and seven species); croakers (Sciaenidae); and soles (Achiridae).

Gery (1969) recognized eight faunistic regions but Lévêque *et al*. (2008) modified this into 10 ichthyofaunal provinces *viz.* i) The South Patagonian Province with12 species of which one species is endemic; ii) The North Patagonian Province with 23 species of which 5 species are endemic; ii) The Trans-Andean (South) Province with 19 species of which 13 species are endemic; iv) The Lake Titicaca Province with 32 species of which 30 species are endemic; v) The Paranean Province with 847 species of which 517 are endemic; vi) The South-East Brazilian Province with 194 species of which 90 species are endemic; vii) The East Brazilian Province, comprising the smaller coastal rivers of eastern Brazil, with 131 species of which 50 species are endemic; viii) The Guianean-Amazonian Province, the richest basin, with about 2400 species and more than 2000 endemics; ix) The North Venezuelan Province with 61 species of which 9 species are endemic; and x) The Trans-Andean Province, with 423 species of which 326 species are endemic.

The South and Central American rivers and streams contain the greatest number of species on Earth, with recent estimates ranging as high as 8000 and 25% of global fish species richness (Vari & Malabarba, 1998).

2.1.5 African region

The African region has a diverse freshwater fish fauna that includes 27 families of primary freshwater species and a number of primitive species as discussed below under archaic distributions. The region contains a total of about 2000 species of primary and secondary fishes belonging to about 280 genera and 47 families (Roberts, 1975). Almost half the species are ostariophysans (300 species of minnows, 190 characins, and more than 360 catfishes from six families). Roberts (1975) recognized 10 ichthyofaunal provinces, *viz.* i) Maghreb Province; ii) Nilo-Sudan Province; iii) Upper Guinea Province; iv) Lower Guinea Province; v) Congo Province; vi) Quanza Province; vii) Zambezi Province; viii) East Coast Province; ix) Southern Province or Cape of Good Hope; and x) Madagascar Province.

2.1.6 Australian region

Australia, Tasmania, New Zealand, New Guinea and the islands of the Australian continental shelf represent a well-delimited biogeographic entity (Lévêque *et al*., 2008). The Wallace line, a hypothetical boundary line that passes between Bali and Lombok, through the Makassar Strait between Borneo and the Celebes, and south of the Philippines separates Oriental and Australian faunas (Berra, 2007). The Australian region has 2, 4 and 14 families of primary secondary and peripheral freshwater fishes (Berra, 2007). The freshwater fish fauna of Australia is depauperate and lacks all Otophysan primary freshwater families found elsewhere in the world (Lévêque, 2008). The majority of freshwater fishes are representatives of marine families with many catadromous species. The only primary freshwater fishes are the Australian lungfish, *Neoceratodus* and some osteoglossids of the genus *Scleropages*. *Neoceratodus* is restricted to Queensland where it survives in swamps and permanent rivers. High endemicity in several provinces: most provinces in southern, central, and western parts of the continent have a large proportion of endemics, whereas Northern and Eastern provinces have few. The pattern results in part from isolation, due to aridity and drainage divides.

The freshwater fish fauna of New Zealand is quite modest but the number of species described increases recently. McDowall (1990) recognized only 27 species, but later studies, especially with the emergence of gene sequencing technology increase the known number of species to 38 under 7 families and 10 genera with several undescribed lineages (McDowall, 2010). The New Zealand freshwater fish fauna is very well known in terms of its taxonomy, life histories and geographical distributions (McDowall, 1990, 2000). This combination of attributes makes the fauna of particular interest from a biogeographical perspective. A notable feature is the complete absence of primary freshwater fishes groups (Myers, 1938, 1949, 1951; Darlington, 1957) that are regarded as having very low tolerances of marine water salinities (McDowell, 2010).

2.1.7 Oriental region

The Oriental region includes India, southern China, Southeast Asia, the Philippines, and the East Indies out to Borneo and Bali. Wallace (1860, 1876) proposed a boundary between the Oriental and Australian faunas that Thomas Huxley named for him as Wallace's Line. Some authors extend the line even farther to the east (Weber's Line) to also include the Celebes (now Sulawesi) and some other Indonesian Islands in the Oriental region. The region contains 28 families of primary freshwater fishes with 12 families of catfishes and four families of cypriniform ostariophysans: minnows (Cyprinidae), loaches (Cobitidae), algae eaters (Gyrinocheilidae), and river loaches (Balitoridae), which are endemic to the region. Nonostariophysan families include snakeheads (Channidae), spiny eels (Mastacembelidae), labyrinth fishes

(Anabantoidei), and a few cichlids. Only two species of primary freshwater fishes occur east of Wallace’s Line. All other fishes in fresh waters east of the line have been derived from marine groups, such as the catfishes and rainbowfishes.

2.1.8 National status

Fish research in India appears to be mediocre in general. The Indian subcontinent exhibits a great variety of ecological habitats, harboring rich icthyofaunal diversity, comprising about 2500 species of which 930 species are freshwater inhabitants and 1570 are marine. Talwar (1991) estimated 2,546 species of fish belonging to 969 genera, 254 families and 40 orders. The Indian fish population represents 11.72% of species, 23.96% of genera, 57% of families and 80% of the global fishes. The Indian species represent about 8.9% of the known fish species of the world. Jayaram (1999) listed 852 freshwater species of fishes under 272 genera, 71 families and 16 orders, including both primary and secondary freshwater fishes from India, Bangladesh, Myanmar, Nepal, Pakistan and Sri Lanka. The checklist of Menon (1999) listed 446 primary freshwater species under 33 families and 11 orders from the Indian region alone. Of the primary freshwater species 68% are constituted by the Cyprinoids, 18% by Siluroids and 14% by other groups. The present checklist of 667 species updated after a span of 10 years includes several new species mostly siluroids and a few cyprinoids and those resurrected from synonyms. The 667 species are grouped under 12 orders, 35 families and 149 genera (Devi & Indra, 2009).

The Western Ghats and the associated river drainages are rich in freshwater fish diversity (Kottelat & Whitten, 1996; Shaji *et al.*, 2000; Dahanukar *et al.*, 2004) and 290 species of freshwater fishes belonging to 11 orders, 33 families and 106 genera are recognized from the region (Dahanukar *et al.*, 2011).The Western Ghats also has a rich endemic fish fauna of 189 species, belonging to seven orders, 23 families and 69 genera and 12 genera are endemic to this region (Dahanukar *et al.*, 2011) which is about 40% of the total number (>544) of native species of freshwater fishes in India (Reid, 2013).

Icthyofaunal studies of the northeast region of India, which has elements of the Indo-gangetic region and, to some extent, elements of the Myanmarese and South-Chinese regions (Yadava & Chandra, 1994), is barely studied. Hora (1921a,b; 1930, 1936, 1937, 1938, 1939, 1940, 1941, 1943, 1951a,b; 1953) is one of the pioneer workers on the fishes of northeastern India; Ghosh & Lipton (1982) had reported 172 species of fishes with reference to their economic importance; Sen (1985) reported 187 species of fishes from Assam and its surroundings; Sinha (1994) compiled a list of 230 species of fishes from northeastern India; Nath & Dey (1997, 2000a) recorded 131 species of fishes from the drainages in Arunachal Pradesh alone; Ramanujam *et al.* (2010) reported 68 species from Meghalaya; and Sen (1995, 1999a,b; 2000) compiled a comprehensive list of 267 species of fishes from northeastern India. Sen (2003) updated the list of ichthyofauna of northeastern India. Vishwanath (1993), Vishwanath & Kosygin (1999, 2000a,b; 2001), Vishwanath & Singh (1986), Vishwanath & Sarojnalini (1988), Vishwanath *et al.* (1987, 1998) made valuable contributions to the ichthyofauna of Manipur. Goswami *et al*. (2012) reported 422 species of fish belonging to 133 genera and 38 families from the Northeastern region of India. This report is largely based on summing up data from publications, so the validity of some of the species reported are questionable (see below). The Conservation Assessment and Management Plan workshop (Molur & Walker, 1998) made valuable contributions to assessing the status of selected fishes of northeastern India.

However, no detailed study has been available on the ichthyofaunal diversity of Mizoram except some pilot survey done by Barman (1988, 1989), Kar *et al.* (2002), Kar (2003), Ramanujam (2005), Kar & Sen (2007), Karmakar & Das (2007). Sen (1977) recorded 9 species under 7 genera and 2 families. Braman (1988) reported *Semiplotus modestus* for the first time in India from the Kaladan drainage of Mizoram. Barman (1989) further recorded 17 species belonging to 14 genera, 8 families and 5 orders from Teirei River and its tributaries in Mizoram. Kar & Sen (2007) recorded 103 species belonging to 57 genera, 17 families and 6 orders from Mizoram. Karmakar & Das (2007) recorded 89 species belonging to 49 genera, 20 families and 8 orders in Mizoram on the basis of available literature and surveys by Zoological Survey of India. The identification and taxonomy of some of the species reported in these studies are doubted and remained in question (Anganthoibi & Vishwanath, 2010a,b,c; Lalramliana, 2012; Lalronunga *et al.*, 2013b; Lokeshwor & Vishwanath, 2013a,b,c; Lokeshwor *et al*., 2013; Ng & Lalramliana, 2010a,b; Ng & Lalramliana, 2012a,b).

Recent ichthyofaunal studies in different drainages of Mizoram resulted in the description of several new species. New species are added each year since 2009. The newly described species includes *Barilius profundus* Dishma & Vishwanath; *Garra dampaensis* Lalronunga, Lalnuntluanga & Lalramliana; *Glyptothorax ater* Anganthoibi & Vishwanath; *G. caudimaculatus* Anganthoibi & Vishwanath; *G. chimtuipuiensis* Anganthoibi & Vishwanath; *G. maceriatus* Ng & Lalramliana; *G. scrobiculus* Ng & Lalramliana; *Hara koladynensis* Anganthoibi & Vishwanath; *Monopterus ichthyophoides* Britz, Lalremsanga, Lalrotluanga & Lalramliana; *Pethia expletiforis* Dishma & Vishwanath; *Pseudecheneis koladynae* Anganthoibi & Vishwanath; *Pseudolaguvia virgulata* Ng & Lalramliana; *P. spicula* Ng &

Lalramliana; *P. nubila* Ng, Lalramliana, Lalronunga & Lalnuntluanga; *Schistura aizawlensis* Lalramliana; *S. porocephala* Lokeshwor & Vishwanath; *S. koladynensis* Lokeshwor & Vishwanath; *S. nebeshwari* Lokeshwor & Vishwanath; and *S. scyphovecteta* Lokeshwor & Vishwanath (Anganthoibi & Vishwanath, 2009, 2010a,b,c; Ng & Lalramliana, 2010a,b, 2012a,b; Britz *et al*., 2011; Lalramliana, 2012; Dishma & Vishwanath, 2012, 2013; Lalronunga *et al.*, 2013a; Lokeshwor & Vishwanath, 2013a,b,c)

2.2 Conservation status of freshwater fishes

Freshwater fishes are the most threatened large taxon in the world (Carrizo *et al*., 2013). While fresh waters are globally scarce (<0·3% of available surface water) they are an ichthyofaunal 'hotspot' with >15 000 species, representing c. 53% of all fishes and 25% of all vertebrates (Reid, 2013). Most of the threats to their survival are human induced (Reid *et al*., 2013). A number of reviews have shown that habitat loss and degradation, water withdrawal, overexploitation and pollution, and the introduction of non-native species are the leading causes of decline in freshwater fish species and other freshwater organisms (e.g., Abramovitz, 1996; McAllister *et al*., 1997; Groombridge & Jenkins, 1998; Revenga *et al*., 2000; Revenga & Kura, 2003; Ellison, 2004). As much as 70 species (50 Vulnerable, 15 Endangered, 5 Critically Endangered) and 97 species (31 Vulnerable, 54 Endangered, 12 Critically Endangered) of freshwarer fishes are categorised as threarened in the IUCN Red List in the Eastern Himalaya and Western Ghats region respectively (Vishwanath *et al*., 2010; Dahanukar *et al*., 2011).

CHAPTER 3

STUDY AREA AND STUDY SITES

3.1 Study Area

Mizoram lies in the north eastern part of India; much of its southern part is sandwiched between Bangladesh and Myanmar. The state is situated between 21º56' to 24º31'N latitudes and 92º16' to 93º26'E longitudes, extending over a geographical area of 21,087 km^2 (Pachuau, 2009). The length of the state from north to south is 285 km and the width from east to west is 115 km. Its major length is in the west, sharing borders with the Chittagong Hill Tracts of Bangladesh, spanning 318 km. In the east and the south, its border with the Chin Hills and Northern Arakans of Myanmar extends to about 404 km. On the Indian side, Mizoram has inter-state boundaries with Assam, Manipur and Tripura.

Mizoram falls under tropical monsoon type climate enjoying a moderate and pleasant climate with high rainfall (2000 mm to 3500 mm) and high humidity. The climatic condition is moderate throughout the year. The temperature range is 8-24^{o}C in winter and 11-35^{o}C in summer (Pachuau, 2009). The entire state comes under the direct influence of the south west monsoon. Three distinct seasons can be recognized- six months rainy or summer season from second part of May to late October, four months of cold or winter season from November to February, and two months of warm season or spring season from March to early May (Pachuau, 2009).

The geomorphology of Mizoram is dominated by a series of parallel hill ranges, generally running from north to south, increasing in elevation from west to east creating a complex drainage pattern with several parallel rivers flowing in opposite directions (Pachuau, 2009; Singh, 1996). The mountain ranges in Mizoram run from north to south and largely taper from the middle of the state towards the north, the west and the south. Elevation ranges from 21 m at Tlabung to 2,157 m at Phawngpui (Pachuau, 2009).

3.2 Drainage system

The rivers of Mizoram are divided into three drainage systems *viz.* Barak drainage, Kaladan drainage and Karnaphuli drainage. The important rivers in the northern part of the state, flowing northwards, are Barak (Tuiruang) and its tributaries, Tlawng (Dhaleshwari), Tuirial (Sonai) and Tuivai. The rivers Tuirial, Tlawng, Tuivai and Serlui join the Barak drainage at different points of their course and this river systems form the Barak drainage. The rivers Tuiruang, Tlawng, Tuivai and Tuirial are navigable for considerable stretches. Tuiruang and Tuivai constitute the borderline between Manipur and Mizoram. The River Barak is the biggest river in southern part of northeastern India constituting the Barak Drainage. Barak is a part of the Ganga-Brahmaputra-Meghna Basin. It originates from Japfu peak in Nagaland, and flows through Karang village along the Manipur-Nagaland border and drains almost the entire Manipur valley before entering Assam. It flows through the southern part of Assam (thus, forming the Barak valley); and, after traversing through a stretch of about 532km from its origin, the river Barak bifurcates into two (the Surma and the Kushiara) at village Harinagar (Haritikar) at the Indo-Bangladesh border. Both these rivers, after flowing for some distance along the Indo-Bangladesh border, enter Bangladesh and join the Meghna basin before entering the Bay of Bengal.

The most important river in the southern region of the state is the Kaladan (Chhimtuipui) River. With its four main tributaries *viz.* Mat, Tuichang, Tiau and Tuipui, theyconstitute the Kaladan drainage. The river Kaladan originates in Myanmar, flows northward along the Indo-Myanmar border for some distance, then, turns south to flow back into Myanmar and drains into the Bay of Bengal at Sittwe (capital of Rakhine State), Myanmar.

The Karnaphuli (Khawthlangtuipui) River and its tributaries *viz.* Tuichawng, Phaireng, Kau, Deh and Tuilianpui form the western drainage system known as Karnaphuli drainage. The river Karnaphuli, after originating from around Marpara region in the Mizoram-Tripura border, flows along the Mizoram-Bangladesh border, enters Bangladesh at Demagiri and ultimately joins the Bay of Bengal at the port city of Chittagong.

The river Tlawng originates from Zopui hill (Lunglei district), about 8 km east of Lunglei town, at the height of about 1,395 m AMSL. It is the longest river in Mizoram which measures about 185.5 km inside Mizoram. Flowing towards north, it divides the state into almost two equal halves. After the confluence with tributaries Tut and Teirei from the western bank near Bairabi village and North Tlangkang village (both Kolasib district) respectively, it enters Cachar district, Assam (where it is known as Dhaleswari), and eventually falls into Barak River near Badarpur. The river Tuirial originates from the northern slope of Chawilung hill (Chawilung village) in Aizawl district. It flows northward to join Barak River in Assam. Its span inside the state is about 117 km. An important tributary is Tuirini, which joins the main stream from the eastern bank near Mualmar village after flowing parallel to it for about 60 km. The river Tuivai originates from Manipur state flowing southwest direction forming an interstate boundary between Manipur and Mizoram. It enters Mizoram in the eastern slope of Daido village and left Mizoram from the western slope of Daido village making a U-shape. The span of the river inside the state is only about 65 km. Apart from other small rivers and streams; Tuivawl is its important tributaries.

3.3 Study sites

Two permanent sampling stations were selected for each river (Figure 3.1; Table 3.1) for calculating Shannon index of diversity. The selections of these sampling stations were based mainly on permission from the local authorities (Young Mizo Association and Village Council) to conduct a study, accessibility and heterogeneity of the riverine habitats.

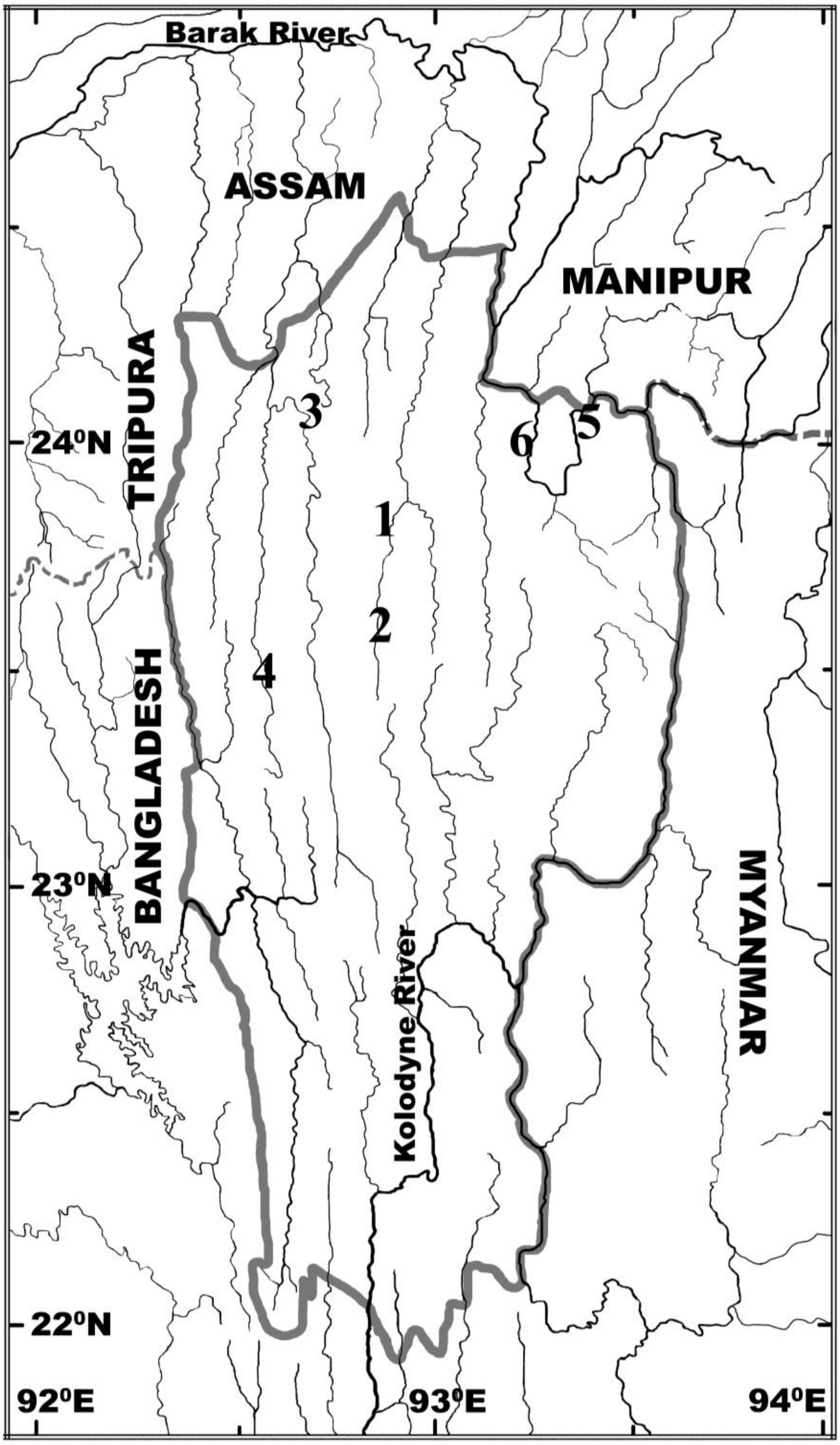

Figure 3.1 Drainage map of Mizram showing permanent sampling stations. Number in map corresponds to sampling stations given in Table 3.1.

Table 3.1 List of permanent sampling stations.

Sl. No.	Sampling stations	River	Location	District	Geocoordinates
1.	Station 1	Tuirial	Vicinity of Tuirial village	Aizawl	23° 46.684'N 92° 48.740'E
2.	Station 2	Tuirial	Vicinity of Melriat village	Aizawl	23° 35.589'N 92° 46.140'E
3.	Station 3	Tlawng	Vicinity of Hortoki	Kolasib	24° 04.385'N 92° 35.259'E
4.	Station 4	Tlawng	Vicinity of Thenzawl village	Serchhip	23° 19.483'N 92° 40.985'E
5.	Station 5	Tuivai	Vicinity of Khawkawn village	Aizawl	24° 02.880'N 93° 12.595'E
6.	Station 6	Tuivai	Vicinity of Suangpuilawn village	Aizawl	23° 57.184'N 93° 04.561'E

CHAPTER 4

METHODOLOGY

4.1 Sampling

Sampling was conducted once every three months from 2011-2014 in the permanent sampling stations. At each sampling station a 300 m transect line was laid along the bank.Fishes were collected using cast net, gill nets, baited hooks and locally available fishing contraptions. Some of the fish caught were preserved for identification and the rest were released after in-situ identification and counting with photography. Random samplings were also carried out in different parts of the rivers and their tributaries so as to collect any restricted and rare species which were not found in the sampling stations.

4.2 Preservation and identification

Specimens were fixed in 10% formalin and later transferred to 70% ethanol for longer preservation. Specimens were deposited at the Pachhunga University College Museum of Fishes (PUCMF), Department of Zoology, pachhunga University College; Mizoram University Biodiversity Museum (MZBM), Department of Environmental Science, Mizoram University and Zoological Survey of India (ZSI), Kolkata. Fishes were measured and identified following Menon (1999), Jayaram (1999, 2009), Talwar & Jhingran (1991), Ng & Dodson (1999), Kottelat (1990, 2013) and other relevant scientific publications and by comparing it with museum specimens from Zoological Survey of India (ZSI), Kolkata and other museums. Taxonomic arrangement follows Kottelat (2013).

4.3 Description of new species

4.3.1 *Schistura*

Counts and measurements were made on the left side of specimens following Kottelat (1990), with the exclusion of total length, and the addition of body depth taken at anal-fin origin. Measurements were made point to point with digital calipers to the nearest 0.1 mm. Measurements, except standard length, are given as proportions of standard length (SL). Sub-units of the head are presented as proportions of dorsal head length (DHL). Fin rays were counted under a stereo microscope, with small posteriormost ray of the dorsal and anal fins, articulating with the same pterygiophore as the preceding ray, counted as ½. For vertebral counts, four specimens were cleared and stained following the method of Taylor & Van Dyke (1985). Vertebral count includes the first four vertebrae of the Weberian apparatus. Numbers in parentheses after a meristic value indicate the frequency of that value.

4.3.2 *Exostoma*

Measurements were made point to point with digital calipers to the nearest 0.1 mm. Counts and measurements were made on the left side of specimens whenever possible, following Ng & Vidthayanon (2014). Subunits of the head are presented as proportions of head length (HL). Head length and measurements of body parts are given as proportions of standard length (SL). Fin-ray and vertebral counts were made from radiographs, with the latter counted following the method of Roberts (1994). Asterisks after a meristic value indicate the condition for the holotype; values in parentheses after a count indicate the frequency of that count.

4.4 Assemblage

4.4.1 Jaccard similarity index

Qualitative similarity between the sites is calculated using Jaccard index (Krebs, 1989). The Jaccard similarity index, which takes into account the presence or absence of a species. The Jaccard index is used to compare species similarities between two sites. This index is given by:

$$C_j = \frac{J}{(a + b - j)}$$

Where, j is the number of species found at both sites, a is the number of species recorded at site A, and b is the number of species recorded at site B.

This index assumes that if the calculated value equals 1, the two sites show a total similarity of species and, if the value is zero, there is no similarity.

4.4.2 Shannon diversity index

Diversity was verified through the Shannon index, which is calculated for each river (Magurran, 2004). Datas of the two sampling stations of each river were calculated together and Shannon index is compared riverwise. This index assumes that each individual is sampled randomly from an infinitely large population and that all species are represented in the sample. The index (H') is given by:

$$H' = -\Sigma \; pi. \ln pi$$

The sum of pi is the proportion of individuals found among these species. The equitability (E) can also be calculated, indicating the abundance of species at each point. The closer to 1, the greater the similarity among species abundances; if the value reaches 1, the species abundance is equal. Shannon index is calculated using BioDiversity Pro software (McAleece, 1997).

4.5 Conservation status and threats

During field works, several factors which can cause threats to freshwater fishes are noted. The species of fish documented during the study are evaluated against IUCN (2014) Red List conservation status. The system is designed to determine the relative risk of extinction, and the main purpose of the IUCN Red List is to catalogue and highlight those plants and animals that are facing a higher risk of global extinction (i.e. those listed as Critically Endangered, Endangered and Vulnerable). It also includes information on organisms that are categorized as Extinct or Extinct in the Wild; on taxa that cannot be evaluated because of insufficient information (i.e., are Data Deficient); and on organisms that are either close to meeting the threatened thresholds or that would be threatened were it not for an ongoing taxon-specific conservation programme (i.e., are Near Threatened).

The different categories of IUCN Red List are:

1) **Extinct (EX):** A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycles and life form.

2) **Extinct in the Wild (EW):** A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.

3) **Critically Endangered (CR):** A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered, and it is therefore considered to be facing an extremely high risk of extinction in the wild.

4) **Endangered (EN):** A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered, and it is therefore considered to be facing a very high risk of extinction in the wild.

5) **Vulnerable (VU):** A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable, and it is therefore considered to be facing a high risk of extinction in the wild.

6) **Near Threatened (NT):** A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.

7) **Least Concern (LC):** A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.

8) **Data Deficient (DD):** A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, if a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.

9) **Not Evaluated (NE):** A taxon is Not Evaluated when it is has not yet been evaluated against the criteria.

CHAPTER 5

RESULTS AND DISCUSSION

5.1 Species account

Class ACTINOPTERYGII

Order OSTEOGLOSSIFORMES

Family NOTOPTERIDAE

Genus *Notopterus* Lacepede

Notopterus Lacepede, 1800: 189 (type species: *Notopterus kapirat* Lacepede, 1800 [= *Gymnotus notopterus* Pallas, 1769]).

***Notopterus notopterus* (Pallas)**

(Figure 5.1A)

Gymnotus notopterus Pallas, 1769: 40 (Poona, Seedataik).

Notopterus notopterus: Talwar & Jhingran, 1991: 64 (valid).

Materials examined: PUCMF 6001, PUCMF 1069.

Diagnosis: Body oblong, strongly compressed, tapers towards tail. Abdomen edge keeled and with prepelvic scutes. Scales minute, considerably larger on opercles than on body. Head compressed; preorbital bone serrated. Dorsal fin short, inserted in the middle of back; pelvic fin rudimentary; anal fin long, continuous with caudal fin.

Order ANGUILLIFORMES

Family ANGUILLIDAE

Genus Anguilla Schrank

Anguilla Schrank, 1798: 304, 307 (type species: *Muraena anguilla* Linnaeus, 1758).

***Anguilla bengalensis* (Gray)**

(Figure 5.1B)

Muraena bengalensis Gray, 1831: pl. 85 (Ganges river).

Anguilla bengalensis: Talwar & Jhingran, 1991: 74 (valid).

Materials examined: PUCMF 1075.

Diagnosis: Body robust and elongated; head conical, flattened dorsally. Mouth terminal, angle of mouth appreciably behind posterior margin of eye; lips prominent; teeth small, forming relatively narrow bands on jaw, but in an anterior broad (but posterior narrow) band on vomer. Dorsal fin inserted nearer to anus than gill opening. Vertebrae 106-112.

Order CYPRINIFORMES

Family CYPRINIDAE

Genus *Amblypharyngodon* Bleeker

Amblypharyngodon Bleeker, 1860: 433 (type species: *Cyprinus mola* Hamilton, 1822).

Amblypharyngodon mola (Hamilton)

(Figure 5.1C)

Cyprinus mola Hamilton, 1822: 334, 392 (ponds and rivers of Gangetic provinces).

Amblypharyngodon mola: Talwar & Jhingran, 1991: 338 (valid).

Materials examined: PUCMF 1063.

Diagnosis: Body with broad silvery lateral band. Scales small; lateral line incomplete, terminate after 9-18 scales; about 66 scales in lateral series; 9-10 scale rows between lateral line and pelvic fin base. Symphysial knob present. Dorsal, anal and caudal fins usually with dark markings; pectoral and pelvic fins hyaline.

Genus *Barilius* Hamilton

Barilius Hamilton, 1822: 266, 384 (type species: *Cyprinus barila* Hamilton, 1822).

Barilius barila (Hamilton)

(Figure 5.1D)

Cyprinus barila Hamilton, 1822: 267, 384 (Northern Bengal).

Barilius barila: Talwar & Jhingran, 1991: 343 (valid).

Materials examined: PUCMF 1100.

Diagnosis: Body with 11-15 blue-black bars on the side of the body; the first five very long, almost reaching the lateral line. Mouth moderate; jaws long, maxilla extends to below anterior-third of orbit. Barbels 2 pairs; rostral barbels very short and maxillary barbels extends upto anterior-third of orbit. Lateral line scales 42-46; predorsal scales 22; lateral transverse scales 8½/1/2½.

Genus *Cabdio* Hamilton

Cabdio Hamilton, 1822: 333, 392 (type species: *Cyprinus jaya* Hamilton, 1822).

***Cabdio morar* (Hamilton)**

(Figure 5.1E)

Cyprinus morar Hamilton, 1822: 264, 384 (Yamuna and Tista rivers, India).

Cabdio morar: Liao *et al*., 2011: 31 (valid).

Materials examined: PUCMF 1105, PUCMF 1106.

Diagnosis: Body elongated and subcylindrical. Mouth inferior, jaw short. Dorsal fin without spine, inserted posterior to pelvic fin with 7 branched rays; anal fin with 9 branched rays. Barbels absent. Scales moderate size; lateral line decurved with 38-40 scales; predorsal scales 15-17. Caudal fin stained black.

Genus *Chagunius* Smith

Chagunius Smith, 1938: 157 (type species: *Cyprinus chagunio* Hamilton, 1822)

***Chagunius chagunio* (Hamilton)**

(Figure 5.1F)

Cyprinus chagunio Hamilton, 1822: 295, 387 (Yamuna River and Narmada Rivers of Bihar and Bengal).

Chagunius chagunio: Talwar & Jhingran, 1991: 167 (valid).

Materials examined: PUCMF1064.

Diagnosis: Body elongated its depth slightly greater than head length. Dorsal spine strong and posterior edge serrated; the denticles strong and recurved. Scales small; lateral line complete with 42-47 scales; lateral transverse scale rows 11-12/1/7; circumpeduncular scales 23-25; 3 scale rows between vent and anal fin. Tubercles on snout and cheeks, female smaller than those of male.

Genus *Crossocheilus* Kuhl & van Hasselt

Crossocheilus Kuhl & van Hasselt, in van Hasselt, 1823: 132 (type species: *Crossocheilus oblongatus* Kuhl & van Hasselt, 1823).

***Crossocheilus latius* (Hamilton)**

(Figure 5.1G)

Cyprinus latius Hamilton, 1822: 345, 393 (Tista River at base of Darjeeling Himalayas, India and Bangladesh).

Crossocheilus latius: Talwar & Jhingran, 1991: 416 (valid).

Materials examined: PUCMF 1102.

Diagnosis: Body rather elongated, cylindrical anteriorly and compressed posteriorly. Head flat and compressed. Barbels two pairs, maxillary and rostral; rostral barbels short and often rudimentary. Dorsal fin with 8 branched rays, caudal fin deeply forked. Scales moderate; lateral line with 39-41 scales, circumpeduncular scales 20. Lower lip without any suctorial disc.

Genus *Danio* Hamilton

Danio Hamilton, 1822: 321, 390 (type species: *Cyprinus dangila* Hamilton, 1822)

***Danio dangila* (Hamilton)**

(Figure 5.1H)

Cyprinus dangila Hamilton, 1822: 321, 390 (Mountain streams of Mongher, Bihar, India).

Danio dangila: Fang, 2003: 717 (valid).

Materials examined: PUCMF 1088, PUCMF 1062.

Diagnosis: Body with dark blue stripes along the flank which break up anteriorly to form a mottled pattern; anal fin with 2-3 blue stripes. Barbels two pairs, well-developed; rostral barbels slightly shorter than head, maxillary barbels slightly longer. Lateral line complete with 36-40 scales; predorsal scales 12-14; circumpeduncular scale rows 14. Branched dorsal fin rays 8-9.

Genus *Devario* Heckle

Devario Heckel, 1843: 990-1099 (type species: *Cyprinus devario* Hamilton, 1822).

Key to species:

1.	Lateral line scales 33-35.	*D. aequipinnatus*
2.	Lateral line scales 44-46.	*D. devario*

***Devario aequipinnatus* (McClelland)**

(Figure 5.1I)

Perilampus aequipannatus McClelland, 1839: 393 (Assam, India)

Devario aequipinnatus: Fang 2001:16 (valid).

Materials examined: PUCMF 1121, PUCMF 11041.

Diagnosis: Body with 4-5 horizontal stripes along the side. Barbels two pairs; rostral barbels about half of eye diameter, maxillary barbels minute. Lateral line complete with 33-35 scales; predorsal scales 13-16; lateral transverse scale 7½/1/2½; circumpeduncular scale rows 12. Branched dorsal fin rays 9-11; anal fin with 12-14 branched rays.

***Devario devario* (Hamilton)**

(Figure 5.1J)

Cyprinus devario Hamilton, 1822: 341 (Bengal).

Devario devario: Fang 2001:16 (valid).

Materials examined: PUCMF 1119.

Diagnosis: Body with 4 horizontal stripes along the side. Infraorbital process and barbels absent. Lateral line complete with 44-46 scales; predorsal scales 15-17; lateral transverse. Branched dorsal-fin rays 16-17; branched anal-fin rays 16-17; circumpeduncular scale rows 16.

Genus *Esomus* Swainson

Esomus Swainson, 1839: 185, 285 (type species: *Esomus vittatus* Swainson, 1839 [= *Cyprinus danrica* Hamilton, 1822]).

Esomus danrica (Hamilton)

(Figure 5.1K)

Cyprinus danrica Hamilton, 1822: 325, 390 (Bengal).

Esomus danricus: Talwar & Jhingran, 1991: 377 (valid).

Materials examined: PUCMF 1128.

Diagnosis: Body elongated, compressed; abdomen rounded. A broad lateral dark band on the side of body. Mouth small, oblique. Barbels two pairs; maxillary barbels extremely long, extend upto middle of body; rostral barbels short and fleshy. Lateral line incomplete with 4-6 scales; 29-31 scales in longitudinal series; predorsal scales 16-17, circumpeduncular scales 14. Dorsal fin with 6 branched rays; anal fin with 5 branched rays.

