DIVERSITY AND DISTRIBUTION OF CYPRINIFORMES IN KOLODYNE RIVER BASIN OF MIZORAM, INDIA

By

S. Beihrosa,

Department of Environmental Science

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

Dedicated to my father S. Laitia (L), who passed away on 21st March, 2014.

CERTIFICATE

This is to certify that the thesis entitled **"Diversity and distribution of Cypriniformes in Kolodyne River basin of Mizoram, India"** submitted to Mizoram University for the award of the degree of Doctor of Philosophy by **S. Beihrosa**, research scholar in the Department of Environmental Science, is a record of original work carried out during the period from 2013-2016 is under our guidance and supervision. This work has not been submitted elsewhere for any degree.

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DECLARATION

I, Mr. S. Beihrosa, hereby declare that the subject matter of this thesis entitled **"Diversity and distribution of Cypriniformes in Kolodyne River basin of Mizoram, India"** 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.

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Place: Aizawl **(S. BEIHROSA)**

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List of acronyms

%	:	Percentage
+	:	Plus
/	:	Per
=	:	Equal to
>	:	Greater than
<	:	Less than
°	:	Degree
°C	:	Degree Celcius
cm	:	Centimeter
E	:	East
eg	:	Example
et al	:	And others
HL	:	Head length
IUCN	:	International Union for Conservation of Nature
km	:	Kilometre
MTP	:	Mara Thyutlia Py
MZUBM	:	Mizoram University Biodiversity Museum
N	:	North
PUCMF	:	Pachhunga University College Museum of Fishes
SL	:	Standard length
VC	:	Village Council
viz	:	Namely
vs	:	Versus
YMA	:	Young Mizo Association
ZSI	:	Zoological Survey of India

CHAPTER 1

INTRODUCTION

Fishes are cold blooded aquatic vertebrates which breathe by means of pharyngeal gills, propelling and balancing themselves by means of fins and there are about 20, 000 species known to inhabit water bodies of various descriptions (Jhingran, 1991). Each continent has its own distinctive freshwater fish fauna and distribution (Berra, 2001) which can be attributed to physical barrier and difference of temperature adaptability among various groups and among the different group of fishes. The bony fishes are one of the most diverse groups and well represented in the freshwaters and the total number of freshwater fishes including brackish water is estimated to be around 15, 000 species (Leveque *et al*., 2008). Nelson (1984) estimated the total number of fish to be 21, 723 species under 4, 044 genera, 445 families and 50 orders in the world and out of these, 8411 belongs to freshwater fishes and 11, 650 species belongs to marine fish. On the other hand Nelson (2006), however, estimates the total number of extant fish species to be closed to around 32, 500. Day (1889) recorded the presence of 1, 418 species of fish under 342 genera from the British India. The number of freshwater fish species is increasing and estimated to be between 9, 000-25, 000 (Cosgrove & Rijsberman, 2000). Freshwater fish species are the most species rich group among European vertebrates which includes 546 native species (Kotellat & Freyhof, 2007). Leveque *et al*. (2008) mentioned how the freshwater fish confinement to a particular drainage system reflects the imprint of past continental and climatic changes.

1.1 Order Cypriniformes

Cypriniformes is the largest order of the freshwater fishes comprising 2, 422 species (Nelson, 1984) and the members shares osteology and musculature similarities with their geographical habitat ranging from tropical to temperate waters of Europe, Africa, Asia and North America (Talwar & Jhingran, 1991).

The order Cypriniformes includes the carps, minnows, loaches and their relatives. It contains 5-6 families, over 320 genera, and more than 3, 250 species identified so far; and the order is included in the superorder Ostariophysis (Fink & Fink, 1981). However, the number of families increased to 12 (Kotellat, 2013). Like other orders of the Ostariophysis, the Cypriniformes possess a Weberian apparatus i.e. the first four vertebrae called Ossicles are modified and connect the inner ear with the swim bladder which functions in transmitting sound vibration to auditory receptor in the brain (Greenwood *et al*., 1966; Rosen & Greenwood, 1970; Fink *et al*., 1984). Because of this, they can hear well in murky fresh water which gives them an advantage for survival, and even, may be one of the reasons why the Cypriniformes groups remain the dominant group. However, they differ from most of their relatives in having only a dorsal fin on their back; most other Ostariophysi have a small fleshy adipose fin behind the dorsal fin. With 3, 862 species, Cypriniformes is the most diverse monophyletic order of vertebrates (Johnson & Patterson, 1993; Springer & Johnson, 2004). Cypriniformes is diagnosed by the absence of teeth on the jaws and palate, a kinethmoid bone, allowing for protrusion of jaws, absence of an adipose fin, three branchiostegal rays, usually scale less head, and several other skeletal synapomorphies (Fink & Fink, 1981). Classification within the order, however, is in a state of flux given that the traditional classification essentially lacked any demonstrable justification. Cypriniformes, the most species rich vertebrate family, had been reported from different parts of the world and is the most widely distributed fishes (Menon, 1964; Kotellat, 1984; Banarescu, 1986; Kotellat *et al*., 1993; Nelson, 1994; Getahun, 2000; Kullander & Fang, 2004).

1.2 Freshwater fish diversity

Gleick (1996) estimated that the total area of freshwater cover is around 0.01% of the world's water which is approximately 0.8% of the earth surface. Freshwater ecosystems are one of the richest and most diverse ecosystems on earth (Ravenga & Mock, 2000) and fish constitute a large part of this biodiversity (Saunders *et al*., 2002). Freshwater fishes are defined as those that spend all or a critical part of their life cycle in freshwaters. The tropical regions harbour majority of the world's freshwater fish species (Lowe-McConnel, 1987; Kotellat & Whitten, 1996). About 10, 000 freshwater fish species are currently recognised (Nelson, 1994) and many more are still awaiting discovery and description (Kotellat & Whitten, 1996). The number of fish species able to use freshwaters, totals to about 13, 000 species or 15, 000 including those of brackish waters (Leveque *et al*., 2008). Fish inhabiting freshwaters comprise 25% of living vertebrates (about 55, 000 described species) and represent 13–15% of the 100, 000 freshwater animal species currently known (Leveque *et al*., 2005).

Freshwater biodiversity constitutes a vitally important component of the planet, with a species richness relatively higher compared to both terrestrial and marine ecosystems (Gleick, 1996). Fish forms the most important wetland product on a global scale, and is certainly the most utilized wetland resource. Asia accounts for 63% of total fish production (Briones *et al.*, 2004) and fish accounts for 30% of the typical diet across Asia as a whole (FAO, 2010). It has great cultural and psychological value to human beings. The number of fish species able to use freshwaters, totals to about 13–15, 000 species, which is 40–45% of the global fish diversity is estimated about 29–30, 000 described species (Leveque *et al*., 2008). Fish inhabiting freshwaters, therefore, comprise 25% of living vertebrates (about 55, 000 described species) and represent 13–15% of the 100, 000 freshwater animal species currently known (Leveque *et al*., 2005). Recent research on the reconstruction of Cypriniformes tree of life generated a number of new insights into the evolutionary history of these diverse clad (Chen & Mayden, 2009; Mayden *et al*., 2008). Cypriniformes geographical location includes the freshwaters of Asia, Africa, Europe and North America but absent from South America and Australia (Berra, 2001)

There are several factors that contribute to the diversity of the freshwater fish species all over the world. Revenga *et al*. (1998) estimated 20% of the freshwater fish species to be vulnerable, endangered or extinct. Arunachalam (2000) reported and identified the habitat features, either biotic or abiotic as the major determinants in the distribution and abundance of fishes from the earlier times. The segregation of fishes based on their positioning in the water column relative to both velocity and vertical position and to a particular substratum types have been reported (Wickramanayake & Moyle, 1989). Ahyaudin *et al*. (1988) stated the occurrence of streamlined body fishes with optimal hydrodynamic efficiency in the hilly streams. Gillian *et al*. (1993) highlighted the role played by the chemical changes in the water quality in streams and rivers leading to alteration of inter specific competition and predation among fish communities that finally contributes to the fish diversity. Eklov *et al*. (1998) recorded the factors such as phosphorus and dissolve oxygen content to be responsible for the icthyofaunal community changes in streams of Sweden. Abram (1993) stated nutrient input as human effect on the environment and an increase in nutrient level in the ecosystem might contribute to a possible decrease in the abundances of all trophic levels when more than two species per level are present. Water pollution in any form by various substances has serious adverse effect on fish reproduction and disruption of various metabolic activities (Nickolsky, 1969). 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). Throughout the world, aquatic environments are experiencing serious threats to both diversity and ecosystem stability and therefore, research is being pursued globally to develop systematic conservation planning to protect freshwater biodiversity (Margules & Pressey, 2000; Saunders *et al.*, 2002).

1.3 Biogeographical regions

Biogeography is important for understanding and assessing the biological and historical processes underlying species distribution patterns (Platnick & Nelson, 1978) and movement of continents leading to distribution and dispersal of species are the fundamental aspects of biogeography (Rosen, 1978; McDowall, 1996). Some authors have carried out works on the vicariance and dispersal biogeography of single taxa or entire regional biotas (Brattstrom, 1990; Water *et al*., 2000; Turner *et al*., 2001; Briggs, 2003; Vences *et al*., 2003). South America is considered as the centre of origin of otophysan fishes (Briggs, 2005) which is indicated by the presence of the most advanced group in the taxa, the apomorphic Gymnotiformes (Matthew, 1915).

Biogeographically , Neotropical region contain 4,035 species of freshwater fish under 705 genera, 2,938 species under 390 genera in Afrotropical, 2,345 species under 440 genera in the Oriental, 1, 844 under 380 genera in the Palaeartic, 1, 411 species under 380 genera in the Neartic and 261 species under 94 genera in the Australian region (Leveque *et al.*, 2008).

1.4 Competitive interaction

Competitive interactions also shaped the community structure in stream ecosystem in the tropical areas. Wikramayanake and Moyle (1989) stated that the pronounced resource partitioning and complementarities suggest that assemblages have co-evolved to reduce inter specific competition. Species richness is related to biological factors like inter specific competition at the local scale (Grossman, 1982; Ross *et al*., 1985). Feeding specialization and habitat preferences by many tropical freshwater fishes are designed to reduce competition from other fishes. For instance, the fish from the family Homalopteridae has become specialized to live in fast-flowing water at the riffles area (Moyle & Cech, 1982), which is not occupied by many other species, hence reduce the competition they have to face. In order to survive in this demanding area, Homalopterids have developed suckers to anchor on boulders in order to avoid being carried away by the fast and turbulent water flow. In lieu to this, these fishes also feed on the abundant algae living on rocks and boulders in the riffles that are not utilized by many other fishes.

1.5 Physicochemical factors

There are some factors in particular such as hydrology, temperature and oxygen that impose energetic constraint on each species and thus resulting in the diversity of species in the hill streams (Blanck *et al*., 2007). The acidity and alkalinity of the water medium in which the hill stream fish survive may also have a lot to do with the diversity of the fish species. Patric (1970) recorded that the low diversity of fish species in the stream may be due to little alkaline nature of the stream which supports fewer species of fishes. Patric (1975) mentioned seasonal fluctuation of the stream as well as narrow channel in promoting survival of small organism much better but however lead to reduction of diversity. The water current flow in stream is usually high and this makes it difficult for plankton to grow properly thereby affecting plankton diversity. High currents not only affect the growth of plankton on which the fish feed but also the habitation as well the distribution of the fishes. Upadhya and Kunjur (2010) highlighted the role of high velocity water in making the drainage system difficult and intolerable for all taxa. Specific conductivity which is an index of soluble ion concentration is a good conductor of productivity (Das *et al*., 2001). Odum and Gray (2005) reported that the solubility of the oxygen is increased by low temperature and also decreased by high salinity. Oxygen also enter into the stream by diffusion from the air enhance with the turbulence of the stream water (Hynes, 1970). Temperature fluctuation is an important component of the aquatic ecosystem and it varies seasonally in different times of the year. The temperature of the water medium is one of the most important factors affecting the maturity, spawning and development of fish (Bhatt *et al*., 1984).

1.6 Bio indicators

Fishes are the keystone species and play a great role in determining the abundance and distribution of the other organisms in the ecosystem they represent, and they also act as a good indicator of the water quality and health of the ecosystem (Bijukumar, 2000). Simon

(1999) highlighted that the use of fish as ecological indicator started at the beginning of the 20th century where fishes have some particular features and advantages as indicator of the health of the freshwater ecosystem. Fishes have multiyear lifespan and mobility, and some species of fish are very sensitive to changes in the water chemistry such as change of pH or dissolved oxygen which may be caused by pollutants, natural change, and tidal flow or due to any other factors. Barton *et al*. (2002) recorded the long term exposure of fish to environmental pollution and low oxygen causes severe detrimental effects on the metabolic processes such as reproduction, growth, resistance to disease and survival of the fish. Adams and Greely (2000) also mentioned the effect of stressors on the fish depends on individual and population level depends on the intensity and duration of stress exposure and species specific features. Noble and Cowx (2007) mentioned that each fish species possess optimal habitat requirements, which resulted to changes in community structure along the upstream and downstream gradients of a river, and similarly Huet (1959) highlighted how habitat requirements have been used to classify different zones in a river.

1.7 Movement of fish

The movements by fishes among the different habitats are frequently non-random, with fishes often exhibiting temporal and spatial variation in habitat use. Xie *et al*. (2000) reported that a community of small fishes was demonstrating seasonal use of habitats. The importance of habitat selection in the life history of fishes is apparent in the consequences it has on their fitness, such as parasite load (Lysne *et al*., 1998), energetic costs (Twiss *et al*., 2000) and foraging success (Keast & Fox, 1992). One way fishes may shift habitats is by adjusting their depth selection and the depth at which particular fish species forage may be an important feature in the diversity studies as the depth selection may be extremely important in the life history of fishes (Schlosser, 1982; Baltz & Moyle, 1984). In fact, physiological functions such as digestion are facilitated by temperature (Temming *et al*., 2002), which in turn can be related to water depth. Depth selection may also be important in foraging (Freeman & Grossman, 1993), reproduction (Aadland, 1993) and in influencing the composition of fish assemblages that contributes a lot to the diversity.