Genus *Garra* Hamilton

Garra Hamilton, 1822: 343, 393 (type species: *Cyprinus lamta* Hamilton, 1822)

Key to species:

1.	Proboscis present.	*G.* cf. *gotyla*
	Proboscis absent.	2
2.	Caudal fin with distinct W-shaped marking.	3

	Caudal fin without W-shaped marking.	4
3.	Chest and belly scales present.	*G.* cf. *dampaensis*
	Chest and belly scales absent.	*G. lissorhynchus*
4.	Lateral line scale lower than 35.	*G.* cf. *manipurensis*
	Lateral line scale higher than 35.	*G.* aff. *naganensis*

***Garra* cf. *dampaensis* Lalronunga, Lalnuntluanga & Lalramliana**

(Figure 5.1L)

Garra dampaensis Lalronunga, Lalnuntluanga & Lalramliana, 2013: 4369 (Seling River, a tributary of Khawthlang Tuipui [Karnaphuli River] in the vicinity of Damparengpui, Mizoram, India). - Arunachalam *et al*., 2013: 62 (valid).

Materials examined: PUCMF 1143.

Diagnosis: Body elongated, subcylindrical, head and body depressed, somewhat flattened on undersurface. Barbels 2 pairs. Lateral line with 27-29 scales, Predorsal scales 10-11, circumpeduncular scales 16, breast and belly scaled. Branched dorsal fin ray 6, branched anal fin ray 4, principal caudal fin rays 10+9. Dorsal fin with submarginal black band, caudal fin with distinct W-shaped black band.

***Garra* cf. *gotyla* (Gray)**

(Figure 5.1M)

Cyprinus gotyla Gray, 1830: 88 (original locality: Mountain stream, northern India).

Garra gotyla: Talwar & Jhingran, 1991: 421 (valid).

Materials examined: PUCMF 1065.

Diagnosis: Body elongated, subcylindrical, head and body depressed, somewhat flattened on undersurface. Lateral line with 33-36 scales, Predorsal scales 9-10, circumpeduncular scales 16. Branched dorsal fin ray 8, branched anal fin ray 5, principal caudal fin rays 10+9.

Garra lissorhynchus (McClelland)

(Figure 5.2A)

Platycara lissorhynchus McClelland, 1842:587 (Khasi Hills, Meghalaya, India).

Garra lissorhynchus: Vishwanath & Sarojnalini, 1988:125 (valid).

Materials examined: PUCMF 1084.

Diagnosis: Body elongated, subcylindrical, head and body depressed, somewhat flattened on undersurface. Barbels 2 pairs. Lateral line with 34-35 scales, Predorsal scales 14-15, circumpeduncular scales 16, breast and belly naked. Branched dorsal fin rays 6, branched anal fin rays 4, principal caudal fin rays 10+9. Dorsal fin with submarginal black band, caudal fin with distinct W-shaped black band.

Garra cf. *manipurensis* Vishwanath & Sarojnalini

(Figure 5.2B)

Garra manipurensis Vishwanath & Sarojnalini, 1988: 124 (type locality: India: Manipur: Manipur River at Sherou [in fact, probably from Tuivai River, Barak drainage; Nebeshwar *et al*., 2009: 201]. - Nebeshwar *et al*., 2009: 201 (valid).

Material examined: PUCMF 1137.

Diagnosis: Body elongated, subcylindrical, head and body depressed, somewhat flattened on undersurface. Lateral line with 34-36 scales, Predorsal scales 12, circumpeduncular scales 16. Branched dorsal fin ray 7, branched anal fin ray 4, Pectoral fin rays with 11 branched rays, principal caudal fin rays 10+9.

Garra aff. *naganensis* Hora

(Figure 5.2C)

Garra naganensis Hora, 1921: 667 (Senapati stream near Kairong, Naga Hills, Assam, Nagaland, India). - Lalronunga *et al*., 2013a: 4372 (valid).

Materials examined: PUCMF 1152, PUCMF 1153.

Diagnosis: Body elongated, subcylindrical, head and body depressed, somewhat flattened on undersurface. Lateral line with 37-38 scales, predorsal scales 12, circumpeduncular scales 16. Branched dorsal fin ray 7, branched anal fin ray 5, principal caudal fin rays 10+9.

Genus *Gymnostomus* Heckel

Gymnostomus Heckel, 1843: 1030 (type species: *Cyprinus ariza* Hamilton, 1807).

***Gymnostomus ariza* (Hamilton)**

(Figure 5.2D)

Cyprinus ariza Hamilton, 1807: 344 (Vedawati stream, tributary of Tungabahdra River, Krishna basin, southern India).

Gymnostomus ariza Hamilton, 1807: Kottelat, 2003b: 400 (valid).

Materials examined: PUCMF 1108.

Diagnosis: Body fairly elongated, deeper than head length; moderately compressed. Snout slightly projecting beyond mouth; pores present. Barbels one pair of short rostrals. Dorsal fin shorter than body depth with 8 branched rays; pectoral fin as long as head length with 15 branched rays; caudal fin deeply forked. Scales hexagonal and moderate; lateral line with 34-38 scales; lateral transverse scale 7/1/5-6.

Genus *Labeo* Cuvier

Labeo Cuvier, 1816: 194 (type species: *Cyprinus niloticus* Forsskal, 1775)

Key to species:

1.	Lateral line scale more than 50.	*L. gonius*
	Lateral line scale less than 50.	2
2.	Barbels one pair.	*L. bata*
	Barbels two pairs.	3
3.	Dorsal fin rays 15 or more.	*L. calbasu*
	Dorsal fin rays less than 15.	*L. dyocheilus*

***Labeo bata* (Hamilton)**

(Figure 5.2E)

Cyprinus bata Hamilton, 1822: 283, 386 (Rivers and ponds of Bengal).

Labeo bata: Talwar & Jhingran, 1991: 199(valid).

Materials examined: PUCMF 1068.

Diagnosis: Body elongated, its dorsal profile more convex than ventral. Mouth inferior; lips thin, lower lip slightly fringed and folded and joined to isthmus by a narrow bridge. Eyes large, not visible from ventral. A pair of minute maxillary barbels, not easily predictable. Dorsal fin with 9-11 branched rays. Scales moderate; lateral line with 37-40 scales; predorsal scales 10-13.

***Labeo calbasu* (Hamilton)**

(Figure 5.2F)

Cyprinus calbasu Hamilton, 1822: 297, 387 (Bengal).

Labeo calbasu: Talwar & Jhingran, 1991: 203(valid).

Materials examined: PUCMF 1103.

Diagnosis: Body stout and rather deep. Eyes moderate, not visible from ventral. Mouth inferior; lips thick and highly fringed and protruding, both lips with a distinct inner fold. Barbels two pairs, maxillary barbels longer than rostral barbels. Dorsal fin with a fairly long base, with 15-18 branched rays; caudal fin deeply forked. Scales moderate; lateral line with 40-44 scales; predorsal scales 15-18.

***Labeo dyocheilus* (McClelland)**

(Figure 5.2G)

Cyprinus dyocheilus McClelland, 1839: 268, 330 (Brahmaputra River, India).

Labeo dyocheilus: Talwar & Jhingran, 1991: 207(valid).

Materials examined: PUCMF 1132.

Diagnosis: Body elongated and fairly deep. Eyes small, not visible from ventral. Mouth wide and inferior; lips thick, not fringed; lower lip with a fold which is interrupted and joined to isthmus by a narrow bridge. Barbel present with one short maxillary pair. Dorsal fin with 11-13 branched rays; caudal fin deeply forked. Scales moderate; lateral line with 40-43 scales.

***Labeo gonius* (Hamilton)**

(Figure 5.2H)

Cyprinus gonius Hamilton, 1822: 292, 387 (Ganges River basin, India).

Labeo gonius: Talwar & Jhingran, 1991: 210(valid).

Materials examined: PUCMF 1145.

Diagnosis: Body elongated, its dorsal profile more convex than ventral.. devoid of lateral lobe, studded with numerous pores. Eyes moderate, not visible from ventral. Mouth narrow and subinferior; lips thick and fringed, with a distinct inner fold in their circumference. Barbels two very short pairs. Dorsal fin with 16-18 branched rays; caudal fin deeply forked. Scales small; lateral line with 65-80 scales.

Genus *Laubuka* Bleeker

Laubuka Bleeker, 1859b: 261 (type species: *Cyprinus laubuca* Hamilton, 1822).

***Laubuka laubuca* (Hamilton)**

(Figure 5.2I)

Cyprinus laubuca Hamilton, 1822: 260, 342 (Northern Bengal, India).

Laubuka laubuca: Kottelat, 2013: 119 (valid).

Materials examined: PUCMF 1092.

Diagnosis: Body strongly compressed; a conspicuous thin black stripe on posterior half of body; abdomen keeled only in between and behind pelvic fins. Mouth large, slightly oblique; upper jaw protractile; no symphyseal process on lower jaw. Lateral line complete with 29-35+2 scales; predorsal scales 15-20.

Genus *Neolissochilus* Rainboth

Neolissochilus Rainboth, 1985: 25 (type species: *Barbus stracheyi* Day, 1871).

Key to species:

1.	Labial fold continuous.	*N. hexastichus*
2.	Labial fold interrupted.	*N. hexagonolepis*

***Neolissochilus hexagonolepis* (McClelland)**

(Figure 5.2J)

Barbus hexagonolepis McClelland, 1839: 270, 336 (All large rivers on the eastern frontier, Assam, India).

Neolissochilus hexagonolepis: Talwar & Jhingran, 1991:229 (valid).

Materials examined: PUCMF 1076.

Diagnosis: Barbels two pairs, longer than orbit. Scales large; lateral line complete with 27-30 scales; 2½-3½ scales between lateral line and pelvic fin origin; predorsal scales 8-11. Mouth truncate, lower jaw edge sharp; lower labial fold widely interrupted in the middle. Side of snout and cheek studded with large tubercles.

***Neolissochilus hexastichus* (McClelland)**

(Figure 5.2K)

Barbus hexastichus McClelland, 1839: 269, 333 (Great rivers in the plains of India).

Neolissochilus hexastichus: Talwar & Jhingran, 1991:230 (valid).

Materials examined: PUCMF 1066.

Diagnosis: Mouth smoothly rounded; lips moderately thick; lower labial fold continuous. Barbels 2 long pairs; longer than orbit. Last unbranched dorsal fin ray osseous and strong. Scales large, devoid of horizontal striae; lateral line with 25-26 scales; predorsal scales 10. No tubercles on snout and cheek.

Genus *Opsarius* McClelland

Opsarius McClelland, 1838: 944 (type species: *Opsarius maculatus* McClelland, 1839).

Key to species:

1.	Barbels absent.	*O. barna*
	Barbels present.	2
2.	Barbels one pair.	*O. tileo*
	Barbels two pairs.	*O. bendelisis*

Opsarius barna (Hamilton)

(Figure 5.2L)

Cyprinus barna Hamilton, 1822: 268, 384 (Yamuna and Brahmaputra Rivers, India).

Opsarius barna: Kottelat, 2013: 131 (valid).

Materials examined: PUCMF 1083.

Diagnosis: Body moderately robust and deep with 9-11 black bars extending upto lateral line; interband width twice the width of band. Barbels absent. Lateral line complete with 36-39 + 2-3 scales; predorsal scales 15-16. Dorsal fin with 7½ branched rays, anal fin with 10 branched rays, pectoral fin with 12 branched rays. Tubercles large and well-developed on snout and lower jaw.

Opsarius bendelisis (Hamilton)

(Figure 5.2M)

Cyprinus bendalensis Hamilton, 1807: 345 (Cedawata stream, headwaters of Krishna River near Heriuru, Mysore, India).

Opsarius bendelisis: Tang *et al.*, 2004: 204 (valid).

Materials examined: PUCMF 1101, PUCMF 1080.

Diagnosis: Scales on body with blue black spots. Barbels two pairs, very short. 8-12 black bars on the side of body reaching the lateral line. Lateral line complete with 39-42 + 2-4, scales, lateral line scale with two black spots at their bases; predorsal scales 19-21. Dorsal fin with 7½ branched rays, anal fin with 7-8 branched rays. Tubercles small and well-developed on snout and lower jaw.

***Opsarius tileo* (Hamilton)**

(Figure 5.2N)

Cyprinus tileo Hamilton, 1822: 276 (Kosi River, Uttar Pradesh).

Opsarius tileo: Tang *et al.*, 2004: 204 (valid).

Materials examined: PUCMF 1070.

Diagnosis: Body with 3-4 rows of alternate black blotches along the side which descend vertically. One pair of rudimentary maxillary barbels. 11-15 black bars on the side of body; the first five long, almost reaching the lateral line. Lateral line complete with 59+4 scales; predorsal scales 22-25, lateral transverse scale ½8/1/2½. Dorsal fin with 7½ branched rays, anal fin with 10 branched rays. Tubercles large and well-developed on snout and lower jaw.

Genus *Pethia* Pethiyagoda, Meegaskumbura & Maduwage

Pethia Pethiyagoda, Meegaskumbura & Maduwage, 2012:80 (type species: *Barbus nigrofasciatus* Gunther, 1868).

***Pethia conchonius* (Hamilton)**

(Figure 5.3A)

Cyprinus conchonius Hamilton, 1822:317, 389 (Ponds of northeastern Bengal; Kosi and Ami rivers, India).

Pethia conchonius: Pethiyagoda *et al*., 2012: 81 (valid).

Materials examined: PUCMF 1061.

Diagnosis: Body deep and compressed. Mouth moderate, barbels absent. Last unbranched dorsal-fin ray stiff and serrated posteriorly, dorsal fin tripped black. Lateral line incomplete, cease after 10-15 scales; 24-26 scales in longitudinal series. A dark round blotch at caudal peduncle.

Genus *Puntius* Hamilton

Puntius Hamilton, 1822: 338, 392 (type species: *Cyprinus sophore* Hamilton, 1822)

Key to species:

1. Barbels absent. *P. sophore*
2. Barbels one pair. *P. chola*

Puntius chola (Hamilton)

(Figure 5.3B)

Cyprinus chola Hamilton, 1822: 312, 389 (Northeastern parts of Bengal).

Puntius chola: Talwar & Jhingran, 1991: 263 (valid).

Materials examined: PUCMF 1067.

Diagnosis: Body fairly deep and compressed, its lower profile less convex than upper profile. Mouth moderate, barbels one short maxillary pair. Lateral line complete with 24-28 scales. A black blotch at the base of caudal peduncle, between 21st and 23rd scales of lateral line row. A black blotch at anterior part of dorsal fin base, dorsal fin spine smooth.

Puntius sophore (Hamilton)

(Figure 5.3C)

Cyprinus sophore Hamilton, 1822:310, 389 (Srimangal town market, from Hail Hoar floodplain near Moulvi Bazaar, Bangladesh).

Puntius sophore: Talwar & Jhingran, 1991: 288 (valid).

Materials examined: PUCMF 1124.

Diagnosis: Body relatively deep, dorsal profile more convex than ventral profile. Mouth terminal, barbels absent. A round black blotch at the base of caudal pecuncle. Lateral line complete with 22-27 scales; 8-10 predorsal scales. A round black blotch at the base of dorsal fin; dorsal fin spine smooth.

Genus *Rasbora* Bleeker

Rasbora Bleeker, 1859a: 435 (type species: *Cyprinus rasbora* Hamilton, 1822).

***Rasbora daniconius* (Hamilton)**

(Figure 5.3D)

Cyprinus daniconius Hamilton, 1822: 327, 391 (Southern Bengal, India).

Rasbora daniconius: Rainboth & Kottelat, 1987: 419 (valid).

Materials examined: PUCMF 1099.

Diagnosis: Body with a black lateral stripes along the centre originating from tip of snout to caudal fin base. Mouth oblique, barbels absent. Lateral line complete with 32-35 scales; predorsal scales 14-15; lateral transverse scale 4½/1/2½; circumpeduncular scale rows 14. Branched dorsal fin rays 7; anal fin with 5 branched rays. Symphysis on lower jaw at the level of middle of pupil.

Genus *Securicula* Gunther

Securicula Gunther, 1968: 332 (type species: *Cyprinus gora* Hamilton, 1822).

***Securicula gora* (Hamilton)**

(Figure 5.3E)

Cyprinus gora Hamilton, 1822: 236, 384 (Brahmaputra River near Goyalpara, India).

Securicula gora: Talwar & Jhingran, 1991: 329 (valid).

Materials examined: PUCMF 1123.

Diagnosis: Body fairly elongated and compressed. Mouth oblique, almost vertical, its cleft extending to the front edge of eye; a small symphyseal knob on lower jaw with a corresponding notch on upper jaw. Abdomen sharply keeled, not covered by scales. Keel is supported anteriorly by an extension of the pectoral girdle. Dorsal fin inserted slightly in advance of anal fin origin.

Genus *Systomus* McClelland

Systomus McClelland, 1838: 948 (type species: *Systomus immaculatus* McClelland, 1839).

***Systomus clavatus* (McClelland)**

(Figure 5.3F)

Barbus clavatus McClelland, 1845: 280 (Rivers at foot of Sikkim Mountains, northern frontier of Bengal).

Systomus clavatus: Pethiyagoda *et al*., 2012: 77 (valid).

Materials examined: PUCMF 1136.

Diagnosis: Body elongated and strongly compressed. Mouth wide and terminal; snout long with many tubercles on tip; barbels in 2 pairs, rostral barbels minute and maxillary barbels small and about one-third of orbit. Last unbranched ray osseous, robust and strongly serrated posteriorly. Lateral line with 39-42 scales; 15-16 predorsal scales; lateral transverse scales 8/1/4.

Genus *Tor* Gray

Tor Gray, 1834: 96 (type species: *Tor hamiltonii* Gray, 1834 [= *Cyprinus tor* Hamilton, 1822]).

***Tor tor* (Hamilton)**

(Figure 5.3G)

Cyprinus tor Hamilton, 1882: 305, 338 (Mahanada [Mahananda] River, India).

Tor putitora: Talwar & Jhingran 1991: 309 (valid).

Materials examined: PUCMF 1150.

Diagnosis: Head broadly pointed, its length more than depth of body. Mouth small, lips fleshy; snout and cheeks smooth, devoid of tubercles. Barbels two pairs, maxillary barbells equal to eye diameter, rostral barbells shorter. Scales large; lateral line complete with 22-27 scales; scales between lateral line and dorsal fin 4½.

Family PSILORHYNCHIDAE

Genus *Psilorhynchus* McClelland

Psilorhynchus McClelland, 1839: 248, 300, 428 (type species: *Cyprinus balitora* Hamilton, 1822).

Key to species:

1.	Lateral line scales 42-44.	*P. homaloptera*
	Lateral line scales 32-36.	2
2.	Branched dorsal fin rays 8.	*P. nudithoracicus*
	Branched dorsal fin rays 9-10.	*P. sucatio*

***Psilorhynchus homaloptera* (Hora & Mukherji)**

(Figure 5.3H)

Psilorhynchus homaloptera Hora & Mukerji, 1935:391 (Emilomi, Keleki stream, Brahmaputra drainage system, Naga Hills, Assam, India). - Conway & Kottelat 2007:47 (valid).

Psilorhynchoides homaloptera: Yazdani *et al*., 1993:18.

Materials examined: PUCMF 2086.

Diagnosis: Body elongate, dorsal profile arched, body depth greatest at dorsal-fin origin. Rostral cap slightly pointed. Principal caudal fin rays 9+8; pectoral fin with 8 unbranched rays and 8-9 branched rays; dorsal fin with 2 unbranched and 8 branched rays; anal fin with 2 unbranched and 6 branched rays. Lateral line scales 37-38; predorsal scales 12-13; lateral transverse scale row 3.5/1/2½.

***Psilorhynchus nudithoracicus* Tilak & Husain**

(Figure 5.3I)

Psilorhynchus nudithoracicus Tilak & Husain, 1980: 35 (Bamrauli Canal, near Bilsanda village, Plilibhit District, western Uttar Pradesh, India). - Conway *et al.*, 2013: 23 (valid).

Psilorhynchus gracilis: Rainboth, 1983: 67 (Jabuneswari River at Badarganj, Rangpur District, Bangladesh).

Materials examined: PUCMF 2050.

Diagnosis: Body elongate, dorsal profile arched, body depth greatest at dorsal-fin origin. Two dorsal saddles anterior to dorsal saddle positioned at dorsal-fin origin. Lateral line scales 32-34, predorsal scales 8-10. Air bladder partly enclosed in bony capsule. Flank with 7 to 10 (typically 8) dark brown lateral blotches arranged in a longitudinal row.

***Psilorhyncus sucatio* (Hamilton)**

(Figure 5.3J)

Cyprinus sucatio Hamilton, 1822: 347, 393 (Rivers of Northern Bengal).

Psilorhyncus sucatio: Talwar & Jhingran, 1991: 442 (valid).

Materials examined: PUCMF 1074.

Diagnosis: Body elongate, dorsal profile arched, body depth greatest at dorsal-fin origin. Post-epiphyseal fontanelle absent. Rostral cap separate from the upper lip around the corner of the mouth, posterior margin of the rostral cap triangular. Branched dorsal-fin rays 8. Abdomen fully scaled. Lateral line scales 33-36, predorsal scales 9-12. Flank with 6-8 (most commonly 7) round to squarish dark brown lateral blotches arranged in a longitudinal row.

Family COBITIDAE

Genus *Botia* Gray

Botia Gray, 1831: 8 (type species: *Botia almorhae* Gray, 1831).

Key to species:

1.	Body marked with regular cross bands.	*B. dario*
2.	Body marked with irregular and partly confluent cross bands.	*B. rostrata*

Botia dario (Hamilton)

(Figure 5.3K)

Cobitis dario Hamilton, 1822: 354, 394 (Bengal).

Botia dario: Talwar & Jhingran, 1991: 537 (valid).

Materials examined: PUCMF 1062.

Diagnosis: Body elongated and laterally compressed. Body marked with 7 to 8 regular oblique cross bands descending from back to abdomen and caudal fin with 2-3 black bars. Mouth small, barbels 4 pairs; rostral barbels 2 pairs, maxillary and mandibular barbels 1 pair each. Lateral line complete.

Botia rostrata Gunther

(Figure 5.3L)

Botia rostrata Gunther, 1868: 367 (Bengal, India).- Ng, 2007:46 (valid).

Botia almorhae: Menon, 1992: 32.

Materials examined: PUCMF 1081.

Diagnosis: Body elongated and laterally compressed. Body marked with irregular and partly confluent cross bands or reticulated with grey or Y shaped bands in young. Mouth small, barbels 4 pairs; rostral barbels 2 pairs, maxillary and mandibular barbels 1 pair each. Lateral line complete.

Genus *Lepidocephalichthys* Bleeker

Lepidocephalichthys Bleeker, 1863: 38, 42 (type species: *Cobitis hasselti* Valenciennes, 1846).

Key to species:

1.	Caudal fin with 3-6 dark bars, single very prominent dark stripe along the side in male.	*L. berdmorei*
2.	Caudal fin with reticulation, no dark stripe along the side in male.	*L. guntea*

***Lepidocephalichthys berdmorei* (Blyth)**

(Figure 5.3M)

Acantopsis berdmorei Blyth, 1860: 168 (Tenasserim provinces, Myanmar).

Lepidocephalichthys berdmorei: Kottelat & Lim, 1992: 205 (valid).

Materials examined: PUCMF 1094.

Diagnosis: Body with 7-13 irregular dark spots on side that may merge and give the appearance of squares or blotches, but never form a stripe. Caudal fin truncated or rounded, 3-6 dark bars on caudal fin. Caudal fin base with a large black spot at base of branched rays 3-6. Predorsal scales about 70. Scales absent on top and side of head. Barbels long, with all pairs usually extending into orbit; fringes not always present.

***Lepidocephalichthys guntea* (Hamilton)**

(Figure 5.3N &5.4A)

Cobitis guntea Hamilton, 1822: 353, 394 (Ganges River, Bengal).

Lepidocephalichthys guntea: Havird & Page, 2010: 153 (valid).

Materials examined: PUCMF 1071.

Diagnosis: Side of body with 8-14 dark spots or blotches in female and there is a single very prominent dark stripe along the side in male. In both sexes there are 3-7 predorsal and 3-6 postdorsal dark bars along the dorsum, with a bar always present at the dorsal-fin origin. A large conspicuous dark spot on the upper caudal base between rays 2-7. Caudal fin truncate with dark reticulations. Predorsal scales about 65. Scales absent on top and side of head. Barbels variable in size; flaps generally fringed.

Genus *Pangio* (Hamilton)

Pangio Blyth, 1860: 169 (type species: *Cobitis pangia* Hamilton, 1822).

Pangio pangia (Hamilton)

(Figure 5.4B)

Cobitis pangia Hamilton, 1822: 355, 294 (Rivers of Ganges).

Pangio pangia: Talwar & Jhingran, 1991: 531 (valid).

Materials examined: PUCMF 1098.

Diagnosis: Species of Oblonga groupwith lower lip interrupted medially, each half with an inner thickened lobe, not ending in barbel-like pointed tip. Conspicuous adipose dorsal and ventral keels on the caudal peduncle. Suborbital spine bifid and inner branch longer.

Family BALITORIDAE

Genus Balitora Gray

Balitora Gray, 1830: 88 (type species: *Balitora brucei* Gray, 1830).

Balitora brucei Gray

(Figure 5.4C)

Balitora brucei Gray, 1830: 88 (Priang River near Cherrapunji, Assam, India).

Balitora brucei: Talwar & Jhingran, 1991: 446 (valid).

Materials examined: PUCMF 1134.

Diagnosis: Body depressed. Scales with very low and strong keel, 5-7 tubercles along posterior margin. Laretal line complete with 61-66 scales. Head with numerous unculi of carious sizes and irregularly shaped, often elongated.

Family NEMACHEILIDAE

Genus *Acanthocobitis* Peters

Acanthocobitis Peters, 1861: 712 (type species: *Acanthocobitis longipinnis* Peters, 1861).

Acanthocobitis botia (Hamilton)

(Figure 5.4D)

Cobitis botia Hmilton, 1822: 350, 394 (Northeastern Bengal).

Acanthocobitis botia: Kottelat, 1990:28 (valid).

Materials examined: PUCMF 1142.

Diagnosis: Body with 8-10 vertical elongated blotches along lateral line. 10-11 brown, irregularly shaped saddles on the back, directed backward. A series of more or less circular blotches above lateral line alternate with the back saddles. 4-6 horizontal series of spots on dorsal fin rays. 7-8 vertical series of spots on dorsal fin rays. Suborbital flap absent in male which is replaced by suborbital groove.

Genus *Physoschistura* Banarescu & Nalbant

Physoschistura Bănărescu& Nalbant, in Singh, Sen, Bănărescu & Nalbant 1982: 208 (type species: *Nemacheilus burnneaus* Annandale, 1918).

Physoschistura tuivaiensis Lokeshwor, Vishwanath & Shanta

(Figure 5.4E)

Physoschistura tuivaiensis Lokeshwor, Vishwanath & Shanta, 2012: 6 (Tuivai River, Manipur, India). - Kottelat, 2012: 103 (valid).

Materials examined: PUCMF 1072.

Diagnosis: Lateral line complete. 12-14 dark olivaceous blotches on the flank and 15-17 dark olivaceous saddles on the back. No black spot at base of dorsal fin rays but last simple dorsal ray with two black spots. Two faintly marked black spots on branched dorsal fin rays. Anal and pelvic fins marked with two rows of faint black spots. Branched caudal fin rays 8+7. Upper lip with small median incision and numerous shallow lateral furrows.

Genus *Schistura* McClelland

Schistura McClelland, 1838: 944, 947 (type species: *Cobitis rupecula* McClelland, 1838).

Key to species:

1.	Lateral line complete.	2
	Lateral line incomplete.	5
2.	Body with lateral stripe.	*S. mizoramensis*
	Body without lateral stripe.	3
3.	Body with reticulated bars in the anterior part.	*S. paucireticulata*
	Body without with reticulated bars in the anterior part.	4
4.	7-7½ branched dorsal-fin rays and 7 pelvic-fin rays.	*S. aizawlensis*
	8½ branched dorsal fin rays and 8 pelvic fin rays.	*S. chindwinica*
5.	11-14 broad body bars.	*S.* cf. *fasciata*
	20-30 thin body bars.	6
6.	Upper lip without median incision.	*S. maculosa*
	Upper lip with small median incision.	*Schistura* sp.

Schistura aizawlensis Lalramliana

(Figure 5.4F)

Schistura aizawlensis Lalramliana, 2012: 98 (Tuirial River, Mizoram, India). - Kottelat, 2012:105 (valid).

Materials examined: PUCMF 1077.

Diagnosis: Body with 5-7 regular broad bars. In smaller specimen bars look like saddles, not reaching beyond lateral line and a broad mid-lateral dark stripe superposed over bar pattern. Dorsal fin with 7-7½ branched rays; pelvic fin with 7 rays. Intestine without loop but slightly bent some distance behind the stomach. Males with sub-orbital flap. Caudal peduncle with very low or no ventral and dorsal adipose crests.

Schistura chindwinica **Tilak & Hussain**

(Figure 5.4G)

Nemacheilus chindwinicus Tilak & Husain, 1990: 51 (Lanjha stream, Manipur, India).

Schistura chindwinica: Vishwanath & Nebeshwar, 2004: 326 (valid).

Materials examined: PUCMF 11022.

Diagnosis: Body with 8-11 obscure dark grey bars; some bars in posterior area may split vertically but still united dorsally. A black spot on basis of simple and first branched rays of dorsal fin. Dorsal fin with 8½ branched rays; pelvic fin with 8 rays. Intestine with a short loop behind the stomach. Males with sub-orbital flap. Processus dentiformis present but weak. Caudal peduncle with no adipose crest.

Schistura **cf.** ***fasciata***

(Figure 5.4H)

Schistura fasciata Lokeshwor & Vishwanath, 2011: 1515 (Barak River at western side of Maram Hill, Senapati District, Manipur, India).-Kottelat, 2012: 109 (valid).

Materials examined: PUCMF 1079.

Diagnosis: Body with 15-18 regular broad bars. Dorsal fin with 8½ branched rays; pelvic fin with 8 rays. Intestine without loop but slightly bent some distance behind the stomach. Lateral line incomplete, extending to vertical of the posterior end of anal fin base. Males without sub-orbital flap. Caudal peduncle with high ventral and dorsal adipose crests. Upper lip with small median incision. Processusdentiformis present. Lower lip with a median interruption. Median notch present in lower jaw.

Schistura maculosa new species

(Figure 5.4I)

Materials examined: Holotype- ZSI FF 4973; Paratype- ZSI FF 4974, MZUBM/F. 130021- 130023, PUCMF 13010-13012.

Diagnosis: Body with 20-30 narrow black bars, bars usually bifurcated, narrower than or equal to interspaces. Incomplete lateral line extending up to vertical through pelvic-fin origin, with 26-35 pores. Dorsal-fin hyaline with two black blotches at base; 3-4 rows of black spots on rays horizontally across the fin; caudal-fin hyaline with 5-7 more or less organized rows of black spots on rays vertically across the fin. Upper lip without median incision. Caudal-fin branched rays 8+8. suborbital flap in male.

Schistura mizoramensis new species

(Figure 5.4J)

Materials examined: Holotype- PUCMF 13021; Paratype- PUCMF 13022-13023.

Diagnosis: Body with wide and irregular shaped black lateral stripe running from the opercular end to the base of caudal fin, regular bars absent. Lateral line complete with 83-95 pores, extending up to caudal fin base. Upper lip with median incision, processus dentiformis present. Median notch absent in lower jaw. Caudal fin with 9+8 branched rays, basal caudal bar dissociated. Sub-orbital flap absent in males. Intestine with loop behind the stomach.

Schistura paucireticulata Lokeshwor, Vishwanath & Kosygin

(Figure 5.4K)

Schistura paucireticulata Lokeshwor, Vishwanath & Kosygin, 2013: 582 (Tuirial River near Aizawl, Mizoram, India).

Materials examined: PUCMF 1082.

Diagnosis: Body with 8-9 brown bars, bars in front of the dorsal fin divided into 2-3 small bars forming a reticulations; basicaudal bar black, dissociated. A black spot at bases of simple and first branched dorsal-fin rays, 2 rows of black spots on each branched dorsal ray. Caudal fin with black spots arranged in 3-4 V-shaped bars with vertices pointed towards caudal base, branched rays 9+8. Upper lip with deep median incision; processus dentiformis present, not prominent; lower jaw without median notch. Suborbital flap present in male.

***Schistura* sp.**

(Figure 5.4L)

Materials examined: PUCMF 1126.

Diagnosis: Body with 18-25 narrow black bars, bars usually bifurcated, narrower than or equal to interspaces. Incomplete lateral line extending up to vertical through pelvic-fin origin. Dorsal-fin hyaline with two black blotches at base; 3-4 rows of black spots on rays horizontally across the fin; caudal-fin hyaline with 2-3 more or less organized rows of black spots on rays vertically across the fin. Upper lip with median incision. Caudal-fin branched rays 8+8 or 9+8. suborbital flap in male.

Order SILURIFORMES

Family AMBLYCIPITIDAE

Genus *Amblyceps* Blyth

Amblyceps Blyth, 1858: 281 (type species: *Amblyceps caecutiens* Blyth, 1858).

Key to species:

1. Caudal fin deeply forked. *A.* aff. *mangois*
2. Caudal fin forked, but not deeply. *A. laticeps*

***Amblyceps laticeps* (McClelland)**

(Figure 5.4M)

Olyra laticeps McClelland, 1842: 588 (Khasi Hills, India).

Amblyceps laticeps: Jayaram, 2006: 156 (valid).

Materials examined: PUCMF 11008.

Diagnosis: Body olive brown above and lighter below. Lower jaw protruding, caudal fin deeply forked, adipose fin not confluent with caudal fin and with rounded posterior margin; posterior end of anal fin vertical through middle of adipose fin. Number of vertebrae 41-46. Branchiostegals 13.

***Amblyceps mangois* (Hamilton)**

(Figure 5.4N)

Pimelodus mangois Hamilton, 1822: 199, 379 (Tanks of North Bihar, Kosi river, India).

Amblyceps mangois: Talwar & Jhingran, 1991: 615 (valid).

Materials examined: PUCMF 1038.

Diagnosis: Body olive brown above and lighter below. A dark lateral band branching towards caudal and anal fin base. Jaws equal, lateral line absent, caudal fin forked, but not deeply; adipose fin not confluent with caudal fin and with rounded posterior margin; posterior end of adipose fin vertical through posterior end of anal fin. Number of vertebrae 34-36. Branchiostegals 12.

Family SISORIDAE

Genus *Bagarius* Bleeker

Bagarius Bleeker, 1853: 121 (type species: *Pimelodus bagarius* Hamilton); Roberts, 1983*:* 436 (revision of the genus).

***Bagarius bagarius* (Sykes)**

(Figure 5.5A)

Pimelodus bagarius Hamilton, 1822: 186, 379 (type locality: Ganges and its tributaries, India).

Bagarius bagarius: Talwar & Jhingran, 1991: 622 (valid).

Materials examined: PUCMF 1019.

Diagnosis: Neural spines distally expanded. body depth 7.6-8.1%SL; pectoral fin 9-12 rays; eye diameter 10.9-11.4% HL; pelvic fin origin at the level anterior to base of last dorsal ray; adipose origin at the level behind anal fin origin; absence of sharp ridges on top of head and bumps on dorsal mid-line behind dorsal fin; size of this species can be measured up to at least 200 mm.

Genus *Erethistoides* Hora

Erethistoides Hora, 1950: 190 (*Erethistoides montana* Hora, 1950).

***Erethistoides* cf. *senkhiensis* Tamang, Chaudhry & Choudhury**

(Figure 5.5B)

Erethistoides senkhiensis Tamang, Chaudhry & Choudhury, 2008: 186 (Senkhi stream, Arunachal Pradesh, India). - Ng *et al*., 2012: 56 (valid).

Materials examined: PUCMF 11001.

Diagnosis: Body broader at anterior part of dorsal-fin origin and gently compressing towards caudal peduncle. Barbels in 4 pairs; nasal, maxillary, and outer and inner mandibular. Maxillary barbels extending almost posterior end of pectoral base. Outer mandibular barbels reaching to or near to pectoral-fin origin. Inner mandibular barbels shorter and reaching to or slightly beyond isthmus. Nasal barbels very short. Pectoral spine strong with 12-29 strong serrae along anterior margin and 9-10 serrae along the posterior margin.

Genus *Exostoma* Blyth

Exostoma Blyth, 1860: 155 (type species: *Exostoma berdmorei* Blyth, 1860).

***Exostoma sawmteai* new species**

(Figure 5.5C)

Materials examined: Holotype- PUCMF 14011; Paratype- PUCMF 14012.

Diagnosis: Body elongate, sub-cylindrical, slightly depressed anteriorly to compressed posteriorly. Dorsal fin with 1 unbranched and 6 branched rays, its origin anterior to pelvic-fin origin, no strong spine and serrations, fin margin slightly concave. Caudal fin lunate with with i,7,7,i (14) principal rays. Lateral line complete and mid-lateral; and 38-39 total vertebrae. Posterior end of the adipose fin adnate with the upper procurrent caudal-fin rays.

Genus *Gagata* Bleeker

Gagata Bleeker, 1858: 204 (type species: *Gagata typus* Bleeker, 1863 = *Pimelodus gagata* Hamilton, 1822).

***Gagata cenia* (Hamilton)**

(Figure 5.5D)

Pimelodus cenia Hamilton, 1822: 174, 376 (type locality: Rivers of North Bengal, India).

Gagata cenia: Talwar & Jhingran, 1991: 637 (valid).

Materials examined: PUCMF 1002.

Diagnosis: Body small and slender. Head and body with 5 saddles. Head compressed, medium longitudinal groove extends to base of occipital process. Barbels 4 pairs; nasal barbels minute; maxillary barbels slightly shorter than head; mandibular barbels considerably shorter, their bases close together and in transverse line behing lower jaw. Dorsal spine short and strong, finely serrated along anterior edge. Caudal fin with square or round spot on each lobe.

Genus *Glyptothorax* Blyth

Glyptothorax Blyth, 1860: 154 (type species: *Glyptosternon striatus* McClelland, 1842).

Key to species:

1.	Adhesive apparatus only on thorax	2
	Adhesive apparatus both on thorax and paired fins.	*G. striatus*
2.	Ventral surface of pectoral spine without furrow.	3
	Ventral surface of pectoral spine with distinct furrow.	*G. scrobiculus*
3.	Thoracic adhesive apparatus not extending up to gular region.	4
	Thoracic adhesive apparatus extending up to gular region.	*G.dikrongensis*
5.	Adhesive apparatus with median depression.	6
	Adhesive apparatus without median depression.	7
6.	Depressed thoracic adhesive apparatus narrowly elliptic.	*G. maceriatus*
	Depressed thoracic adhesive apparatus ovoid.	*G. cavia*
7.	Body with no saddles.	*G. botius*
	Body with dark brown saddles.	*G. telchitta*

Glyptothorax botius (Hamilton)

(Figure 5.5E)

Pimelodus botius Hamilton, 1822: 192, 378 (rivers of Northern Bengal, India).

Glyptothorax botius: Ng, 2005: 3 (valid).

Materials examined: PUCMF 1004.

Diagnosis: Dorsal and lateral surfaces of head, and dorsal surface of body very pale brown, fading to a lighter color ventrally. A series of narrow darker brown saddles along dorsal surfaces of body, extending upto lateral line. Thoracic adhesive apparatus consisting of broad longitudinal pleats of skin in narrow elliptical field and without a median depression. Pectoral fin with a spine and 8-10 soft rays; anterior spine margin smooth, posterior margin with 5-12 serrations.

***Glyptothorax cavia* (Hamilton)**

(Figure 5.5F)

Pimelodus cavia Hamilton, 1822: 188, 378 (rivers of Northern Bengal, India).

Glyptothorax cavia: Talwar & Jhingran, 1991: 649 (valid).

Materials examined: PUCMF 1057.

Diagnosis: Body elongated; head depressed, occipital process not reaching basal bone of dorsal fin. Thoracic adhesive apparatus ovoid with a deep central pit or depression. Dorsal fin inserted equidistant between snout tip and adipose fin; dorsal spine strong and smooth. Pectoral fin with a spine and 8-9 soft rays. Body olivaceous brown above and dirty yellowish below; the flank and dorsal surface mottled with deep coloured spots.

***Glyptothorax* cf. *dikrongensis* Tamang & Chaudhry**

(Figure 5.5G)

Glyptothorax dikrongensis Tamang & Chaudhry, 2011: 2 (Dikrong River at Doimukh, Midpu, Arunachal Pradesh, northeastern India). -Ng & Lalramliana, 2012a: 49 (valid).

Materials examined: PUCMF 1040-1041, PUCMF 14007.

Diagnosis: Pale yellow body mottled with light and dark brown marks and spots dorsally. Thoracic adhesive apparatus moderately divergent, chevronshaped with a somewhat broad anterior apex at the isthmus. Unculiferous striae of the thoracic adhesive apparatus extending anteriorly onto the gular region. Pectoral fin with a spine and 7-9 soft rays; anterior spine margin smooth, posterior margin with 8 serrations (size of serrae increasing towards tip from the base).

Glyptothorax maceriatus Ng & Lalramliana

(Figure 5.5H)

Glyptothorax maceriatus Ng & Lalramliana, 2012a: 45 (Tlawng River at Sairang, Mizoram, India). - Anganthoibi & Vishwanath, 2013: 2 (valid).

Materials examined: PUCMF 1104.

Diagnosis: Faint pale mid-dorsal stripe on dorsal surface of body and midlateral stripe running along entire length of body. Thoracic adhesive apparatus consisting of ridges of skin (striae) in oblong field extending from isthmus to level of middle of pectoral-fin base, with narrow elliptic median depression on posterior half almost enclosed posteriorly by skin ridges. Pectoral fin with a spine and 9 soft rays. Anterior pectoral spine margin smooth, its posterior margin with 8-14 serrae.

Glyptothorax scrobiculus Ng & Lalramliana

(Figure 5.5I)

Glyptothorax scrobiculus Ng & Lalamliana, 2012b: 2 (Mausam River in the vicinity of NE Khawdungsei village, Tuivai River drainage, Mizoram, India). - Anganthoibi & Vishwanath, 2013: 2 (valid).

Materials examined: PUCMF 1093.

Diagnosis: Faint pale mid-dorsal stripe on dorsal surface of body and midlateral stripe running along entire length of body. Thoracic adhesive apparatus consisting of ridges of skin (striae) in rhomboidal field extending from isthmus to level of middle of pectoral-fin base, with chevron-shaped median depression on posterior half. Pectoral fin with a spine and 10 soft rays. Anterior pectoral spine margin smooth; posterior margin with 10-18 serrae. Ventral surface of spine with distinct furrow running along entire length of spine.

***Glyptothorax striatus* (McClelland)**

(Figure 5.5J)

Glyptosternon striatus McClelland, 1842: 587 (Khasi Hills, Meghalaya, India).

Glyptothorax striatus: Talwar & Jhingran, 1991: 663 (valid).

Materials examined: PUCMF 1058.

Diagnosis: Distinct pale mid-dorsal stripe on dorsal surface of body and midlateral stripe running along entire length of body. A prominently plicate ventral surface of the pectoral-fin spine and the first pelvic-fin ray. Thoracic adhesive apparatus consisting of ridges of skin (plicae) in rhomboidal field extending from isthmus to level of middle of pectoral-fin base. Pectoral fin with a spine and 10 soft rays. Anterior pectoral spine margin smooth, its posterior margin with 8-10 serrae.

***Glyptothorax telchitta* (Hamilton)**

(Figure 5.5K)

Pimelodus telchitta Hmilton, 1822: 185 (North Bengal).

Glyptothorax telchitta: Talwar & Jhingran, 1991: 663 (valid).

Materials examined: PUCMF 1046.

Diagnosis: A pale but distinct stripe running laterally along dorsal second quarter of body (immediately above lateral line). Thoracic adhesive apparatus consisting of narrow longitudinal pleats of skin in elliptical field; without median depression. Pectoral fin with a spine and 8-9 soft rays; anterior spine margin smooth, posterior margin with 8-10 serrations.

Genus *Gogangra* Roberts

Gogangra Roberts, 2001: 83 (type species: *Pimelodus viridescens* Hamilton, 1822).

***Gogangra viridescens* (Hamilton)**

(Figure 5.5L)

Pimelodus viridescens Hamilton, 1822: 197, 379 (type locality: Rivers of North Bengal, India).

Gogangra viridescens: Roberts & Ferraris, 1998: 334 (valid).

Materials examined: PUCMF 1001.

Diagnosis: Head large and broad, median groove on head extends to base of occipital process, lateral cranial fontanel absent. Barbels 4 pairs; nasal barbels minute or rudimentary; maxillary barbels much shorter than head; mandibular barbels much shorter, outer and inner barbels widely separated, origin of inner barbels anterior to origin of outer barbels. Dorsal spine strong and smooth. Pectoral spine strong, strongly serrated on its inner edge.

Genus *Hara* Blyth

Hara Blyth, 1860: 152 (type species: *Hara buchanani* Blyth, 1860 [= *Pimelodus hara* Hamilton, 1822]).

***Hara hara* (Hamilton)**

(Figure 5.5M)

Pimelodus hara Hamilton, 1822: 190, 378 (Hooghly River south of Ranaghat, India).

Hara hara: Talwar & Jhingran, 1991:667 (valid).

Materials examined: PUCMF 1008.

Diagnosis: Dorsal fin with a curved spine and 5½ soft rays; dorsal spine with serrated anterior margin and posterior margin with 8-13 serrae. Pectoral fin with a spine and 7 soft rays; anterior spine margin with 17-24 small distally directed serrations, posterior margin with 12-17 large medially directed serrations. Caudal fin deeply forked.

Genus *Nangra* Day

Nangra Day, 1877: 493 (type species: *Pimelodus nangra* Hamilton, 1822).

***Nangra nangra* (Hamilton)**

(Figure 5.5N)

Pimelodus nangra Hamilton, 1822: 193, 378 (type locality: Kosi River, Uttar Pradesh).

Nangra nangra: Thomson & Page, 2006: 36 (valid).

Materials examined: PUCMF 1022.

Diagnosis: Barbels 4 pairs; nasal barbels very long, extends to margin of head or beyond; maxillary barbels extends to pectoral fin or beyond; bases of mandibular barbels set wide apart. Dorsal spine strong and smooth; pectoral spine strong and broad, strongly denticulated in its inner edge. Dorsal fin typically with 8 branched rays. Adipose fin small but well marked.

Genus *Pseudolaguvia* Misra

Pseudolaguvia Misra, 1976: 253 (type species: *Glyptothorax tuberculatus* Prashad & Mukerji, 1929).

Key to species:

1. Dorsal surface of the head with Y-shaped marking. *P. virgulata*
2. Dorsal surface of the head without Y-shaped marking. *P. spicula*

***Pseudolaguvia spicula* Ng & Lalramliana**

(Figure 5.6A)

Pseudolaguvia spicula Ng & Lalramliana, 2010b: 62 (Bawrai River in the vicinity of Zawinuam, Mizoram, India). - Ng *et al*., 2013: 518 (valid).

Materials examined: PUCMF 1045.

Diagnosis: Body with two irregular cream bands; first band on sides of body between dorsal and adipose fins, second band on caudal peduncle.Barbels in four pairs. Anterior margin of dorsal spine smooth; posterior margin with 3-5 larger, indistinct serrations. Pectoral fin with stout, blade-like spine, sharply pointed at tip; anterior spine margin with 9-15 small, distinct serrae; posterior spine margin with 5-7 large, distinct serrae.

Pseudolaguvia virgulata Ng & Lalramliana

(Figure 5.6B)

Pseudolaguvia virgulata Ng & Lalramliana, 2010a: 61 (Sihthiang River, a tributary of the Teirei River in the vicinity of Sihthiang, Mizoram, India). - Ng & Tamang, 2012: 81 (valid).

Materials examined: PUCMF 1073.

Diagnosis: Body with a series of two to three pale, narrow longitudinal stripes running along the sides. A pale Y-shaped marking present on the dorsal surface of the head. Barbels in four pairs. Dorsal-fin spine flattened, anterior margin with 9-17 small, distinct serrations; posterior margin with 3-5 larger, indistinct serrations. Anterior margin of pectoral fin with 11-17 small, distinct serrations; posterior margin with 6-8 large, very distinct serrae.

Family SILURIDAE

Genus _Ompok_ Lacepede

Ompok Lacepede, 1803: 49 (type species: *Ompok siluroides* Lacepede, 1803).

Ompok bimaculatus (Bloch)

(Figure 5.6C)

Silurus bimaculatus Bloch, 1794: 24 (Tranquebar, India).

Ompok bimaculatus: Talwar & Jhingran, 1991: 582 (valid).

Materials examined: PUCMF 1043.

Diagnosis: Body elongated, laterally compressed and narrowed towards tail. Dorsal profile raised at nape region. Mouth upturned; cleft small, not reaching eye; haws subequal, lower jaw slightly prominent. Body brow, usually marmorated body with conspicuous round black above pectoral base; 59-74 anal fin rays; maxillary barbels longer than head; pelvic fins not reaching anal fin origin with 8 rays.

Genus *Wallago* Bleeker

Wallago Bleeker, 1851: 265 (type species: *Silurus mulleri* Bleeker, 1846 [= *Silurus attu* Bloch & Schneider, 1801]).

Wallago attu (Schneider)

(Figure 5.6D)

Silurus attu Bloch & Schneider, 1801: 378 (Malabar).

Wallago attu: Talwar & Jhingran, 1991: 590 (valid).

Materials examined: PUCMF 1054.

Diagnosis: Body elongated and compressed. Eyes small. Mouth wide, its gape extends posteriorly beyond eyes. Barbels 2 pairs; maxillary pair long, extend posteriorly to well beyond origin of anal fin; the mandibulary pair much shorter, about as long as snout. Pectoral spine weak, often poorly serrated on its inner edge.

Family CHACIDAE

Genus *Chaca* Gray

Chaca Gray, 1931: 9 (type species: *Chaca hamiltonii* Gray, 1931 [= *Platystacus chaca* Hamilton, 1822]).

***Chaca chaca* (Hamilton)**

(Figure 5.6E)

Platystacus chaca Hamilton, 1822: 140, 374 (Rivers and ponds of north-eastern part of Bengal).

Chaca chaca: Talwar & Jhingran, 1991: 692 (valid).

Materials examined: PUCMF 12009.

Diagnosis: Body depressed dorsoventrally in the anterior half and compressed laterally in the posterior half. Head greatly depressed, appearing square in dorsal view. Eye small and oval in shape. Lateral line complete. Barbels short and slender, in three pairs, nasal barbels absent. Pectoral fin with broad spine and 5 rays. Anterior margin of spine with 14-15 curved serrae; posterior margin of spine smooth.

Family CLARIIDAE

Genus *Clarias* Scopoli

Clarias Scopoli, 1777: 455 (type species: *Silurus anguillaris* Linnaeus, 1758).

***Clarias magur* (Linnaeus)**

(Figure 5.6F)

Macropteronotus magur Hamilton, 1822: 145, 374 (Ganges River, India).

Clarias magur: Ng & Kottelat, 2008: 731 (valid).

Materials examined: PUCMF 1086.

Diagnosis: Barbels 4 pairs (1 pair of nasal barbel, 1 pair of mandibulary barbel and 2 pairs of maxillary barbels). The maxillary barbels extend considerably beyond base of pectoral fin while the nasal barbels extend to gill opening; the nasal barbles equal to the mandibulary barbels. Pectoral spine strong, prominent serration on both edges. Dorsal and anal fins not confluent with caudal fin.

Genus *Heteropneustes* Muller

Heteropneustes Muller, 1840 (type species: *Silurus fossilis* Bloch, 1794).

***Heteropneustes fossilis* (Blotch)**

(Figure 5.6G)

Silurus fossilis Bloch, 1794: 46 (Tranquebar, Tamil Nadu, India).

Heteropneustes fossilis: Talwar & Jhingran, 1991: 689 (valid).

Materials examined: PUCMF 1024.

Diagnosis: Body elongated, subcylindrical to pelvis fin base, compressed behind. Head depressed, occipital process not extending to base of dorsal fin. Barbels well-developed, in 4 pairs. Dorsal fin short, inserted in anterior third of body; pectoral fin small with strong spine, serrated along its inner edge and with few serration at its anterior edge. Anal fin base long, not confluent with caudal fin.

Family SCHILBEIDAE

Genus *Ailia* Gray

Ailia Gray, 1830: 85 (type species: *Malapterus bengalensis* Gray, 1830 [=*Malapterurus coila* Hamilton, 1822]).

***Ailia coila* (Hamilton)**

(Figure 5.6H)

Malapterurus coila Hamilton, 1822: 158, 375 (Bengal).

Ailia coila: Talwar & Jhingran, 1991: 593 (valid).

Materials examined: PUCMF 11002.

Diagnosis: Body elongated, its ventral profile not pronouncedly arched. Mouth subinferior, its cleft extends posteriorly halfway to front edge of eye. Jaws subequal, lower jaw slightly longer. Barbels 4 pairs; 1 pair each of maxillary and nasal; 2 pairs of mandibular; well developed, all are almost equal in length. Adipose fin small, inserted above last sixth of anal fin. Pectoral spine slender, finely serrated along its inner edge.

Genus *Eutropiichthys* Bleeker

Eutropiichthys Bleeker, 1862: 398 (type species: *Pimelodus vacha* Hamilton, 1822).

Key to species:

1. Cleft of mouth extending upto anterior border of orbit. *E. murius*
2. Cleft of mouth extending upto posterior border of orbit. *E. vacha*

***Eutropiichthys murius* (Hamilton)**

(Figure 5.6I)

Pimelodus murius Hamilton, 1822: 195, 378 (Mahananda River, West Bengal, India).

Eutropiichthys murius: Talwar & Jhingran, 1991: 602 (valid).

Materials examined: PUCMF 1014.

Diagnosis: Body elongated and laterally compressed. Mouth wide, its cleft extends to anterior border of orbit. Barbels 4 pairs, maxillary ones extend beyond base of pectoral fin, the nasal barbels extend slightly beyond orbit. Pectoral fin with 11-12 branched rays; anterior edge of pectoral spine smooth; anal fin with 32-37 branched rays; adipose fin small. Total vertebrae 43-45. Branchiostegal rays 5.

***Eutropiichthys vacha* (Hamilton)**

(Figure 5.6J)

Pimelodus murius Hamilton, 1822: 196, 378 (Larger fresh water rivers, Gangetic provinces, India).

Eutropiichthys vacha: Talwar & Jhingran, 1991: 603 (valid).

Materials examined: PUCMF 1091.

Diagnosis: Body elongated and laterally compressed. Mouth wide, its cleft extends to posterior border of orbit. Barbels 4 pairs, maxillary ones extend beyond base of pectoral fin, the nasal barbels extend upto opercle. Pectoral fin with 14-15 branched rays; anterior edge of pectoral spine with fine roughened ridge; anal fin with 44-48 branched rays; adipose fin small. Total vertebrae 49-51. Branchiostegal rays 11.

Family BAGRIDAE

Genus *Batasio* Blyth

Batasio Blyth 1860: 149 (type species: *Batasio buchanani* Blyth, 1860 [= *Pimelodus batasio* Hamilton, 1822]).

Batasio batasio (Hamilton)

(Figure 5.6K)

Pimelodus batasio Hamilton, 1822: 179, 377 (Tista River, North Bengal, India).

Batasio batasio: Talwar & Jhingran, 1991: 550 (valid).

Materials examined: PUCMF 1020.

Diagnosis: Body with a longitudinal band on upper side of lateral line and on lateral line; the midlateral stripe expanded to form an elliptical dark brown spot immediately below the dorsal fin base. A dark spot at the shoulder region. Snout length 43.9-46.2% HL.

Genus *Mystus* Scopoli

Mystus Scopoli, 1777: 451 (type species: *Bagrus halepensis* Valenciennes, 1840).

Mystus bleekeri (Day)

(Figure 5.6L)

Macrones bleekeri Day, 1877: 451 (Sind, Jamuna, upper water of Ganges and Burma).

Mystus bleekeri: Talwar & Jhingran, 1991: 558 (valid).

Materials examined: PUCMF 1021.

Diagnosis: Two light longitudinal bands above and below lateral line. A black spot at the shoulder just behind operculum. Fins edged black. A *Mystus* species with a smooth dorsal spine; occipital process extending to basal bone of dorsal fin; maxillary barbel reaching posteriorly to anal fin; two light longitudinal bands above and below lateral line.

Genus *Olyra* McClelland

Olyra McClelland, 1842: 588 (type species: *Olyra longicaudatus* McClelland, 1842)

***Olyra* aff. *longicaudata* McClelland**

(Figure 5.6M)

Olyra longicaudatus McClelland, 1842: 588 (type locality: Khasi hills, Shillong, India).

Olyra longicaudata: Talwar & Jhingran, 1991: 695 (valid).

Materials examined: PUCMF 1053.

Diagnosis: Body olivaceous brown. Anal fin with 5 unbranched and 13 branched rays; posterior end of adipose fin base at vertical level of posterior end of anal fin base; pelvic fin not reaching half length of distance between pelvic and anal fins.

Genus *Sperata* Holly

Sperata Holly, 1939: 143 (type species: *Bagrus lamarrii* Valenciennes, 1840).

Key to species:

1.	Snout rounded; gill rakers 19 or 20.	*S. aor*
2.	Snout truncate; gill rakers 13-15.	*S. seenghala*

***Sperata aor* (Hamilton)**

(Figure 5.6N)

Platystoma aor Hamilton, 1822: 205, 379 (Gangetic provinces).

Sperata aor: Ferraris & Runge, 1999: 410 (valid).

Materials examined: PUCMF 1018.

Diagnosis: Body elongated, wide anteriorly and gradually compressed posteriorly. Head long, dorsolaterally flattened. Mouth wide, subterminal. Jaws subequal, lower jaw more prominent. Barbels 4 pairs, the maxillary pair extends to the middle of caudal fin, the outer mandibular pair reaches to the middle of pectoral fin. Dorsal and pectoral spine with serrae on their inner edges. Lateral line complete, almost straight.

***Sperata seenghala* (Sykes)**

(Figure 5.7A)

Platystoma seenghala Sykes, 1839: 164 (Deccan, India).

Sperata seenghala: Ferraris & Runge, 1999: 416 (valid).

Materials examined: PUCMF 1017.

Diagnosis: Head long, dorsolaterally flattened. Mouth wide, subterminal. Jaws subequal, lower jaw more prominent. Barbels 4 pairs, the maxillary pair extends to the middle of caudal fin, the outer mandibular pair reaches to the middle of pectoral fin. Dorsal and pectoral spine with serrae on their inner edges. Lateral line complete, almost straight.

Order MUGILIFORMES

Family MUGILIDAE

Genus *Rhinomugil* Gill

Rhinomugil Gill, 1863: 169 (type species: *Mugil corsula* Hamilton, 1822).

***Rhinomugil corsula* (Hamilton)**

(Figure 5.7B)

Mugil corsula Hamilton, 1822: 221, 381 (Most Rivers of Gangetic provinces, introduced in dome ponds).

Rhinomugil corsula: Talwar & Jhingran, 1991: 897 (valid).

Materials examined: PUCMF 1078.

Diagnosis: Body elongated, rather stout and compressed. Head moderate, concave between eyes; eyes prominent and projecting dorsally on head. Mouth ventral, protrusible. Two dorsal fins, well separated; first dorsal fin inserted nearer to caudal fin base than to tip of snout; caudal fin emarginated. Scales cycloid in young and ctenoid in adult; lateral line absent, 48-52 scales in lateral series

Genus *Sicamugil* Fowler

Sicamugil Fowler, 1938: 9 (type species: *Mugil hamiltoni* Day, 1870).

***Sicamugil cascasia* (Hamilton)**

(Figure 5.7C)

Mugil cascasia Hamilton, 1822: 217, 380 (Rivers of North Bengal).

Sicamugil cascasia: Talwar & Jhingran, 1991: 899 (valid).

Materials examined: PUCMF 1095.

Diagnosis: Opercle with a strong spine. Two dorsal fins which are widely separated, first dorsal spiny and second dorsal soft. First dorsal fin inserted conspicuously nearer to tip of snout than to caudal fin base. Anal fin origin opposite to second dorsal fin origin. Scales 36-39 in longitudinal series. Lateral line absent. Scales strongly ctenoid.

Order BELONIFORMES

Family BELONIDAE

Genus *Xenentodon* Regan

Xenentodon Regan, 1911: 332 (type species: *Esox cancila* Hamilton, 1822).

***Xenentodon cancila* (Hamilton)**

(Figure 5.7D)

Esox cancila Hamilton, 1822: 213 (Ponds and smaller rivers of Gangetic Provinces).

Xenentodon cancila: Talwar & Jhingran, 1991: 743 (valid).

Materials examined: PUCMF 1087.

Diagnosis: Body very elongated and cylindrical; upper and lower jaws extend into long beaks armed with sharp teeth to their tips. A silvery band extends on the flank of the body.Dorsal fin inserted slightly to anal fin insertion. Caudal fin truncate; pelvic fin very small.

Order CYPRINODONTIFORMES

Family APLOCHEILIDAE

Genus *Aplocheilus* McClelland

Aplocheilus McClelland, 1839: 301, 426 (type species: *Aplocheilus chrysostigmus* McClelland, 1839).

Aplocheilus panchax (Hamilton)

(Figure 5.7E)

Esox panchax Hamilton, 1822: 211, 380 ((Ditches and ponds of Bengal).

Aplocheilus panchax: Talwar & Jhingran, 1991: 752 (valid).

Materials examined: PUCMF 1097.

Diagnosis: Body elongated and compressed posteriorly. Eyes large, its diameter about one-third of head length. Mouth terminal; teeth villiform, in several rows in jaw. Dorsal fin with 4 branched rays and a large black occelus at its base; pelvic fin small, without a prolonged ray; anal fin almost square shaped; caudal fin rounded. Lateral line absent, found as pores in head region. Scales fairly large, 30-34 in longitudinal series.

Order SYNBRANCHIFORMES

Family SYNBRANCHIDAE

Genus *Monopterus* Lacepede

Monopterus Lacepede, 1800: 138 (type species: *Monopterus javanensis* Lacepede, 1800).

Key to species:

1.	Branchiostegal rays 6.	*M. cuchia*
2.	Branchiostegal rays 2.	*M. ichthyophoides*

***Monopterus cuchia* (Hamilton)**

(Figure 5.7F)

Unibranchapertura cuchia Hamilton, 1822: 16, 363 (Southern Bengal, India).

Monopterus cuchia: Talwar & Jhingran, 1991: 776 (valid).

Materials examined: PUCMF 1089.

Diagnosis: Body eel-like and robust, not whip-like. Head not conspicuous; mouth wide; eye superior, covered by skin. Scales extending anteriorly up to the head. Teeth on jaws in a single row, palatine teeth also uniserial. Dorsal and anal 'fin folds' or ridges rudimentary. Lateral line present. Branchiostegal rays 6. Vertebrae 99-112 + 55-70 = 166-188.

***Monopterus ichthyophoides* Britz, Lalremsanga, Lalrotluanga & Lalramliana**

(Figure 5.7G)

Monopterus ichthyophoides Britz, Lalremsanga, Lalrotluanga & Lalramliana, 2011: 52 (Barak River drainage, Mizoram, India).

Materials examined: PUCMF 11046.

Diagnosis: Body very elongate, eel-like, round to oval in cross section, but laterally compressed in its caudal portion. Eye small, covered by thick skin. Posterior part of body covered by numerous small, circular (cycloid) scales extending further anteriorly on dorsum than on venter. All fins and their supporting skeleton absent. Branchiostegal rays 2. Vertebrae 79-82 + 34-37 = 114-117.

Family MASTACEMBELIDAE

Genus Macrognathus Lacepede

Macrognathus Lacepede, 1800: 283 (type species: *Ophidium aculeatum* Bloch, 1786).

Key to species:

1.	Rostrum with concave ventral surface lined with paired toothplates.	*M. aral*
2.	Rostrum rounded in cross-section, without toothplates	*M. pancalus*

Macrognathus aral (Bloch & Schneider)

(Figure 5.7H)

Rhynchobdella aral Bloch & Schneider, 1801: 479 (Tranquebar, Tamil Nadu, India).

Macrognathus aral: Talwar & Jhingran, 1991: 1026 (valid).

Materials examined: PUCMF 1090.

Diagnosis: Body relatively slender, eel-like. Rostrum relatively large, with concave ventral surface lined with 16-23 paired toothplates. No spines on preorbital or preoperculum bones. Dorsal fin with 3-11 ocelli at its base. Anal fin with three spines. Lateral line present.

Macrognathus pancalus Hamilton

(Figure 5.7I)

Macrognathus pancalus Hamilton, 1822: 30, 364 (Ganges River drainage, India). - Talwar & Jhingran, 1991: 1027 (valid).

Materials examined: PUCMF 1117.

Diagnosis: Body relatively slender, eel-like. A distinct streak of longitudinal spots run along lateral line from eye to caudal fin base. Rostrum rounded in cross-section, devoid of tooth plate. Preopercle with 3-5 spines. Dorsal and anal fins not confluent with caudal fin. Anal fin with three spines. Lateral line present.

Genus *Mastacembelus* Scopoli

Mastacembelus Scopoli, 1777: 458 (type species: Ophidium mastacembelus Banks & Solander, 1794).

***Mastacembelus armatus* (Lacepede)**

(Figure 5.7J)

Macrognathus armatus Lacepede, 1800: 283, 286 (type locality not known).

Mastacembelus armatus: Talwar & Jhingran, 1991: 1031 (valid).

Materials examined: PUCMF 1085.

Diagnosis: Body relatively slender, eel-like. Preopercle with 2-3 spines, usually conspicuous but often one or more may be embedded in skin. Mouth small, gape extending to below posterior nostrils. Anal and dorsal fins confluent with caudal fin. Dorsal spines 35-36, Caudal fin with 14-15 rays. Lateral line present.

Order PERCIFORMES

Family AMBASSIDAE

Genus *Chanda* Hamilton

Chanda Hamilton, 1822:103, 370 (type species: *Chanda nama* Hamilton, 1822).

***Chanda nama* Hamilton**

(Figure 5.7K)

Chanda nama Hamilton, 1822: 109, 371 (Ponds throughout Bengal). - Talwar & Jhingran, 1991: 799 (valid).

Materials examined: PUCMF 1060.

Diagnosis: Body ovate and strongly compressed. Mouth large, with a prominent lower jaw; teeth villiform on jaws, with 34 canines on either side of lower jaw. Scales minute, often irregularly arranged. Lateral line with 100 to 107 scales. Cheek with 7 transverse scale rows.

Family BADIDAE

Genus *Badis* Bleeker

Badis Bleeker, 1853: 106 (type species: *Labrus buchanani* Bleeker, 1854).

Key to species:

1.	A dark spot between 3-5 dorsal fin spines.	2
	No dark spot between 3-5 dorsal fin spines.	*B. badis*
2.	Bars narrow, circumpeduncular scales 16.	*B. kanabos*
	Bars broad, circumpeduncular scales 20.	*B. tuivaiei*

***Badis badis* (Hamilton)**

(Figure 5.7L)

Labrus badis Hamilton, 1822: 70, 368 (Shore of Tumapao River, Ganges River drainage, West Bengal, India).

Badis badis: Talwar & Jhingran, 1991: 882 (valid).

Materials examined: PUCMF 1141.

Diagnosis: Body elongated, moderately compressed. Conspicuous dark blotch covering superficial part of cleithrum above pectoral fin base. Dark caudal peduncle blotch absent; series of prominent dark blotches along dorsal fin base and/or a series of dark blotches along middle of dorsal fin. Lateral scale row 25-28; upper lateral line scale 21, lower lateral line scale 4; circumpeduncular scale 19-20.

***Badis kanabos* Kullander & Britz**

(Figure 5.7M)

Badis kanabos Kullander & Britz, 2002: 316 (Janali River, Raimana, Brahmaputra River drainage, Kokrajhar District, Assam, India). - Vishwanath & Shanta, 2004: 1620 (valid).

Materials examined: PUCMF 1113.

Diagnosis: Body elongated, moderately compressed. Conspicuous dark blotch covering superficial part of cleithrum above pectoral fin base. A dark blotch at dorsal fin base between 3rd and 5th spine. Lateral scale row 25-26; upper lateral line scale 22, lower lateral line scale 4; circumpeduncular scale 16-17.

***Badis tuivaiei* Vishwanath & Shanta**

(Figure 5.8A)

Badis tuivaiei Vishwanath & Shanta, 2004: 1619 (Tuivai River, Churachandpur District, Manipur, India). - Geetakumari & Vishwanath, 2010: 646 (valid).

Materials examined: PUCMF 1122.

Diagnosis: Body elongated, moderately compressed. Caudal fin with a small rounded brownish blotch at middle of base, also covering lateral line scale on body. A dark blotch at dorsal fin base between 3rd and 5th spine. Lateral scale row 26-32; upper lateral line scale 24, lower lateral line scale 4; circumpeduncular scales 20.

Family GOBIIDAE

Genus *Glossogobius* Gill

Glossogobius Gill, 1859: 46 (type species: *Gobius platycephalus* Richardson, 1846).

***Glossogobius giuris* (Hamilton)**

(Figure 5.8B)

Gobius giuris Hamilton, 1822: 51, 366 (Ganges River, India).

Glossogobius giuris: Roberts, 1978: 61 (valid).

Materials examined: PUCMF 1096.

Diagnosis: Body with 5-6 blotches on flank. Eye large, superior, in the middle of head. Pelvic fins oblong, united midventrally. Two dorsal fins. Dorsal, pectoral and caudal fins mottled with dark spots, spots darkest along spine of second dorsal fin.

Family OSPHRONEMIDAE

Genus *Trichogaster* Bloch & Schneider

Trichogaster Bloch & Schneider, 1801: 164 (type species: *Trichogaster fasciata* Bloch & Schneider, 1801).

***Trichogaster fasciata* (Bloch & Schneider)**

(Figure 5.8C)

Trichogaster fasciatus Bloch & Schneider, 1801: 164 (Tranquebar, India).

Trichogaster fasciata: Derijst, 1997: 22 (valid).

Materials examined: PUCMF 1154.

Diagnosis: Body ovate and strongly compressed; several oblique dark-blue bands across flanks. Craniodorsal profile convex. Lips simple and non-papillated but highly protrusible. Preorbital serrae in young ones. Base of dorsal and anal fins long; pelvic fin thread-like, extending up to caudal fin. A green spot on the distal part of opercle.

Family CHANNIDAE

Genus *Channa* Scopoli

Channa Scopoli, 1777: 459 (type species: *Channa orientalis* Bloch & Schneider, 1801).

Key to species:

1.	U- shaped isthmus, cephalic sensory pores arranged singly.	2
	V- shaped sharp isthmus, cephalic sensory pores arranged in groups.	*C. marulius*
2.	Pectoral fin with transverse black bars.	3
	Pectoral fin with no transverse black bars.	*C. punctata*
3.	Numerous black spots on sides of body.	*C. melanostigma*
	No numerous black spots on sides of body.	*C. gachuai*

***Channa gachua* (Hamilton)**

(Figure 5.8D)

Ophicephalus gachua Hamilton, 1822: 68, 367 (Ponds and ditches of Bengal).