1.8 Fish as food

Human dependence on wild fish for food is increasing, substantial and unsustainable as is currently practice (McAllister *et al*., 1997; Parrish *et al*., 1998). World capture fisheries have reached its maximum at approximately 94 million tonnes (FAO, 2007). Fish forms the most important wetland product on a global scale, and is certainly the most utilized wetland resource. Asia accounts for 63% of total fish production (Briones *et al.*, 2004) and fish accounts for 30% of the typical diet across Asia as a whole (FAO, 2010). The richness of fish muscle in protein, mineral elements and the unsaturated fatty acids has been reported (Fuentes *et al*., 2010; Zhou *et al.*, 2010). Thompson and Subasinghe (2011) mentioned that in many low income countries possessing water and fishery resources, fish and fishery plays an important part in their livelihood, income and as food especially for the rural poor who suffered from under nutrition and facing micro nutrient deficiency problems. Fish is known to be a source of protein rich in essential amino acids such as lysine, methionine, cystine, threonine, and tryptophan (Sikorski, 1994), micro and macro elements such as calcium, phosphorus, fluorine, iodine, fats that are valuable sources of energy, fat soluble vitamins, and unsaturated fatty acids that, amongst other benefits, have a hypocholesterolemic effect (Fernandez & Venkatrammann, 1993; Ismail, 2005). EFSA (2014) also mentioned that seafood provides long chain polyunsaturated fatty acid and protein with high biological value and several essential nutrients such as iodine, selenium, calcium, vitamin A and D.

1.9 Fish production and consumption

The current capture fish production has been estimated to be approximately around 90 million tonnes per year and aquaculture has continued to show substantial growth at around 6.5% a year faster than other food sectors (FAO, 2012, 2014). The global fish production has grown steadily in the last five decades with an annual average rate of 3.2% outpacing the world population growth at 1.6% and the dramatic increase in the fish production is mainly due to the expansion of fish production in China (FAO, 2014). FAO (2014) also states that the world per capita consumption of fish increase from an average of 9.9 kg in the 1960s to 19.2 kg in the 2012 and this impressive figure is partly contributed by population growth, urbanization and rising incomes which is also facilitated by strong expansion of fish production and more efficient distribution. The total capture of fish production in 2011 was estimated to be 93.7 million tonnes which is slightly below 93.8 of 1996 record and in 2012 a new maximum record of 86.6 million tonnes excluding anchoveta fish was recorded (FAO, 2014). The proportion of fish production used for direct human consumption increased from about 71% in the 1980s to more than 86% in the 2012 and the remaining destined for non food uses such as oil and fishmeal (FAO, 2014). The importance of promoting sustainable use of small indigenous species of fish in both culture and fishery system has been mentioned, considering the extent to which small indigenous species of fish play an important role in providing nutrition to the rural poor, and also in maintaining biodiversity (Jhingran, 1991).

1.10 Threat to fish diversity

1.10.1 *Dam construction*

The constructions of dam fragment and regulate the flow of river flow by removing turbulent river section and create tranquil water bodies thereby affecting the flow and temperature regimes (Nilsson *et al*., 2005).The other consequences of dam construction includes sequestration of transported sediments (Vorosmarty *et al*., 2000) blocked migration routes for river fishes by transforming free flowing water reaches into standing water (Limburg & Waldman, 2009). Lytle and Poff (2004) highlighted channelization and levee construction activities in reducing the extent and frequency of inundation, thereby affecting the fishes that depend on the floodplains. The shifts from lotic to lentic environment after dam construction lead to the homogenization of general fish species over the unique specialist species and easily put endemic species at the risk of extinction (Poff *et al*., 2007). There have been certain record on the influence of sediment detainments and turbidity effects on fish (Waters, 1995; Anderson *et al*., 1996) leading to substrate reduction on the downstream habitat that are in critical stage of their life cycle, such as nesting and refuge for many species. Dam construction also greatly affects the fish migration for spawning and reproduction (Kruk & Penczak, 2003). Dam construction modifies the rate and flow of water in the rivers and is harmful to the fish diversity of the freshwater ecosystem. There are an estimated one million dams globally resulted in the fragmentation of rivers (Strayer & Dudgeon, 2010).

1.10.2 ***Pollution***

Some authors mention the sources of aquatic pollution as urban, industrial and agriculture activities leading to rapid deterioration of water quality (Richtr *et al*., 1997; Dudgeon, 2000) that increase mortality rates, decrease reproduction and growth rate of fish (Moyle & Leidy, 1992). Kalff (2002) mentioned the most important nutrients such as phosphorus and nitrogen are the ones that are usually in short supply and have limiting effect on phytoplankton and macro invertebrates. Fish has been identified as easy indicator for biological assessment (Gaston, 2000). Khanna and Ishaq (2013) also recorded the sensitiveness of fishes to changes in the water chemistry, due to various anthropogenic activities and its responses to environmental disturbances as well as highlighting the effect of water pollution on the aquatic life and menaces to human health. Thirumala *et al*. (2011) reported the decline of few species from the freshwater ecosystem of India due to irrational fishing practices, water abstraction and pollution. Fertilizer runoff from agriculture and industrial dumping of toxic waste chemical directly into rivers and lakes lead to poisoning of the fish habitat which can no longer support the fish aquatic ecosystem (Strayer & Dudgeon, 2010). The mining processes of certain metals such as lead, cadmium, mercury and chromium by extractive industries lead to pollution of freshwater in some part of the world which causes biomagnifications to aquatic organisms and human beings (Wright & Welbourn, 2002; Bradl, 2005 & Lima *et al*., 2008). Pollution is one of the determining factors responsible for the decline and habitat loss of fish species in several countries of the world. Water pollution is generally caused by a number of factors including domestic waste, industrial and agriculture effluent, river transportation and sedimentation. Excessive loading of nutrients and toxins from land use and point source changes of water leads to eutrophication of water to the extent that it no longer support its natural biotic communities (Smith, 2003). The increasing use of pesticides in agriculture poses serious threats and health hazards, both to public health and fisheries of ponds, lakes and rivers (Jhingran, 1991). Kulreshtha and Arora (1984) found the impairments induced by sub-lethal doses of two pesticides in the ovaries of a freshwater teleost *Channa striatus* and another study by Sastry and Gupta (1978) also noticed the effect of mercury metal in inhibiting the activities of all enzymes in *Heteropneustes fossilis* when exposed to sub-lethal concentration. Several studies have been carried out in India to estimate the acute toxicity level of various pesticides on aquatic fauna (Arora *et al*., 1971; Basak & Konar, 1977; Verma *et al*., 1981)

1.10.3 *Habitat degradation*

Habitat loss and degradation are the primary factors responsible for the loss of fish diversity in the freshwater rivers. Habitat loss and degradation can occur due to several factors but it generally occurs due to deforestation and agricultural practices in several parts of the world. Helfman (2007) states that the principal cause for the decline and extinction of freshwater fish as habitat degradation and similarly, McKinney (1997) also mentioned that not a single case of non anthropogenic species extinction can be documented in the past 8000 years. Some activities such as agriculture, mining and urbanization discharged high amounts of pollutants into the rivers that are detrimental to vegetation cover that forms an important component of river ecosystems (Eklov *et al*., 1998; Amisah & Cowx, 2000; Raat, 2001; Penczak & Sierakowska, 2003) and changes of riparian vegetation can influence channel morphology, rates of soil erosion or deposition (Allan, 2004) which have negative impact on the diversity of the aquatic life. When these activities occur especially in the upper catchment portion, sedimentation occurs due to soil erosion which is carried downstream towards the river with a resulting heavy siltation of the river bed. Tockner *et al*. (2008) recorded deforestation and cultivation of soils as the main human activities that have cause major modification to inland waters largely through changes in river discharge and sediment transport. Most of the countries that are home to a high numbers of endemic and threatened species, their consumption of the freshwater is expected to increase further in the coming years due to increasing demand as well as climate change (Alcamo *et al*., 2008; Bates *et al*., 2008) which will ultimately lead to more habitat loss and diversity loss in several countries all over the world.

1.10.4 *Predators*

Harvey and Stewart (1991) highlighted the role of predation risk in habitat selection by animals, and for many taxa, more than one kind of predators may be important and the same is applicable for the fish. Another study on the role of predator in habitat selection by Grossman and Freeman (1987) further confirmed and stated that predators have been shown to effect distribution of stream fishes especially through avoidance. Moyle and Cech (1982) highlight the profound adaptation that represents co-evolution between predators and prey leads to high diversity of fish. Walls *et al*. (1990) highlighted piscivorous fish as the main predator group of juvenile fish and the prey species try to escape mainly by behavioural means and the mode of predation also select for fast growth of the juvenile stage to proceed rapidly to less vulnerable stages. Predators play an important part in the diversity and habitat selection of many animal species including fishes. Small fish may try to avoid predators by several ways (Mittelbach, 1986) which includes forming schools, increase vigilance and seeking refuge from predators (Schlosser, 1987). Shoaling is a common response to predation as it provides anti predator benefits through dilution, confusion and vigilance effects (Morgan & Colgan, 1987). However, shoaling doesn't always reduce the number of prey attacked by piscivorous fish (Walls *et al*., 1990). Harvey and Stewart (1991) mentioned predation risk as an important factor in habitat selection by animals. Grossman and Freeman (1987) also stated the predator effect in the distribution of stream fishes especially through avoidance. Planktivorous fish predations have a major impact on zooplankton species composition and diversity (Vanni, 1987) and predation by fish may also greatly affect juvenile fish survival (Miller *et al*., 1989).

1.10.5 *Invasive species*

Invasive species are those species that are intentionally or unintentionally introduced into new area outside their natural range and played a major role in disrupting the freshwater ecosystem in some parts of the world. The introduction of Nile Perch and Nile Tilapia to Lake Victoria in Africa in the 1970's aims to increase catches, which had declined due to overfishing in the 1950s and 1960s (Ogutu-Ohwayo, 1990) but leads to the decline of the several native fish species (Witte *et al*., 1999). Zebra mussel and water hyacinth are the other introduced alien species that have long term negative impacts on the freshwater ecosystem (Strayer & Dudgeon, 2010). Alien fish species are considered as an important factor in the degradation and deterioration of the native fish species of different freshwater ecosystem (Lakra *et al*., 2008; De Silva *et al*., 2009). Most of the exotic fish species introduction occurred in freshwater and aquaculture is considered as the major factor though some of the invasion occurred due to recreational fishing (Cambray, 2003; Casal, 2006). In India alone, more than 300 alien fish species including 291 ornamental fish species, 31 aquaculture species and 3 larvicidal fish species are already recorded which may be intentionally or unintentionally introduced by human effort and may cause bio invasion (Singh, 2014). Garcia-Barthou (2007) mentioned that the problem of alien species has become one of the most important global problems as a result of direct or indirect connection of hydrological systems. Singh and Lakra (2011) listed the presence of 31 alien fish species from the aquaculture in India. The introduction of alien species of fish brought both positive and negative impact for the management of fishery as well as for the native components of the icthyofauna of the natural ecosystem (De Silva *et al*., 2009). Gopalakrishnan and Basheer (2000) recorded the introduction of Indian major carps in Kuttanad Rivers. Bijukumar (2000) in their studies on the fish diversity of Bharathapuzha revealed abundant presence of Tilapia population and they also mention that the introduced species replace the native population in many areas. Pimentel *et al*. (2000) mentioned how introduce fish species frequently alter the aquatic ecology by changing the water quality and cause the extinction of native fish by predation and also by competitive interaction of the resources available.

1.10.6 *Deforestation*

Deforestation causes several modifications in the riverine ecology physically, chemically and biologically in several ways. Woodwell (2002) states the role played by forest in the sequestration of carbon from the atmosphere and also in the preservation of biodiversity. The removal of streamside vegetation disable the retention of sediments from the stream banks (Couceiro *et al*., 2006) and this ultimately result in the influx of siltation in the adjacent stream or river. Bojsen and Barigga (2002) mentioned how siltation generally reduces the number of pool sites and also increases the habitat homogeneity. Deforestation also limits the availability of large woody debris to stream which lead to the increase of water availability and decreases the number of safe oviposition sites (Wright & Flecker, 2004; Couceiro *et al*., 2006). Deforestation also eliminate the dense forest canopy provided by dense forest canopies, exposing streams to sunlight and hence ultimately leading to the increase of temperature (Couceiro *et al*., 2006; Kishi *et al*., 2004). Wright and Flecker (2004) mentioned the role played by deforestation leading to change in physical factors such as siltation and presence of large woody debris in influencing the formation of abundant pools and riffles zones. Deforestation also causes severe changes in the chemical composition of the river and stream ecology. Thomas *et al*. (2004) recorded how the changes in certain chemical levels such as nitrogen, phosphorus, carbon dioxide and dissolved oxygen ultimately lead to change in the stream pH and nutrient saturation. Thomas *et al*. (2004) also mentioned how greater siltation occurring due to deforested streams leads to a more organic rich stream bed which may ultimately resulted to more aquatic vegetation. The general change in the ecosystem of the aquatic habitat due to organic matter can leads to a decrease in the taxa richness of the invertebrates (Bernstead & Pringle, 2004) and also have negative impact on the higher vertebrates like fish species diversity and abundance as they feed on the lower invertebrates (Bosjen & Barigga, 2002; Kishi *et al*., 2004)

1.10.7 *Overexploitation*

A large number of freshwater fishes around the world are facing decline due to overexploitation (Allan *et al*., 2005; Dudgeon *et al*., 2006). Several authors mentioned overexploitation as one of the factors responsible for the decline of fish diversity (Allan & Flecker, 1995; Jackson *et al*., 2001; Dudgeon *et al*., 2006; Prenda *et al*., 2006).The population of many fish species are declining considerably due to overfishing and intensive fishing is widespread especially in the developing world (Russ, 1991; Roberts & Hawkins, 1999).