Channa gachua: Kottelat *et al*., 1993: 165 (valid).

Materials examined: PUCMF 1056.

Diagnosis: Dorsal fin with 32-37 rays; lateral line scales 39-48; pelvic fin shorter than half of pectoral fin length; pectoral fin rays 15-17; anal fin rays 21-27; caudal fin rays 12. One or two large cycloid scale on each side of lower jaw undersurface. Isthmus U-shaped, cephalic sensory pores arranged in a single row. In young ones, a large ocellus with a light edge is often present on the last five dorsal rays.

***Channa marulius* (Hamilton)**

(Figure 5.8E)

Ophicephalus marulius Hamilton, 1822: 65, 367 (India).

Channa marulius: Vishwanath & Geetakumari, 2009: 101 (valid).

Materials examined: PUCMF 1107.

Diagnosis: A large black ocellus on upper caudal fin base, three spots on body. Dorsal fin rays 50-55, anal fin rays 31-35. Side of lower jaw without scales. Isthmus V- shaped, and anterior to it many longitudinal striae are present. Cephalic sensory pores arranged in groups. Lateral line scales 60-70, 4-5 ocelli.

***Channa punctatus* (Bloch)**

(Figure 5.8F)

Ophicephalus punctatus Bloch, 1793: 139 (Rivers and lakes of Coromandel cost).

Channa punctatus: Vishwanath & Geetakumari, 2009: 101 (valid).

Materials examined: PUCMF 1055.

Diagnosis: Body with two rows of bars. Pelvic fin longer than half of pectoral fin, pectoral fin without bars, dorsal fin rays 28-32, anal fin rays 19-21. Isthmus U-Shaped, cephalic sensory pores arranged in a single row. Maxila and premaxillary processs extending to vertical of beyond the middle of orbit, side of jaw with one large cycloid scale. Lateral line scales 35-40.

Channa melanostigma **Geetakumari &Vishwanath**

(Figure 5.8G)

Channa melanostigma Geetakumari & Vishwanath, 2011:231(Lohit River, Brahmaputra drainage at Tezu, Arunachal Pradesh, India).

Materials examined: PUCMF 1127.

Diagnosis: Black spots scatteredthroughout the body 4-5 rows of spots on dorsal fin, caudal fin with distinct 14-15 zigzag cross bars at irregular intervalsDorsal fin rays 36-37 simple rays, dorsal fin origin after 3-4 scales vertically above the pectoralfin origin; pectoral fin one simple and 14-15 branched rays, pelvic fin 5 simplerays, caudal fin 14 branched rays, predorsal scales 13-14,lateral line scales dropping one row following 15-17th anteriormostscales. Two large cycloid scales on each side of lowerjaw. Isthmus U- shaped, cephalic sensory pores arranged in a single row. Lateral line scales 46-47.

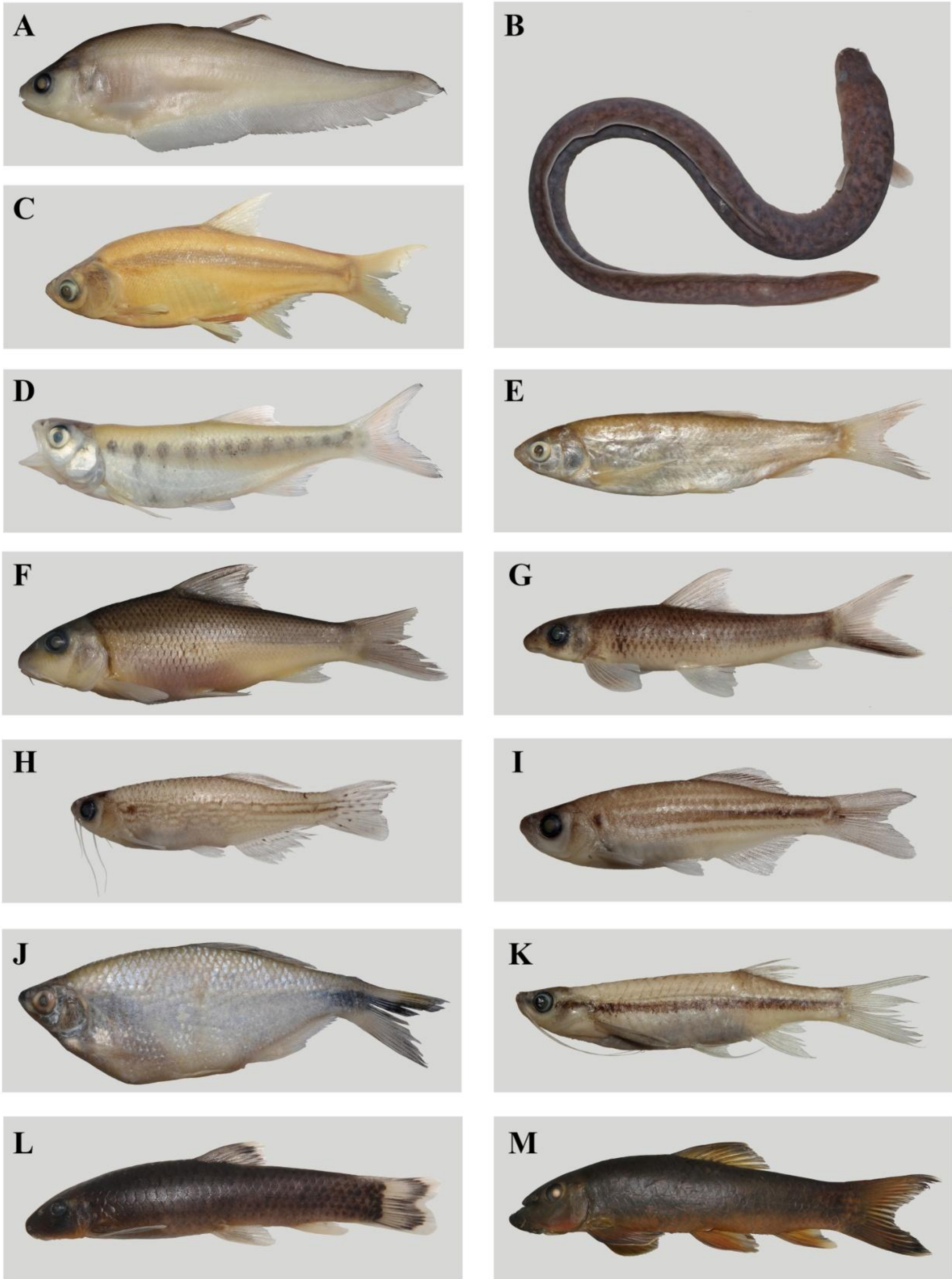

Figure 5.1 A) *Notopterus notopterus*; B) *Anguilla bengalensis*; C) *Amblypharyngodon mola*; D) *Barilius barila*; E) *Cabdio morar*; F) *Chagunius chagunio*; G) *Crossocheilus latius*; H) *Danio dangila*; I) *Devario aequipinnatus*; J) *Devario devario*; K) *Esomus danrica*; L) *Garra* cf. *dampaensis*; M) *Garra* cf. *gotyla*.

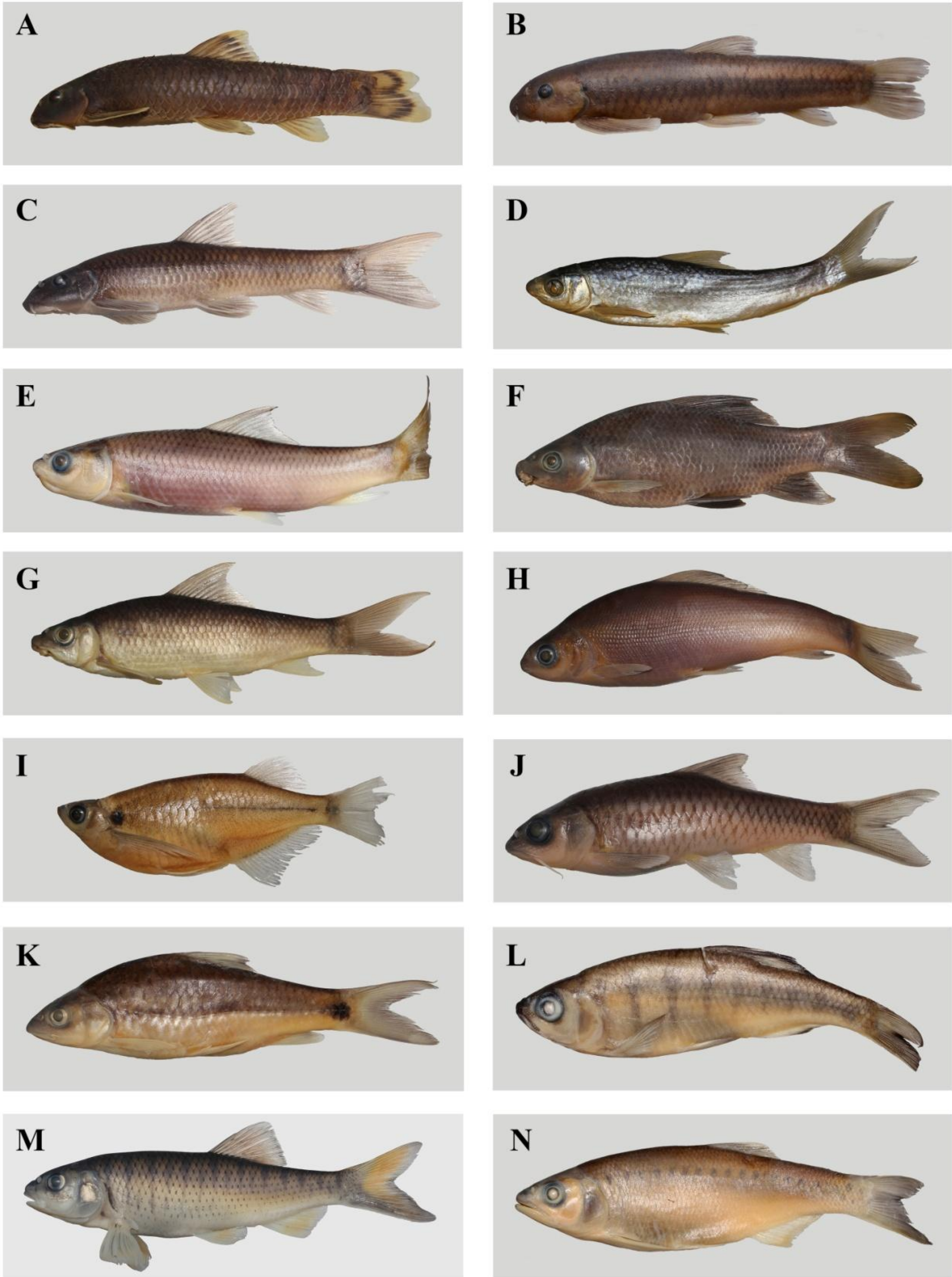

Figure 5.2 A) *Garra lissorhynchus*; B) *Garra* cf. *manipurensis*; C) *Garra* aff. *naganensis*; D) *Gymnostomus ariza*; E) *Labeo bata*; F) *Labeo calbasu*; G) *Labeo dyocheilus*; H) *Labeo gonius*; I) *Laubuka laubuca*; J) *Neolissochilus hexagonolepis*; K) *Neolissochilus hexastichus*; L) *Opsarius barna*; M) *Opsarius bendelisis*; N) *Opsarius tileo*.

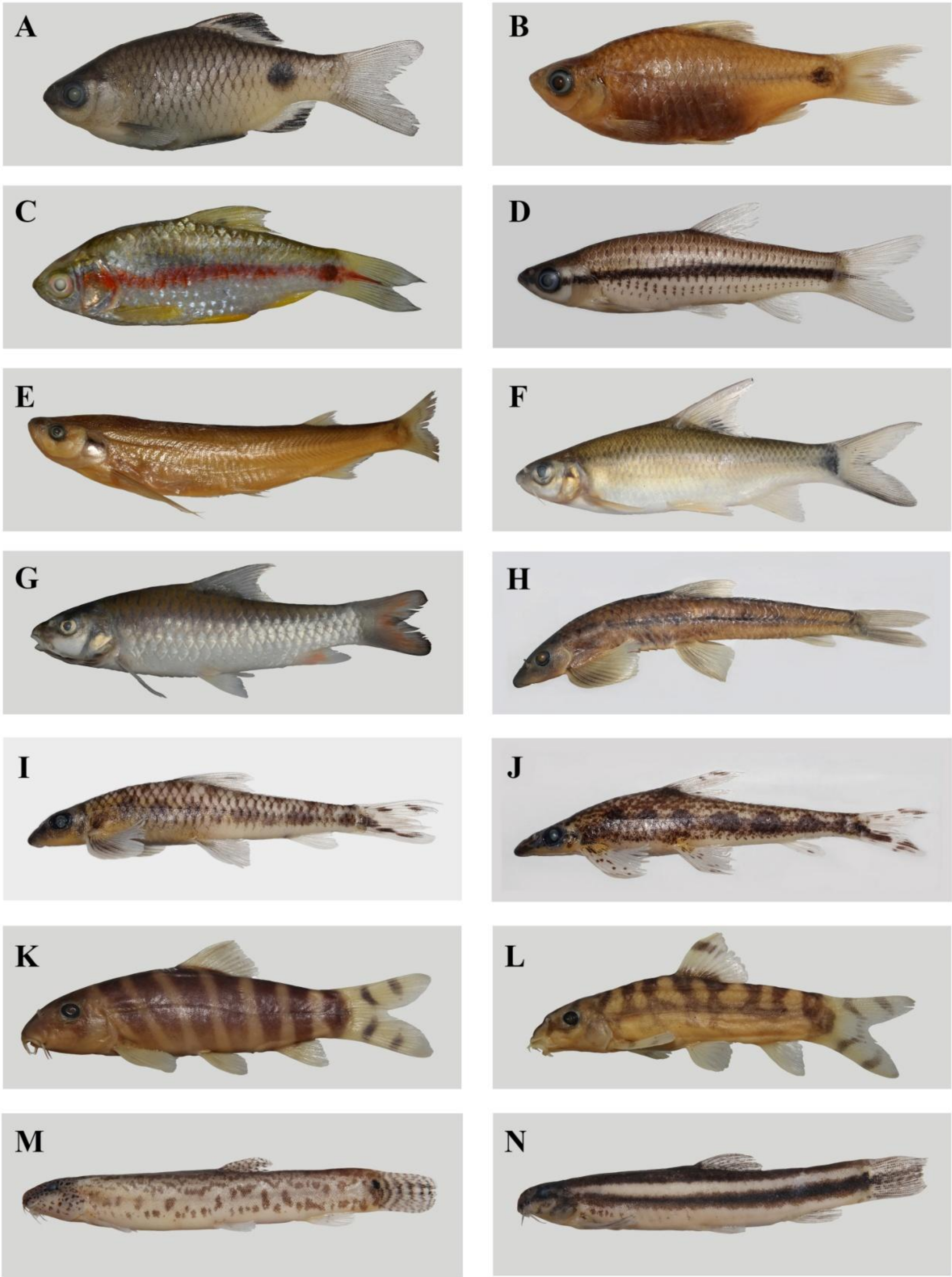

Figure 5.3 A) *Pethia conchonius*; B) *Puntius chola*; C) *Puntius sophore*; D) *Rasbora daniconius*; E) *Securicola gora*; F) *Systomus clavatus*; G) *Tor tor*; H) *Psilorhynchus homaloptera*; I) *Psilorhynchus nudithoracicus*; J) *Psilorhyncus sucatio*; K) *Botia dario*; L) *Botia rostrata*; M) *Lepidocephalichthys berdmorei*; N) *Lepidocephalichthys guntea* (♂).

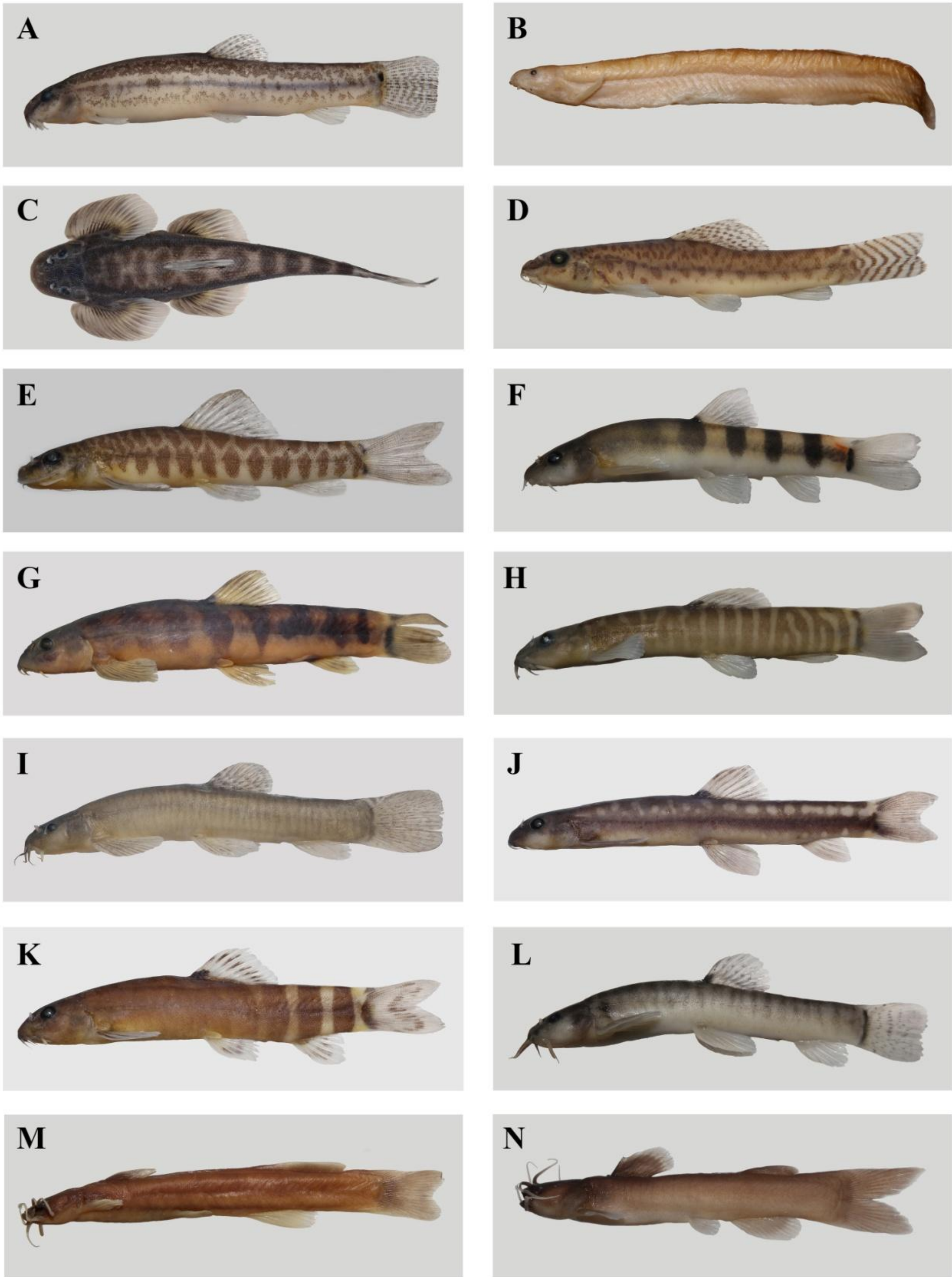

Figure 5.4 A) *Lepidocephalichthys guntea*(♀); B) *Pangio pangia*; C) *Balitora brucei*; D) *Acanthocobitis botia*; E) *Physoschistura tuivaiensis*; F) *Schistura aizawlensis*; G) *Schistura chindwinica*; H) *Schistura* cf. *fasciata*; I) *Schistura maculosa*; J) *Schistura mizoramensis*; K) *Schistura paucireticulata*; L) *Schistura* sp.; M) *Amblyceps laticeps*; N) *Amblyceps mangois*.

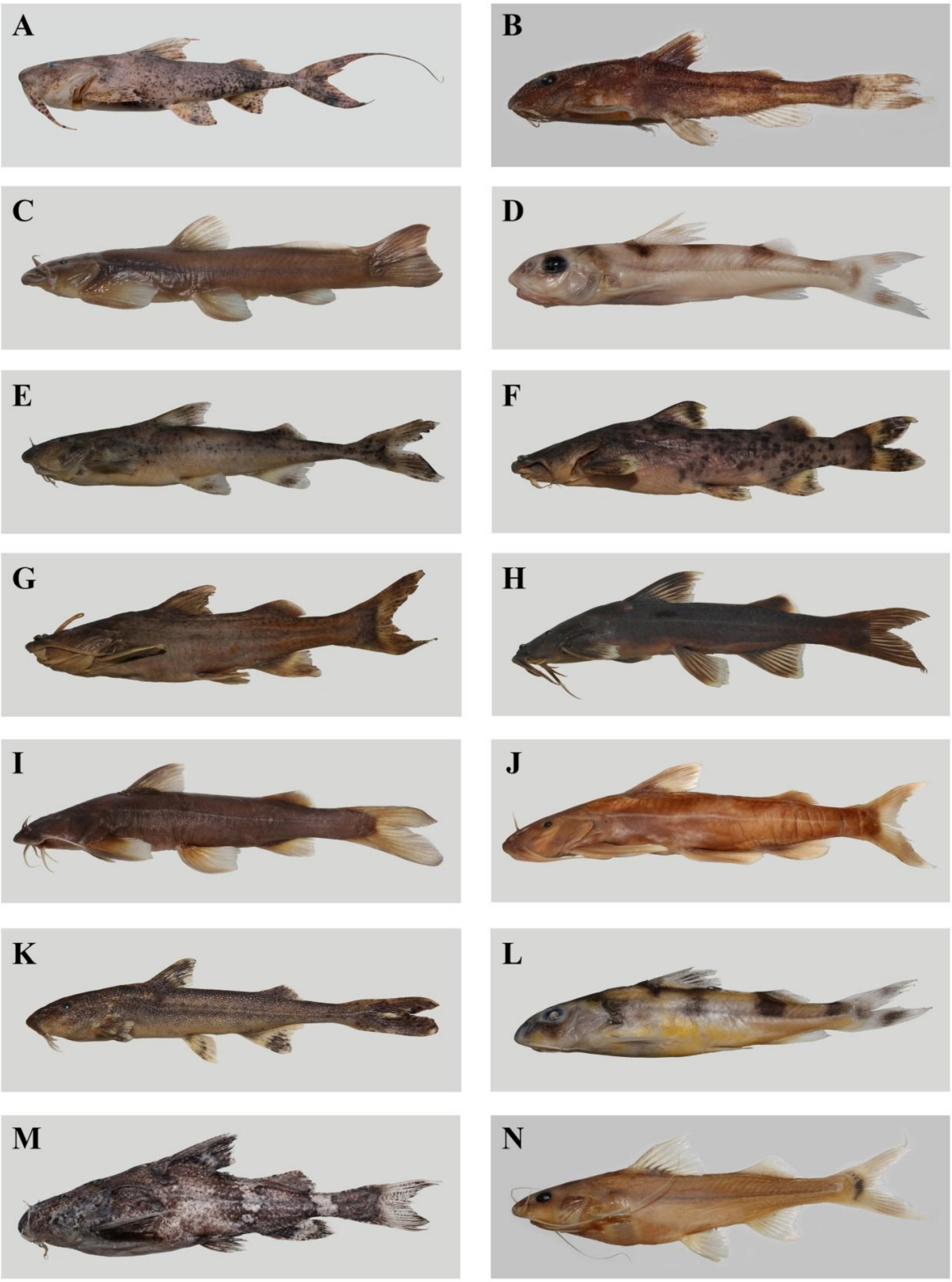

Figure 5.5 A) *Bagarius bagarius*; B) *Erethistoides* cf. *senkhiensis*; C) *Exostoma sawmteai*; D) *Gagata cenia*; E) *Glyptothorax botius*; F) *Glyptothorax cavia*; G) *Glyptothorax dikrongensis*; H) *Glyptothorax maceriatus*; I) *Glyptothorax scrobiculus*; J) *Glyptothorax striatus*; K) *Glyptothorax telchitta*; L) *Gogangra viridescens*; M) *Hara hara*; N) *Nangra nangra*.

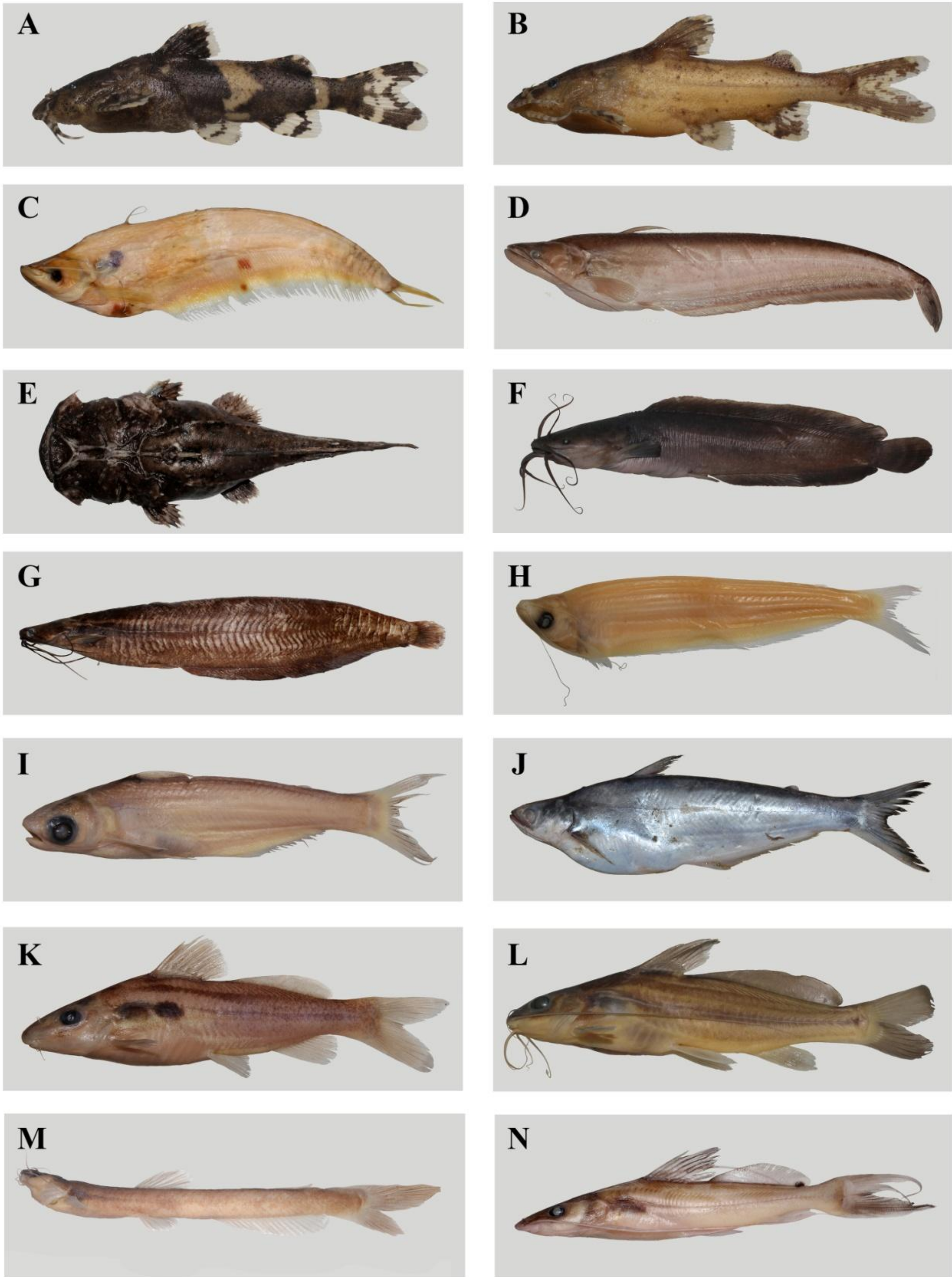

Figure 5.6 A) *Pseudolaguvia spicula*; B) *Pseudolaguvia virgulata*; C) *Ompok bimaculatus*; D) *Wallago attu*; E) *Chaca chaca*; F) *Clarias magur*; G) *Heteropneustes fossilis*; H) *Ailia coila*; I) *Eutropiichthys murius*; J) *Eutropiichthys vacha*; K) *Batasio batasio*; L) *Mystus bleekeri*; M) *Olyra* aff. *longicaudata*; N) *Sperata aor*.

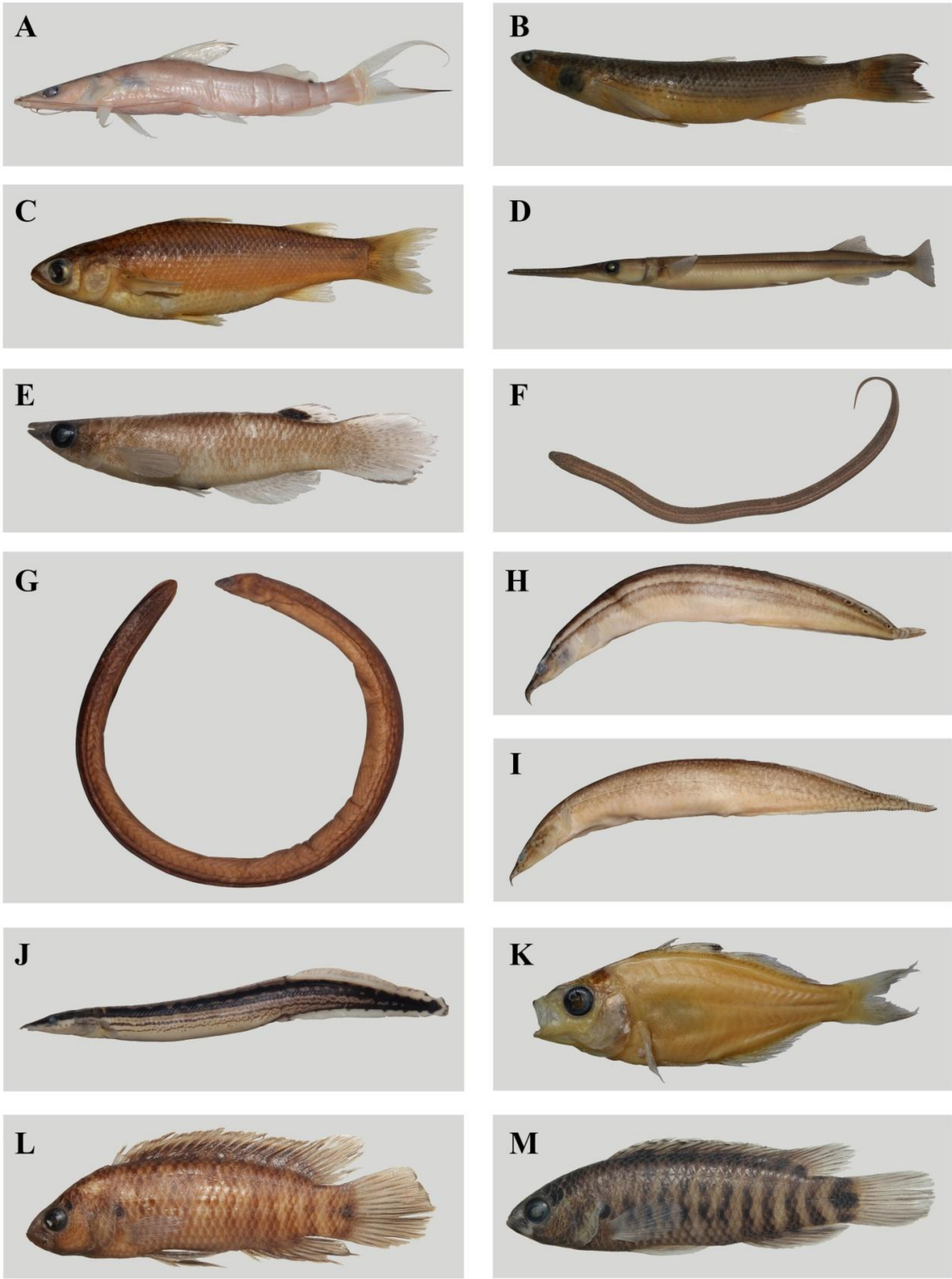

Figure 5.7 A) *Sperata seenghala*; B) *Rhinomugil corsula*; C) *Sicamugil cascasia*; D) *Xenentodon cancila*; E) *Aplocheilus panchax*; F) *Monopterus cuchia*; G) *Monopterus ichthyophoides*; H) *Macrognathus aral*; I) *Macrognathus pancalus*; J) *Mastacembelus armatus*; K) *Chanda nama*; L) *Badis badis*; M) *Badis kanabos.*

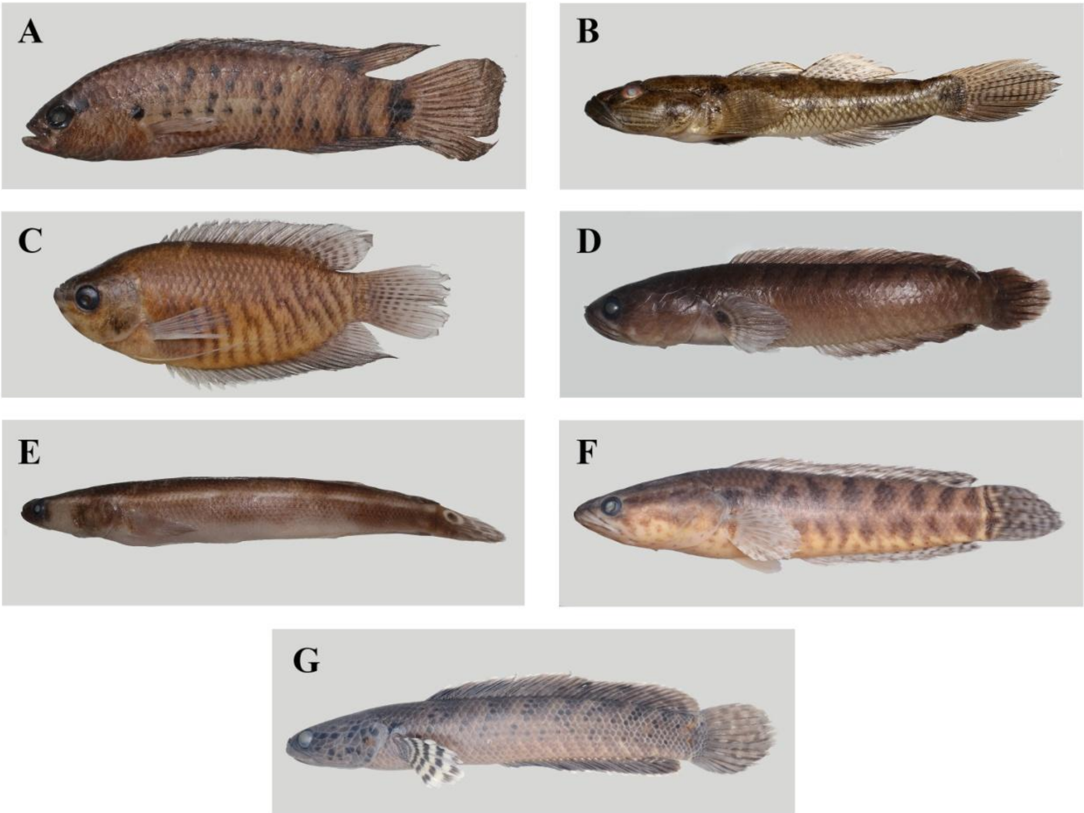

Figure 5.8 A) *Badis tuivaiei*; B) *Glossogobius giuris*; C) *Trichogaster fasciata*; D) *Channa gachua*; E) *Channa marulius*; F) *Channa punctatus*; G) *Channa melanostigma.*

5.2 New species description

5.2.1 *Schistura maculosa* Lalronunga, Lalnuntluanga & Lalramliana, 2013 (Figure 5.9)

Type material: Holotype. ZSI FF 4973, 75.3 mm SL; India: Mizoram, Pharsih River, a tributary of Tuivai River (Barak drainage) in the vicinity of Kawlbem, Champhai District, 23°51'58"N; 93°17'20"E; Samuel Lalronunga *et al*., 20 April 2013.Paratypes. ZSI FF 4974 (3), 56.9-69.0 mm SL; MZUBM/F. 130021- 130023 (3), 46.4-71.0 mm SL; PUCMF 13010 (8), 33.9-76.0 mm SL; PUCMF 13011 (4), 57.6-75.6 mm SL (cleared and stained); data as for holotype; PUCMF 13012 (2), 60.4-68.8 mm SL; India: Mizoram, Tuingo River, a tributary of Tuivai River (Barak drainage) in the vicinity of Kawlbem, Champhai District, 23°52'40"N 93°19'01"E; Vanlalmalsawma, 25 March 2013.

Diagnosis: *Schistura maculosa* differs from other species of the genus from the Ganga-Brahmaputra basin and its adjacent basins by the combination of the following characters: 3-4 rows of black spots horizontally across dorsal-fin; 5-7 more or less organized rows of black spots on rays vertically across caudal-fin; slightly emarginate caudal-fin with 8+8 branched rays; 20-30 narrow black bars on the body; incomplete lateral line extending up to vertical through pelvic-fin origin, with 26-35 pores; males with a sub-orbital flap; and intestine looped behind the stomach.

Description: Biometric data are given in Table 5.1. Body elongate; dorsal profile rising evenly from tip of snout to level of eye, gradually increasing thereafter to dorsal-fin origin, then sloping gently to end of caudal peduncle. Body cylindrical anteriorly to dorsal-fin origin, becoming increasingly compressed thereafter. Head long, depressed; snout rounded. Eyes ovoid, large, positioned near top of head, slightly anterior towards snout, not visible in ventral view.

Anterior nostril pierced anteriorly, a flap-like tube, not reaching eye, nearer to eye than snout tip. Mouth subterminal, large, moderately arched, its gape (about 1.7-2.0 times) wider than long.Lips thick, fleshy (Figure 5.10A), covered by furrows. Upper lip without median incision.Lower lip with median interruption. Processusdentiformis present. Inner rostral barbel extending to vertical through middle of orbit, outer rostral barbel extending up to ⅓ of distance between orbit posterior margin and opercular posterior margin; maxillary barbel extending slightly farther than outer rostral barbel. Barbels covered with unculi.

Dorsal-fin with 2 (4) or 3 (17) simple and 7½ (21) branched rays, its origin posterior to pelvic-fin origin; its distal margin convex; last unbranched ray shorter than first branched ray. Pectoral-fin sub-acuminate, shorter than head length, with 11 (3) or 12 (4) or 13 (14) rays, its origin slightly anterior to posterior edge of opercle, adpressed fin tip not reaching pelvic-fin base but surpassing midway between its origin and pelvic-fin origin; small tubercles present on dorsal surface of pectoral-fin rays of males, covering branched rays 1-6. Pelvic-fin sub-acuminate, shorter than head length, with 8 (21) rays, its origin anterior to dorsal-fin origin, midway between snout tip and caudal-fin base, adpressed fin tip not reaching anus. Axillary pelvic lobe present at pelvic-fin base. Anal-fin sub-acuminate with 3 simple and 5½ (21) branched rays, its origin closer to caudal-fin base than pelvic-fin origin. Caudal-fin branched rays 8+8 (21). Caudal-fin slightly emarginate, its lobes sub-equal. Caudal peduncle 1.3 times longer than deep, with very low or no adipose crest.

Entire body covered by minute cycloid scales, deeply embedded, sparse on chest and belly, no scales on head and cheeks. Lateral line incomplete with 26-35 pores, extending to vertical through pelvic-fin origin. Cephalic lateral line system with 8 supraorbital, 4+10 infraorbital, 10 pre-operculomandibular and 3 supratemporal pores. Intestine looped behind stomach (Figure 5.10B).

Vertebrae: 22+13 = 35 (3) or 23 + 13 = 36 (1)

Sexual dimorphism: A prominent sub-orbital flap present in males. Small tubercles present on dorsal surface of pectoral-fin rays in males, covering branched rays 1-6. Note on biology: A dissected female 75.6 mm SL contained ovulae 0.8-1.2 mm in diameter.

Coloration: In 70% alcohol: Body light-yellowish brown with 20-30 narrow black bars; bars usually bifurcated, narrower than or equal to interspaces; bars posterior to dorsal-fin origin coalesce dorsally; bars reaching to level of pelvic-fin base ventrally, beneath lateral-line scale in smaller specimens. Black basal caudal bar well marked, complete.Dorsal surface of head dark brown. Dorsal-fin hyaline with two black blotches at base, first blotch covering simple and first branched rays, second blotch covering third and fourth or third to fifth branched rays; 3-4 rows of black spots on rays horizontally across the fin; caudal-fin hyaline with 5-7 more or less organized rows of black spots on rays vertically across the fin; 2-4 isolated black spots at upper extremity of caudal-fin. Anal-fin hyaline.Pectoral and pelvic fin hyaline, with dark markings on interradial membrane.

Etymology: The specific name is derived from the Latin for ‘spotted’, referring to the numerous black spots on the caudal and dorsal fins. It is used as an adjective.

Distribution and habitat: The species has been collected only from the Tuingo and Pharsih Rivers, tributaries of Tuivai River, Mizoram, India (Figure 5.11). Specimens were collected from a small pool in slow-flowing water. The substrate was composed of sand, gravel and rocks. The ambient temperature varied from 19-26°C (morning to afternoon) and the water pH ranged from 7.8-8.0. The species was associated with *Exostoma sawmteai*, *Garra* spp. and *Lepidocephalichthys guntea*.

Comparision: The genus *Schistura* is the most speciose genus within the Nemacheilidae. Kottelat (1990), in his revision of Indochinese nemacheiline loaches, mentioned the difficulty of quantifying the major diagnostic features of the various species, but highlighted that characters such as overall body shape, number of fin rays, extent of lateral line and color pattern are useful in distinguishing species.

Schistura maculosa differs markedly from other species of the genus reported from the Ganga-Brahmaputra and its adjacent basins, with the exception of *S. manipurensis* (Chaudhuri) of the Chindwin-Irrawaddy basin, *S. porocephala* Lokeshwor & Vishwanath, and *S. koladynensis* Lokeshwor & Vishwanath of the Kaladan basin, and *S. multifasciata* (Day), *S. obliquofascia* Lokeshwor, Barat, Sati, Darshan, Vishwanath & Mahanta and *S. tigrina* Vishwanath & Nebeshwar of the Ganga-Brahmaputra basin, in having greater numbers of rows of dark spots on the dorsal- and caudal-fin rays. It is additionally distinguished from *S. manipurensis* (Chaudhuri) in having a shorter dorsal-fin (9.7-13.0 % SL, vs. 13.1-18.7), more branched caudal-fin rays (8+8, vs. 8+7) and the presence of an axillary pelvic lobe (vs. absent or rudimentary); from *S. porocephala* in having fewer branched caudal-fin rays (8+8 vs. 9+8) and absence (vs. presence) of a median incision on the upper lip; and from *S. koladynensis* in having fewer branched dorsal-fin rays (7½, vs. 8½), an incomplete lateral line (vs. complete) and more bars on the body (20-30 vs. 10-11). It is further distinguished from *S. multifasciata*, *S. obliquofascia* and *S. tigrina* in males possessing a sub-orbital flap (vs. no flap in all the three species) and an incomplete lateral line extending up to vertical through pelvic-fin origin (vs. complete lateral line in *S. multifasciata*, *S. obliquofascia*, and an incomplete lateral line extending up to vertical through anal-fin origin in *S. tigrina*).

Kottelat (2012) reviewed the taxonomy and nomenclature of fishes of the superfamily Cobitoidae and treated 193 species of the genus Schistura as valid, out of which 19 species *viz.* , *S. aizawlensis* Lalramliana, *S. beavani* (Günther), *S. chindwinica* (Tilak & Hussain), *S. devdevi* (Hora), *S. fasciata* Lokeshwor & Vishwanath, *S. gangetica* (Menon), *S. minuta* Vishwanath & Shantakumar, *S. multifasciata* (Day), *S. papulifera* Kottelat, Harries & Proudlove, *S. reticulofasciata* (Singh & Banarescu), *S. rosammai* (Sen), *S. savona* (Hamilton), *S. scaturigina* (McClelland), *S. shebbearei* (Hora), *S. sijuensis* (Menon), *S. singhi* (Menon), *S. tigrina*, *S. tirapensis* Kottelat, and *S. zonata* (McClelland) are distributed in the Ganga-Brahmaputra basin. Subsequently, Lokeshwor *et al*. (2012) described *S. obliquofascia* from Kalsa River (Ganga basin) of India.

Schistura maculosa is distinguished from all the species of the genus occurring in the Ganga-Brahmaputra basin, with the exception of *S. devdevi*, *S. fasciata*, *S. minuta*, *S. papulifera*, *S. reticulofasciata*, *S. tigrina* and *S. tirapensis*, in having an incomplete lateral line (vs. complete in all other species). It is also distinguished from all the above excepted species in having a sub-orbital flap in males (vs. no flap) and fewer dorsal-fin branched rays (7½, vs. 8-8½). It further differs from *S. devdevi* in having more bars on the body (20-30, vs. 4-6) and presence (vs. absence) of scales on the ventral surface; from *S. fasciata* in having fewer caudal-fin branched rays (8+8 vs. 9+8) and shorter lateral line (extending up to vertical through pelvic-fin origin, vs. extending up to vertical through anal-fin insertion); from *S. minuta* in having fewer caudal-fin branched rays (8+8, vs. 9+8), more bars on the body (20-30, vs. 14-18) and a strongly developed (vs. weakly developed) processusdentiformes; from *S. papulifera* in having fewer pores in the supratemporal canal of the cephalic lateral-line system (3, vs. 5) and fewer caudal-fin branched rays (8+8, vs. 9+8); from *S. reticulofasciata* in having fewer unbranched dorsal-fin rays (2-3, vs. 4), 5-7 rows of black spots on rays vertically across the caudal-fin (vs. 2 distinct rows) and a slightly emarginate (vs. forked) caudal-fin; and from *S. tirapensis* in having more bars on the body (20-30, vs. 10-12) and a slightly emarginate (vs. forked) caudal-fin.

There is little information available on the diversity of fish, particularly species of *Schistura*, from Barak drainage in Mizoram. *Schistura* species listed and described from Barak drainage of Mizoram includes *S. aizawlensis*, *S. corica* Hamilton, *S. chindwinica*, *S. kangjupkhulensis* (Hora), *S. multifasciata, S. paucireticulata, S. rupecula, S. savona, S. scaturigina*, *S. sikmaiensis, S. tirapensis* and *S. vinciguerrae* (Hora)(Ramanujam, 2005; Kar & Sen, 2007; Karmakar & Das, 2007; Lokeshwor *et al*., 2013). *S. maculosa* is distinguished from *S. corica* in having more branched caudal fin rays (8+8 vs. 8+7), higher caudal peduncle (11.5-12.9 % of SL vs. 8.0-11.6 % of SL), and the absence of blotches along the lateral midline (vs. present). The reported occurrence of *S. rupecula*, *S. sikmaiensis* and *S. vinciguerrae* (Ramanujam, 2005; Kar & Sen, 2007) in rivers of the Barak drainage (Brahmaputra basin) and *S. kanjupkhulensis* (Karmakar & Das, 2007) from Tiau River (Kaladan basin) of Mizoram, India, is doubtful. Since the type locality of *S. rupecula* is the Indus basin of India, and that of *S. kangjupkhulensis*, *S. sikmaiensis* and *S. vinciguerrae* the Chindwin-Irrawaddy basin, it is unlikely that the above-mentioned species would occur also in the Ganga-Brahmaputra basin, which is unconnected with the two aforementioned basins even in the floodplains. Nevertheless, *S. maculosa* is distinguished from all these species in possessing a sub-orbital flap in males (vs. no flap in all the mentioned species). *S. maculosa* is distinguished from *S. paucireticulata* in having incomplete (vs. complete) lateral line, 20-30 (8-9) bars on body, 8+8 (vs. 9+8) branched caudal fin rays, 5½ (vs. 6) branched anal fin rays. The distinguishing characters of *S. maculosa* from other species listed from Barak drainage of Mizoram were already noted above.

A comparison of *Schistura maculosa* with the species occurring in the nearby adjacent basins (Kaladan and Chindwin-Irrawaddy basins) shows it to share some characters similar to *S. acuticephala* (Hora), *S. callidora* (Bohlen & Šlechtová), *S. kangjupkhulensis*, *S. khugae* Vishwanath & Shanta, *S. malaise* Kottelat, *S. nagaensis* (Menon), *S. manipurensis*, *S. pausifasciata* (Hora) and *S. porocephala* in having an incomplete lateral line. It is, however, distinguished from all these species, with the exception of *S. manipurensis* and *S. porocephala*, in having a sub-orbital flap in males (vs. no flap in all the species) and more bars on the body (20-30, vs. 3-17). The characters that distinguish *S. maculosa* from *S. kangjupkhulensis*, *S. manipurensis* and *S. porocephala* have already been discussed above.

Table 5.1 Biometric data for *Schistura maculosa* (n=21). Ranges include values of holotype.

	holotype	range	mean	SD
Standard length (mm)	75.3	33.9-76.0		
In % of standard length				
Dorsal head length	18.6	17.7-22.1	18.9	1.0
Lateral head length	22.0	21.0-25.7	22.7	1.2
Pre-dorsal length	54.1	52.2-56.3	54.3	1.1
Pre-pelvic length	47.5	47.3-50.3	48.6	0.9
Pre-anus length	72.9	71.2-74.5	73.4	0.8
Pre-anal length	76.4	74.5-78.4	76.8	0.8
Head depth at eye	9.8	9.4-11.2	10.3	0.5
Head depth at occiput	12.1	12.1-13.9	13.0	0.6
Body depth at dorsal-fin	15.5	14.4-17.3	15.6	0.6
Body depth at anal-fin	13.0	12.9-14.4	13.6	0.4
Depth of caudal peduncle	11.6	11.5-12.9	12.2	0.4
Length of caudal peduncle	15.5	15.0-17.0	16.0	0.6
Head width at eye	13.8	13.2-16.8	14.5	0.9
Maximum head width	17.0	16.2-18.6	17.5	0.7
Body width at dorsal-fin origin	13.8	11.5-15.1	13.5	0.9
Body width at anal-fin origin	9.7	8.3-11.0	10.2	0.7
Height of dorsal-fin	9.7	9.7-13.0	11.2	1.2
Length of upper caudal-fin rays	20.8	18.8-22.1	20.6	1.2
Length of lower caudal-fin rays	20.6	18.3-22.2	20.5	1.2
Length of median caudal-fin rays	19.0	17.3-20.9	19.3	1.1
Length of anal-fin	17.4	16.2-18.3	17.2	0.6
Length of pelvic-fin	19.5	18.3-21.6	20.3	0.9
Length of pectoral-fin	20.3	19.1-21.8	20.7	0.8
In % of dorsal head length				
Snout length	47.9	44.7-52.4	49.0	1.9
Eye diameter	15.0	14.4-19.6	16.1	1.5
Interorbital width	42.1	41.1-46.7	44.2	1.6

Figure 5.9 *Schistura maculosa*; ZSI FF 4973, holotype, 75.3 mm SL; lateral, dorsal and ventral view.

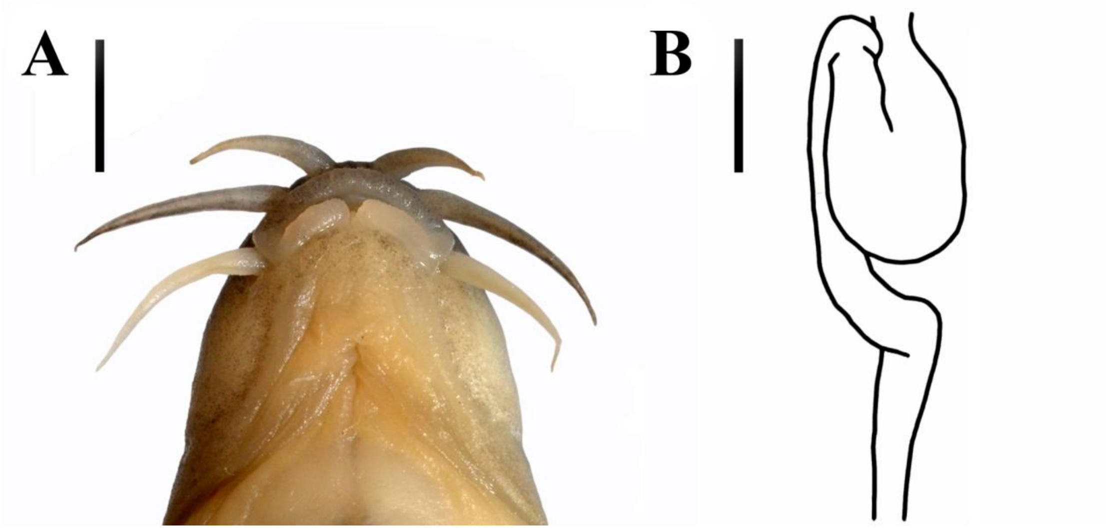

Figure 5.10 *Schistura maculosa*; A) ZSI FF 4974, paratype, 69.0 mm SL, ventral view of head; B) PUCMF 13011, paratype, 75.6 mm SL, digestive tract. Scale bars 5 mm.

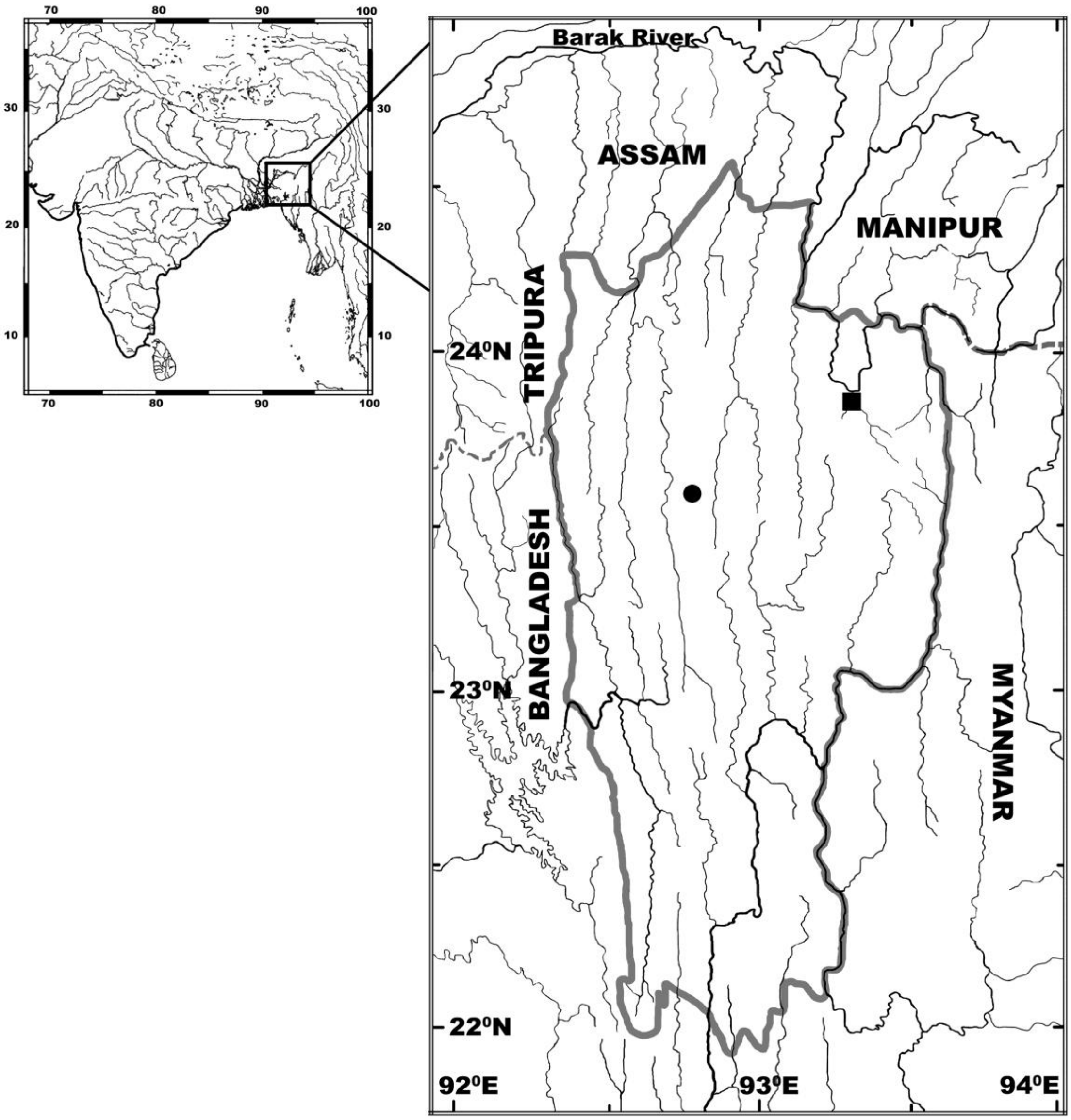

Figure 5.11 Map showing the collection sites of *Schistura maculosa* (square), symbol may indicate more than a single locality; *Schistura mizoramensis* (circle); *Exostoma sawmteai* (square).

5.2.2 *Schistura mizoramensis* Lalramliana, Lalronunga, Vanramliana & Lalthanzara, 2014 (Figure 5.12)

Type material: Holotype. PUCMF 13021, 53.2 mm SL; India: Mizoram: Aizawl District: Tuirivang River, a tributary of Tuirial River (Barak drainage) in the vicinity of Phulpui, 23°32'01" N 92°45'29" E; Vanramliana & Hmar Lalthanzara, 20 Oct 2012.Paratypes. PUCMF 13022, 6, 44.9-56.0 mm SL; PUCMF 13023, 2, 46.8-53.3 mm SL (cleared and stained); same data as holotype.

Diagnosis: *Schistura mizoramensis* is a species with a complete lateral line and without suborbital flap in males. It differs from other species of the genus from Ganges-Brahmaputra basin and its adjacent basin by having an unique color pattern with a prominent dark brown longitudinal stripe along midlateral line from upper edge of gill opening to middle of caudal-fin base; a dark brown stripe on the dorsal midline from dorsal-fin origin to dorsal part of caudal-fin base; a network of bars which reduce the light yellowish ground color to isolated spots on the flanks and predorsal region of dorsum; 3-4 postdorsal bars posterior to anal-fin origin extending beyond lateral line and coalesce ventrally.

Description: Biometric data are given in Table 5.2. Body elongate; dorsal profile rising evenly from tip of snout to head, slowly increasing from head upto dorsal-fin origin, sloping gently to end of caudal peduncle. Body cylindrical anteriorly to dorsal-fin origin, compressed posteriorly thereafter. Head depressed, snout rounded. Eyes large, near top of head, slightly nearer to snout tip than end of opercle, not visible from ventral view.

Anterior nostril pierced in front side of a flaplike tube, not reaching eye. Nostrils nearer to eye than snout tip. Mouth sub-terminal, large and moderately arched. Mouth gape about 1.9-2.1 times wider than long. Lips thick and fleshy (Figure

5.13A) with deep furrows. Upper lip with a median incision. Lower lip with a median interruption. Processus dentiformis present. No median notch in lower jaw. Inner rostral barbel extending up to vertical through nostril, outer rostral barbel almost reaching vertical through anterior rim of orbit, maxillary barbel extending to vertical through middle of orbit. Barbels covered with unculi.

Dorsal-fin with 3 simple and 7½(1) or 8½ (8) branched rays, origin slightly anterior through origin of pelvic-fin. Distal margin of dorsal-fin slightly convex. Last unbranched ray shorter than first branched ray. Pectoral-fin shorter than head, with 10 (1), 11 (7) or 12 (1) rays, its origin slightly anterior to posterior edge of opercle, tip of adpressed fin reaching midway between its origin and origin of pelvic-fin. Pelvic-fin shorter than head, with 7 (1) or 8 (8) rays, its origin slightly posterior through origin of dorsal-fin, tip of adpressed fin not reaching anus. Axillary pelvic lobe present. Anal fin with 3 simple and 5 1/2 (9) branched rays, closer to caudal-fin base than to origin of pelvic fin. Caudal fin with 9+7 (1) or 9+8 (8) branched rays, slightly forked, lower lobe slightly longer. Caudal peduncle 1.3-1.6 times longer than deep, with very low or no adipose crest.

Whole body covered by minute cycloid scales, deeply embedded, sparse on anterior portion; belly between pectoral fin scaleless. Lateral line complete with 83-95 pores, extending up to caudal-fin base. Cephalic lateralis system with 6 supraorbital, 4+9 infraorbital, 9-10 pre-operculomandibular and 3 supratemporal pores. Intestine bent some distance behind stomach (Figure 5.13B).

Vertebrae: 23 + 12 = 35 (2).

Sexual dimorphism: No sexual dimorphism observed.

Coloration: In 70 % alcohol: ground color light yellowish. A prominent dark brown longitudinal stripe along midlateral line from upper edge of gill opening to middle of caudal-fin base. All bars meet their antimere on back extending to both flanks and fused to a dark brown longitudinal stripe. Body with 5-6 predorsal dark brown bars usually reticulated and interconnected each other on back and on flanks, 3-4 subdorsal and 4-6 postdorsal dark brown bars. 3-4 of the postdorsal bars posterior to anal-fin origin extending beyond lateral line and coalescing ventrally. Interconnection of bars and fusion of bars with midlateral longitudinal stripe reducing light yellowish ground color to isolated spots (usually obliquely arranged on predorsal region) on flanks and predorsal region of dorsum. Between dorsalfin origin and caudal-fin base, a wide dark brown middorsal stripe formed by the coalescence of the bars at their upper extremity. Basal caudal bar dissociated with a slightly vertical elongated dark blotch at centre of caudal-fin base confluent with posterior end of longitudinal stripe, and a small dark spot at upper extremity of caudal-fin base. Top and upper half of lateral side of head dark brown, lower half of lateral and ventral sides of head dark yellowish. Top of head with a darker area appearing as blotch on supratemporal region, two small dark spots at interorbital and internarial region. Dorsal-fin rays with minute dark pigments scattered on rays forming an indistinct row of dark spots across fin, interradial membranes hyaline. Distal half of last unbranched dorsal-fin ray spotted dark brown. Base of dorsal fin spotted black covering unbranched and first two branched rays. Caudal-fin with 2 indistinct vertical rows of dark spots on rays across fin. Scattered dark pigments more concentrated on anterior half of upper and lower caudal fin. Anal, pectoral and pelvic fins hyaline with dark pigments scattered on rays.

In life, similar to preserved specimens except for presence of a faint black stripe extending from snout to anterior orbit.

Etymology: The species is named after the state, Mizoram, northeastern India, where it was collected. An adjective.

Distribution and habitat: *Schistura mizoramensis* is known only from Tuirivang, a tributary ofTuirial River, Mizoram, India (Figure 5.11). It was collectedfrom slow flowing water with a substrateof sand, gravel and rocks. The species is foundassociated with *Glyptothorax maceriatus*, *Garra* cf. *naganensis* and *Schistura* cf. *fasciata*.

Comparision: *Schistura mizoramensis* is placed in the genus *Schistura* as it shares the characters defined by Kottelat (1990): moderately arched mouth; lower lip with a median interruption, but not forming two triangular pads, deeply furrowed; no median notch on the lower jaw; a black bar at caudalfin base; dorsal fin with one black mark along its base; no acuminate scales on caudal peduncle; and a slightly forked caudal fin. *Schistura mizoramensis* is distinguished from all the species of the genus occurring in the Ganges-Brahmaputra basin in having a prominent dark brown longitudinal stripe along midlateral line from upper edge of gill opening to middle of caudal-fin base (vs. no lateral stripe), a dark brown stripe on the dorsal midline from dorsal-fin origin to dorsal part of caudal-fin base (vs. no dorsal stripe) and a light yellowish isolated spots on the flanks and predorsal region of dorsum (vs. absence of light yellowish isolated spots on the body). It is also distinguished, with the exception of *S. aizawlensis, S. beavani*, *S. chindwinica*, *S. gangetica, S. multifasciata*, *S. obliquofascia, S. paucireticulata,S. savona*, *S. scaturigina*, *S. sijuensis* and *S. zonata*, in having a complete lateral line (vs. incomplete in all other species). It further differs from *S. aizawlensis* in having 5-6 predorsal bars usually reticulated and interconnected each other on the back and on the flanks (vs. 2 predorsal bars without reticulation or interconnection), 8½ (vs. 7-7½) branched dorsal-fin rays and absence (vs. presence) of suborbital flap in males; from *S. chindwinica* in having a dissociated basal caudal bar with a slightly vertical elongated dark blotch at the centre and a small dark spot at the upper extremity of the caudal-fin base (vs. bar dissociated with a dorsal spot and a ventral thin bar covering ⅔ of caudal peduncle), median incision at the upper lip (vs. upper lip without median incision), absence (vs. presence) of median notch in lower jaw and absence (vs. presence) of suborbital flap in males; from *S. paucireticulata* in having 2 (vs. 3-4) rows of black spot across caudal fin, scattered dark pigments more concentrated on anterior half of upper and lower caudal fin (vs. two red elongated patches, one each on dorsal and ventral portions of caudal fin); from *S. gangetica, S. scaturigina* and *S. sijuensis* in having a dissociated basal caudal bar with a slightly vertical elongated dark blotch at the centre and a small dark spot at the upper extremity of the caudal-fin base (vs. more elongated black blotch at base of caudal fin in *S. gangetica*; dissociated with lower one as vertically elongated black blotch below lateral line and upper one as oblique black blotch at upper extremity of the caudal-fin base in *S. scaturigina*; more elongated and almost complete grey band at base of caudal fin in *S. sijuensis*) and absence of suborbital flap in males (vs. flap present in all three species); from *S. beavani* in having a dissociated basal caudal bar with a slightly vertical elongated dark blotch at the centre and a small dark spot at the upper extremity of the caudal fin base (vs. completed and broad, covering the whole caudal-fin base), and 12-16 dark brown bars usually reticulated and interconnected predorsally (vs. 8 or 9 non reticulated dark cross bands on the body); from *S. multifasciata* in having more branched dorsal-fin rays (8½ vs. 7½), slightly forked caudal fin (vs. slightly emarginated) and median incision at the upper lip (vs. upper lip without median incision); from *S. obliquofascia* in having 12-16 dark brown bars usually reticulated and interconnected predorsally (vs. 12-14 obliquely arranged olivaceous dark bars on body), inconspicuous rows of black spot on dorsal and caudal fins (vs. irregularly arranged but prominent rows of black spot on dorsal and caudal fins) and in having 9+8 branched caudal fin rays (vs. 8+8); from *S. savona* and *S. zonata* in having 12-16 dark brown bars usually reticulated and interconnected predorsally (vs. 9-10 narrow, yellowish band on the body in *S. savona* and 11 complete rings in *S. zonata*), 8 1/2 (vs. 7½ in *S. savona*) branched dorsal-fin rays and indistinct spotted rows (vs. non spotted in *S. zonata*) on dorsal- and caudal-fin rays.

Schistura mizoramensis is also compared with the species occurring in the nearby adjacent basins (Kaladan and Chindwin-Irrawaddy basins) and differs from them, with the exception of *S. koladynensis*, *S. puncticeps* Bohlen & Šlechtová, *S. reticulate* Vishwanath & Nebeshwar Sharma, *S. rubrimaculata* Bohlen & Šlechtová, *S. scyphovecteta* Lokeshwor & Vishwanath, and *S. sikmaiensis* in having a complete lateral line (vs. incomplete). It differs from all these species in having a prominent dark brown longitudinal stripe along midlateral line from the upper edge of gill opening to middle of caudal-fin base (vs. no lateral stripe in all other species, except in *S. rubrimaculata* and *S. scyphovecteta*), a dark brown stripe on the dorsal midline from dorsal-fin origin to dorsal part of caudal-fin base (vs. no dorsal stripe), and a light yellowish isolated spots on the flanks and predorsal region of dorsum (vs. absence of light yellowish isolated spots on the body in all the species). It further differs from *S. koladynensis*, *S. reticulata*, *S. rubrimaculata* and *S. scyphovecteta* in having 12-16 dark brown bars usually reticulated and interconnected predorsally (vs. 10-11 dark olivaceous bars, coalescing on dorsal midline and extends to both flanks in *S. koladynensis*; 17-29 bars in *S. reticulata*; 6 dark brown saddles ventrally reaching midlateral stripe in *S. rubrimaculata*; and 6 dark brown saddles, each continuing to the flank, forming globular shaped bars in *S. scyphovecteta*), a dissociated basal caudal bar with a slightly vertical elongated dark blotch at the centre and a small dark spot at the upper extremity of the caudal-fin base (vs. dissociated, forming a vertically elongated blotch at middle and another two spots, one each at dorsal and ventral extremities of fin base in *S. koladynensis*; black bar extending from dorsal to ventral extremities of caudal-fin base in *S. reticulata*; black blotch at middle of caudal-fin base extending on base of branched caudal-fin rays in *S. rubrimaculata*; and incomplete with black blotch at midlateral, leaving gaps of about half eye diameter each on both extremities of caudal-fin base in *S. scyphovecteta*) and absence of suborbital flap in male (vs. flap present in all four species); from *S. puncticeps* in the absence of regularly distributed dark brown spots on head (vs. regularly distributed dark brown spots, except ventral surface, on head), a single black spot at dorsal-fin base covering unbranched and first two branched rays (vs. 2-3 dark brown to grey blotches at base of dorsal fin) and deeply embedded minute cycloid scales covering whole body (vs. body in front of dorsal fin scaleless); and from *S. sikmaiensis* in having a processus dentiformis (vs. absent) and fewer bars on the body (12-16 vs. 17-20).

There is little information available on the diversity of fish, particularly species of *Schistura*, from Barak drainage in Mizoram. *Schistura* species listed and described from Barak drainage of Mizoram includes *S. aizawlensis*, *S. corica* Hamilton, *S. chindwinica*, *S. kangjupkhulensis, S. multifasciata, S. paucireticulata, S. rupecula, Schistura savona, S. scaturigina*, *S. sikmaiensis*, *S. tirapensis* and *S. vinciguerrae* (Ramanujam, 2005; Kar & Sen, 2007; Karmakar & Das, 2007; Lokeshwor *et al*., 2013). *S. mizoramensis* is distinguished from *S. corica* in the absence of suborbital flap (vs. presence) in male and the presence of a prominent dark brown longitudinal stripe along midlateral line from upper edge of gill opening to middle of caudal-fin base (vs. vs. no lateral stripe). The identity of *S. kangjupkhulensis*, *S. rupecula*, *S. sikmaiensis* and *S. vinciguerrae* is doubtful as *S.*

rupecula is originally described from the Indus basin whereas *S. kangjupkhulensis* is known only from Chindwin basin and *S. sikmaiensis* and *S. vinciguerrae* are known only from the Irrawaddy basin. Nevertheless, *S. mizoramensis* is distinguished from *S. kangjupkhulensis, S. rupecula* and *S. vinciguerrae* in having a prominent dark brown longitudinal stripe along midlateral line from upper edge of gill opening to middle of caudal-fin base (vs. no lateral stripe), a dark brown stripe on the dorsal midline from dorsal-fin origin to dorsal part of caudal-fin base (vs. no dorsal stripe). It is further distinguished from *S. kangjupkhulensis* in having 16-17 (vs. 15) branched caudal fin rays from *S. rupecula* in having 16 or 17 (vs. 18) branched caudal fin rays and from *S. vinciguerrae* in having a single black spot at dorsal-fin base covering unbranched and first two branched rays (vs. 2 dark blotches, one blotch covering base of simple and first branched rays and a second one covering base of 4-8 branched rays). The distinguishing characters of *S. mizoramensis* from other species listed from Barak drainage of Mizoram were already noted above.