1.11 Threatened category

Research has been carried out to develop tools relevant to conservation strategies of prioritized and endangered species (Lakra *et al*., 2010) and adequate priority is maintained to keep pace with developing approaches and technological advancements (Lakra *et al*., 2006). Many systems of categorization and criteria's have been developed globally to assess the conservation status of a species such as International Union for Conservation of Nature (IUCN), American Fishery Society (AFS) and Australian Society for Fishery Biology (ASFB) (Lakra *et al*., 2010). More importance has been given to population size, distribution range and its habitat (Pollard *et al*., 1990). The AFS is the simplest without any supporting conditions by which categories can be assessed (Miller *et al*., 1989; William & Miller, 1990).

According to IUCN Red list (2008) of all life form, 16, 928 species are facing threatened category and out of these, 1, 275 species belong to fish. The number of organism facing threatened category from Asia totally is around 6, 106 and out of these, 688 species belong to fin fishes (Lakra *et al*., 2010). Out of the 659 globally threatened Indian species, 42 species of fishes are included under IUCN (2008) and among the Asian countries, India possesses the maximum number of endemic freshwater fin fish species which is 27.8% followed by China, Indonesia and Myanmar (Lakra *et al*., 2010). Myers *et al*. (2000) predicts that there could be at least 5, 000 species of fish still waiting to be discovered. Fish forms one of the highest diversity species among vertebrate groups and India, which is one of the mega diversity hotspot, contribute about 11.72% of global fish diversity mainly from the greater Himalayan ranges on the northern plains, eastern and western Ghats (Lakra *et al*., 2010).

According to IUCN Red list, 1, 275 species of fishes are under threatened category and in Asia, 688 fin fishes are under threaten category (Anon, 2008). Overall, the conservation status of the endemic fish species in Asia can be considered to be relatively satisfactory (De Silva *et al.,* 2007). Kottelat and Whitten (1996) consider the biological change that environmental degradation brings about, and enumerated pollution, increased sedimentation, flow alteration, water diversion and introduces species as the main causes for decreased Ichthyofaunal diversity in Asian countries.

1.12 Conservation of fish.

Various human activities have led to the extinction of about 10,000 - 20,000 freshwater species globally (Strayer, 2006). Carrizo *et al*. (2013) mentioned the need for conservation of freshwater fishes and highlighted that they are the most threatened large taxon in the world. While fresh waters are globally scarce representing less than 0·3% of available surface water, they are an ichthyofaunal 'hotspot' for more than 15,000 species, representing 53% of all fishes and 25% of all vertebrates (Reid *et al*., 2013). Reid *et al*. (2013) also mentioned the essential of freshwater for all life and freshwater fishes as a direct indicator of the health of our planet and also reported most of the threats to their survival are human induced. Reis (2013) mentioned that many small, distinctive or brightly coloured Neo-tropical species are kept by hobbyists and displayed in public aquariums. Some authors mentioned how there have been comparatively few regional conservation assessments or worthwhile initiatives to date, in- situ or ex-situ (Baigun *et al*., 2012; Tlusty *et al*., 2013). Certain authors highlighted the various strategies that could be adopted to conserve the freshwater fish species through aquariums, research, cryopreservation, gene banking and ecotourism (Kumar & Devi, 2013; Reid *et al*., 2013; Tlusty *et al*., 2013). The use of marine reserve for fish conservation due to extensive fishing has been reported by several authors (Polunin, 1984, 1990; Bohnsack, 1990; Dugan & Davis, 1993; Rowley, 1994).

The population of many fish species are declining considerably due to overfishing and intensive fishing is widespread especially in the developing world (Russ, 1991; Roberts & Hawkins, 1999) and the freshwater fish of the Indian region has been rapidly dwindling because of increasing degradation of inland water (Bagra *et al.*, 2009). Diversity of fishes in North Eastern India are also threatened by various factors such as pollution, habitat alteration, overexploitation, loss of habitat, invasive species (Vishwanath *et al*., 2010). Keeping in mind the importance of conserving the fish diversity of the study areas, the following objectives came to be highlighted as follows;

Objectives:

The objectives of the study are as follows-

(1) To collect and identify the fish for documentation, museum preservation and scientific study.

(2) To study the diversity of the Cypriniformes in Kolodyne basin and its tributaries

(3) To take conservative measures for freshwater fishes in Mizoram.

CHAPTER 2

REVIEW OF LITERATURE

2.1 International

Berra (2001) however estimated the total number of fish species of the world to be 31, 500 species when all inventories are completed. According to Nelson (2006), the total number of fish species is close to 28, 900 including both freshwater and marine which is 51% of the 54, 711 recognized living vertebrate species of the world. At the global scale the total species of fish may be projected to be close to 32, 500 (Nelson, 2006). The total number of extant fish species at the global scale including both freshwater and marine belong to 207 families and 2, 513 genera, out of which freshwater fish species is estimated to be at around 13, 000 species while the remaining 16, 000 species live in saltwater (Leveque *et al*.,2008). However, Cohen (1970) mentioned of the 21, 723 living fish species, about 58% are marine, 41% are freshwater and the remaining 1% are migratory fishes that migrate regularly between marine and freshwaters.

Talwar and Jhingran (1991) mentioned that the India subcontinent comprising of India, Pakistan, Nepal, Burma, Srilanka and Bangladesh are endowed with rich fish diversity. Talwar and Jhingran (1991) present recent compilation on fish for India as well as Burma whereas a series of checklist that helps in identification of the common fishes of India and Pakistan were carried out by certain authors which includes, Misra (1949, 1959), Jayaram (1981) and Day (1889). Hora in his lifetime published 440 papers, established 3 families, 28 genera consisting of 139 species, many of which are considered still valid (Jayaram, 1976).

2.1.1 *Cyprinidae*

This is the largest family of fish known and most dominant group of primary freshwater fishes which is widely distributed in Africa, Europe and North America (Talwar & Jhingran, 1991; Nelson, 1984). This large family comprises of the gold fish, minnows barbs, rasboras and danios (Talwar & Jhingran, 1991) with 194 genera and 2, 070 species (Nelson, 1984). Chen *et al*. (1984) works on the phylogenetic analysis of the family Cyprinidae sub groups while Howes (1978; 1979; 1980) carry out several works on the osteology of this family and propose a diphyletic arrangement based on the presence or absence of the anterior maxillary barbell with accompanying maxillary foramen. Fink and Fink (1981) indicates that the separate second and third vertebral centra as a primitive feature of the Cyprinidae family. The separation of old world and new world Cyprinidae family based on separate and fused second and third centra have been mentioned by some authors (Nelson, 1969; Ramaswami, 1953; Weitzman, 1962; Alexander, 1962; 1964; Greenwood *et al*., 1966). Page and Burr (1991) stated that the family Cyprinidae contains about 2, 100 species of fish worldwide and represent the largest number of fishes in North America. Cyprinidae family is the most dominant family of all the freshwater fishes in Asia and have more genera and species than any other family of freshwater fishes (Roberts, 1989) and it also represent the world's largest family of freshwater fishes comprising 3, 268 species (Nelson, 2006). Several authors work at different species belonging to different genera under the Cypriniformes groups and to mention a few, *Barillius* (now *Opsarius*) (Hamilton, 1822; Talwar & Jhingran, 1991; Rainboth, 1996; Day, 1878; Hora, 1921; Smith, 1945), *Crossocheilus* (Banarescu, 1968; Fowler, 1934; Inger & Chin, 1962; Fang, 1981; Chu & Chen, 1989; Su *et al*., 2000; Kotellat, 1989, 2003), *Devario* (Barman, 1991; Rahman, 1989; Jayaram, 1991; Talwar & Jhingran, 1991; Conway *et al.*, 2009), *Garra* (Blyth, 1860; Menon, 1964; Getahun, 2000; Kottelat, 1984, 2000; Zhang & Chen, 2002; Kullander & Fang, 2004), *Rasbora* (Hora, 1921; Hora & Mukherji, 1935; Brittan, 1954), *Laubuka* (Hamilton, 1822; Silas, 1958; Banarescu, 1969; Talwar & Jhingran, 1991; Pethiyagoda *et al*., 2008), *Puntius* (Kortmulder, 1972; Kotellat & Pethiyagoda, 1989; Jayaram,1991; Menon, 1999; Arunkumar & Singh, 2003; Kullander & Fang, 2005; Shantakumar & Vishwanath, 2006; Kullander, 2008), *Pethia* (Hamilton, 1822; Day, 1878; Kullander & Fang, 2005; Kullander & Britz, 2008; Pethiyagoda *et al*., 2012), *Salmostoma* (Swainson, 1839; Silas, 1958; Banarescu, 1986), *Osteobrama* (Hora, 1921; Hora & Misra, 1940; Menon, 1954, 1999; Talwar & Jhingran, 1991; Vishwanath, 2000).

2.1.2 *Psilorhynchidae*

Fish species under the genus *Psilorhynchus* McClelland are small fishes with arched back and flattened, frequently absence of scale on the ventral surface (Conway & Britz, 2010) and inhibit fast flowing rivers and streams and their geographical range includes the foothills of the Himalayas, Indo Burma and Western Ghats (Rainboth, 1983; Arunachalam & Muralidharan, 2008). Several new species have been described under the genus *Psilorhynchus* in the recent years by some authors such as, *Psilorhynchus robustus*, *P. melissa* (Conway & Kotellat, 2007 & 2010), *P. arunachalensis* (Nebeshwar *et al*., 2007), *P. amplicephalus* (Arunachalam *et al*., 2007), *P. tenura* (Arunachalam & Muralidharan, 2008), *P. breviminor*, *P. rahmani* (Conway & Mayden, 2008a & 2008b), *P. piperatus, P. gokkyi, P. olliei* (Conway & Britz, 2010), *P. chakpiensis, P. maculata, P. ngathanu* (Shangningam & Vishwanath, 2013a, 2013b & 2014). Recent species description under the genus *Psilorhynchus* increase the total number of species recognized to 24 (Lalramliana *et al*., 2015). The interrelationship amongst its species are unknown (Conway & Kotellat, 2007) though several works have been carried out on the phylogeny (DeBry, 1992; Rosenberg & Kumar, 2003; Cummings & Meyer, 2005; Slechtova *et al*., 2007; He *et al*., 2008).

2.1.3 *Cobitidae*

The family Cobitidae, popularly known as the spined loaches are small sized bottom dwellers and are mainly found in streams, rivers and lakes of hilly areas (Acharjee & Barat, 2010; 2014; Talwar & Jhingran, 1991) and their geographical distribution includes most of Eurasia and Northwestern Africa but the greatest diversity is in the southern Asia (Sawada, 1982; Talwar & Jhingran, 1991; Kotellat & Freyhof, 2007). These fishes have bifid suborbital spine and are sexually dimorphic (Nalbant, 2002). Loaches under the genus

Lepidocephalichthys are widely distributed in Asia ranging from India to China, Vietnam, Laos, Cambodia, Borneo and Java (Kotellat & Lim, 1992; Menon, 1992; Arunkkumar, 2000). The genus *Lepidocephalichthys* is diagnosed as having the seventh and eight pectoral rays modified in the mature male and comprises of about 17 valid species (Havird and Page, 2010). Several authors' works on fish under the genus *Lepidocephalichthys* (Hamilton, 1822; Blyth, 1860; Chaudhuri, 1912; Hora, 1920; Pilai & Yazdani, 1976; Tilak and Husain, 1978; Datta & Barman, 1985) and recent description and revision of the species have led to several new descriptions (Kotellat & Lim, 1992; Menon, 1992; Arunkumar, 2000; Havird & Page, 2010; Havird *et al.*, 2010).

2.1.4 *Balitoridae*

Fishes under the family Balitoridae are small freshwater fishes commonly found in the swift flowing rivers and streams of Eurasia (Neely *et al*., 2007) and more than 450 species have been described under the family with the highest diversity in Southeast Asia (Kotellat, 1990; Nelson, 2006) and the family is subdivided into two subfamilies, Nemacheilinae and Balitorinae (Sawada, 1982). The subfamily Homalopterinae includes about 28 and 120 species and the genus *Balitora* includes 8 species (Kotellat, 1988). Kotellat and Chu (1988) investigated the relationships of *Balitora* and its related genera. Several authors' works on the revision and description of *Balitora* species (Gunther, 1868; Day, 1878; 1889; Hora, 1920; Liu *et al*., 2012; Kotellat, 1988; Kotellat & Chu, 1988; Li & Chen, 1985). Several new descriptions have been carried out on *Balitoridae* (Kotellat, 2000; Chen *et al*., 2005; Conway & Mayden, 2010; Bhoite *et al*., 2012; Liu *et al*., 2012).

2.1.5 *Nemacheilidae*

The Nemacheilidae family is the largest group in Cobitoidea with numerous morphological similar species (Jamsidi *et al*., 2013) and the taxonomic problems remain at the species level as the nemacheilid loaches of the western Asia are still poorly known (Tang *et al*., 2006).The family Nemacheilidae, comprises of 46 genera (Kotellat, 2012), are one of the most widely distributed freshwater fishes. They have a characteristic element of the Eurasian icthyofauna comprising of about 30 genera and 720 nominal species, and their geographical location mostly known from South and Southeast Asia (Bohlen & Slechtova, 2011).

The Nemacheilid fishes of the genus *Schistura* McClelland contain about 192 nominal species within the family Nemacheilidae (Lokeswhor & Vishwanath, 2012c). The genus *Acanthocobitis* comprises of about seven valid species and distributed mainly in south and Southeast Asia (Menon, 1987; Kotellat, 1990; Pethiyagoda, 1991; Rainboth, 1996). The genus *Physoschistura* (Banarescu & Nalbant, 1982) comprises of small adult size fish characterized by unique mouth shape, strongly arched mouth, presence of median interruption in the lower lip, broadly triangular pads with deep parallel furrows (Kotellat, 1990; 2012; Chen *et al*., 2011; Lokeshwor & Vishwanath, 2012e) and is represented by about 8 valid species (Lokeshwor & Vishwanath, 2012a).