Table 5.2 Biometric data of *Schistura mizoramensis* (n=9). Ranges include values of holotype.

	holotype	**range**	**mean**	**SD**
Standard length (mm)	53.2	44.9-56.0		
In % of standard length				
Dorsal head length	20.3	19.5-21.4	20.3	0.7
Lateral head length	20.7	20.2-22.7	21.2	0.9
Pre-dorsal length	52.8	51.3-54.8	52.8	1.1
Pre-pelvic length	53.0	50.7-54.0	52.3	1.1
Pre-anus length	71.8	69.3-75.3	71.9	1.9
Pre-anal length	80.5	77.5-82.1	79.3	1.6
Head depth at eye	9.4	8.9-10.0	9.6	0.4
Head depth at occiput	11.1	10.2-11.7	11.1	0.5
Body depth at dorsal-fin	13.0	11.4-13.8	12.9	0.7
Body depth at anal-fin	12.0	10.5-12.2	11.8	0.6
Depth of caudal peduncle	10.0	8.9-10.3	9.9	0.5
Length of caudal peduncle	14.5	13.6-14.7	14.2	0.4
Head width at nare	10.7	9.8-10.7	10.2	0.3
Head width at eye	13.3	12.0-13.3	12.7	0.4
Maximum head width	14.3	14.1-14.9	14.5	0.3
Body width at dorsal-fin origin	12.0	11.3-12.4	12.0	0.4
Body width at anal-fin origin	7.3	6.8-8.0	7.5	0.4
Height of dorsal-fin	12.6	11.5-13.1	12.3	0.6
Length of upper caudal-fin rays	19.2	17.4-20.7	19.2	1.0
Length of lower caudal-fin rays	18.8	18.8-21.7	20.3	1.1
Length of median caudal-fin rays	14.1	12.4-14.3	13.8	0.7
Length of anal-fin	15.2	13.6-15.2	14.4	0.6
Length of pelvic-fin	17.7	16.1-18.5	17.2	0.8
Length of pectoral-fin	20.5	19.0-20.7	19.8	0.7
In % of dorsal head length				
Snout length	46	45-50	47	1.2
Eye diameter	20	19-21	20	0.8
Interorbital width	32	30-33	32	0.9

Figure 5.12 *Schistura mizoramensis*; PUCMF 13021, holotype, 53.2 mm SL; lateral, dorsal and ventral views.

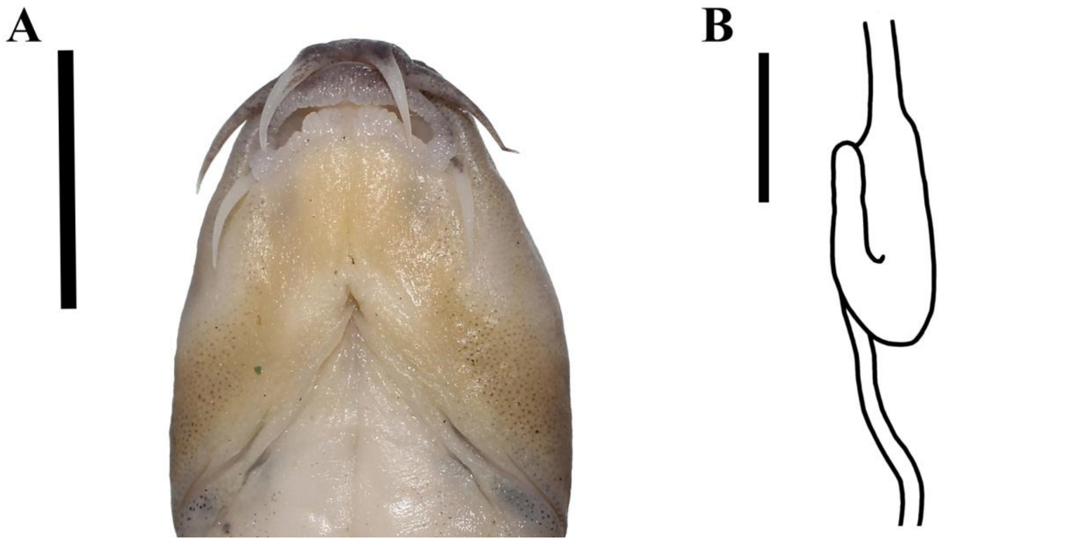

Figure 5.13 *Schistura mizoramensis*, A) PUCMF 13022, paratype, 51.8 mm SL; ventral view of head; B) PUCMF 13023, paratype, 56.0 mm SL; digestive tract. Scale bar 5 mm.

5.2.3 *Exostoma sawmteai*, Lalramliana, Lalronunga, Lalnuntluanga & Ng, 2015 (Figure 5.14)

Type material: Holotype. PUCMF 14011, 79.3 mm SL; India: Mizoram: Champhai District: Pharsih River, a tributary of Tuivai River (Barak River drainage) in the vicinity of Kawlbem, 23°51'58" N 93°17'20" E; S. Lalronunga *et al*., 13 April 2013. Paratypes. PUCMF 14012, 13, 52.1-84.9 mm SL; data as for holotype.

Diagnosis: *Exostoma sawmteai* differs markedly from the other species of the genus from Ganges-Brahmaputra basin in having the posterior end of the adipose fin adnate with (vs. separated by a distinct notch from) the dorsal procurrent caudal-fin rays. It further differs from all congeners in having a unique combination of the following characters: snout length 48-55 % HL; eye diameter 8-11 % HL; pectoral-pelvic distance 28.6-32.8 % SL; body depth at anus 11.5-14.1 % SL; length of adipose-fin base 30.7-37.2 % SL; caudal-peduncle length 18.4-20.3 % SL; caudalpeduncle depth 10.1-11.7 % SL; lunate caudal fin; and 38-39 total vertebrae.

Description: Biometric data as in Table 5.3. Body elongate, sub-cylindrical, slightly depressed anteriorly to dorsal-fin origin; compressed posteriorly; dorsal profile rising evenly from tip of snout to head, slowly increasing from head upto origin of dorsal fin, sloping gently to end of caudal peduncle. Ventral profile flat to anal-fin base, sloping gently dorsally from anal-fin base to end of caudal peduncle. Anus closer to anal-fin base than posterior base of pelvic fin. Head and predorsal region of body strongly depressed, snout broadly rounded. Head and abdominal region moderately broad. Gill openings moderate, extending ventrally from origin of lateral line to base of pectoral fin. Eye small, subcutaneous, located dorsally on head.

Mouth inferior and transverse; lips thick, fleshy, papillate; post-labial fold continuous. Teeth large, flattened, oar-shaped; deeply embedded in skin; dentition homodont. Premaxillary tooth patches almost entirely exposed when mouth closed. Tooth patches separated at midline in both jaws. Barbels four pairs. Maxillary barbell short, extending to edge of opercle, base wide with thin flap of skin tapering towards pointed tip, ventral surface with closely arranged vertical furrows. Nasal barbel reaching posterior margin of orbit, base wide with thin flap of skin. Medial mandibular-barbel origin close to midline, extending to midway between its base and that of pectoral fin. Lateral mandibular barbel originating posterolateral of medial mandibular barbel, extending beyond base of pectoral fin. Tubercles small, scattered all over dorsal and lateral part of head, clustered and larger at base of pectoral fin.

Dorsal fin with i,6 (14), its origin anterior to pelvic-fin origin, no strong spine and serrations, fin margin slightly concave. Adipose fin long and deep, posterior end adnate with upper procurrent caudal-fin rays. Pectoral fin large, with i,8,i (2), i,9 (5) or i,10* (7) rays, margin broadly rounded, first unbranched ray broad with regular striae on ventral surface. Pelvic fin enlarged, with i,5 (14) rays, slightly concave or rounded margin, its origin posterior to dorsal-fin origin, first unbranched ray broad with regular striae on ventral surface, tip of adpressed fin not reaching anus. Anal fin with ii,4,i (6) or ii,5* (6) rays, slightly concave posterior margin, tip of adpressed fin reaching midway between its origin and caudalfin base. Caudal fin lunate, with i,7,7,i (14) principal rays. Skin smooth and scaleless. Lateral line complete and mid-lateral. Vertebrae 23 + 15 = 38 (6), 24 + 14 = 38 (4), 23 + 16 = 39 (1) or 24 + 15 = 39* (1).

Coloration: In 70 % ethanol: dorsolateral surfaces of body brown; ventral surface of body anterior to anal-fin origin light cream. Dorsal, pectoral, pelvic and anal fins hyaline with brown interradially on anterior half of fins. Adipose fin light cream. Caudal fin hyaline with scattered dark melanophores arranged vertically across posterior half of fin. Maxillary and nasal barbells brown dorsally, light cream ventrally. Mandibular barbels light cream.

Etymology: The species is named after Sawmtea (Vanalalmalsawma), the field assistant to Lalramliana, who assisted in collecting the specimens.

Distribution and habitat: *Exostoma sawmteai* is known only from the type locality, Pharsih River, a tributary of Tuivai River (Barak River drainage) in Mizoram, northeast India (Figure 5.11), the same type locality as *Schistura maculosa*. The species was collected from a small moderately flowing river with having a substratum of rocks, pebbles and sand. It was found associated with *S. maculosa*.

Comparision: *Exostoma sawmteai* can be distinguished from the only species of *Exostoma* known from the Surma-Meghna river system, *viz. E. barakensis* Vishwanath & Joyshree in having the posterior end of the adipose fin adnate with (vs. separated by a distinct notch from) the dorsal procurrent caudal-fin rays, a shorter snout (48-55 % HL vs. 58-62) and a more slender body (depth at anus 11.5-14.1 % SL vs. 14.0-16.5). *Exostoma sawmteai* differs from *E. labiatum* (McClelland) (typelocality: Mishmee Hills, Meghalaya, India), the only congener known from the neighboring Brahmaputra River drainage, in having a longer adipose fin (length of base 30.7-37.2 % SL vs. 26.2) and the posterior end of the adipose fin adnate with (vs. separated by a distinct notch from) the dorsal procurrent caudal-fin rays. *Exostoma sawmteai* differs from *E. berdmorei* Blyth in having a shorter snout (48-55 % HL vs. 57-58), a shorter pectoral-pelvic distance (28.6-32.8 % SL vs. 32.8-36.0), and a lunate (vs. gently forked) caudal fin.

Among species from the Irrawaddy River drainage, *E. sawmteai* differs from *E. stuarti* (Hora) in having a larger eye (diameter 8-11 % HL vs. 7), a narrower head (16.5-19.8 % SL vs. 23.3), a more slender body (depth at anus 11.5-14.1 % SL vs.

16.3), the posterior end of the adipose fin adnate with (vs. separated by a distinct notch from) the upper procurrent caudal-fin rays and a deeper caudal peduncle (10.1-11.7 % SL vs. 7.7); and from *E. vinciguerrae* Regan in having a deeper caudal peduncle (10.1-11.7 % SL vs. 7.6-9.3) and fewer total vertebrae (38-39 vs. 40-42).

Exostoma sawmteai is distinguished from the two congeners of the Chao Phraya River drainage: from *E. effrenum* Ng & Vidthayanon in having an adipose fin with a longer base (30.7-37.2 % SL vs. 25.8-29.0) and its posterior end adnate with (vs. separated by a distinct notch from) the upper procurrent caudalfin rays, a shorter (18.4-20.3 % SL vs. 20.5-21.3), a deeper caudal peduncle (10.1-11.7 % SL vs. 5.1-7.0), a shorter snout (48-55 % HL vs. 57-65) and a smaller eye (diameter 8-11 % HL vs. 12-15); and from *E. peregrinator* Ng & Vidthayanon in having a shorter snout (48-55 % HL vs. 56-61) and a deeper caudal peduncle (10.1-11.7 % SL vs. 6.2-8.5).

There is some indication that additional undescribed species of *Exostoma* may already be known in the Indian subcontinent. Material from the Brahmaputra River drainage in Arunachal Pradesh and Nagaland identified as *E. labiatum* by Hora & Silas (1952) differs from the holotype of *E. labiatum* in having the adipose fin confluent with (vs. separate from) the upper procurrent caudal-fin rays, suggesting that it may represent an unnamed species. Further, the records of *E. berdmorei* from the Gumti and Feni rivers (the fomer is part of the Surma-Meghna river system and the latter is an independent river drainage to the southeast of the Surma-Meghna River system) by Kar & Sen (2007) also await verification.

Table 5.3 Biometric data for *Exostoma sawmteai* (n = 14).

	holotype	**range**	**mean**	**SD**
Standard length (mm)	79.3	52.1-84.9		
Percent of standard length				
Predorsal length	42.2	39.8-44.0	41.6	1.29
Preanal length	73.8	71.0-74.5	72.5	1.44
Prepelvic length	47.7	46.3-49.5	47.8	1.03
Prepectoral length	15.5	14.6-19.2	17.0	1.51
Length of dorsal-fin base	12.5	12.4-13.5	12.9	0.41
Length of anal-fin base	7.9	7.5-10.4	8.7	1.09
Pelvic-fin length	17.7	15.9-19.0	17.6	0.89
Pectoral-fin length	23.6	21.8-24.7	23.1	0.86
Caudal-fin length	21.3	19.0-25.2	21.5	2.02
Length of adipose-fin base	32.7	30.7-37.2	33.4	2.27
Dorsal-to-adipose distance	13.9	7.4-16.7	12.6	2.97
Length of caudal peduncle	20.3	18.4-20.3	19.0	0.63
Depth of caudal peduncle	10.1	10.1-11.7	10.9	0.53
Body depth at anus	11.5	11.5-14.1	13.0	0.81
Pectoral-pelvic distance	32.8	28.6-32.8	30.8	1.26
Head length	22.7	22.0-25.0	23.5	1.01
Head width	18.0	16.5-19.8	18.5	0.91
Head depth	11.1	10.8-12.4	11.6	0.44
Percent of head length				
Snout length	51	48-55	52	2.3
Interorbital distance	27	27-30	28	1.2
Eye diameter	8	8-11	9	0.7
Nasal barbel length	41	35-46	42	3.7
Maxillary barbel length	67	67-89	80	6.3
Inner mandibular barbel length	6	6-14	11	2.9
Outer mandibular barbel length	27	27-40	31	4.1

Figure 5.14 *Exostoma sawmteai*, PUCMF 14011, holotype, 79.3 mm SL; India, Mizoram, Pharsih River.

5.3 Diversity

The study resulted in the documentation of 102 species of fish belonging to 9 orders, 24 families and 62 genera (Table 5.4), which is about 24% of the freshwater fishes recorded from northeast India (Goswami *et al.*, 2012). The study shows that the fish diversity is dominated by the order Cypriniformes (48.98% of the total species) followed by order Siluriformes with 29.59% of the total species, which is in accordance with other studies from northeast India (Nath & Dey, 2000b; Ramanujam, 2005; Kar & Sen, 2007; Karmakar & Das, 2007; Vishwanath *et al.*, 2007; Bagra *et al.*, 2009; Bagra & Das, 2010; Ramanujam *et al.*, 2010; Goswami & Ali, 2012; Acharjee *et al.*, 2012; Goswami *et al.*, 2012; Tesia & Bordoloi, 2012; Humtsoe & Bordoloi, 2014; Islam *et al.*, 2013). The percentage wise distribution of different orders is shown below (Figure 5.15). At present, 9 species *viz. Schistura aizawlensis*, *S. maculosa*, *S. mizoramensis*, *S. paucireticulata*, *Exostoma sawmteai*, *Glyptothorax maceriatus*, *G. scrobiculus*, *Pseudolaguvia virgulata* and *Monopterus ichthyophoides* are recorded only from Mizoram.

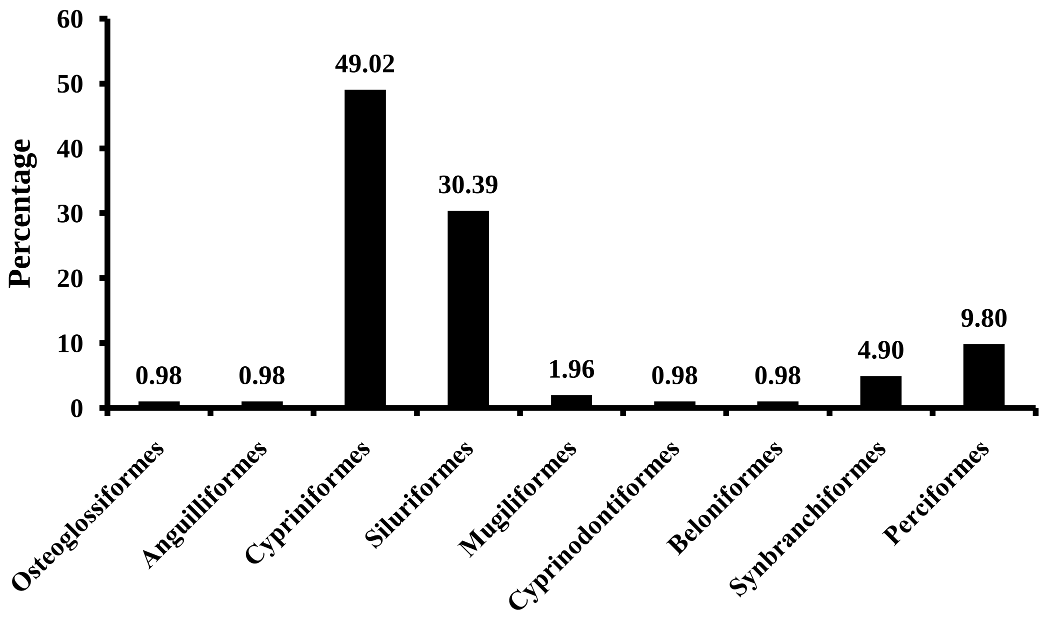

Figure 5.15 Percentage-wise distributions of different orders.

Cyprinidae is the most species rich family with 32 species (31.37% of the total species) followed by Sisoridae with 15 species (15.69% of the total species). The percentage wise distribution of different families is shown below (Figure 5.16). *Schistura* and *Glyptothorax* are the most speciose genus with seven species each, which is 6.86% of the total species recorded.

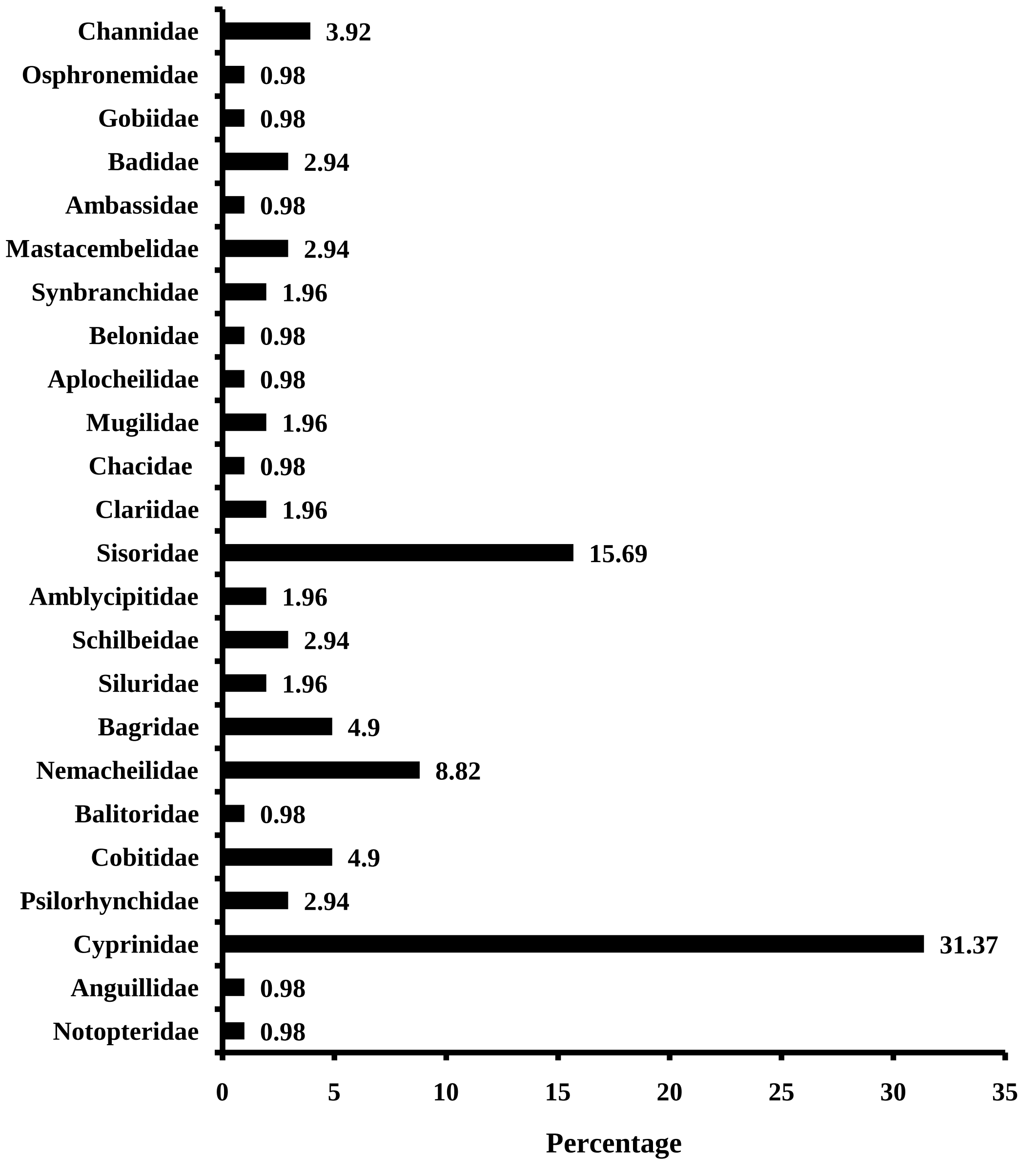

Figure 5.16 Percentage-wise distribution of different families.

Barman (1989), Ramanujam (2005), Kar & Sen (2007) and Karmakar & Das (2007) recorded 101 species of fish belonging to 61 genera, 19 families and 7 orders from rivers of Barak drainage of Mizoram. However, the identity of some of the species recorded by these workers are doubted by subsequent authors (Anganthoibi & Vishwanath, 2010a,b,c; Ng & Lalramliana, 2010b; Darshan *et al*., 2011; Rameshori & Vishwanath, 2012; Dishma & Vishwanath, 2012, 2013; Lokeshwor & Vishwanath, 2013a,b). These studies conducted so far have focused only on a miniscule part of the 3 drainages (Kar & Sen, 2007); it is therefore not surprising to find that closer study of the freshwater fishes of these drainage reveals numerous species (often previously unnamed) endemic to it, particularly the hill stream component of this fauna (e.g. Anganthoibi & Vishwanath, 2010; Dishma & Vishwanath, 2012; Ng *et al*., 2013, Lalronunga *et al*., 2013a). Several new species were recently described from the Barak drainage of Mizoram (Ng & Lalramliana, 2010a,b, 2012a,b; Lalramliana, 2012; Lokeshwor *et al*., 2013,) which reveals that the ichthyofaunal diversity is highly underestimated. The ichthyofaunal inventorisation of this drainage in Mizoram is far from complete, and the number of species is likely to increase in the future.

The order Osteoglossiformes is represented by a single family, Notopteridae. Only a single species, *Notopterus notopterus* is recorded during the survey. Ramanujam (2005), Kar & Sen (2007) and Karmakar & Das (2007) recorded *N. notopterus* from the Barak drainage of Mizoram. Karmakar and Das (2007) further reported the occurrence of *Chitala chitala* (Hamilton) from Mizoram on the basis of specimens observed in the field which were not collected. Since their sampling covers ponds, lakes and fish farms and further did not mention the locality where specimens of *C. chitala* were observed, the report occurence of this species from Mizoram didn’t confirm its occurrence in the river system.

The order Anguilliformes is represented by a single family, Anguillidae. A single species *Anguilla bengalensis* is collected during the study. Ramanujam (2005) reported the occurrence of this species from Kaladan river of Mizoram; the present study reports the occurrence of *A. bengalensis* for the first time in Barak drainage of Mizoram.

The Order Cypriniformes is represented by five families *viz.* Cyprinidae, Psilorhynchidae, Cobitidae, Balitoridae and Nemacheilidae. The family Cyprinidae is the most speciose family with thirty two species belonging to nineteen genera. Out of these species four species of *Garra* cannot be readily determined to the species level. Out of the thirty two species recorded in this study, twenty four species *viz. Amblypharyngodon mola*, *Barilius barila*, *Opsarius barna*, *O. bendelisis*, *O. tileo*, *Cabdio morar*, *Chagunius chagunio*, *Crossocheilus latius*, *Danio dangila*, *Devario aequipinnatus*, *Esomus danrica*, *Garra lissorhynchus*, *Gymnostomus ariza*, *Labeo calbasu*, *L. gonius*, *Laubuka laubuca*, *Neolissochilus hexagonolepis*, *Pethia conchonius*, *Puntius chola*, *P. sophore*, *Rasbora daniconius*, *Securicula gora*, *Systomus clavatus* and *Tor tor* were previously recorded from rivers of Barak drainage of Mizoram (Barman, 1989; Ramanujam, 2005; Kar & Sen, 2007; Karmakar & Das, 2007).

Several species *viz. Barilius vagra* (Hamilton), *Opsarius bakeri* Day, *O. barnoides* (Vinciguerra), *O. shacra* (Hamilton), *Cirrhinus mrigala* (Hamilton), *Crossocheilus burmanicus* Hora, *Devario naganensis* (Chaudhuri), *Danio rerio* (Hamilton), *Garra annandalei* Hora, *G. gotyla*, *G. gravelyi* (Annandale), *G. kempi* Hora, *G. nasuta* (McClelland), *G. notata* (Blyth), *Pethia ticto* (Hamilton), *Rasbora rasbora* (Hamilton), *Salmostoma bacaila* (Hamilton), *S. phulo* (Hamilton), *Systomus sarana* (Hamilton), *Tor mosal* (Hamilton) and *T. putitora* (Hamilton), which were recorded from rivers of Barak drainage of Mizoram by previous workers (Barman, 1989; Ramanujam, 2005; Kar & Sen, 2007; Karmakar & Das, 2007) were not recorded in the present study. The absence of *Opsarius shacra*, *Pethia ticto*, *Systomus sarana*, *Rasbora rasbora*, *Salmostoma bacaila*, *S. phulo*, *Tor mosal* and *T. putitora* in this study could be due to difference in sampling methods and locality, further sampling in different rivers and tributaries of Barak drainage may lead to the confirmation of these species. *Labeo bata* and *Neolissochilus hexastichus* are reported for the first time from Barak drainage of Mizoram. These two species were previously recorded only from Kaladan drainage of Mizoram (Kar & Sen, 2007) whereas *Labeo dyocheilus* is reported for the first time from Mizoram.

Howes (1983) stated that *Barilius* was not monophyletic, identifying two separate lineages: one group included *B. barila*, the type species, as well as *B. evezardi* Day, *B. modestus* Day, and *B. vagra*; the other group contained all of the remaining species of *Barilius*, what Howes (1980) identified as ‘‘group (ii)” *Barilius*. Following Howes (1983), Tang *et al*. (2010) restricted *Barilius* to four species: *B. barila*, *B. evezardi*, *B. modestus* and *B. vagra*; and all other species previously classified as *Barilius* are placed in the genus *Opsarius*. This classification is followed by Kottelat (2013). The reported occurrence of *Opsarius bakeri* (Kar & Sen; 2007) and *O*. *barnoides* (Ramanujam, 2005; Kar & Sen; 2007) from Barak drainage of Mizoram is doubtful as *O. bakeri* is endemic to the Western Ghats of India (Talwar & Jhingran, 1991; Raagam & Rema Devi, 2005; Rema Devi *et al*., 2005) and *O. barnoides* is known only from the Irrawaddy and Salween drainage of Myanmar (Talwar & Jhingran, 1991; Doi, 1997; Tejavej, 2012).

Ramanujam (2005) reported *Cirrhinus reba* (Hamilton) from Tlawng River and subsequently Kar & Sen (2007) reported *Gymnostomus ariza* from Tlawng River.

These two species are infact a same species as *C. reba*, which is commonly treated as a valid species of *Cirrhinus* (e.g. Talwar & Jhingran, 1991) is a junior synonym of *G. ariza* (Roberts, 1997). *Cirrhinus mrigala* (Hamilton) was reported from Tlawng River by both Ramanujam (2005) and Kar & Sen (2007). Karmakar & Das (2007) also included this species in their checklist based on specimens observed it in the field (not collected) but failed to mention from which river and drainage it was observed. Kottelat (2013) tentatively follows Roberts (1997) in placing *C. mrigala* as a junior synonym of *C. cirrhosus.* Only *Gymnostomus ariza* is collected in the present study.

The record of *Crossocheilus burmanicus* Horafrom Tuirial River, Barak drainage (Ramanujam, 2005; Kar & Sen, 2007) is doubtful as *C. burmanicus* is known only from the Chindwin, Irrawaddy and Salween basins of India, Myanmar and China (Kottelat, 2003b). *Devario naganensis* (Chaudhuri) was recorded from Barak, Karnaphuli and Kaladan drainages of Mizoram (Ramanujam, 2005; Kar & Sen, 2007; Karmakar & Das, 2007). Only Karmakar & Das (2007) provides a description of the species which is very brief and may point to several other species within the genus and the description is also inconsistent with the description of *D. naganensis*. Chaudhuri (1912) described *D. naganensis* from Chindwin basin of Nagaland and Manipur, Northeast India as a species with two pairs of barbels and a complete lateral line (from drawing) which is also observed by subsequent authors (Ramananda & Vishwanath, 2014). Karmakar & Das (2007) diagnosed their specimens as having barbels in a pair of one or two or entirely absent and an incomplete or entirely absent lateral line. The records of *D. naganensis* may be due to misidentification as this speciesis known only from Chindwin basin of Nagaland and Manipur (Talwar & Jhingran, 1991; Vishwanath *et al*., 2007). The species has not been recorded in surveys and further survey must be made in the adjacent basins in Myanmar (Vishwanath, 2010a).

Five species of *Garra viz. G.* cf. *dampaensis*, *G.* cf. *gotyla*, *G. lissorhynchus*, *G.* cf. *manipurensis* and *G.* aff. *naganensis* were collected during the study. *G. lissorhynchus* was hitherto recorded from rivers of Barak drainage of Mizoram (Ramanujam, 2005; Kar & Sen, 2007). Lalronunga *et al*. (2013a) described *G. dampaensis* from Seling River (tributary of Karnaphuli River) within Dampa Tiger Reserve. The species is among the *lissorhynchus* complex of Menon (1964) in having a dark streak near the free margin of the dorsal fin, W-shaped band on the caudal fin. It differs from *G*. *lissorhynchus* and other species within the complex in having scaled (vs. naked) breast and belly. A species which fits the description of *G. dampaensis* were collected from Tuirial River, addidional studies and comparision using molecular technique will help in resolving the identity of this species.

A species of *Garra* with proboscis cannot be determined to the species level. Four species of *Garra* with proboscis *viz. G. gotyla* (Gray), *G. gravelyi* (Annandale), *G. nasuta* (McClelland), *G. notata* (Blyth) were recorded from rivers of Barak drainage of Mizoram (Ramanujam, 2005; Kar & Sen, 2007; Karmakar & Das, 2007). The present species closely resembles *G. gotyla* in its proboscis morphology but have some differences, especially in its higher range of lateral line scales (33-36 vs. 33-34) and fewer transverse scale rows between lateral line and anal-fin origin (3½ vs. 4½). Further comparision of this species with proboscis bearing species of the region is required to verify its identity. The record of *G. gravelyi* from Tuirial River by Kar & Sen (2007) may be due to misidentification as the type locality this species is He-Ho stream Southern Shan State, Myanmar (Annandale, 1919) and is currently considered to be occurring in Salween river basin of Myanmar and Manipur river basin

(Chindwin drainage). Blyth (1860) described *Platycara notata* from Tenasserim, Myanmar which was recognised as a *Garra* species by subsequent authors. The species was redescribed (Hora, 1921; Menon, 1964) but it is not clear whether the two authors use the same or different materials (Kullander & Fang, 2004). The only record of this species after these authors was from the Maharastra, India (Rao, 1974) which was very doubtful (Talwar & Jhingran, 1991). McClelland (1838) described *G. nasuta* from a single specimen collected from the Khasi hills. Neither McClelland's text nor the accompanying illustration displays sufficient information to diagnose the species from its congeners except for the presence of a pit between the nares (Nebeshwar & Vishwanath, 2013). No specimens bearing a pit between the nares were collected during the study period.

Ramanujam (2005) listed *Garra manipurensis* from Kaladan drainage of Mizoram. A species of *Garra* were collected from the study area which fits the description of *G. manipurensis* except in dorsal and caudal fin. Vishwanath & Sarojnalini (1988) mentioned the type locality of *G. manipurensis* as Manipur River at Sherou in the Chindwin drainage of Manipur. However the type locality as mentioned in the original description may be wrong as several subsequent collections from the type locality did not represent the species, but instead it is represented in the collections from Tuivai River in the Barak drainage of Manipur (Nebeshwar *et al*., 2009). The present species differs from *G. manipurensis* in having dark pigmentataion (vs. no pigmentation) on dorsal and caudal fins. Subsequent comparision of this species with *G. manipurensis* through molecular technique will help in resolving the identity of this species.

A species of *Garra* which resembles *G. naganensis* are collected from all the study sites. This species is similar to *G. naganensis* in its overall shape, morphology and number of lateral line scales, but differs from *G. naganensis* in having lesser number of branched dorsal fin rays (7 vs. 8). Further studies are required to clarify the identity of this species. *Garra annandalei* (Ramanujam, 2005; Kar & Sen, 2007; Karmakar & Das, 2007) and *Garra kempi* (Kar & Sen, 2007) were listed from rivers of the Barak drainage of Mizoram. Since they did not give any description, photograph or mention where the specimens were deposited, further studies and sampling are required to confirm these species.

The family Psilorhynchidae is represented by three species *viz. Psilorhynchus homaloptera*, *P. nudithoracicus* and *P. sucatio*. Three species groups of *Psilorhynchus* were recognised (Conway, 2011; Conway *et al*., 2013) *viz. P. homaloptera* species group, *P. nudithoracicus* species group and *P. balitora* species group. *P. sucatio* is not referable to these species groups. Three species of *Psilorhynchus* are listed from rivers of Barak drainage of Mizoram (Ramanujam, 2005; Kar & Sen, 2007; Karmakar & Das, 2007): *P. balitora*, *P. nudithoracicus* and *P. sucatio*. Many authors have considered *P. balitora* to be a wide spread species, occurring in Bangladesh, India, Myanmar and Nepal (Jayaram, 1981; Rainboth, 1983; Talwar & Jhingran, 1991; Menon, 1999; Karmakar, 2000). *P. balitora* is restricted to the Ganges tributaries of eastern Nepal, northwest Bengal and west Bengal, and the north bank tributaries of Brahmaputra in West Bengal (Conway & Mayden, 2008a). Many new species of *P. balitora* species group are recently described (Conway & Mayden, 2008a,b; Conway & Britz, 2010; Conway *et al*., 2013; Shangningam & Vishwanath, 2013a,b; Lalramliana *et al*., 2014, 2015) which may account for its wide geographical distribution in older literatures. *P. balitora* is restricted to the Ganges tributaries of eastern Nepal, northwest Bengal and west Bengal, and the north bank tributaries of Brahmaputra in West Bengal (Conway & Mayden, 2008a). The reported occurrence of *P. balitora* in the Barak drainage of Mizoram (Ramanujam, 2005; Kar & Sen, 2007) needs confirmation. This study reports the occurrence of *P. homaloptera* in Mizoram for the first time. Yazdani *et al*. (1990) assigned a new and separate generic name *Psilorhynchoides* for *P. homaloptera* and *P. pseudecheneis* Menon & Datta (the only known species of *P. homaloptera* group known then); however, the characters used to diagnose the genus are not restricted to these two species but have a mosaic distribution among species within the genus *Psilorhynchus* (Conway & Kottelat, 2007; Conway, 2011; Conway *et al*., 2013). Therefore, *Psilorhynchus* is still preferred for these species.

The family Cobitidae is represented by five species belonging to three genera *viz. Botia dario*, *B. rostrata*, *Lepidocephalichthys berdmorei*, *L. guntea* and *Pangio pangia*. All the species observed in this study had already been reported by previous workers from rivers of the Barak drainage of Mizoram (Barman, 1989; Ramanujam, 2005; Kar & Sen, 2007; Karmakar & Das, 2007). Apart from these species, Kar & Sen (2007) listed *Lepidocephalichthys annandalei* from Tlawng River. This species is known from the Ganges and Brahmaputra drainages of India, Bangladesh and Nepal and is easily distinguished from all other members of *Lepidocephalichthys* by unique caudal fin coloration, consisting of two distinct black spots; one at upper base of fin and one at center of posterior edge of fin (Havird *et al*., 2010). The record of this species from the Barak drainage of Mizoram needs confirmation as Kar & Sen (2007) neither gives any description nor mention where specimens were deposited. Karmakar and Das (2007) placed *L. berdmorei* and *L. guntea* in the genus *Lepidocephalus*, with which it is often confused with (Deein *et al*., 2014). *Lepidocephalichthys* differs from *Lepidocephalus* in having no lateral line (vs. complete lateral line); 6 (vs. 8-9) branched dorsal-fin rays; 7 (vs. 9-13) pectoral-fin rays and lamina circularis (fusion and hardening of pectoral rays) of mature male on 7th and 8th rays (vs. 2nd ray) of pectoral fin (Havird *et al*., 2010; Deein *et al*., 2014). Menon (1992) considered *B. rostrata* as a junior synonym of *B. almorhae* which was followed by Kottelat (2004). But the two species can be easily distinguished from their colour pattern and in their body depth (Ng, 2007).

The family Balitoridae is represented by a single species, *Balitora brucei.* The species is distributed in northern and northeastern India, Nepal, Bangladesh and Bhutan (Chen *et al*., 2005; Vishwanath *et al*., 2007; Britz, 2010; Bhoite *et al*., 2012). It was previously recorded from river of Barak drainage of Mizoram (Ramanujam, 2005; Kar & Sen, 2007; Karmakar & Das, 2007).

The family Nemacheilidae is represented by nine species belonging to three genera *viz. Acanthocobitis botia, Physoschistura tuivaiensis, Schistura aizawlensis, S. chindwinica, S.* cf. *fasciata, S. maculosa, S.mizoramensis, S. paucireticulata* and an unidentified species of *Schistura*. *Acanthocobitis botia* was recorded by previous workers from the rivers of Barak drainage of Mizoram (Ramanujam, 2005; Kar & Sen, 2007; Karmakar & Das, 2007). Lokeshwor *et al.* (2012) described *Physoschistura tuivaiensis* from Tuivai River (Barak drainage) of Manipur, India. The present study records this species for the first time from Mizoram. *Schistura aizawlensis, S. maculosa, S. mizoramensis* and *S. paucireticulata* were all recently described from the Barak drainage of Mizoram (Lalramliana, 2012; Lokeshwor *et al.*, 2013; Lalronunga *et al*., 2013b; Lalramliana *et al*., 2014). Lokeshwor *et al.* (2013) described *S. paucireticulata* from Tuirial River and remarks that this species is known only from Tuirial River. The present study documents this species from Tlawng River and its tributaries. Tilak & Hussain (1990) described *S. chindwinica* from the Chindwin drainage in Manipur, India, but Vishwanath & Nebeshwar (2004) redescribedthe species and reported that the typelocality mentioned in the original description iserroneous, and that the specimens had been collectedin the Barak drainage in Manipur. To support the above report, Lalramliana (2012) collected *S. chindwinica* from Tuila River, a tributary of Tuivai River (Barak River drainage) in Mizoram. The present study also documents this species from Tuivai River and its tributaries.

A species of *Schistura* which fits the description of *S. fasciata* are collected from all the major rivers of the study sites. Lokeshwor & Vishwanath (2011) described *S. fasciata* from the Barak River of Manipur. They later described *S. nebeshwari* from the Kaladan drainage of Mizoram which closely resemble *S. fasciata* (Lokeshwor & Vishwanath, 2013c). *S. nebeshwari* differs from *S. fasciata* in having the lower lip with a broad moderately developed lateral pad (vs. slender without forming pads), plain fins (vs. a single row of black bar on dorsal, pectoral, pelvic and anal fins), in the absence (vs. presence) of a shallow median incision on the upper lip, and in the presence (vs. absence) of a median notch on the lower jaw (Lokeshwor & Vishwanath, 2013c). The present species is similar to *S. fasciata* but differs from it in the presence (vs. absence) of a median notch on the lower jaw. Molecular studies will be an important tool in determining the conspecificity of *S. fasciata*, *S. nebeshwari* and *S*. cf. *fasciata*. Another species of *Schistura* cannot be identified to the species level. Further comparison with other species occurring in the Ganges-Brahmaputra-Meghna basin and adjacent basins will help in resolving the identity of this species. A species of *Schistura* resembling *S. porocephela* from the Kaladan drainage were collected from Tuirial River. Since drainage isolation is an important factor in determining the species of nemachilid (Lokeshwor & Vishwanath, 2013a), comparing this species with *S. porocephela* through morphological and molecular studies will help in determining the identity of this species. The reported occurrence of *S. rupecula, S. savona, S. scaturigina, S. sikmaiensis* and *S. vinciguerrae* in the Barak drainage of Mizoram (Ramanujam, 2005; Kar & Sen, 2007; Karmakar & Das, 2007) is doubtful and the reasons have already been discussed earlier.

The family Amblycipitidae is represented by two species belonging to a single genus *viz. Amblyceps laticeps* and *A. mangois*. *A. mangois* is an widespread species which is recorded from Nepal, India, Bhutan, Bangladesh and Pakistan (Eschmeyer, 2015) but precise distribution is unknown as literature accounts of this species may refer to almost any of the species in this genus (Ferraris, 2007). Five species of *Amblyceps viz. A. arunchalensis* Nath & Dey, *A. apangi* Nath & Dey, *A. cerinum* Ng & Wright, *A. laticeps* and *A. tenuispinis* Blyth were subsequently described from the Ganges-Brahmaputra drainage and out of which Kar & Sen (2007) listed *A. mangois* from Tlawng River of Mizoram. The present study also listed this species from the three studied rivers. McClelland (1842) described *Olyra laticeps* from Kasyah Mountains (Khasi Hills), India. Vinciguerra (1890) placed this species under the genus *Amblyceps* which was followed by subsequent authors. Talwar & Jhingran (1991) placed *A. laticeps* as a synonym of *A. mangois* but it is readily distinguished from *A. mangois* in having a truncate (vs. deeply forked) caudal fin. It is known from South Asian country of India and Bangladesh (Ferraris, 2007; Eschmeyer, 2015) but its distribution is not well documented (Ferraris, 2007). The present record of *A. laticeps* from Tuivai River of Mzoram is a new addition to the ichthyofauna of the state.

The family Sisoridae is represented by sixteen species belonging to nine genera *viz. Bagarius bagarius*, *Erethistoides* cf. *senkhiensis*, *Exostoma sawmteai*., *Gagata cenia*, *Glyptothorax botius*, *G. cavia*, *G.* cf. *dikrongensis*, *G. maceriatus*, *G.*

scrobiculus, *G. striatus*, *G. telchitta*, *Gogangra viridescens*, *Hara hara*, *Nangra nangra*, *Pseudolaguvia spicula* and *P. virgulata*. Previous workers recorded eight species belonging to four genera under this family *viz. Conta conta* (Hamilton), *Erethistes pussilus* Müller & Troschel, *Nangra nangra*, *Gogangra viridescens*, *Glyptothorax cavia*, *G. conirostris* (Steindachner), *G. telchitta*, *G. trilineatus* Blyth, *Glyptothorax* sp., *Pseudolaguvia ribeiroi* (Hora), *P. shawi* (Hora) and *P. tuberculatus* (Prashad & Mukerji) (Kar & Sen, 2007; Karmakar & Das, 2007; Lalramliana, 2010b) from the Barak drainage of Mizoram. Out of these, only four species *viz. Nangra nangra*, *Gogangra viridescens*, *Glyptothorax cavia* and *G. telchitta* are collected in the present study.

Bagarius bagarius is the largest fish recorded from Mizoram. It is called ‘Thaichhawninu” or “Thaiinu” in the local language and is also the the most well known fish among the Mizo people and earned many places in Mizo folklores. It has not been reported from Mizoram by previous workers (Ramanujam, 2005; Kar & Sen, 2007; Karmakar & Das, 2007) despite its enormous size and fame among the local people. The species *B. bagarius* along with the genus *Bagarius* is reported for the first time from Mizoram. Apart from the Barak drainage of Mizoram, extensive ichthyological surveys taken up in different parts of Mizoram confirmed the occurrence of this species in Kaladan drainage. The probability of this species to be present in the Karnaphuli drainage of Mizoram is also high but no specimen had so far been collected or observed which may be attributed to the minimal ichthyological survey conducted in this drainage. The absence of this species in the checklists of former workers also reflects the need for thorough and organised ichthyological surveys. *Conta conta* which was earlier reported from Tlawng River (Karmakar & Das, 2007) is not collected in this study. The type locality of *C. conta* is Mahamanda

River (Ganges drainage) and it is reported from Ganges and Brahmaputra drainages of India and Bangladesh (Thomas & Page, 2006; Ferraris, 2007). The absence of this species in the present study may be due to difference in sampling methods and further collections are required to confirm its presence. *Gagata cenia* and *G. sexualis* Tilak were earlier reported from the Karnaphuli drainage of Mizoram (Kar & Sen, 2007; Karmakar & Das, 2007). The present study reports *G. cenia* and the genus *Gagata* for the first time from the Barak drainage of Mizoram. *G. sexualis* was described from North Koel River at Daltonganj, Chotanagpur, southern Bihar, India (Tilak, 1970) and is known from the Ganges and Brahmaputra River basins of India, Bangladesh and Nepal (Roberts & Ferraris, 1998; Eschmeyer, 2015). The reported occurrence of *G. sexualis* in the Karnaphuli drainage of Mizoram is doubtful but the justification is beyond the scope of this study.

Specimens of *Erethistoides* which fits the description of *E. senkhiensis* were collected from a small stream (a tributary of Tlawng River) in the vicinity of Saikhawthlir village. This represents the first record of this genus from Mizoram. *E. senkhiensis* was described from Senkhi stream (Brahmaputra basin) of Arunachal Pradesh, India (Tamang *et al.*, 2008). The genus *Erethistoides* are torrent-inhabiting catfish and torrential hill stream forms are often restricted to a particular river basin (Ng & Rachmatika, 2005; Vishwanath & Linthoingambi, 2007). Presence of specimens which resembles *E. senkhiensis* in the Barak drainage (Surma-Meghna basin) of Mizoram needs further studies. Collection of fresh materials and subsequent comparision with *E. senkhiensis* using morphology and molecular techniques will help in identifying this species.

Ramanujam (2005) and Kar & Sen (2007) listed *Erethistes pussilus* from the rivers of Barak drainage of Mizoram whereas *Hara hara* is listed only from the

Karnaphuli drainage of Mizoram (Kar & Sen, 2007). *H. hara* is recorded for the first time from the rivers of Barak drainage of Mizoram. The reported occurrence of *Erethistes pussilus* (Ramanujam, 2005; Kar & Sen, 2007) from rivers of the Barak drainage of Mizoram may be due to difference in sampling site and methods or misidentification of *H. hara* as the two species are very hard to tell apart because of their morphological and colouration similarities. The two species can be distinguished from each other on account of divergent pectoral spine serrae in *E. pussilus* as opposed to convergent pectoral spine serrae in *H. hara*, but these are almost impossible to see with the naked eye.

The genus *Exostoma* is reported for the first time from Mizoram. It is represented by a single species, *E. sawmteai*, a recently described species from Pharsih River, a tributary of Tuivai River.

Glyptothorax is the most species-diverse genus in the Sisoridae, with more than ninety nominal and about seventy valid species (Ng & Hadiaty, 2009), of which about fourty are distributed only in the Indian subcontinent (Ng & Lalramliana, 2013). The genus *Glyptothorax* is represented by seven species and is the most speciose genera in this study. Among the seven species recorded in the study, two species *viz.* *G. maceriatus* and *G. scrobiculus* were recently described from Barak drainage of Mizoram (Ng & Lalramliana, 2012a,b). Previous workers reported the occurrence of *G. cavia*, *G. conirostris* (Steindachner), *G. telchitta*, *G. trilineatus* Blyth and species which could not be identified to the species level from the Barak drainage of Mizoram (Kar and Sen, 2007; Karmakar and Das, 2007). Among the species of *Glyptothorax* previously recorded from the Barak drainage of Mizoram, only *G. cavia* and *G. telchitta* are collected in the study. *G. conirostris* is known from Jamuna River, Mahananda River basin and Indus River basin whereas *G. trilineatus* is known from

Salween River and Irrawaddy River (Ferraris, 2007). The type localites of *G. conirostris and G. trilineatus* are Simla, Himachal Pradesh, northwestern India and Tenasserim, Myanmar respectively. Fishes of the genus *Glyptothorax* are torrential hill stream forms, and the distribution of a species of the genus is often restricted to a particular river basin (Ng & Rachmatika, 2005), so the record of *G. conirostris* and *G. trilineatus* from the Barak drainage of Mizoram (Surma-Meghna basin) are very doubtful.

Glyptothorax botius is reported for the first time in Mizoram. The absence of this species from the list of previous workers may be due to the fact that it closely resembles *G. telchitta* causing much confusion on its identity (see Ng, 2005). Hamilton (1822) described *G. botius* from “Pargong, fluviis Kamrupa borealis” (=Patgaon in Assam) and *G. telchitta* from Jungipur (in West Bengal) and Nathpur (in Uttar Pradesh). Hora & Menon (1949) synonymized them retaining *G. telchitta* as the valid name, which was followed by sudsequent workers (eg. Talwar & Jhingran, 1991; Menon, 1999). Ng (2005) resurrescted *G. botius* from the synonym of *G. telchitta* and had been adopted by consequent workers (eg. Thomas & Page, 2006; Ferraris, 2007). *G. botius* differs from *G. telchitta* in having a more triangular snout when viewed laterally, the absence (vs. presence) of dark saddles on the body, a thoracic adhesive apparatus with narrower folds of skin, a shorter adipose-fin base and a deeper caudal peduncle (Ng, 2005).

McClelland (1842) described *Glyptothorax striatus* from Khasi Hills (Meghalaya) and is recorded from Meghna and Brahmaputra drainages, India and Bhutan (Eschmeyer, 2015). Karmakar & Das (2007) listed *G. striatus* from Tiau River (Kaladan basin) of Mizoram which needs verification. This species is reported for the first time from the Barak drainage of Mizoram.

A species of *Glyptothorax* which resembles *G. dikrongensis* in having an anterior extension of the unculiferous striae of the thoracic adhesive apparatus onto the gular region are collected from Tlawng and Tuirial rivers. Only 4 species with this type of adhesive apparatus are known *viz. G. indicus* Talwar & Jhingran (Ganges drainage of India and Nepal); *G. rugimentum* Ng & Kottelat (Antran, Salween and Sittang River drainages of Myanmar and Thailand) and *G. obliquimaculatus* Jiang, Chen & Yang (Salween drainage of Yunnan, China). Tamang & Chaudhry (2011) described *G. dikrongensis* from Dikrong River (Brahmaputra drainage) at Doimukh, Arunachal Pradesh, northeastern India. It is distinguished from the South-east Asian species in having a uniformly coloured body contrasting to the presence of vertical bars on the body and caudal peduncle in *G. rugimentum* and dark oblique blotches on the body in *G. obliquimaculatus*. It is further distinguished from its Indian congener, *G. indicus* by the following combination of characters: equal distance between the posterior end of the pectoral-fin base and the pelvic-fin origin and between the pelvic-fin and the anal-fin origin (vs. distance between posterior end of pectoral-fin base and pelvic-fin origin greater than between pelvic-fin origin and anal-fin origin), and the pelvic-fin origin anterior to or almost at a vertical through the posterior end of the dorsal-fin base (vs. posterior to the dorsal-fin base) (Tamang & Chaudhry, 2011). There is no clear cut difference in the morphometry and meristic counts of *G. indicus* and *G. dikrongensis* except for the above stated differences. *G. indicus* is known from the Ganges drainage of India and Nepal and the report of this species from Kameng, Subansiri and Siang rivers of Arunachal Pradesh (Nath & Dey, 2000b) needs re-examination as these rivers are very close to the type locality of *G. dikrongensis* and Dikrong River (type locality of *G. dikrongensis*) itself is a tributary of Subansiri River. The specimens from Barak drainage of Mizoram differs from *G. dikrongensis* in having distance between posterior end of pectoral-fin base and pelvic-fin origin greater than between pelvic-fin origin and anal-fin origin. Comparision with *G. dikrongensis* from the type locality using advance molecular technique (DNA barcoding) will help in determining the identity of this species.

Pseudolaguvia virgulata was described from rivers of Barak drainage in Mizoram (Ng & Lalramliana, 2010a) and *P. spicula* was subsequently described from Surma-Meghna River system in India and Bangladesh (Ng & Lalramliana, 2010b). Two species of *Pseudolaguvia* were previously known from Tlawng River *viz. P. shawi* and *P. tuberculatus* (Kar & Sen, 2007; Karmakar & Das, 2007). The record of these species from Barak drainage of Mizoram is doubtful (for eg. see Ng & Lalramliana, 2010b). Kar & Sen's (2007) record of *P. shawi* from the Tlawng River could refer to *P. spicula* due to its superficial resemblance and since the record of *P. shawi* from the Surma-Meghna system originates from further downstream in Bangladesh and there is no current indication that *P. shawi* is otherwise present in the Barak River drainage (Ng & Lalramliana, 2010b). The type locality of *P. tuberculata* is Sankha, a large hillstream, midway between Kamaing and Mogaung, Myitkyina district, Upper Myanmar (Prashad & Mukerji, 1929) and is known only from Irrawaddy drainage of Myanmar (Thomas & Page, 2006; Ferraris, 2007; Tamang & Sinha, 2014). The report of *P. tuberculata* from Barak drainage of Mizoram may likely be due to misidentification as the distribution of rheophilic species of catfish are often restricted to a particular region and they are not likely to occur outside of it (Ng and Rachmatika, 2005). The recent discovery of two new species of *Pseudolaguvia* from Barak drainage of Mizoram may as well be an explanation for the record of *P. shawi* and *P. tuberculata* from Barak drainage of Mizoram. Ng &

Lalramliana (2010b) recorded another species, *P. ribeiroi* from Teirei River based on a single specimen but no additional specimens are collected in the present study.

The family Siluridae is represented by two species *viz. Ompok bimaculatus* and *Wallago attu*. Ramanujam (2005) listed both this species from the Karnaphuli drainage of Mizoram wheres Karmakar & Das (2007) listed both this species from Mizoram on the basis of specimens which were observed in the field and were not collected. Since they did not mention the place where these species were observed, the present record confirms these two species in the rivers of Barak drainage of Mizoram.

The family Chacidae is reported for the first time from Mizoram. *Chaca chaca* is observed and collected from the river stretch and ponds of Tlawng River. The species is distributed in the Ganges-Brahmaputra drainage of India, Bangladesh, Pakistan and Nepal. Among the four species of the genus *Chaca* recognised, two species i.e. *C. chaca* and *C. burmensis* Brown & Ferraris (South Asian form) are restricted in Indiansubcontinent and Myanmar whereas theother two species i.e. *C. serica* Ng & Kottelat and *C. bankanensis* Bleeker (Malayan form)are restricted to Malay Peninsula and Borneo. The Malayan form superficially resembles each other in having nasal barbles (vs. absent in South Asian form) and 4 pectoral fin rays (vs. 5 in South Asian form). The morphological examination of skeletal system and integument reveals that the South Asian forms are more closely related to each other than the Malayan form (Brown & Ferraris, 1988). *C. chaca* is further distinguished from *C. burmensis* by the presence of 1 dorsal spine (vs.2) and greater number of serration in pectoralspine (Brown & Ferraris, 1988; Jayaram, 2009). Jayaram (2006) used the number of serrae in the pectoral spine as one of the most important distinguishing character between the two species and indicated that *C. chaca* have lower number of serrae (8-10) as compared to *C. burmensis* (12-19).

The family level classification of Heteropneustidae created a disagreement among ichthyologists. It was synonymised with family Clariidae based on their osteology (Diogo *et al.*, 2003) which was followed by some authors (eg. Ferraris, 2007; Kottelat, 2013), whereas some authors still recognised Heteropneustidae (eg. Jayaram 2006, Nelson 2006, Sullivan, 2006; Van der Laan, 2014). Heteropneustidae is retained here as a synonym of Clariidae before further molecular works are done with more sampling. The family Clariidae is represented by two species belonging to two genera *viz. Clarias magur* and *Heteropneustes fossilis*. *C. batrachus* Linnaeus was believed to be a common species widely distributed throughout South and Southeast Asia (e.g. Hora, 1936; Kottelat, 2001) but a problem regarding its identity and nomenclature arises which subsequently leads to the designation of neotype and its redescription (Ng & Kottelat, 2008). The distribution of *C. batrachus* is restricted to the river drainages of Java and *C. magur* is the oldest name referable to the species of *Clarias* occurring in north-eastern India previously identified as *C. batrachus* (Ng & Kottelat, 2008). Ramanujam (2005) reported the occurrence of *C. magur* (as *C. batrachus*) in Karnaphuli drainage of Mizoram. The present study records this species for the first time from the rivers of Barak drainage of Mizoram. *Heteropneustes fossilis* was reported from Karnaphuli drainage (Ramanujam, 2005); Karmakar & Das (2007) also reported their observation of this species in the field which were not collected. Since they did not mention where it was observed, this study confirmed the occurence of *H. fossilis* in rivers of Barak drainage of Mizoram.

The family Schilbeidae is represented by three species *viz. Ailia coila* and *Eutropiichthys murius* and *E. vacha*. Kar & Sen (2007) listed *Ailia coila*, *Clupisoma* *garua* (Hamilton), *Eutropiichthys murius* and *E. vacha* from rivers of Barak drainage of Mizoram whereas Ramanujam (2005) and Karmakar & Das (2007) listed only *E. vacha* from Tlawng River. The absence of *C. garua* in the present study may be due to difference in sampling methods but this record needs verification as the authors did not give any description or photo of the species nor mention where the specimens were deposited.

The family Bagridae is represented by *Batasio batasio*, *Mystus bleekeri*, *Sperata aor*, *S. seenghala* and *Olyra* aff. *longicaudata*. *Batasio batasio* is reported for the first time from the Barak drainage of Mizoram. The recorded occurrence of *B. batasio* in the Kaladan drainage of Mizoram (Ramanujam, 2005; Kar & Sen, 2007) is doubtful as this species is known only from the Ganges-Brahmaputra basin of India, Bangladesh, Bhutan and Nepal (Talwar & Jhingran, 1991; Vishwanath *et al*., 2007; Ng, 2009, 2010a; Eschmeyer, 2015) and instead, anew species, *B. convexirostrum* Darshan, Anganthoibi & Vishwanath was recently described from this drainage (Darshan *et al.*, 2011). *Mystus bleekeri* was previously recorded from Teirei River, a tributary of Tlawng River (Barman, 1986) whereas Ramanujam (2005) and Kar & Sen (2007) listed another species, *M. vittatus* (Bloch) from Serlui River, a tributary of Tuirial River of Mizoram. *M. vittatus* was described from Tranquebar (Tharangambadi) in southeastern India (Bloch, 1794). This species is thought to occur throughout the entire Indian subcontinent (Roberts, 1994), but the conspecificity of populations throughout the subcontinent should be verified (Ng, 2010b). Several records of *M. vittatus* from northeastern India and Gangetic basin were due to misidentifications of either *M. tengara* (Hamilton) or *M. carcio* (Hamilton) (Darshan *et al*., 2010). The absence of *M. vittatus* in the present study could be due to difference in sampling methods and sampling location or probably due to misidentification by previous workers. The identity of the *Mystus* species recorded as *M. vittatus* from Barak drainage of Mizoram (Ramanujam, 2005; Kar & Sen, 2007) needs confirmation as the authors neither give description nor mention where specimens were deposited.

The occurrence of *Sperata seenghala* in rivers of the Barak drainage of Mizoram was reported by Kar & Sen (2007). They listed this species from Tlawng and Tuirial river of Mizoram. They further listed *Sperata aor* from Tuivai River of Mizoram. Both these species are collected from all the major rivers of the Barak drainage of Mizoram.

Karmakar & Das (2007) recorded *Olyra longicaudata* from Serlui River, Barak drainage of Mizoram but their description is very brief and can point to other species within the genus. *O. longicaudata* was originally described and illustrated with a lanceolate caudal fin with elongate central fin rays (McClelland, 1842); which caused later workers to erroneously consider material otherwise identical in all respects, except for caudal fin shape, to belong to different species (Ng *et al.*, 2014). Ng *et al*. (2014) remarked that the caudal fin of *O. longicaudata* appears lanceolate when collapsed which likely led to the description of new species without a lanceolate caudal-fin. *O. longicaudata* is a valid species from the Surma- Meghna River system and the Brahmaputra River drainage in Bangladesh and northeastern India, which is diagnosed by its slender body and long adipose-fin base (Ng *et al*., 2014). Ng *et al.* (2014) considered *O. collettii* (Steindachner) and *O. kempi* Chaudhuri as ajunior synonym of *O. longicaudata* as there appears is no significant differences between. *O. longicaudata* is readily distinguished from its congeners on the account of its long-based adipose fin (Ng *et al*., 2014). The specimens of *Olyra* collected in the present study could not be referred to *Olyra longicaudata* on account of its shorter adipose fin base. The present species of *Olyra* and Karmakar & Das (2007) *Olyra longicaudata* may be conspecific.

The order Mugiliformes is reported for the first time from Mizoram which is represented by two species belonging to two genera *viz. Rhinomugil corsula* and *Sicamugil cascasia* belonging to the family Mugilidae. *R. corsula* is a freshwater and brackish form and is widely distributed in rivers and brackish waters of Southern Asia (Talwar & Jhingran, 1991; Vishwanath *et al*., 2007; Eschmeyer, 2015). *S. cascasia* is a freshwater form and is widely distributed in rivers of Southern Asian countries: Pakistan, India, Nepal, Bangladesh and Myanmar (Talwar & Jhingran, 1991; Vishwanath *et al*., 2007; Eschmeyer, 2015).

The order Beloniformes is represented by one species, *Xenentodon cancila* belonging to the family Belonidae. The species is widely distributed in South and Southeast Asia: Pakistan, India, Sri Lanka, Bangladesh, Bhutan, Myanmar, Malaysia and Thailand (Talwar & Jhingran, 1991; Vishwanath *et al*., 2007; Eschmeyer, 2015). It was previously reported from rivers of the Barak drainage of Mizoram (Ramanujam, 2005; Kar & Sen, 2007; Karmakar & Das, 2007).

The order Cyprinodontiformes is represented by a single species, *Aplocheilus panchax* belonging to the family Aplocheilidae. Ramanujam (2005) listed *A. panchax* from Teirei River wheres Karmakar & Das (2007) listed this species from Tamdil Lake. *A. panchax* is a freshwater and brackish form and is widely distributed in rivers and brackish waters of South and Southeast Asian countries: Pakistan, India, Nepal, Bangladesh, Myanmar, Malaysia, Indonesia and Thailand (Talwar & Jhingran, 1991; Vishwanath *et al*., 2007; Eschmeyer, 2015).

The order Synbranchiformes is represented by two families *viz.* Synbranchidae and Mastacembelidae. The family Synbranchidae is represented by two species *viz.*

Monopterus cuchia and *M. ichthyophoides*. *M. cuchia* is widespread and has been recorded from Pakistan, Nepal, northern and northeasternIndia and Myanmar (Talwar & Jhingran 1992); the species is recorded for the first time from Mizoram. *M. ichthyophoides* was described from rivers of Barak drainage of Mizoram (Britz *et al*., 2011) and at present known only from Barak drainage of Mizoram. It differs from *M. cuchia* in number of branchiostegal rays (2 vs. 6 in *M. cuchia*) and number of vertebrae (79-82 + 34-37 = 114-117 vs. 99-112 + 55-70 = 166-188 in *M. cuchia*). The family Mastacembelidae is represented by three species belonging to two genera *viz. Macrognathus aral*, *M. pancalus* and *Mastacembelus armatus. Macrognathus pancalus* and *Mastacembelus armatus* were already reported from rivers of Barak drainage of Mizoram (Ramanujam, 2005; Kar & Sen, 2007; Karmakar & Das, 2007). This study records *Macrognathus aral* for the first time from Mizoram.

The order Perciformes is represented by five families *viz.* Ambassidae, Badidae, Gobiidae, Osphronemidae and Channidae. Ambassidae is represented by a single species *Chanda nama.* Kar & Sen (2007) reported *Parambassis ranga* (Hamilton) from Tlawng River and *P. tenasserimensis* Roberts from Tlawng River and Tuivai River. The absence of *P. ranga* (Hamilton) in the present study may be due to difference in sampling method and location. *P. tenasserimensis* was described from Tenasserim basin of southern Myanmar (Roberts, 1995) and is considered as a junior synonym of *P. alleni* (Datta & Chaudhuri) (Kottelat, 2003a). *P. alleni* is known only from the Tenasserim River basin of Myanmar (Kottelat, 2003a) and the report of this species from the Barak drainage may be due to wrong identification which needs confirmation.

The family Badidae is represented by a single genera, *Badis*. Only a single species of *Badis* i.e. *B. badis* is hitherto recorded from Barak drainage of Mizoram

(Barman, 1989; Ramanujam, 2005; Kar & Sen, 2007). The species identification among the genus is difficult as they resemble each other in sharing very similar (or even identical) morphometric data (Kullander & Britz, 2002). A thorough revision of the genus by Kullander & Britz (2002) increases the number of known species from three to twelve. Three species *viz. B. badis*, *B. kanabos* and *B. tuivaiei* are collected in the present study. *B. kanabos* and *B. tuivaiei* are reported for the first time from Mizoram. *B. badis* and *B. kanabos* are found in sympatry at Tlawng and Tuirial rivers. The family Gobiidae is represented by a single species, *Glossogobius giuris* which was also reported by previous workers (Barman, 1989; Ramanujam, 2005; Kar & Sen, 2007) from Barak drainage of Mizoram. The family Osphronemidae is represented by a single species, *Trichogaster fasciata.* Ramanujam (2005) listed this species from the Karnaphuli drainage of Mizoram. The present study records this species for the first time in the Barak drainage of Mizoram.

The family Channidae is represented by five species *viz. Channa gachua*, *C. marulius*, *C. punctatus* and *C. stewartii.* Two species, *C. orientalis and C. punctatus* were previously reported from rivers of the Barak drainage of Mizoram (Barman, 1989; Ramanujam, 2005; Kar & Sen, 2007). *C. orientalis* Bloch & Schneider is among the group of snakeheads in which the pelvic fins are absent (Britz, 2013) and the previous workers didn't give any description or where the specimens were deposited. The record of this species from Barak drainage of Mizoram seems to be a misidentification as Courtenay & Williams (2004) clearly noted that *C. orientalist* is endemic to Sri Lanka which has always been confused with *C. gachua*. The present record of *C. gachua*, *C. marulius* and *C. melanostigma* are a new addition to the ichthyofauna of Mizoram.

5.4 Assemblage

Most species are common and found in all three (64 species) or two (11 species) rivers. The highest species richness (88 species) was recorded in Tlawng River followed by Tuirial River (82 species) and Tuivai River (71 species) (Table 5.4). Twenty four species are uncommon and found in only one river. Tlawng River have the highest number of confined species (13 species) followed by Tuirial River and Tuivai River (7 species each). The species which were collected only from Tlawng River are *Opsarius tileo*, *Erethistoides* cf. *senkhiensis*, *Glyptothorax cavia*, *G. striatus*, *Hara hara*, *Nangra nangra*, *Ompok bimaculatus*, *Chaca chaca*, *Batasio batasio*, *Rhinomugil corsula*, *Sicamugil cascasia* and *Trichogaster fasciata.* The order Mugiliformes (represented by 1 family, 2 genera and 2 species) was collected only from Tlawng River. The species which were collected only from Tuirial River are *Devario devario*, *Garra* cf. *dampaensis*, *Laubuka laubuca*, *Securicula gora*, *Schistura mizoramensis*, *Schistura* sp. and *Ailia coila.* The species which were collected only from Tuivai River are *Systomus clavatus*, *Psilorhynchus homaloptera*, *Schistura chindwinica*, *S. maculosa*, *Amblyceps laticeps*, *Exostoma sawmteai* and *Badis tuivaiei*. Two important factors influencing freshwater fish species richness are (i) stream morphology/substrate type and (ii) site location in relation to the coast (Haynes *et al*., 1989; McDowall, 1991; Pusey *et al*., 1993; Jowett & Richardson, 1994). Freshwater fish species richness is often higher in areas with rock or gravel substrates than mud or sand as this substrate provides a variety of habitat niches for a range of species (Marquet and Mary, 1999; Haynes *et al*., 1989). In this study the average species richness was higher in sites with gravel substrates than those with mud substrates. Generally, freshwater fish species richness decreases with distance from the coast (McDowall & Taylor, 2000). This pattern is mainly due to natural fish barriers e.g.

waterfalls, which restrict the movement of most fish species from more coastal areas to higher inland sites. In addition, lowland coastal sites often have a number of estuarine fish species that spend some of their life cycle in freshwater which adds to the species richness of these areas (Jowett *et al*., 1996).

Shannon index is the highest in Tlawng River (1.835) followed by Tuirial River (1.791) and Tuivai River (1.737). The Shannon index (H') for the fish species from the three rivers within the period of study were within the range of 1.5 to 3.5 as posited by Magurran (2004). The difference can be attributed to disparity in ecological zones. Fish communities in riverine system typically follow a pattern of increasing species richness, diversity and abundance from upstream to downstream (Welcomme, 1985; Bayley & Li, 1994; Granado, 2000) which is also the case in the present study.

The similarity in species composition among the rivers was analyzed using the Jaccard index for calculating the extent of similarity between pairs of data sets. The Jaccard index value between Tlawng River and Tuirial River (0.77) was the highest while it was the lowest for the comparison between Tlawng River and Tuivai River (0.65 each). The highest similarity in the fish species composition between Tlawng River and Tuirial River may be due to the fact that their confluences at the Barak River are more close to each other than that of Tuivai, and hence more similar species composition. Tuirial River is sandwitched by Tlawng and Tuivai rivers and hence Jaccard similarity index between Tuirial River and Tuivai River is higher than that of Tlawng River and Tuivai River.

Table 5.4 List of species collected during the survey, their distribution and conservation status as assessed by IUCN Red List (2014). (+ indicates presence, - indicates absence, NE indicates Not Evaluated, DD indicates Data Deficient, LC indicates Least Concern, NT indicates Near Threaten, VU indicates Vulnerable, EN indicates Endangered).