2.2. National

Several workers reported the icthyofaunal diversity of fishes in different part of the country at different times and their report revealed the occurrence of several species of the Cypriniformes groups (Day, 1889; Sharma & Tandon, 1990; Talwar & Jhingran, 1991; Barman, 1998; Jayaram, 1981; 1999; Vishwanath *et al*., 2007; Mehta & Sharma, 2008). In fact, the Cypriniformes groups constitute generally a large group of the icthyofaunal diversity in different regions at the national level in both the riverine ecosystem and streams as well. Barman (1998) in his study reported the diversity of fish in India which accounts for 11.72% of species, 23.96 % of genera, 57% of families and 805 orders of the world. Day (1889) in his study of fish diversity from British India listed the presence of 1418 species of fish under 342 genera out of which 223 turns out to be endemic fish. Jayaram (1981) however, recorded 742 species of freshwater fishes belonging to 233 genera, 64 families and 16 orders from India. Jayaram (1999) in his recent study of fish from India estimated the total number of fish species to be 852 belonging to 71 families and 16 orders. The fish fauna of India include 223 endemic species which represent 8.75% of the fish species known to India and 127 monotypic genera which represent about 13.10% of the fish genera in India (Barman, 1998). Talwar and Jhingran (1991) mentioned that out of a total of 2, 500 species of fish present in India, 930 occurs in the freshwater that belongs to 326 genera, 99 families and 20 orders.

Patra and Dutta (2010) recorded 31 species of Cypriniformes fish from River Kerala and, again, Patra *et al*. (2011) recorded 55 species fish from the same river. Banerjee *et al*. (2009) recorded 71 fish species from different rivers in Darjeeling district of North Bengal. Das (2015) reported the occurrence of a total of 105 fish species belonging to 9 orders and 29 families from the river Torsa, West Bengal out of which the family Cyprinidae represented the highest number of recorded species, followed by family Bagridae, family Sisoridae and family Cobitidae. Shukla and Singh (2013) listed 18 species of fishes from the Aami River, Gorakhpur and out of the 18 species mentioned, Cypriniformes groups accounts for the highest percentage and family Cyprinidae was the most dominant in the assemblage composition with 39%. Johnson *et al.* (2012) also listed the occurrence of 50 species of fishes belonging to 32 genera, 15 families and four orders from Ken River at Gharighat, Madhya Pradesh and highlighted that Cyprinids were the dominant assemblage members in all streams where the cyprinids includes, *Tor tor, Garra gotyla, Nemacheilus denisoni, Rasbora daniconius, Puntius sophore, Puntius* (now *Pethia*) *conchonius, Barilius* (now *Opsarius*) *bendelisis* etc. and among the species, *Devario aequipinnatus* and *Channa gachua* had highest local dominance followed by *Esomus danricus* and *Garra mullya* which were represented in most of the study sites. In India, few studies have been initiated to document the fish diversity and assemblage structure along the environmental gradients (Johnson, 1999;

Arunachalam, 2000; Bhat, 2003, 2004; Sreekantha *et al*., 2007; Shahnawaz *et al*., 2010). Some information related to fish diversity is also available on fishes of Ramsagar reservoir and fish assemblages of Betwa River, Khan and Khashipra rivers of Madya Pradesh (Ganasan & Hughes, 1998; Garg *et al*., 2007; Lakra *et al*., 2010). Ravindra *et al*. (2014) listed a total of 165 fish species belonging to 82 genera, 26 families and 9 orders from Maharastra. Similarly, Sakhare (2001) also listed the occurrence of 23 species of fish belonging to 7 orders in Jawolgaon reservoir from Solapur district of Maharastra where the order Cypriniformes dominate the collections (11 species) followed by the order Siluriformes (4 species). Daniels (2001) recorded 218 species of freshwater fish from the Western Ghats and out of these, 114 species are endemic to the Western Ghat. Shaji *et al*. (2000) also listed 287 fish species from the same region where 67% of the species are endemic species and 18 species turn out to be exotic fish species. Dahanukar *et al*., (2004) listed 288 freshwater fish species out of which118 are endemic to Western Ghat. India is one of the mega biodiversity countries in the world and occupies the ninth position in terms of freshwater mega biodiversity (Mittermeier & Mittermeier, 1997). Out of the 2500 species of fish recognised in the Indian subcontinent, 930 species are categorised under the freshwater species (Kumar & Devi, 2013).

2.3. North East India

Roach (2005) mentioned that the northeastern region of India forms two out of the 34 biodiversity hotspots listed by Conservation. Yadav and Chandra (1994) listed a total of 129 species of fish and mentioned that the northeastern region of India shares its fish fauna with that of the Indo- gangetic fauna and also to small extent with that of the Burmese and South China fish fauna. Ghosh and Lipton (1982) listed 172 species of fish while Sen (1985) and Mahanta *et al*. (1998) listed187 species of fish from Assam and the neighboring northeastern states of India. Sinha (1994), in his review, listed a total of 230 species of fish available from the northeastern region of India and further, Sen (2000) listed a total of 267 species of fish from the northeastern region of India. Talwar and Jhingran (1991) mentioned that the northeastern region is represented by 267 species belonging to114 genera, under 38 families and 10 orders which represent approximately one third of the Indian freshwater fishes. According to Ramanujan *et al*. (2010), the fish diversity of the northeastern region from the updated record shows the presence of 267 species belonging to 114 genera under 38 families and 10 orders. Sen (2003) recorded 291 species of fish from northeast India and out of these Cypriniformes turn out to be the most dominant order with 161 species followed by Siluriformes accounting for 77 species. Goswami *et al*. (2012) listed a total of 422 fish species representing 133 genera, and 38 families which contains more than 62.81% of the total available freshwater fish species in India and the study also highlights maximum diversity in the family Cyprinidae which is represented by 154 species. With respect the diversity of fin fish, Silas (2006) recorded 136 endemic fin fish species from North Eastern India.

The different areas and regions of Northeast India have rich freshwater fish diversity. Kottelat and Whitten's (1996) map of freshwater fish diversity hotspots in Asia included the several areas of Northeast India and Myanmar. The diversity within these regions can be attributed to several factors and conditions such as habitat diversity, existence of different drainage basins, recent geological history with respect to the collision of Indian, Chinese and Burmese plates and the Himalayan orogeny which played an important role in the speciation and evolution of groups inhabiting mountain streams (Kottelat, 1989). The evolution of the river drainages in Northeast India and adjoining areas has been the subject of several studies that utilize geological evidence to reconstruct the Palaeodrainage patterns. Phylogenetic studies of fishes of the region have indicated vicariance events which may have played important role in shaping the current distribution pattern of the freshwater fishes of the region (Guo *et al.*, 2005, Ruber *et al.*, 2004).

Northeastern Region of India is known as a global hotspot for fish faunal diversity. The diversity of fish species in the North East India is attributed to the recent geological history, especially the Himalayan orogeny (Kottelat, 1989).

Sen (1985) compiled monograph of the fishes of northeast states of India. Further, she listed a total of 267 species (Sen, 2000). Vishwanath (2002) recorded 240 species of 103 genera and 33 families from northeast India. Chaudhuri (1912) described two new species from hill streams of Ukhrul District viz., *Danio naganensis* (now *Devario nagaensis*) and *Nemacheilus manipurensis* (now *Schistura manipurensis*). Hora (1921) also recorded a comprehensive account on the fish and fisheries of Manipur including descriptions of new species, viz., *Barilius dogarsinghi* (now *Opsarius dogarsinghi*), *Lepidocephalichthys irrorata*, *Nemacheilus kangjupkhulensis*, *N. prasadi* (now *Physoschistura prasadi)*, *N. sikmaiensis* (all *Nemacheilus* are now *Schistura*). Later, Hora and Mukherji (1935) recorded 44 species of fishes from the Naga Hills (hill areas of present Manipur and Nagaland), sorted fishes of Brahmaputra and Chindwin basins and described *Psilorhynchus homaloptera*. Hora (1936) then reported fishes from the Barak River and its tributaries of Naga Hills, Manipur. Hora (1937) further reported fishes from Chindwin drainage viz., Khunukhong, Chahong Khullen, Namya, Lokchao and Chakpi rivers of Ukhrul and Chandel districts respectively. Thirteen species of the genus Barilius are hitherto known from the Eastern Himalaya region (Vishwanath *et al*., 2010).

Menon (1954) in his study from the Loktak Lake, Imphal River and the Barak River made extensive collection of the fishes from different localities. Description of several new taxa, revision of certain genera and families were carried out by subsequent workers such as Vishwanath and Manojkumar (1995) on the Manipur River and its system, Selim and Vishwanath (1997) on the Chatrick River of Ukhrul District, Kosygin and Vishwanath

(1998b) on the Tizu River. Vishwanath (2000) further recorded 165 species under 84 genera and 27 families from Manipur.

There are several reports on description of new species recently from Manipur which includes *Garra elongata* (Viswanath & Kosygin, 2000b), *Pethia ornata, Rasbora ornata,* (Vishwanath & Laisram, 2004a; 2004b), *Garra nambulica* (Vishwanath & Joyshree, 2005), *Garra paralissorhynchus* (Vishwanath & Shanta, 2005), *Schistura khugae* (Vishwanath & Shantakumar, 2005), *Schistura reticulata* (Vishwanath & Nebeshwar, 2004), *Physoschistura chindwinensis*, *P. tigrina, Schistura koladynensis, S. porocephala* (Lokeshwar & Vishwanath, 2012a; 2012b; 2012c; 2012d), *Physoschistura tuivaiensis* (Lokeshwar *et al*., 2012), *Garra namyaensis, Psilorhynchus chakpiensis, P. maculatus, P. ngathanu,* (Shangningam & Vishwanath, 2012; 2013a; 2013b; 2014), *Schistura phamhringi* (Shangningam *et al*., 2014). Only three species of *Barilius* (*Opsarius*) have been reported earlier from Manipur namely *O. barila, O. bendelesis* and *O. dogarsinghi* but with the description of a new species *O. chatricensis* (Selim & Vishwanath, 2002) the number increased to 4. A new species of bariline fish, *Opsarius ngawa* have also been reported in Manipur from the river system leading to the Chinwin River in Myanmar (Viswanath & Manojkumar, 2002). Ten species of the genus *Devario* have been treated to be valid with the description of a new species *Devario deruptotalea* from the Dutah stream of Manipur, Chindwin drainage (Ramananda & Viswanath, 2014). Vishwanath and Sarojnalini (1988) recorded the occurrence of only five species of *Garra* from the earlier reports from Manipur and include the description of a new species *Garra manipurensis*.

Nath and Dey (2000) published their pioneering works on systematic account of fish resources of Arunachal Pradesh revealing 131 species whereas 171 fish species were recorded in the water system of seven northeastern states (Sinha, 1994). Bagra *et al.* (2009) however, recorded 138 species of fishes from Arunachal Pradesh. From different districts of

Arunachal Pradesh, 143 ichthyo species were reported (Sen, 2006), moreover, two more new species have been described, *Pseudechenies sirenica* (Vishwanath & Darshan, 2007) and *Psilorhynchus arunachalensis* (Nebeshwar *et al*., 2007). Several other authors also contributes on fish diversity from Arunachal Pradesh (Barman, 1989; 1992; 1994; 2002 ; Nath & Dey, 1985; 1997; 2000; Nath *et al*., 2010; Jayaram, 1963; Jayaram & Mazumdar, 1964; Jhingran & Sehgal, 1978; Sinha, 1994; Yadava & Chandra, 1994; Sen, 1995; 1999a; 1999b; 2000; 2003; 2006; Menon, 1999; Daniels, 2001; Ramanujan, 2005; Kar & Sen, 2007; Vishwanath *et al*., 2007; Ao *et al*., 2008; Jayaram, 2008; Lakra *et al*., 2010 ; Darshan *et al*., 2010; Jayaram, 2010; Sarkar & Ponniah, 2000; Tamang *et al*., 2007; Nebeshwar *et al*., 2007; Jha *et al*., 2008; 2012).

Almost 149 species of fish, belonging to 22 families have been found to occur in the state of Nagaland (Ao *et al*., 2008). Acharjee *et al*. (2012) recorded the presence of 34 fish species belonging to 24 genera,13 families and 5 orders from the river Dhansiri, Dimapur district of Nagaland and it is noteworthy that out of all the orders collected, Cypriniformes was the most common while Osteoglossiformes turn out to be the least common. Humtsoe and Bordoloi (2014) recorded a total of 27 fish species belonging to 16 genera, 9 families and 3 orders from the selected streams of Wokha district, Nagaland. Karmakar and Das (2006) published 108 species of fish from different water bodies of Nagaland including 81 species from their own collection.

Several works has been carried out by many researchers with respect to the diversity of fish species in Assam and to mention a few, Bhattacharjya *et al*. (2003) recorded 217 fish species belonging to 104 genera, 37 families and 10 orders from the water bodies of Assam including wetlands. Assam wetland ecosystem is endowed with many species of fishes and it is very rich in fish diversity (Agarwala, 1996; Dey, 1981; Goswami & Goswami, 2006; Nayak & Mishra, 2008). Chakravartty *et al*. (2012) identified 67 species of fish from the

Kapla Beel, Barpeta District, Assam and highlighted the highest occurrence of the order Cypriniformes groups, accounting for more than 50% of the overall species of fish collected. Bhattacharjya *et al*. (2003) listed the presence of 217 fish species belonging to 104 genera, 37 families and 10 orders from the water bodies of Assam including wetlands. Nath and Deka (2012) in their study of fish species from the Chandubi tectonic lake of Assam recorded the presence of 63 species of fish, out of which 7 endangered species and 8 vulnerable species were also listed.

2.4 Regional (Mizoram)

There has been hardly any report on the diversity of fish species from the rivers of Mizoram. Karmakar and Das (2007) in their extensive field survey from Mizoram mentioned the fish collected from eastern and southern part to have Burmese elements; northern and north western part to have Assamese elements whereas those in the central part have endemic elements. A total of 89 species belonging to 8 orders, 20 families and 49 genera have been recorded out of which, 24 species belonging to 17 genera were recorded for the first time from Mizoram and 3 species under 3 genera were recorded for the first time from India. There are three drainages in Mizoram namely Kolodyne, Barak and Karnaphuli and only few authors' works on fish diversity on the past (Karmakar & Das, 2007; Kar & Sen, 2007). Kar and Sen (2007) in their extensive icthyological survey conducted in the major rivers of Mizoram from 1996 to 2006 reported the presence of 42 species of fish in Tuirial and Kolodyne, 31 species in Karnaphuli, 25 species in river Mat, 36 species in river Tlawng, 9 species in Tuirini, 14 species in Serlui and 25 species in Tuivai River.