Sl. No.	Species	Tlawng	Tuirial	Tuivai	IUCN
Osteoglossiformes					
	Notopteridae				
1.	*Notopterus notopterus*	+	+	+	LC
Anguilliformes					
	Anguillidae				
2.	*Anguilla bengalensis*	+	+	+	NT
Cypriniformes					
	Cyprinidae				
3.	*Amblypharyngodon mola*	+	+	+	LC
4.	*Barilius barila*	+	+	+	LC
5.	*Cabdio morar*	+	+	+	LC
6.	*Chagunius chagunio*	+	+	+	LC
7.	*Crossocheilus latius*	+	+	+	LC
8.	*Danio dangila*	+	+	+	LC
9.	*Devario aequipinnatus*	+	+	+	LC
10.	*Devario devario*	-	+	-	LC
11.	*Esomus danrica*	+	+	+	LC
12.	*Garra* cf. *dampaensis*	-	+	-	LC
13.	*Garra* cf. *gotyla*	+	+	+	LC
14.	*Garra lissorhynchus*	+	+	+	NE
15.	*Garra* cf.*manipurensis*	+	+	+	VU
16.	*Garra* aff. *naganensis*	+	+	+	NE
17.	*Gymnostomus ariza*	+	+	-	LC
18.	*Labeo bata*	+	+	+	LC
19.	*Labeo calbasu*	+	+	+	LC
20.	*Labeo dyocheilus*	+	+	+	LC

21.	*Labeo gonius*	+	+	+	LC
22.	*Laubuka laubuca*	-	+	-	LC
23.	*Neolissochilus hexagonolepis*	+	+	+	NT
24.	*Neolissochilus hexastichus*	+	+	+	NT
25.	*Opsarius barna*	+	+	+	LC
26.	*Opsarius bendalensis*	+	+	+	LC
27.	*Opsarius tileo*	+	-	-	LC
28.	*Pethia conchonius*	+	+	+	LC
29.	*Puntius chola*	+	+	+	LC
30.	*Puntius sophore*	+	+	+	LC
31.	*Rasbora daniconius*	+	+	+	LC
32.	*Securicula gora*	-	+	-	LC
33.	*Systomus clavatus*	-	-	+	NT
34.	*Tor tor*	+	+	+	NT
	Psilorhynchidae				
35.	*Psilorhynchus homaloptera*	-	-	+	LC
36.	*Psilorhynchus nudithoracicus*	+	+	+	LC
37.	*Psilorhyncus sucatio*	+	+	+	LC
	Cobitidae				
38.	*Botia dario*	+	+	+	LC
39.	*Botia rostrata*	+	+	+	VU
40.	*Lepidocephalichthys berdmorei*	+	+	+	LC
41.	*Lepidocephalichthys guntea*	+	+	+	LC
42.	*Pangio pangia*	+	+	+	LC
	Balitoridae				
43.	*Balitora brucei*	+	+	+	NT
	Nemacheilidae				
44.	*Acanthocobitis botia*	+	+	+	LC
45.	*Physoschistura tuivaiensis*	+	+	+	NE
46.	*Schistura aizawlensis*	+	+	-	NE
47.	*Schistura chindwinica*	-	-	+	VU
48.	*Schistura* cf. *fasciata*	+	+	+	NE

49.	*Schistura maculosa*	-	-	+	NE
50.	*Schistura mizoramensis*	-	+	-	NE
51.	*Schistura paucireticulata*	+	+	-	NE
52.	*Schistura* sp.	-	+	-	NE
Siluriformes					
	Amblycipitidae				
53.	*Amblyceps laticeps*	-	-	+	LC
54.	*Amblyceps mangois*	+	+	+	LC
	Sisoridae				
55.	*Bagarius bagarius*	+	+	+	NT
56.	*Erethistoides* cf. *senkhiensis*	+	-	-	DD
57.	*Exostoma sawmteai*	-	-	+	NE
58.	*Gagata cenia*	+	+	-	LC
59.	*Glyptothorax botius*	+	+	+	LC
60.	*Glyptothorax cavia*	+	-	-	LC
61.	*Glyptothorax* cf. *dikrongensis*	+	+	-	NE
62.	*Glyptothorax maceriatus*	+	+	+	NE
63.	*Glyptothorax scrobiculus*	+	+	+	NE
64.	*Glyptothorax striatus*	+	-	-	NT
65.	*Glyptothorax telchitta*	+	+	+	LC
66.	*Gogangra viridescens*	+	-	-	LC
67.	*Hara hara*	+	-	-	LC
68.	*Nangra nangra*	+	-	-	LC
69.	*Pseudolaguvia spicula*	+	+	-	NE
70.	*Pseudolaguvia virgulata*	+	+	-	NE
	Siluridae				
71.	*Ompok bimaculatus*	+	-	-	NT
72.	*Wallago attu*	+	+	+	NT
	Chacidae				
73.	*Chaca chaca*	+	-	-	LC
	Clariidae				
74.	*Clarias magur*	+	+	+	EN

75.	*Heteropneustes fossilis*	+	+	+	LC
	Schilbeidae				
76.	*Ailia coila*	-	+	-	NT
77.	*Eutropiichthys murius*	+	+	-	LC
78.	*Eutropiichthys vacha*	+	+	+	LC
	Bagridae				
79.	*Batasio batasio*	+	-	-	LC
80.	*Mystus bleekeri*	+	+	+	LC
81.	*Olyra* aff. *longicaudata*	+	+	-	LC
82.	*Sperata aor*	+	+	+	LC
83.	*Sperata seenghala*	+	+	+	LC
Mugiliformes					
	Mugilidae				
84.	*Rhinomugil corsula*	+	-	-	LC
85.	*Sicamugil cascasia*	+	-	-	LC
Beloniformes					
	Belonidae				
86.	*Xenentodon cancila*	+	+	+	LC
Cyprinodontiformes					
	Aplocheilidae				
87.	*Aplocheilus panchax*	+	+	+	LC
Synbranchiformes					
	Synbranchidae				
88.	*Monopterus cuchia*	+	+	+	LC
89.	*Monopterus ichthyophoides*	+	+	+	NE
	Mastacembelidae				
90.	*Macrognathus aral*	+	+	+	LC
91.	*Macrognathus pancalus*	+	+	+	LC
92.	*Mastacembelus armatus*	+	+	+	LC
Perciformes					
	Ambassidae				
93.	*Chanda nama*	+	+	+	LC

	Badidae				
94.	*Badis badis*	+	+	-	LC
95.	*Badis kanabos*	+	+	-	DD
96.	*Badis tuivaiei*	-	-	+	EN
	Gobiidae				
97.	*Glossogobius giuris*	+	+	+	LC
	Osphronemidae				
98.	*Trichogaster fasciata*	+	-	-	LC
	Channidae				
99.	*Channa gachua*	+	+	+	LC
100.	*Channa marulius*	+	+	+	LC
101.	*Channa punctatus*	+	+	+	LC
102.	*Channa melanostigma*	+	+	+	LC

5.5 Conservation status and threats

5.5.1 Conservation status

The fishes sampled during the study period falls within six categories of the IUCN Red List criterias *viz.* Not Evaluated, Data Deficient), Least Concern, Near Threatened, Vulnerable and Endangered (Table 5.5). The Red List Category of threat assigned to each species is given in Table 5.4. More than half of the fish species are categorized as Least Concern. Many of the fish species assessed as Least Concern are either widely distributed through the region, or their population sizes are believed to be relatively large. Unfortunately, the empirical data required to strongly support their assessment status is lacking for a number of these species and many of the species currently assessed as Least Concern may require reassessment in the future as they are suspected to belong to species complexes containing several morphologically similar (cryptic) species that may exhibit more geographically circumscribed ranges (Vishwanath *et al*., 2010).

The next highest number of species (15.69%) is in the Not Evaluated category. These species were recently described are not yet assessed against IUCN Red List categories and may be classified in the Endangered categories if proper studies on their range and assessment are carried out. Data Deficient category comprises of two species (27.1%). Species in this category possess one or more of the following features: 1) Small body size, with little commercial value (either as food or as ornamental fishes), 2) Very recent recognition as distinct taxonomic entities, 3) Known only from the type series and/or a very small number of museum records, 4) Little or no information on their biology, and 5) Taxonomic uncertainties surrounding the validity of the species. For all these groups, there are often no data on their occurrence, population trends and so on (Vishwanath *et al*., 2010).

Of the remaining species, a total of five (4.90%) are categorized as threatened (EN and VU assessments) while eleven (10.78%) have been assessed as Near Threatened. Two (1.96%) are Endangered and three (2.94%) are Vulnerable. Among the five Endangered species, three are endemic in the Barak River and the two remaining species are endemic to Ganga-Brahmaputra. One species, *Clarias magur* is common to both the Ganga-Brahmaputra and the Chindwin. The five Critically Endangered species are either endemic to hill streams located within the Ganga-Brahmaputra and Chindwin.

Table 5.5 Number and percentage of fishes under IUCN Red List category.

	IUCN Red List category	**Number of species**	**Percentage**
	Extinct	0	0
	Extinct in the Wild	0	0
Threatened categories	Critically Endangered	0	0
	Endangered	2	1.96
	Vulnerable	3	2.94
	Near Threatened	11	10.78
	Least Concern	68	66.67
	Data Deficient	2	1.96
	Not Evaluated	16	15.69
	Total	102	100

5.5.2 Threats

The threats to global freshwater biodiversity can be grouped under five interacting categories: overexploitation; water pollution; flow modification; destruction or degradation of habitat; and invasion by exotic species (Allan & Flecker, 1993, Naiman *et al.*, 1995; Naiman & Turner, 2000; Jackson *et al.*, 2001; Malmqvist & Rundle, 2002; Rahel, 2002; Postel & Richter, 2003; Revenga *et al.*, 2005).

The main threats for fish identified during the survey period were unsustainable fishing practices, overexploiatation and degradation of habitat. Many fishing practices are carried out in many parts of Mizoram which pose a threat not only to fishbut also other other aquatic organism (Lalronunga *et al*., 2014). Destructive methods of fishing like electrofishing, chemical poisoning and dynamo fishing become very popular in most parts of Mizoram although preventive measures are being taken by the state government (Lalthanzara & Lalthanpuii, 2010). Modern (destructive) methods of fishing like using dynamite, chemicals poisoning and electrofishing might have been introduced in the state after 1950's, 1960's and 1980's onwards, respectively (Lalthanzara & Lalthanpuii, 2010). Electrofishing kills fishes of all ages and proved very harmful for fish population in a long run. The fish that survive the exposures despite electrofishing injury or physiological stress likely suffer complications that affect their long-term survival, growth, reproduction and early life stage (Snyder, 2003). Fishing with explosives and poisons such as cyanides are of frequent occurrence. These two had become a major problem in Southeast Asian countries such as Phillipines, Indonesia, Malaysia and Thailand (McManus, 1988; UNEP, 1994; Pratt, 1996). Dynamite fishing caused severe habitat destruction and declines of rare substrate-dwelling loach fishes, and many important native food fishes (Lalronunga *et al*., 2011). Use of chemical poison for fishing did not target only fish and cause a mass die out of all aquatic organisms for long stretches down river. It takes a long time for the aquatic communities to regain its normal state (Lalronunga *et al*., 2014). The use of the above mentioned methods of fishing is more efficient than nets and other local fishing methods and in turn leads to overexploitation of riverine fish resources. An example of this is *Wallago attu* and *Bagarius bagarius*, which are facing extreme population decline across the landscape, mainly attributed to dynamite fishing (Lalronunga *et al*., 2011).

Habitat degradation is brought about by an array of interacting factors. It may involve direct effects on the aquatic environment (such as excavation of river sand) or indirect impacts that result from changes within the drainage basin. Clearing of forested river banks, construction of roads, damming, excavation of river sand and quarrying of river rocks are main causes of riverine habitat degradation. Clearing of forest and construction of roads leads to changes in surface runoff and increased river sediment loads that can lead to habitat alterations such as shoreline erosion, smothering of littoral habitats, clogging of river bottoms or floodplain aggradation. The construction of roads also brought about easy access to rivers and thereby increases the chance of overexploitation. Dams can cause decreasing population trends (Parrish *et al*., 1998; Jackson & Marmulla, 2001) and reduce species diversity and catch per unit effort of fisheries for short and long-distance migratory species (Fernandes *et al*., 2009). Suspended sediment can harm incubating fish eggs and fry (Cedarholm *et al*., 1982), and reduce the abundance of insect larvae, a food source for fish, by filling up the larvae's guts or nets with indigestible material (Hynes, 1973). Extraction of river sand, gravels and stones leads to changes in channel form, physical habitats and foodweb (Starnes, 1983; Rivier & Seguier, 1985; Thomas, 1985; Sandecki, 1989; Kitetu & Rowan, 1997). The enhanced levels of suspended solids smother the benthic community, clogs the gills of fishes and as a result the fishes are forced to leave their habitat. Turbidity reduces vision and mask odours, both important for the survival of many fishes.

Invasion by exotic species is among the biggest threat to freshwater biodiversity (Dudgeon *et al*., 2006), but no exotic species were caught during the study period. Solo *et al*. (in press) collected *Oreochromis mossambicus* (Peters) from Lik River (tributary of Tlawng River) in the vicinity of Sialsuk village. *O. mossambicus* (Mozambique tilapia) is native to the eastward flowing rivers of central and southern Africa (Philippart & Ruwet, 1982; Trewavas, 1982). Due to their perceived utility as an aquaculture species, it is now widely distributed around the world (Arthington *et al*., 1984; Philippart & Ruwet, 1982). Invasive populations are now causing environmental and ecological problems in many countries (Canonico *et al*., 2005) and is listed in the Global Invasive Species Database as being in the top 100 invasive alien species on the planet (Ganie, 2013). *O. mossambicus* was introduced by the state Government (Solo *et al*., in press) but the cause of their occurence in the riverine system is unknown. It may be from the release of fish seedlings by the state Fisheries Department or from fish ponds near river banks. The recent record of this species from Lik River (Solo *et al*., in press) is the first record of this species in the riverine system of Mizoram, but the extent of their invasiveness is not known and seems to be localised in this particular area (Lik River). Speedy action has to be taken to eradicate this population before we face its consequences.

CHAPTER 6

SUMMARY

- A total of one hundred two species of fish belonging to nine orders, twenty four families and sixty two generawere collected from the three selected rivers and their tributaries. This constitutes about 24% of the freshwater fishes recorded from northeast India.
- Order-wise distribution is dominated by Cypriniformes (48.98%) followed by Siluriformes (29.59%); Perciformes (9.80%); Synbranchiformes (4.90%); Mugiliformes (1.96%); Osteoglossiformes, Anguilliformes, Cyprinodontiformes and Beloniformes (0.98% each).
- Family-wise distribution is dominated by Cyprinidae (31.37%) followed by Sisoridae (15.69%); Nemacheilidae (8.82%); Cobitidae and Bagridae (4.90% each); Channidae (3.92%); Psilorhynchidae, Schilbeidae, Mastacembelidae and Badidae (2.94% each); Siluridae, Amblycipitidae, Clariidae, Mugilidae and Synbranchidae (1.96% each); Notopteridae, Anguillidae, Balitoridae, Chacidae, Aplocheilidae, Belonidae, Ambassidae, Gobiidae and Osphronemidae (0.98% each).
- Of this occurrence was dominated by the genus *Schistura* and *Glyptothorax* are the most speciose genus with seven species each, which is 6.86% of the total species recorded.
- As far as geographical area of the study region and number of species of freshwater fish recorded during the present study are considered and compared, itreflected the diversity and richness of freshwater fish in Mizoram.
- The study resulted in the description of three new species *viz. Schistura maculosa*, *Schistura mizoramensis* and *Exostoma sawmteai*.
- Nineteen species *viz. Labeo dyocheilus*, *Psilorhynchus homaloptera*, *Physoschistura tuivaiensis*, *Schistura* cf. *fasciata*, *Amblyceps laticeps*, *Bagarius*

bagarius, *Erethistoides* cf. *senkhiensis*, *Glyptothorax botius*, *Glyptothorax* cf. *dikrongensis*, *Chaca chaca*, *Rhinomugil corsula*, *Sicamugil cascasia*, *Monopterus cuchia*, *Macrognathus pancalus*, *Badis kanabos*, *Badis tuivaiei*, *Channa gachua*, *Channa marulius* and *Channa melanostigma* were recorded for the first time from Mizoram

- Thirteen species *viz. Anguilla bengalensis*, *Garra* cf. *dampaensis*, *Garra* cf. *manipurensis*, *Labeo bata*, *Labeo gonius*, *Neolissochilus hexastichus*, *Glyptothorax striatus*, *Hara hara*, *Ompok bimaculatus*, *Wallago attu*, *Clarias magur*, *Batasio batasio* and *Trichogaster fasciata* were recorded for the first from the Barak drainage of Mizoram.
- Several species which were listed by previous workers were not collected in this study which may be due to difference in sampling strategies, difference in sampling sites and largely due to misidentifications.
- Shannon diversity index is highest in Tlawng River (1.835) followed by Tuirial River (1.791) and Tuivai River (1.737).
- Jaccard similarity index is the highest between Tlawng and Tuirial rivers (0.77) followed by Tuirial and Tuivai rivers (0.71) and Tlawng and Tuivai rivers (0.65).
- Among the fishes recorded, five species were categorised as Threatened (two species Endangered and three species Vulnerable) in the IUCN Red List whereas Near Threatened, east Concern, Data Deficient and Not Evaluated categories were represented by eleven, sixty two, two and sixteen species each.
- The main threats for freshwater fish identified during the survey period were unsustainable fishing practices, overexploitation and degradation of habitat.

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APPENDICES

Appendix I: Comparative materials for new species description

Exostoma berdmorei: NIFI 0894, 2, 34.3-54.0 mm SL; Thailand: Mae Hong Son Province: Mae Sariang District: Huay Po.– NIFI 1669, 1, 66.4 mmSL; Tak Province: Tha Song Yang District: Mae Jawang.– ZRC 54293, 1, 53.4 mm SL; Thailand: Mae Hong SonProvince: left side tributary of Mae Nam Pai, about14 km N of Mae Sariang at bridge on road 108.

E. effrenum: NIFI 4955, holotype, 51.3 mm SL; NIFI3765, 2 paratypes, 51.6-65.0 mm SL; UMMZ 250050, 1paratype, 54.2 mm SL; Thailand: Mae Hong Son Province:Mae La Noi District: Ping Noi stream close to DoiOm Phai in Chiang Mai Province, 18°23'43" N 98°7'56" E.

E. labiatum: BMNH 1860.3.19.97, holotype, 73.0 mmSL; India: Arunachal Pradesh: Mishmi Hills.

E. peregrinator: NIFI 3831, holotype, 70.2 mm SL;NIFI 3762, 4 paratypes, 45.6-65.6 mm SL; NIFI 3764, 8paratypes, 23.3-67.4 mm SL; UMMZ 250051, 6 paratypes,26.2-65.1 mm SL; Thailand: Mae Hong SonProvince: Mae La Noi District: Ban Tun, 18°18'31" N98°8'37" E.

E. stuarti: ZSI F9742/1, holotype, 43.0 mm SL;Myanmar: Kachin State: Nam-Yak River at Tanja [= NamYak, approximately 1.5 km S of Langtao, 27°15' N 97°35' E].

E. vinciguerrae: ZSI F9741/1, holotype of *E. chaudhurii*, 53.9 mm SL; Myanmar: Kachin State: Putao Plains.– CAS 230826, 31, 22.9-85.4 mm SL; China: Yunnan:small tributary to Dulongjiang near Bapo.

Published information used for comparison: Vishwanath& Joyshree (2007) for *E. barakensis.*

Schistura aizawlensis: PUCMF 11026, holotype, 48.9 mm SL; PUCMF 11027 (17), paratypes, 31.5–46.2 mm SL; India: Mizoram: Muthi River, a tributary of Tuirial River in the vicinity of Zemabawk, Aizawl, 23°44'54" N 92°45'27" E.

Schistura chindwinica: MUMF 4042 (8), 45.2–62.8 mm SL; India: Manipur: Barak drainage (Brahmaputra basin): Iyei River, Noney. PUCMF 11022 (11), 41.9–59.2 mm SL; India: Mizoram: Barak drainage (Brahmaputra basin): Tuila (Tributary of Tuivai), Northeast Khawdungsei, 23°59'11"N 93°14'16"E.

Schistura fasciata: MUMF 11010, holotype, 51.3 mm SL; MUMF 11001–11005 (5), paratypes, 37.1–53.2 mm SL; MUMF 11018-11021 (4), paratypes, 39.0–66.4 mm SL; India: Manipur: Senapati District: Brahmaputra basin: Barak River, Maram Hill, 25°23’24”N 94°04’09”E.

Schistura kangjupkhulensis: MUMF 3007 (3), 42.8–46.3 mm SL; India: Manipur: Chandel District: Chindwin- Irrawaddy basin: Khujairok, Moreh. Schistura khugae: MUMF 5013, holotype, 65.9 mm SL; ZSI FF4145, paratype, 65.2 mm SL; India: Manipur: Churachandpur District: Chindwin-Irrawaddy basin: Khuga River.

Schistura koladynensis: PUCMF 12019 (5), 47.6–74.5 mm SL; India: Mizoram, Kolodyne River, in the vicinity of Kawlchaw, Lawngtlai, 22°23'48"N 92°57'47"E; Samuel Lalronunga & Vanlalmalsawma 24 April 2012. PUCMF 12021 (4), 55.8–62.8 mm SL; India: Mizoram, Kolodyne River, in the vicinity of Kawlchaw, Lawngtlai, 22°23'48"N 92°57'47"E; Andrew Arunava Rao & Lalramliana, 24 April 2010. Additional data from Lokeshwor & Vishwanath (2012).

Schistura manipurensis: Uncatalogued (3), 48.7–50.9 mm SL; India: Manipur: Chandel District: Chindwin- Irrawaddy basin: Khujairok, Moreh. Schistura minuta: MUMF 1005–1006 (2), 35.6–37.1 mm SL; India: Manipur: Barak Drainage (Brahmaputra basin): Iyei River, Noney.

Schistura minuta: MUMF 1005-1006, 2, 35.6-37.1 mm SL; India: Manipur: Barak drainage (Brahmaputra basin): Iyei River, Noney.

Schistura multifasciata: ZSI F26771/1, holotype, Darjeeling, India. Additional data from Day (1878) and Menon (1987).

S. paucireticulata: PUCMF 13020, 13, 44.3-52.1 mm SL; India: Mizoram: Barak drainage (Brahmaputra basin): Tuirial River, Aizawl. Additional data from Lokeshwor *et al*. (2013).

Schistura porocephala: PUCMF 13001 (16), 37.6–59.8 mm SL; India: Mizoram, Iana River, a tributary of Kolodyne River in the vicinity of Lungbun, Saiha District, 22°28'45"N; 93° 07'01"E; Beihrosa Solo & Party, 20 October 2012. Additional data from Lokeshwor & Vishwanath (2013).

Schistura reticulata: MUMF 4400, holotype, 57.1 mm SL; ZSI FF 4146 (1), paratype, 57.8 mm SL; India: Manipur: Ukhrul district: Chindwin-Irrawaddy basin: Maklang River.

Schistura reticulofasciata: MUMF 11070–110716 (2), 36.7–47.9 mm SL; India: Barapani (Brahmaputra basin) near ICAR complex, Meghalaya, India.

Schistura scaturigina: MUMF 3008 (1), 39.6 mm SL; India: Manipur: Barak drainage: Tuivai River.

S. scaturigina: MUMF 3008, 1, 39.6 mm SL; India: Manipur: Barak drainage: Tuivai River.

Schistura sikmaiensis: MUMF 11220–11222 (3), 63.4-74.6 mm SL; India: Manipur: Chindwin-Irrawaddy basin: Senalok. Schistura tigrina: MUMF 4105, holotype, 93.5 mm SL; India: Manipur: Tamenglong District: Barak River, Khunphung.

S. tigrina: MUMF 4105, holotype, 93.5 mm SL; India: Manipur: Tamenglong District: Barak River, Khunphung.

Schistura vinciguerrae: ZSI F 11754/1 (1), 49.9 mm SL; Burma: Meekalan.

Published information used for comparison: Bohlen & Šlechtová (2011) for *S. callidora*; Bohlen&Šlechtova (2013) for *S. rubrimaculata*, Günther (1868) and Menon (1987) for *S. beavani*, Menon (1987) for *S. carletoni* (1822), Menon (1987) for *S. gangetica*, Menon (1987) for *S. nagaensis*, Menon (1987) for *S. singhi*, Menon (1987) for *S. triapensis*and Menon (1987) for *S. savona*; Hora (1935) for *S. shebbearei*; Hora (1935) and Menon (1987) for *S. devdevi*; Kottelat (1990) for *S. acuticephala*, *S. malaisei* and *S. paucifasciata*; Kottelat *et al*. (2007) for *S. papulifera*; Lokeshwor *et al*. (2012) for *S. obliquofascia*; McClelland (1839) for *S. zonata*; and Sen(2009) for *S. rosammai*.

Appendix II: List of publications

Peer reviewed journal:

1. Lalramliana, **Lalronunga, S.**, Lalnuntluanga, Ng, H.H. (2015) *Exostoma sawmteai*, a new sisorid catfish from northeast India (Teleostei: Sisoridae). *Ichthyological Exploration of Freshwaters*. 26(1): 59-64.

2. Lalramliana, Lalnuntluanga and **Lalronunga, S.** (2015) *Psilorhynchus kaladanensis*, a new species (Teleostei: Psilorhynchidae) from Mizoram, northeastern India. *Zootaxa*. 3962 (1): 171–178.

3. Lalramliana **Lalronunga, S.**, Vanramliana and Hmar Lalthanzara (2014) *Schistura mizoramensis*, a new species of loach from Mizoram, northeastern India (Teleostei: Nemacheilidae). *Ichthyological Exploration of Freshwaters*. 25 (3): 205-212.

4. Solo, B., Lalramliana, **Lalronunga, S.** and Lalnuntluanga (2014) *Schistura andrewi*, a new species of loach (Teleostei: Nemacheilidae) from Mizoram, northeastern India. *Zootaxa*. 3860 (3): 253–260.

5. Ng, H.H., Lalramliana, **Lalronunga, S.** and Lalnuntluanga (2014) *Eutropiichthys cetosus*, a new riverine catfish (Teleostei: Schilbeidae) from northeastern India. *Journal of Threatened Taxa*. 6 (8): 6073–6081.

6. Lalramliana, Beihrosa, S., **Lalronunga, S.** and Lalnuntluanga (2014) *Psilorhynchus khopai*, a new fish species (Teleostei: Psilorhynchidae) from Mizoram, northeastern India. *Zootaxa*. 3793 (2): 265-272.

7. **Lalronunga, S.,** Lalnuntluanga and Lalramliana (2013) *Schistura maculosa*, a new species of loach (Teleostei: Nemacheilidae) from Mizoram, northeastern India. *Zootaxa*. 3718 (6): 583–590.

8. **Lalronunga, S.,** Lalnuntluanga and Lalramliana (2013) *Garra dampaensis*, a new ray-finned fish species (Cypriniformes: Cyprinidae) from Mizoram, northeastern India. *Journal of Threatened Taxa*. 5(9): 4368-4377.

9. Ng, H.H., Lalramliana, **Lalronunga, S.** and Lalnuntluanga (2013) *Pseudolaguvia nubila*, a new sisorid catfish (Teleostei: Sisoridae) from northeastern India. *Zootaxa*. 3647 (4): 518–526.

Proceedings/Book chapter:

1. Lalremsanga, H.T., Sailo, S., Lalrinchhana, C., **Lalronunga, S.** and Lalrotluanga (2015) Herpetofaunal survey on Tam Dil National Wetland, Mizoram, India. In: Sanyal, A.K., Gupta, S.K. and Manna, S. (eds.) *Biodiversity and livelihood*, p 207-216.

2. Hrima, V.L., Hriatzuala Sailo, V.L., Fanai, Z., **Lalronunga, S.,** Lalrinchhana, C., Zothansiama and Lalremsanga, H.T. (2014) Nesting ecology of the King Cobra, *Ophiophagus hannah*, (Reptilia: Squamata: Elapidae) in Aizawl District, Mizoram, India. In: Lalnuntluanga, Zothanzama, J., Lalramliana, Lalduhthlana and Lalremsanga, H.T. (eds.) *Issues and Trends of Wildlife Conservation in Northeast India*, p. 268-274.

3. Lalhmingliani, E., Gurusubramanian, G., Lalremsanga, H.T., Lalrinchhana, C. and **Lalronunga, S.** (2014) Wild silk moths (Lepidoptera: Saturniidae) of Hmuifang community forest, Aizawl Mizoram: Conservation concerns. In: Lalnuntluanga, Zothanzama, J., Lalramliana, Lalduhthlana and Lalremsanga, H.T. (eds.) *Issues and Trends of Wildlife Conservation in Northeast India*, p. 261-267.

4. Lalrosangpuii, Famkima Varte, V.L., Hmingthantluangi, J., Lalhmingliani, E., Khiangte, Z., Lalhmingliana, C., Lalrotluanga, Lalrinchhana, C., **Lalronunga, S.,** Zothansiama, Sailo, S. and Lalremsanga, H.T. (2014) A case study on the nest

occupation of birds in the artificial nest boxes in Mizoram. In: Lalnuntluanga, Zothanzama, J., Lalramliana, Lalduhthlana and Lalremsanga, H.T. (eds.) *Issues and Trends of Wildlife Conservation in Northeast India*, p. 240-250.

5. **Lalronunga, S.,** Lalramliana and Lalnuntluanga (2014) Diversity and conservation status of the Genus *Schistura* (Teleostei: Nemacheilidae) in Barak and Kolodyne drainage of Mizoram. In: Lalnuntluanga, Zothanzama, J., Lalramliana, Lalduhthlana and Lalremsanga, H.T. (eds.) *Issues and Trends of Wildlife Conservation in Northeast India*, p. 180-185.

6. Lalhmingliani, E., Gurusubramanian, G., Lalfelpuii, R., Senthil Kumar, N., **Lalronunga, S.** and Lalremsanga, H.T. (2013) Wild silk moth (Lepidoptera: Saturniidae) of Mizoram University campus, Aizawl, Mizoram, northeast India. In: Singh, K.K., Das, K.C. and H. Lalruatsanga (eds.) *Bioresources and Traditional Knowledge of Northeast India*, p. 223-228.

7. **Lalronunga, S.,** Lalrinchhana, C., Lalnuntluanga and Lalramliana (2013) First record of frogmouth catfish, *Chaca chaca* (Hamilton, 1822) (Teleostei: Chacidae) from Mizoram. In: Singh, K.K., Das, K.C. and H. Lalruatsanga (eds.) *Bioresources and Traditional Knowledge of Northeast India*, p. 165-169.

8. **Lalronunga, S.,** Lalnuntluanga and Lalramliana (2011) Diversity of Catfish (Teleostei: Siluriformes) in Rivers of Barak Drainage of Mizoram, Northeastern India. In: Tiwari, D. (ed.) *Advances in Environmental Chemistry*, p. 297-300.

Appendix III: List of papers presented in symposium/conference

1) *Diversity of Catfish (Teleostei: Siluriformes) in Rivers of Barak Drainage of Mizoram, North East India*at International Conference on Advances in Environmental Chemistryorganized by Department of Chemistry, Mizoram University, Aizawl held on 16th to 18th November 2011 at Mizoram University, Aizawl, Mizoram.

2) *First Record of Frogmouth Catfish, Chaca chaca (Hamilton, 1822) (Teleostei: Chacidae) from Mizoram* at National Conference on Bioresource Inventory and Emerging Conservation Startegies with Special Reference to Northeast Indiaorganized by Department of Environmental Sciaence and Department of Botany, Pachhunga University College, Mizoram University, Aizawl held on 7th to 8th March 2013 at Pachhunga University College, Aizawl, Mizoram.

3) *Assessing the Municipal Solid Waste management practices in Aizawl city, India at National Seminar on Green Chemistry for Greener Environment*organized by Department of Chemistry, Pachhunga University College, Mizoram University, Aizawl held on 26th to 27th November 2012 at Mizoram University, Aizawl, Mizoram.

4) *Diversity of Catfish (Teleostei: Siluriformes) in rivers of Kolodyne drainage of Mizoram, Northeastern India* at National Seminar on Emerging Trends in Biosciences and Future Prospects organized by Department of Zoology, Pachhunga University College, Mizoram University, Aizawl and Department of Zoology, Mizoram University, Aizawl held on 29th to 30th November 2011 at Pachhunga University College, Aizawl, Mizoram.

Appendix IV: List of conference/seminars/workshop attended

1) *National Seminar cum Training Program on Green & Environmental Chemistry*organized by Department of Chemistry, Mizoram University, Aizawl held on 30th March 2011 at Mizoram University, Aizawl, Mizoram.

2) *State level workshop on Status and Conservation of Forest Resources in Mizoram*organized by Department of Environmental Science, Mizoram University, Aizawl held on 7th to 8th April 2011 at Mizoram University., Aizawl, Mizoram.

3) *One Day State Level Symposium on "Chemistry- our life, our future"*organized by Mizo Post-Graduate Society and Mizoram Council of Science, Technology and Environment, Government of Mizoram held on 31st August 2011 at Pi Zaii Hall, Synod Conference Centre, Aizawl, Mizoram.

4) *National Seminar on Emerging Trends in Biosciences and Future Prospects*organized by Department of Zoology, Pachhunga University College, Mizoram University, Aizawl and Department of Zoology, Mizoram University, Aizawl held on 29th to 30th November 2011 at Pachhunga University College, Aizawl, Mizoram.

5) *International Conference on Advances in Environmental Chemistry*organized by Department of Chemistry, Mizoram University, Aizawl held on 16th to 18th November 2011 at Mizoram University, Aizawl, Mizoram.

6) *National Seminar on Faunal Diversity and Ecophysiology*organized by Department of Zoology, NEHU, Shillong held on 28th to 29th February 2012 at NEHU, Shillong, Meghalaya.

7) *One day State level Seminar on Sustainable Energy for All*organized by Mizo Post-Graduate Society and Mizoram Council of Science, Technology and

Environment, Government of Mizoram held on 24th August 2012 at Pi Zaii Hall, Synod Conference Centre, Aizawl, Mizoram.

8) *Sensetization workshop for development of location specific R&D and demonstration project for SC/ST*organized by Mizoram Council of Sciences, Technology & Environment held on 28th August 2012 at I&PR Auditorium, Aizawl, Mizoram.

9) *National Seminar on Green Chemistry for Greener Environment*organized by Department of Chemistry, Pachhunga University College, Mizoram University, Aizawl held on 26th to 27th November 2012 at Mizoram University, Aizawl, Mizoram.

10) *National Workshop on Molecuar Phylogenetics and Evolution*organized by Department of Biotechnology, Mizoram University, Aizawl, Mizoram held on 26th to 28th November 2012 at DBT-BIF Centre, Department of Biotechnology, Mizoram University, Aizawl, Mizoram.

11) *National Seminar on Recent Advances in Natural Product Research (RANPR)* organized by Department of Zoology, Pachhunga University College, Mizoram university, Aizawl and Department of Pharmacy, Regional Institute of Paramedical and Nursing Sciences (RIPANS), Aizawl held on 29th November to 1st December 2012 at Pachhunga University College, Aizawl, Mizoram.

12) *National Conference on Bioresource Inventory and Emerging Conservation Startegies with Special Reference to Northeast India*organized by Department of Environmental Sciaence and Department of Botany, Pachhunga University College, Mizoram University, Aizawl held on 7th to 8th March 2013 at Pachhunga University College, Aizawl, Mizoram.

13) *Hands on training on DNA barcoding*organized by Department of Zoology, Pachhunga University College, Mizoram University, Aizawl held on 14th to 16th

March 2013 at the Department of Zoology, Pachhunga University College, Aizawl, Mizoram.