Several new descriptions of fish species have come out from these study areas by the works of several authors, and some of the new description includes *Pethia rutila* Lalramliana, Knight & Laltlanhlua, *Psilorynchus khopai* Lalramliana, Solo, Lalronunga & Lalnuntluanga, *Garra dampaensis* Lalronunga, Lalnuntluanga & Lalramliana, *Schistura* *aizawlensis* Lalramliana, *Schistura andrewi* Solo, Lalramliana, Lalronunga & Lalnuntluanga , *Schistura mizoramensis* Lalramliana, Lalronunga, Vanramliana & Lalthanzara, *Psilorynchus kaladanensis* Lalramliana, Lalnuntluanga & Lalronunga, *Schistura maculosa* Lalronunga, Lalnuntluanga & Lalramliana, *Schistura koladynensis* Lokeshwor & Vishwanath, *Schistura porocephala* Lokeshwor & Vishwanath, *Opsarius profundus* (Dishma & Vishwanath), *Pethia expletiforis* Dishma & Vishwanath, *Schistura scyphovecteta* Lokeshwor & Vishwanath, *Schistura nebeshwari* Lokeshwor & Vishwanath, *Garra khawbungi* Arunachalam, Nandagopa & Mayden, *Garra tyao* Arunachalam, Nandagopa & Mayden, *Pseudolaguvia virgulata* Ng & Lalramliana, *Pseudolaguvia spicula* Ng & Lalramliana, *Psudolaguvia nubila* Ng, Lalramliana, Lalronunga & Lalnuntluanga , *Schistura paucireticulata* Lokeshwor, Vishwanath & Kosygin. (Ng & Lalramliana, 2010a; 2010b; Lalramliana, 2012; Lokeshwor & Vishwanath, 2012a; 2012b; (Dishma & Vishwanath, 2012; 2013); Ng *et al.*, 2013; Lalronunga *et al.*, 2013a; 2013b; Lokeshwor *et al.*, 2013; Lokeshwor & Vishwanath, 2013a; 2013b; Lalramliana *et al.*, 2014a; 2014b; 2014c; Solo *et al.*, 2014; Arunachalam *et al.*, 2014; Lalramliana *et al.*, 2015).

CHAPTER 3

STUDY AREA

3.1 Study area

Mizoram is a small state located in the high hills of the northeastern part of India, endowed with endless variety of landscape, hilly terrains, meandering streams, rich wealth of flora and fauna. This small state achieved its statehood only on 20th Feb, 1987 to become the 23rd state of India. The state of Mizoram covers an area of 21,087 sq km and it shares geographical boundaries on the north-west by the state of Tripura, on the north by the state of Assam, on the north east by the state of Manipur and it also shares a total of 585 km of international border with Myanmar and Bangladesh. The geographical location of Mizoram is 21˚56' to 24˚31' N. Latitudes, 92˚16' to 93˚26' E. Longitudes covering a distance of 285 km from north to south and 115 km from east to west. Mizoram have tropical type of monsoon climate and the climatic condition is moderate and favourable throughout the year round and its temperature range is 11^{o}C-23^{o}C in winter and 25^{o}C-34^{o}C in summer. There are three distinct seasons in Mizoram, rainy seasons from second part of May to late October, winter season from November to February and summer season from March to early May and the state comes under the influence of the southwest monsoon receiving an annual average rainfall of 250 cm (Pachuau, 2009).

The terrain of Mizoram is hilly and there are a number of valleys, rivers and lakes in the state. It has the most variegated hilly terrain in the north eastern part of India an there are as many as 21 hill ranges which are rugged and run in ridges from north to south with peaks ranging different heights, an average height of around 900 meters, and the highest point being Phawngpui (Blue Mountain) at an altitude of 2, 157 meters above sea level. The average height of the hills in the west is about 1, 000 meters and that on the east are 1, 300 meters. Out of the geographical area, 68% is comprises of dense forest whereas the remaining 20% is of open forest and the types of forests in Mizoram is of three types namely, Sub tropical forest, Semi-evergreen forests and sub-montane tropical forests. Mizoram have many rivers flowing through different parts of the state and it comprises a major division of the state and the rivers in Mizoram are of perpetual in nature, assisted by heavy rainfalls mainly during monsoon seasons and by intermittent rainfall during the year. The river drainage system in Mizoram comprises of three drainages viz. Barak (Ganga – Brahmaputra basin), Karnaphuli and Kolodyne basin (Lalronunga *et al*. 2011). Major rivers of Mizoram includes Chimtuipui (Kolodyne), Tlawng, Tut, Mat, Tuirial, Tuivawl, Tuichang etc. The northern part of Mizoram is drained by the rivers Tlawng, Tuivawl, Tuirial, Langkaih and Tuivai all flowing northwardly and joined Barak river in Cachar plain of Assam whereas the southern part is drained by the river Chhimtuipui and its tributaries such as Mat, Tuichang, Tiau and Tuipui Rivers. The western part of Mizoram is drained by Khawthlangtuipui (Karnaphuli) with its tributaries Kawrpui, Tuichawng, Phairuang, Kau and De Rivers (Pachuau, 2009).

3.2 Kolodyne River drainage system

The Kolodyne (=Chhimtuipui) drainage system drains the northeastern part of Mizoram. The main river, Kolodyne is the biggest river by volume in Mizoram which originates from the western part of Myanmar near Vanum village at an altitude of 2,325 meters and flows in south direction. It enters Mizoram near Sabawngte village from which it takes north direction for some 138 km marking the international boundary and meets Tiau River in the opposite direction. From this point, the flow direction is diverted towards north - west and meets Tuichang River near Hnahthial village and eventually flow southern-wards where tributaries mat confluent to it (Pachuau, 2009). The river continues its course on the southern part where it is joined by the Ngengpui River to finally enter Myanmar region near Longmasu village of Saiha district.

3.3 Study sites

One permanent sampling station, covering a distance of approximately 500 meters was assigned for each study sites and the sampling was carried out from these study sites once every four month. The selection of each study sites was carried out with the help of the local field experts who assist in the identification of the rich diversity spots for fish sampling in the rivers. Proper permission was taken before field survey was carried out from the concerned VC's, YMA's and MTP's of each study site as they were responsible in safeguarding and conservation of the rivers.

Table 3.1 List of sampling sites.

Sl. No.	Sampling sites	River	Location	District	Coordinates
1.	Site 1	Kolodyne	Vicinity of Lungbun	Saiha	22° 27' 57.4056" N 93° 7' 58.2312" E
s2.	Site 2	Kolodyne	Vicinity of Kawlchaw	Saiha	22° 23' 20.0004" N 92° 57' 47.2788" E
3.	Site 3	Tuisi	Vicinity of Khopai	Saiha	22° 11' 44.7" N 93° 2' 34.0224" E
4.	Site 4	Sala	Vicinity of Lungpuk	Saiha	22° 4' 45.5412" N 92° 55' 13.5552" E
5.	Site 5	Ngengpui	Vicinity of Khawmawi	Lunglei	22° 31' 17.0328" N 92° 46' 27.0372" E
6.	Site 6	Mat	Vicinity of Serchhip	Serchhip	23° 16' 33.8232" N 92° 49' 40.0764" E
7.	Site 7	Tuichang	Vicinity of Keitum	Serchhip	23° 15' 58.8384" N 92° 57' 7.7292" E
8.	Site 8	Tiau	Vicinity of Zokhawthar	Champhai	23° 22' 19.7724" N 93° 23' 12.9192" E

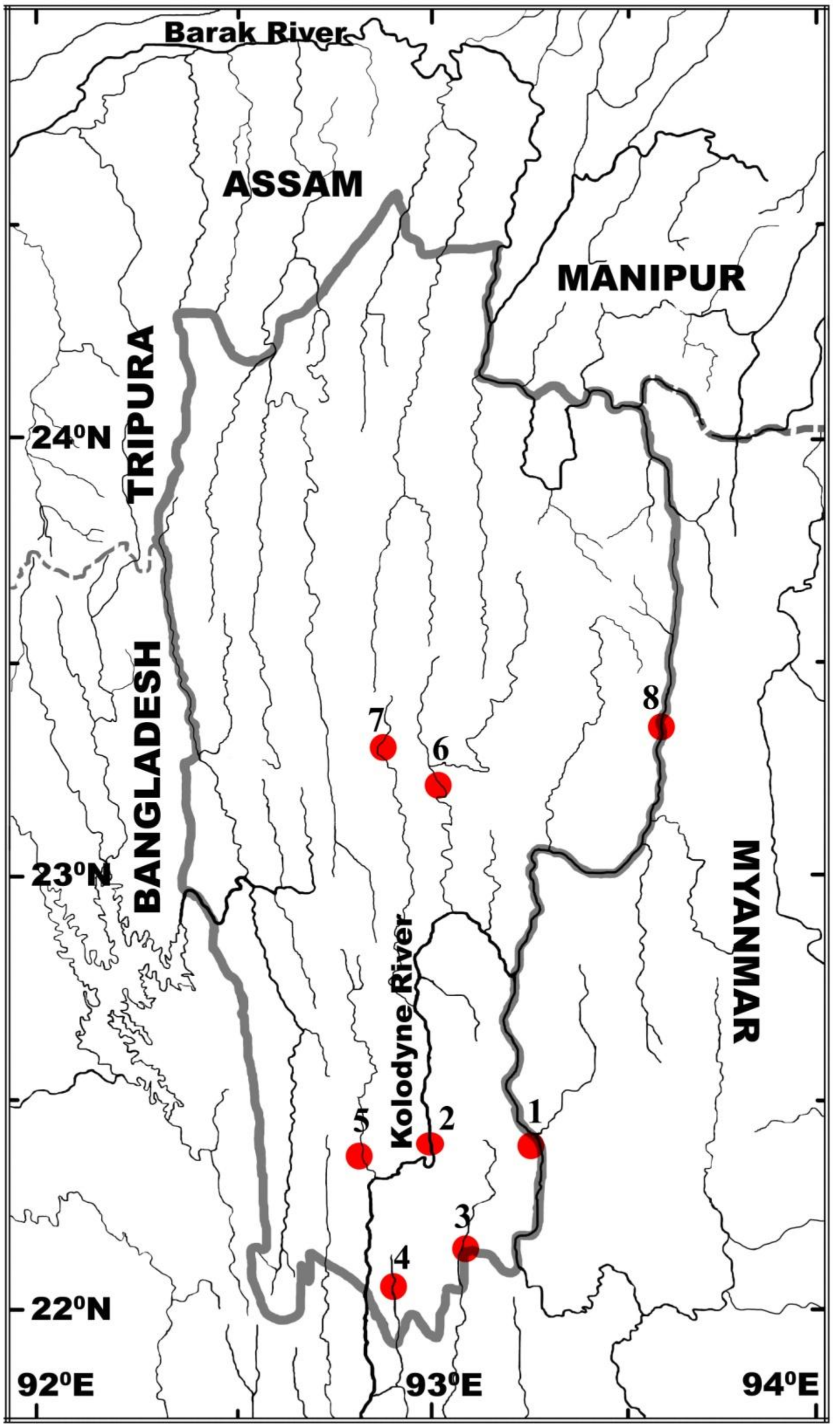

Figure 3.1 Drainage map of Mizoram showing permanent sampling stations. Number in map corresponds to sampling stations given in Table 3.1.

CHAPTER 4

METHODOLOGY

4.1 Specimen collection

Specimen collection was carried out once every four months in each of the study sites by laying an approximate 500 m transect line. Sampling was carried out using various types of fishing equipments which includes cast nets, gill nets, hooks, electro fishing and local fishing methods.

4.2 Preservation

Most of the specimen collected were immediately preserved in 10 % formalin solution in the field itself and later transferred to freshly prepared 10% formalin solution in the laboratory whereas specimens for DNA studies were preserved in 100 % ethanol solution for future study. Specimens were deposited at the Pachhunga University College Museum of Fishes (PUCMF), Department of Zoology, Pachhunga University College; Mizoram University Biodiversity Museum (MZUBM), Department of Environmental Science, Mizoram University

4.3 Identification

Fishes were measured and identified following Talwar & Jhingran (1991), Jayaram (1999; 2008), Menon (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. For taxonomic arrangement Kottelat (2013) was followed.

4.4 Assemblage

4.4.1. Shanon index

The diversity of the study areas were carried out using Shannon diversity index (Shannon, 1948) and data's of the two sampling stations, taking Kolodyne River as the main river and the other rivers, its tributaries for river wise comparison. Shannon index is an information statistics index which assumes that all species are represented in a sample provided the sampling is carried out randomly. The index is represented by ‘H’ and is shown below;

$$H = \sum_{i=0}^{s} \text{Pi} \ln \text{Pi}$$

Where P is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), **ln** is the natural log, ∑ is the sum of calculations, and **s** represents the number of species. The closure the value is to 1, the greater the similarity and complete similarity occur at 1.

4.4.2. Sorenson’s coefficient

Community similarity was measured using Sorenson’s coefficient which is represented by ‘CC’ and it helps us determine species to species comparison between the study sites and is indicated by the formula as shown below:

$$\text{CC} = \frac{2\text{C}}{\text{S}_1 + \text{S}_2}$$

Where **C** indicates the number of species the two communities have in common, $\mathbf{S_1}$ is the total number of species found in community **1** and $\mathbf{S_2}$ is the total number of species found in community **2**. Sorenson’s coefficient gives a value between 0 and 1and the closure the value is to 1,the more the communities have in common and complete community overlap occur at 1 whereas complete dissimilarity occur at 0.

4.5 Conservation status

The different species of fish collected from the study sites are evaluated based on IUCN (2015) red list to assess the conservation status. The system helps to determine the relative risk of extinction faced by a species and it categories different species base on the different conservation criteria such as 1. Extinct (EX) 2. Extinct in the Wild (EW) 3. Critically Endangered (CR) 4. Endangered (EN) 5. Vulnerable (VU) 6. Near Threatened (NT) 7. Least Concern (LC) 8. Data Deficient (DD). Not Evaluated (NE).

CHAPTER 5

RESULTS AND DISCUSSION

5.1 Species account

Class ACTINOPTERYGII

Order CYPRINIFORMES

Family CYPRINIDAE

Genus *Opsarius* (= *Barilius*) McClelland

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

Opsarius profundus (Dishma & Vishwanath)

Barilius profundus Dishma & Vishwanath, 2012: 2363(Kolodyne River, Mizoram)

Material examined: PUCMF 14021/13061/15005/15006

Description

Body laterally compressed, abdomen slightly rounded. Dorsal profile of body ascends from snout to base of dorsal fin origin then gently sloping towards caudal peduncle. Ventral profile of body ascends from tip of snout to abdominal portion thereafter sloping posterior to end of caudal peduncle. Depth of body greatest at dorsal fin origin. Head moderately compressed; shorter than wide. Snout blunt, profile dorsally curved and rounded when viewed laterally. Orbit large, slightly bulging, visible from ventral and dorsal side of head; interorbital space slightly arched. Predorsal region scaled with 16-17 scales. Presence of 7–10 dark blue transverse bars against background of body, width of bar narrower than interspaced width. Dorsal fin inserted posterior to pelvic-fin origin with 2-3 simple, 7½ branch rays,1&2 branched ray longest, presence of dark streak, distal margin without dark streak and convex. Pectoral fin with 1 simple, 11-12 branch rays, sub-acuminate, first branched ray longest, absence of dark spot or dark streak, distal margin not reaching base of pelvic fin origin. Pelvic fin with 1 simple, 7-8 branch rays, first branched ray longest, distal margin almost reaching anal-fin origin, its origin much nearer to anal-fin origin than pectoral-fin, absence of dark spot or dark blotch. Anal fin with 2-3 simple, 10 ½ -11 branch rays, its origin just below base of last dorsal fin ray, not reaching caudal fin. Lateral line scales complete with 31–32 + 2 scales. Lateral line scale in transverse row ½7/1/2½ scales; 12 circumpeduncular scales; Tubercles on snout either absent or poorly developed. Presence of two pairs of very short barbels. Minute embedded scales present on the chest between pectoral fins and abdominal portion

Genus *Cabdio* Hamilton

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

***Cabdio* sp.**

Material examined: PUCMF 13075/12046/14058

Description

Body moderate to large, elongated and laterally compressed. Dorsal profile of ascend slightly from snout to predorsal region and become almost straight at base of dorsal-fin origin, gently sloping thereafter towards caudal peduncle. Depth of body greatest at base of pelvic-fin origin. Ventral profiles ascend from tip of snout to base of pelvic fin then slope downing gently towards caudal peduncle. Head moderately large, mouth upturned, orbit large, located at anterior half of head. Snout rounded, barbel absent. Dorsal fin with 2 simple and 8-8 ½ branched rays, its origin posterior to pelvic-fin origin,first branched ray longest, distal margin slightly convex without dark spot or blotches. Pectoral fin with 1 simple and 13-14 branched rays, first branched ray longest, fin large and long with pointed tip, not reaching base of pelvic-fin origin. Pelvic fin with 1 simple and 7-8 branched ray, first branched ray longest, moderately large and triangular in shape without any dark or black spot, fin tip not reaching vent or base of anal-fin origin. Anal fin with 3 simple and 11 ½-13 branched rays, first branched ray longest, last branched ray not reaching caudal peduncle. Caudal fin with 10+9 principal rays, deeply emarginated, lower lobe longer than upper lobe.

Lateral line scale complete with 42-43+2 scales. Lateral transverse scales 6-7/1/2-2½. Predorsal scales 19 and circumpeduncular scales 16.

Genus *Salmostoma* (Swainson)

Salmostoma Swainson, 1839: 184 (type species: *Salmostoma bacaila* Hamilton-Buchanan, 1822)

***Salmostoma* sp.**

Material examined: PUCMF 15051

Description

Body moderate to large, elongated and laterally compressed. Upper half of body dark grey, lower part silvery white. Dorsal profiles of body ascend from tip of snout towards predorsal region and tapering downward at dorsal fin base. Ventral profile of body ascends from snout tip to about one third of entire length thereafter sloping down towards caudal peduncle. Body depth greatest at about one third of entire length from snout tip. Head large, mouth upturned; snout rounded. Orbit large, located towards the posterior portion of the head. Barbels absent. Dorsal fin with 1 simple 9 branched rays, distal margin convex, second branched ray the longest. Dorsal-fin origin anterior to anal-fin origin. Pectoral fin with 1 simple 11 branched ray, acuminate, first branched ray the longest, absence of dark spot or streak. Pelvic fin with 1 simple 8 branched rays, subacuminate. Anal fin with 1 simple, 15 branched rays, short, second branched ray longest. Caudal fin with 10+9 principal rays, forked, lobes unequal, lower lobe longer than upper lobe. Lateral line complete with 54 pored scales. Lateral line scale in transverse row 8/1/2. Predorsal scale 34 and circumpeduncular scale 16.

Genus *Crossocheilus* Kuhl & van Hasselt

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

Crossocheilus* cf. *burmanicus (Hora)

Crossocheilus latius burmanicus Hora, 1936a: 324 (Myanmar; Assam, India)

Crossocheilus burmanicus Kotellat, 2003:399 (valid)

Material examined: PUCMF 13049//13042

Description

Body elongated, small to moderately large size. Dorsal profile of the body ascends from snout to dorsal fin origin thereafter sloping gradually towards caudal peduncle till reaching base of caudal fin. Ventral profiles of body also ascend slightly from mouth to pectoral fin and become almost straight at pelvic fin origin thereafter sloping down towards caudal peduncle. Head moderately large, orbit in centre of head and moderate size. Rostral lobe present with pair of barbels. Maxillary barbel absent. Snout rounded with numerous small tubercles. Dark spot or blotch absent on fins but small dark streak presents. Dorsal fin with 2 simple, 9 branched rays, convex, second branched ray longest. Dorsal-fin origin anterior to pelvic fin-origin. Pectoral fin with 1 simple 14-15 branched rays, third branched ray longest, margin not extending to base of pelvic-fin origin, dark spot or blotch absent but dark streak present on interradial membrane. Pelvic fin with 1 simple 8 branched rays, second branched ray longest, tip portion not reaching anal-fin origin. Anal fin with 2 simple, 9 branched rays, convex, second branched ray longest, tip not reaching base of caudal fin origin. Caudal fin with 10+9 principal rays (9+8 branched rays), forked, lobes unequal, upper lobe longer than lower lobe. Lateral line complete with pored scale of 32-33+2-3 scales.

Lateral line scale in transverse row 4-5/1/3-3 ½. Chest and abdomen scaled. Predorsal region scaled with 8-9 scales. Circumpeduncular scale 16. Faint brown spot present on anterior part of lateral line above pectoral fin rays.

Genus *Devario* Heckel

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

Devario aequipinnatus (McClelland)

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

Devario aequipinnatus: Fang 2001:16 (valid).

Material examined: PUCMF 13065/14029

Description

Body elongated and laterally compressed. Dorsal profile of body slightly ascend from tip of snout to base of dorsal-fin origin then gently sloping towards posterior part of caudal peduncle. Ventral profile of body also ascends from mouth to base of pelvic-fin origin and then sloping towards caudal peduncle. Snout rounded, mouth upturned. Head depressed, almost straight dorsally but ventrally it ascend towards pectoral fin. Depth of body not greatest at base of dorsal-fin origin but at base of pelvic-fin origin. Predorsal region scaled with 14-17 scales. Dorsal fin with 3 simple 10-11 branched rays, convex, second branched ray longest, presence of numerous minute dark streaks. Pectoral fin with 1 simple 11-12 branched rays, second branched ray longest, longest tip not reaching base of pelvic-fin origin. Pelvic-fin origin anterior to dorsal-fin origin. Pelvic fin with 1 simple, 6-7 ½ branched rays, second branched ray longest, tip almost reaching vent and not reaching base of anal-fin origin. Anal fin with 3 simple, 12-12 ½ branched rays, second branched ray longest, fin not reaching base of caudal-fin origin. Caudal fin with 10+9 principal rays (9+8 branched rays), forked, both lobes of equal length. Lateral line scale complete with pored scale of 33+2.

Lateral line scales in transverse row ½ 7/1/1-2. Presence of 4-5 horizontal stripes and 4 interstripes.

Genus *Esomus* Swainson

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

Esomus danrica (Hamilton)

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

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

Material examined: PUMF 13060/14032/15009

Description

Body small and elongated. Dorsal profile of body from tip of snout to dorsal-fin origin slightly ascending thereafter sloping towards caudal peduncle. Ventral profile of body from tip of snout to anal fin slightly convex but becomes straight towards caudal fin. Head dorsoventrally depressed, orbit located in anterior centre of head. Mouth upturned. Snout rounded with absence of rostral lobe and tubercles. Predorsal region scaled with 16 scales. Dorsal fin with 2 simple, 6 branched rays, absence of dark spot but present of dark streak in interradial membrane. Second branched dorsal fin longest. Dorsal-fin origin posterior to pelvic-fin origin. Pectoral fin with 1 simple 10-11 branched rays, reaching base of pelvic-fin origin, first simple ray longest. Pelvic fin with 1 simple 6-6 ½ branched rays, without dark blotch or spot, tip pointed but not reaching anal-fin origin. Anal fin with 3 simple 5-5 ½ branched rays, not reaching base of caudal-fin origin. Vent to anal fin shorter than vent to pelvic fin. Caudal fin with 10+9 principal rays (9+8) branched rays, deeply forked, both lobes of equal length. Lateral line pore incomplete with 30-32+2 scales, presence of lateral dark band extending from tip of snout to base of caudal fin. Lateral line scales in transverse row 2-

3/1/2-3. Circumpeduncular scale 12-14. Presence of pair of very long maxillary barbel reaching 2/3 of pectoral fin length. Absence of rostral barbel.

Genus *Garra* Hamilton

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

Key to species identification of the genus *Garra*:

1	Presence of W shaped dark band in the caudal fin. Lateral line complete with 28 scales. Presence of short longitudinal dark band below the eye extending from the snout not reaching the pectoral fin..	*Garra rakhinica*
-	Absence of short longitudinal dark band below the eye extending from the snout...	2
2	Presence of 2 vertical rows of irregular black spots in the caudal fin. Lateral line complete with 27-29 scales. Presence of shallow transverse groove..	*Garra flavatra*
-	Lateral line more than 29..	3
3	Lateral line complete with 34 scales. Presence of a distinct W shaped dark band on the caudal fin..	*Garra lissorhynchus*
-	Lateral line more than 34 scales...	4
4	Presence of indistinct W shaped band in the caudal fin. Presence of complete lateral line with 36-37 scales. Transverse groove present..	*Garra khawbungi*
-	W shaped dark band absent on the caudal fin............................	5
5	Lateral line complete with 31scale. Snout smooth....................	*Garra* cf. *vittatula*
-	Lateral line more than 31...	6

6 Lateral line 33-34. Presence of medium transverse groove and 9-13 tubercles on the snout. *Garra* cf. *gotyla*

\- Absence of transverse groove on the snout............................ 7

7 Lateral line complete with 33 scales. Presence of a narrow dark band connecting left to right side of pectoral fin bases.. *Garra nigricollis*

Garra flavatra Kullander & Fang

Material examined: PUCMF 12062

Description

A small species of *Garra* with elongated body, predorsal contour of body ascending from snout to dorsal-fin origin and posteriorly descending but only less deep. Chest and abdomen scaled including predorsal regions. Snout rounded presence of slight transverse groove. Rostral lobe present, conical tubercles on rostral lobe and snout. Presence of two pairs of barbel. Dorsal fin with 2 -3 simple, 7 -7 ½ branched rays insertion anterior to pelvic-fin origin. First unbranched ray longest, extent to almost anal-fin origin. Pectoral fin with 1 simple and 12-14 rounded, inner rays forming straight margin, fifth branched ray longest, not extending to base of pelvic-fin. Pelvic fin with 1 simple, 8 branched ray with blunt tip, inner rays forming straight margin, second branched ray longest, not extending to base of anal fin. Anal fin short, subacuminate with 2 simple 4 ½ branched rays, first branched ray longest, tip extending slightly beyond base of caudal fin. Caudal fin with 10-9+9 rays, emarginated, both lobes of equal length, tip rounded, inframarginal band along posterior margin, black on lobes, dark grey on middle rays; two vertical row s of irregular black spots across middle of fin. Lateral line scale complete with 28-29+2 scales, lateral transverse scale in transverse rows ½ 3/1/3. Circumpeduncular scale 16.

Garra cf. _gotyla_ (Gray)

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

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

Material examined: PUMF 14054

Description

Snout rounded with 9-13 medium size tubercles, transverse lobe present, prominent proboscis with shallow depression in middle that gives bilobed appearance moderately elevated upwards. Body elongated, compressed laterally till caudal peduncle region. Dorsal profile of body ascending slightly to dorsal-fin origin, ventral profile of body more or less straight to anal-fin origin. Head region moderately depressed and large. Eyes placed in posterior part of head, located dorsolaterrally. Barbels occur in two pair, maxillary barbel and rostral barbel. Upper jaw covered by thin rostral cap disc, elliptical, shorter than wide. Dorsal fin with 2-3 simple, 8 ½ branched rays inserted anterior to vertical from pelvic-fin origin, first branch ray longest. Pectoral fin with 1 simple and 14-15 branch rays reaching beyond midway to pelvic-fin origin. Pelvic fin with 1 simple and 7 ½ branch rays, reaching beyond midway to anal fin-origin. Anal fin with 2 simple, 5 ½ branch rays, first branched ray longest, reaching base of caudal-fin base. Caudal fin with 9-10+9 rays, forked, tips pointed lobes of equal length. Lateral line complete with 31-32 + 2-3 scales and the lateral scaled in transverse row is ½ 4-4/1/3.

Garra cf. _lissorhynchus_ (McClelland)

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

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

Material examined: PUCMF 14040

Description

Body moderately short and rounded. Snout semi circular; blunt; absence of transverse groove and proboscis. Presence of few tubercles on snout and cheek. Head moderately compressed, interorbital region slightly convex. Dorsal profile of body ascends slightly from snout to dorsal-fin origin and become almost straight at dorsal-fin origin thereafter sloping down towards caudal peduncle. Ventral profile of body almost straight from pectoral fin to pelvic-fin origin. Predorsal region scaled absence of scale on chest and abdominal portion. Dorsal fin with 2 simple, 6 branched rays, presence of dark streak or bar near free margin of dorsal fin. Pectoral fin with 1 simple 14-16 branched rays. Anal fin with 2 simple, 4 ½ branched rays and short. Pelvic fin with 1 simple, 6 ½-7 ½ branched rays. Predorsal scale 13-14. Caudal fin with 10+9 (9+8 branched) rays. Presence of thin, light black W- shaped band on posterior half of caudal fin. Upper and lower lobe of caudal fin of equal length. Lateral line complete with 30-31+2 scales. Lateral line scales in transverse row ½ 3-4/1/3; circumpeduncular scale 14-16. Presence of 1 pair of barbel.

Garra nigricollis Kullander & Fang

Material examined: PUCMF 12058

Description

Moderately large species of *Garra*, with elongated body, predorsal contour ascending about straight up to dorsal fin and posteriorly, only slightly less deep. Ventral surface of head and chest flattened, abdomen appears rounded. Presence of black band across posterior margin of head, between left and right side of pectoral-fin base. Snout rounded with appearance of shallow transverse groove, presence of short rostral lobe. Snout tip and rostral lobes demarcated by presence of pointed tubercles. Central pad wider than long, short papiliferous fold extending from corner of mouth between exposed lower jaw and upper lip. Dorsal fin inserted anterior to pelvic fin-origin, falcate with 2 simple and 8 ½ branched rays.

Pectoral fin with 1 simple, 16 branched rays, sub acuminate, fourth branch ray longest but not extending up to pelvic-fin base. Pelvic fin with 1 simple 7 ½ branched rays, sub acuminate, first branch ray longest, margin not extending beyond anal-fin base. Anal fin with 2 simple, 5 ½ branched rays, short, subacuminate, first branched ray longest, margin extending beyond base of caudal-fin origin. Caudal fin with 9-10+9 rays, deeply emarginated, lobe pointed. Lateral line scale 32-34+3, lateral line scale in transverse rows 4/1/3. Predorsal scale 10-12; circumpeduncular scales 16. Chest scale between pectoral fin deeply embedded in skin. Presence of indistinct dark grey rounded blotch on posterior side of caudal peduncle.

Garra rakhinica Kullander & Fang

Material examined: PUCMF 13066/14039//13068

Description

Body elongated, predorsal contour ascend up to dorsal-fin origin and descent towards deep caudal peduncle. Ventral surface flat, scaled from head to chest and belly, become rounded towards posterior end of pelvic fin insertion. Snout rounded, tip portion embedded with tubercles. Two pairs of barbel present. Rostral lobe present on snout, proboscis absent. Anterior barbel short, flattened, not extending to margin of rostral cap. Central pad in lower lip slightly wider than long. Dorsal-fin origin anterior to pelvic-fin origin. Dorsal fin falcate, long subacuminate tip with 2 simple and 8 branch fin rays. Anal fin with 2-3 simple, 5 branched rays, short with straight posterior margin, first branched ray longest, extending slightly beyond base of caudal fin. Pectoral fin with 1 simple, 15 branched ray, subacuminate, fourth branched ray longest. Caudal fin with 10+9 rays, emarginated, lobes equal, tips blunt, of a distinct w shaped dark band. Pelvic fin with 1 simple, 8 branched rays. Circumpeduncular scales 16. Lateral line complete with 29+1-2 scales. Lateral transverse scales 3/1/2-3.

Garra* cf.*vittatula Kullander & Fang

Material examined: PUCM 12042/13069

Description

Body moderate to small, elongated, predorsal contour slightly ascending from snout to base of dorsal-fin origin thereafter sloping slightly towards caudal peduncle. Ventral profile of body flattened from head to anal-fin base then slightly sloping towards caudal peduncle. Snout rounded absence of transverse groove, presence of minute pointed tubercles at tip. Orbit moderately large, located at centre of head. Rostral lobe present with 2-3 tubercles in smaller specimen but 7-8 tubercles in large specimen. Narrow band of papiliferous tissue occurs along upper jaw, central pad wider than long. Dorsal fin with 3 simple, 8 ½ branched rays, smoky, second branched ray longest and presence of black streak on interradial membrane. Dorsal-fin origin anterior to pelvic-fin origin. Pectoral fin with 8-9 simple, 10-11 branched rays, smoky, rounded, eight branched ray longest, not extending to pelvic-fin origin with white margin to anterior ray tips. Pelvic fin with 2 simple 8 ½-9 ½ branched rays, smoky, rounded tip, third branched ray longest, not extending to base of anal-fin origin. Anal fin with 3 simple 5 ½ branched rays; short, subacuminate, second branched ray longest and tips extending towards caudal-fin base but not reaching it. Caudal fin with 10+9 principal rays (9+8) branched rays, slightly emarginated, lobe tips slightly rounded, both lobes of equal length. Predorsal region with 19-20 scales. Chest scale deeply embedded in skin. Circumpeduncular scale consisted of 16-18 scales. Lateral line complete with 30-33+2 scales, lateral line scales in transverse row ½ 4/1/3.

Garra* cf. *khawbungi Arunachalam, Nandagopal & Mayden

Material examined: PUMF 13063/1406

Description

Body elongated, almost cylindrical, generally not compressed towards posterior part of body to dorsal-fin base. Dorsal profiles of body shows gradual ascend up to dorsal-fin base then remain straight towards caudal fin. Ventral profile of body from pectoral-fin origin to pelvic-fin origin show convex appearance, from pelvic-fin origin to anal-fin origin remains straight. Head large; interorbital region convex. Snout rounded from dorsal view, shorter, not elongated as proboscis, presence of weak transverse groove with pointed tubercles arranged irregularly as three rows on each side. Two pairs of barbells; maxillary and rostral barbels present. Rostral cap well developed, cover entirely upper jaw region. Central pad elliptical shape with width greater than length. Dorsa fin with 2-3 simple, 8 branched rays; origin slightly anterior to pelvic fin-origin, first branched dorsal fin ray longest. Pectoral fin with 1 simple, 16 branched ray with slightly pointed posterior margin, fin insertion close to gill opening region, fourth branch ray longest. Pelvic fin with 1 simple, 8 branched ray, posterior margin not reaching anal-fin origin but covers anus region. Anal fin with 2 simple, 5 branched rays; posterior margin not reaching base of caudal fin. Caudal fin with 9+8 branch rays, forked, both upper and lower lobe of equal length. Lateral line complete with 32-33+2 scales. The lateral line scales in transverse row ½ 3-4/1/2. Circumpeduncular scale 16, predorsal scale 9-10.

Laubuka* cf. *laubuca (Hamilton)

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

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

Material examined: PUCMF 12066

Description

Body elongated, deep, laterally compressed. Dorsal profile of body ascends from tip of snout to predorsal region, become straight at dorsal-fin base. Ventral profile of body also ascends from mouth to midpoint between pelvic and anal-fin origin thereafter sloping deeply towards caudal peduncle. Body depth not greatest at dorsal-fin origin but at midpoint between pelvic and anal-fin origin. Mouth upturned and oblique; orbit large, located at anterior half of head. Dorsal fin with 2 simple, 7 ½ branched rays, distal margin slightly convex. Dorsal-fin origin posterior to anal-fin origin. Pectoral fin long, wing like with 1 simple, 10 branched rays, margin covering almost distal margin of pelvic fin. Pelvic fin with 1 simple, 5 branched rays, short, not reaching anal-fin origin or vent. Anal fin with 3 simple, 18 ½ branched rays, margin almost reaching caudal-fin base. Caudal fin with 9+9 principal rays, deeply emarginated, both lobes of equal length. Lateral line scale complete with 25+2 scales, presence of dark broad stripe on sides commencing just behind head and runs along middle of body to caudal-fin base. Lateral line scale in transverse row 6/1/2. Predorsal scale 14; circumpeduncular scale 12. Barbels absent.

Genus *Neolissochilus* Rainboth

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

***Neolissochilus* sp.**

Material examined: PUCMF 12063

Description

Body moderate to large, elongated and laterally compressed. Dorsal profile convex with slight ascending from tip of snout to dorsal-fin origin; body depth greatest at dorsal-fin origin. Ventral profile of body from snout to pectoral fin ascends and become straight at pelvic-fin origin. Head large with slight lateral compression, orbit large located at anterior half of centre. Snout rounded presence of 2 pairs of barbel, 1 pair of maxillary barbel and 1 pair of rostral barbel. Maxillary barbel longer than rostral barbel; absence of rostral lobe. Presence of 8-14 tubercles on lateral side of anterior portion of head below snout. Mouth smoothly rounded, lips thick, lower lip present medially. Presence of gillrakers, long, slender, 6-9 on first arch. Dorsal fin with 3 simple, 8- ½ branched rays, distal margin slightly convex, first branched ray longest, absence of dark spot or blotch. Dorsal-fin origin anterior to pelvic-fin origin. Pectoral fin with 1 simple, 14-15 branched ray, long, wing like, second branched ray longest, absence of dark spot, margin not reaching pelvic-fin origin. Pelvic fin with 1 simple, 7-8 branched ray, triangular shape, first branched ray longest, absence of dark spot, margin not reaching vent or anal-fin origin. Anal fin with 3 simple, 5 ½ branched rays, first branched ray longest, margin not reaching caudal-fin base. Caudal fin with 10+9 principal rays, deeply forked, lobes unequal, upper lobe longer than lower lobe. Lateral line complete with 23-25+2 pored scales, presence of dark blotch covering 23-25 scales. Lateral line in transverse scale ½ 3-4/1/2. Predorsal region scaled with presence of 8-10 scales. Circumpeduncular scales 13-14.

Genus *Osteobrama* Heckel

Osteobrama Heckel, 1842 (type species: *Cyprinus cotio* Hamilton, 1822)

Osteobrama* cf. *cunma (Day)

Rohtee cunma Day, 1888: 343, 807 (Myanmar, India)

Osteobrama cunma Vishwanath and Shantakumar 2002: 69 (valid)

Material examined: PUCMF 15052

Description

Body trapezoid, not much elongated and laterally compressed. Dorsal profile of body steeply ascends from occiput to dorsal-fin origin thereafter sloping down towards caudal peduncle. Ventral profiles of body concave from snout tip to last branch anal-fin ray; body depth greatest at dorsal-fin origin. Head short, mouth small, presence of very large eyes, visible from ventral side of head, located in anterior half of head. Snout rounded, maxillary and rostral barbels absent; upper half of body dark grey, lower half silvery white. Dorsal fin with 3 simple, 8 ½ branched ray, first branched ray longest, distal margin slightly convex, absence of dark spot and presence of 20-21 serration at last unbranched ray of dorsal spine. Dorsal-fin origin anterior to anal-fin origin. Pectoral fin with 1 simple, 15 branched rays, acuminate, first branched ray longest, distal margin reaching ventral-fin origin, absence of dark spot. Ventral fin with 2 simple, 9 branched rays, subacuminate, second branched ray longest, distal margin reaching anal-fin origin. Anal fin very elongated with 3 simple, 29 branched rays. Caudal fin with 10+9 principal rays, deeply forked, lobes unequal, lower lobe longer than upper lobe. Lateral line complete with 53 scales. Lateral line scale in transverse row 6/1/2. Predorsal scale 33; circumpeduncular scale 20.

Genus *Pethia* Pethiyagoda, Meegaskumbura & Maduwage

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

Key to species of the genus *Pethia*:

1	Predorsal scale 8-9. Lateral line incomplete with 24 pored scales. Presence of a black spot on the caudal peduncle covering 17-19 or 18-20 scales....................	*Pethia conchonius*
-	Lateral line complete..	2
2	Lateral line complete with 21-23 pored scales. Dorsal fin last unbranched ray serration 14-19.......................	*Pethia expletiforis*
-	Serration less than 14..	3
3	Lateral line complete with 20 pored scales. Dorsal fin last unbranched ray serration 11-13. Presence of black spot on the anterior lateral line covering 2-3 scale and a bigger black spot on the caudal peduncle covering	

15-17 scale.. *Pethia* sp.

Pethia conchonius (Hamilton)

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

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

Material examined: PUCMF 13084/14044

Description

Body short, laterally compressed and slightly elevated. Dorsal profile of body from snout to caudal peduncle convex. Dorsal profile from tip of snout to dorsal-fin origin ascending deeply, thereafter sloping deeply towards caudal peduncle. Ventral profile of body from snout to anal fin appears concave with highest concavity at pelvic-fin origin then slanting towards caudal peduncle. Head short, laterally compressed; mouth short, sub terminal, nape slightly elevated. Presence of interruption in lower lip fold. Orbit large, slightly bulging, located in lateral centre of head nearing anterior portion. Snout rounded presence of very short barbel. Infraorbital broad. Dorsal-fin origin opposite to pelvic fin-origin; depth of body greatest at dorsal-fin origin. Dorsal fin with 3 simple, 8 ½ -9 branched rays, first branched ray longest, last unbranched ray serrated with 11-13 serrations, presence of dark band in the distal margin of fin. Pectoral fin with 1 simple, 11-15 branched rays, sub-acuminate, second branched ray longest, absence of dark spot or blotch, reaching almost tow third from snout tip to anal-fin origin and not reaching pelvic-fin origin. Pelvic fin with 1 simple, 7-8 branched rays, rounded, second branched ray longest, presence of dark band in distal margin, fin margin reaching vent and almost reaching anal-fin origin. Anal fin with 3 simple, 5 ½ - 6 branched rays, second branched ray longest, triangular, presence of dark streak in distal margin, almost reaching caudal-fin origin. Caudal fin with 10+9 principal rays, deeply forked, lobes unequal, upper lobe slightly longer than lower lobe. Lateral line incomplete with 24+2 scales, presence of dark blotch covering 17-20 scales. Lateral line in transverse scale 4- ½ 5/1/3 ½-4. Predorsal region scaled with 9 scales. Abdomen and chest scaled, presence of deeply embedded scale between pectoral fins. Circumpeduncular scale with 12 scales.

Pethia expletiforis Dishma & Vishwanath

Material examined: PUCMF 14064/14043/15002

Description

Body short, small, elongated and laterally compressed. Dorsal profile of body ascends steeply from snout tip to dorsal-fin origin thereafter sloping down steeply towards caudal peduncle. Ventral profile of body ascends from tip of snout to posterior margin of anal fin thereafter sloping down towards caudal peduncle.Body depth greatest at dorsal-fin origin. Head short, laterally compressed, mouth short and sub-terminal. Snout rounded. Orbit large, slightly bulging, located in anterior centre of head, interorbital width large. Absence of barbels and tubercles in snout. Lip thin, curved; lower lip interrupted medially. Dorsal fin with 3 simple, 8 ½-9 branched rays, second branched ray longest, distal margin convex, last simple ray strong and serrated with 14-19 serration; absence of dark spot or blotch in the dorsal-fin rays or fin base. Pectoral fin with 1 simple 11-12 branched rays, second branched ray longest, sub- acuminate, almost reaching pelvic-fin origin, covering almost two third from tip of snout to anal-fin origin without any dark or black spot. Pelvic fin with 1 simple, 7-8 branched rays, second branched ray longest, distal margin slightly rounded, absence of dark spot, its origin slightly posterior to dorsal-fin origin, reaching vent and almost reaching anal-fin origin without dark spot. Anal fin with 3 simple 5-5 ½ branched rays, second branched ray longest, triangle, absence of dark spot, almost reaching caudal peduncle. Caudal fin with 10+9 principal rays, forked, both lobes of equal length, absence of black spots. Lateral line complete with 21-22+2 pored scales, presence of dark blotch starting from 17-18 to 20th scale. Lateral line in transverse scale ½ 4/1/3- 3 ½. Predorsal region scaled with 8-9 scales. Circumpeduncular scales 12.

***Pethia* sp.**

Material examined: PUCMF 12067

Description

Body small, very deep, laterally flattened. Dorsal profile of body ascends steeply from tip of snout to dorsal-fin origin thereafter sloping downward towards caudal peduncle. Depth of body greatest at dorsal-fin origin. Ventral profiles of body from snout tip to caudal-fin base concave, greatest depth at pelvic-fin origin. Head moderately large, orbit small, located in anterior part of lateral side of head; barbel absent. Predorsal and chest region scaled. Predorsal scale 8-9, circumpeduncular scale 12. Dorsal fin with 3 simple, 9 branched rays, first branched ray longest, distal margin convex, last unbranched ray serrated with 11-13 serrations, presence of 2-3 rows of transverse dark blotch. Pectoral fin with 1 simple, 13-14 branched rays, second branched ray longest, long, wing like, margin just reaching pelvic-fin origin. Pelvic fin with 2 simple, 8 branched rays, first branched ray longest, margin reaching anal-fin origin. Anal fin with 3 simple, 5 ½ -6 branched rays, margin not reaching caudal-fin origin, presence of dark streak in interradial membrane. Caudal fin with 10+9 principal rays, forked, both the lobes equal, absence of dark spot or blotch. Lateral line complete with pored scale of 20+2, presence of small dark spot in anterior part of lateral line from 2-3 scale, presence of bigger dark spot in posterior part covering 15-17 scale. Lateral line scale in transverse row ½ 4/1/2 ½.

Key to species of the genus *Puntius*:

1	Barbel absent. Lateral line complete with 22-23 pored scales..	*Puntius sophore*
-	Barbel present..	2
2	Barbel present. Lateral line complete with 22-23 pored scales...	*Puntius chola*
-	Lateral line more than 23...	3
3	Barbel present. Lateral line 25-26...............................	*Puntius* sp.

Puntius sophore (Hamilton)

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

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

Material examined: PUCMF 13056

Description

Body small to moderate, elongated, laterally compressed. Dorsal profile of body ascends steeply from snout tip to dorsal-fin origin, thereafter gently sloping towards caudal peduncle. Ventral profile of body convex from tip of snout to distal margin of anal fin, thereafter gently sloping towards caudal peduncle. Head short, laterally compressed; orbit large, slightly bulging and located in anterior portion of lateral side of head. Snout rounded, located in dorsolateral portion of head. Mouth U shaped in ventral aspect, lip fleshy, barbels absent totally. Presence of black spot or blotch at caudal peduncle region. Dorsal fin with 3 simple, 8 -8 ½ branched rays; second branched ray the longest, last unbranched ray smooth and strong, absence of serration, fin origin posterior to pelvic-fin origin, distal margin slightly convex, presence of dark blotch at fin base covering 3-5 branched rays . Pectoral fin with 1 simple 15 branch rays, third branched ray longest, sub-acuminate, distal margin not reaching two third from tip of snout to anal-fin origin. Pelvic fin with 1 simple, 7-8 branch rays, second branched ray longest, rounded; distal margin not reaching vent or anal-fin origin, absence of dark spot or blotch. Anal fin with 3 simple, 5 branched rays, second branched ray longest, absence of dark spot. Caudal fin with 10+9 principal rays (9+8 branched rays), deeply forked with pointed lobes, Lateral line complete with 22-23+2 pored scales, presence of dark blotch covering 21-23 scales . Lateral transverse scale with ½ 4/1/3.

Puntius chola (Hamilton)

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

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

Material examined: PUCMF 14050/14051

Description

Body very deep, short and laterally compressed. Dorsal profile of body ascends from tip of snout towards predorsal region to dorsal-fin origin thereafter sloping down towards caudal peduncle. Dorsal profile appears convex from tip of snout to caudal peduncle; body depth greatest at the dorsal-fin origin. Ventral profile of body from snout tip to anal-fin margin appears concave with greatest concavity at pelvic-fin origin. Head large, laterally compressed, rising deeply from the tip of snout to the occiput. Orbit large, slightly bulging, located in the anterior half and nearing the upper portion of the head. Presence of dark vertical bar behind operculum starting from above lateral line to pectoral fin. One pair of maxillary barbel present. Mouth slightly arch; absence of median interruption in lips, upper lip bordered by papilae. Dorsal fin with 3-4 simple, 8 ½ branched rays, first branched ray longest, last simple ray straight, strong, absence of serration, presence of dark blotch at base covering first to third branched ray, presence of vertical dark bar. Pectoral fin with 1 simple, 14-15 branched rays, second branched ray longest, sub-acuminate, absence of dark blotch, reaching almost two third from tip of snout to anal-fin origin and not reaching pelvic fin-origin. Pelvic fin with 1 simple, 8 branched rays, second branched ray longest, ovoid, reaching vent and almost reaching anal-fin origin, absence of dark blotch. Anal fin with 3 simple, 5 ½ branched rays, triangle, first branched ray longest, last simple ray strong, absence of serration. Caudal fin with 10+9 principal rays, deeply forked, lower lobe slightly longer than upper lobe, absence of dark blotch or dark bars. Lateral line complete with pored scale of 22-23+2. Lateral line scale in transverse row ½ 4/1/3 ½ scales. Presence of distinct dark blotch in lateral line covering 21-23 scales. Predorsal region scaled with 9 scales; abdominal portion between pectoral fins scaled. The circumpeduncular scale 14.

***Puntius* sp.**

Material examined: PUCMF 15004

Description

Body small to moderate, elongated, slender and laterally compressed. Dorsal profile of body ascends from tip of snout to dorsal fin origin and almost become straight towards dorsal fin origin thereafter slanting towards caudal peduncle. Ventral profile of body ascends from tip of snout to pectoral fin, almost become straight towards anal fin origin thereafter sloping towards caudal peduncle. Head small, slightly elevated. Orbit large, slightly bulging, located towards anterior half of head. Absence of median interruption in lips; barbels absent. Dorsal fin with 3 simple, 8 ½ branched rays, second branched ray longest, distal margin convex, presence of dark spot at fin base covering 3-5 branched rays, presence of dark streak in distal margin of fin. Dorsal and ventral-fin origin vertically equivalent to each other. Pectoral fin with 1 simple, 3 branched rays, sub-acuminate, third branched ray longest, just reaching pelvic-fin origin, absence of dark spot. Pelvic fin with 1 simple, 7 branched rays, second branched ray, longest, ovoid, just reaching vent but not reaching anal-fin origin. Anal fin with 3 simple, 5 ½ branched rays, second, branched ray longest, distal margin not reaching caudal-fin origin, absence of dark spot. Caudal fin with 10+9 principal rays, lobes unequal, upper lobe slightly longer than lower lobe, absence of dark spot or bar but presence of faint dark margin in distal part. Lateral line complete with pored scale of 25-26+2-3. Lateral line scale in transverse row ½ 4/1/3 ½. Predorsal region scaled with 9 scales. Circumpeduncular scale 12. Presence of dark blotch in lateral line covering 23-24+2 scales. Scales above lateral line dark blue, below lateral line pale yellowish in formalin preserved specimen.

Genus *Rasbora* Bleeker

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

Key to the species of the genus *Rasbora*:

1. Dark coloured lateral longitudinal band extend from opercle to caudal fin base...*Rasbora rasbora*.
2. Dark coloured lateral longitudinal band extend from snout tip to caudal fin base..*Rasbora daniconius.*

Rasbora daniconius (Hamilton)

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

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

Material examined: 12065

Description

Body elongated and laterally compressed. Ventral profile of body ascends from tip of snout to base of dorsal-fin origin thereafter sloping down towards caudal peduncle. Body depth greatest at dorsal-fin origin. Ventral profile of body ascends slightly from tip of snout to pelvic-fin origin thereafter gently sloping towards anal-fin origin then sloping deeper towards caudal fin. Head moderately large, orbit large, located at anterior half of head, interorbital space wide. Mouth moderately wide, directed upwards, snout rounded; barbels absent. Dorsal fin with 2 simple 8-9 branched rays, distal margin slightly convex. Dorsal-fin origin posterior to pelvic-fin origin. Pectoral fin with 1 simple, 13 branched rays, pointed, second branched ray longest, distal margin almost reaching pelvic-fin origin. Pelvic fin with 2 simple, 8 branched rays, absent of dark blotch or spot, fourth branched ray longest, not reaching vent or anal-fin origin. Anal fin with 3 simple, 5 ½ branched rays, moderate in length. Caudal fin with 10+9 principal rays, deeply emarginated, both lobes equal, presence of black hind margin. Lateral line complete with 25+2 scales, presence of black stripe of regular width from tip of head to base of caudal fin. Lateral scale in transverse row 4- ½ 4/1/1-2. Predorsal scale 10; circumpeduncular scale 12.

Rasbora rasbora (Hamilton)

Cyprinus rasbora Hamilton, 1822: 329 (Bengal, India)

Rasbora rasbora Brittan, 1972: 42 (valid)

Material examined: PUCMF 12070

Description

Body small to moderate, elongated and laterally compressed. Dorsal profile of body ascends from snout tip to dorsal-fin origin then sloping towards caudal peduncle. Body depth greatest at dorsal-fin origin. Ventral profile of body appears concave from tip of snout to caudal peduncle, but appears almost straight between pectoral and pelvic-fin origins. Head slightly compressed laterally, orbit large, slightly bulging and located in anterior centre of head. Snout rounded, mouth upturned, absence of barbels and tubercles in head region. Predorsal region with 11 scales. Ventral portion between pectoral fin deeply embedded with scales. Dorsal fin with 2 simple 7 ½ branched rays, first branched ray longest, distal margin convex, absence of dark spot or blotch. Pectoral fin with 1 simple, 13-14 branched rays, wing like but not reaching pelvic-fin origin, first branched ray longest. Pelvic fin with 1 simple, 8 branched rays, absence of dark spot, fin almost reaching vent and not reaching anal-fin origin. Anal fin with 3 simple, 6 branched rays, presence of dark longitudinal streak at anal-fin origin, fin margin not reaching caudal-fin origin. Caudal fin with 10+9 principal rays, deeply forked, both lobes equal, presence of yellow blotch in mid caudal portion in both lobes of live specimen, presence of dark blotch following yellow blotch in distal caudal portion and dark streak in caudal margins. Lateral line complete with pored scale of 24+3, presence of longitudinal dark stripe, darker below dorsal fin towards caudal end but fainter towards anterior end of lateral line region. Lateral line scale in transverse row ½ 4/1/1. Circumpeduncular scale 14.

***Genus Semiplotus* Bleeker**

Semiplotus Bleeker, 1863: 25 (type species: *Cyprinion semiplotus* McClelland)

Semiplotus modestus Day

Material examined: PUCMF 14025/15011

Description

Body moderate to large, laterally compressed, not elongated, convex on dorsal and ventral side. Dorsal profile of body ascends deeply from tip of snout to base of dorsal-fin origin thereafter sloping down deeply towards caudal peduncle. Depth of body greatest at dorsal-fin origin. Ventral profile of body convex from snout to anal fins but becomes straight towards caudal peduncle. Head depressed laterally, orbit large, located at anterior half of head laterally. Snout rounded, rostral lobe absent, presence of 2-4 pairs of tubercles in snout of small specimen. Maxillary and rostral barbels absent, absence of dark spot or blotch on fins but presence of dark streak on interradial membrane of dorsal and caudal fin. Dorsal fin with 3 simple, 21-21 ½ branched rays, last dorsal fin ray heavily serrated and pointed, second dorsal branched ray longest. Pectoral fin with 1 simple, 14 branched rays, second branched ray longest, distal margin not reaching pelvic-fin origin. Pelvic fin with 1-2 simple, 8 branched rays, second branched ray longest, fin reaching vent portion and almost reaching anal-fin origin. Anal fin with 3 simple, 8 branched rays, second branched ray longest, distal margin reaching caudal-fin base. Caudal fin with 10+9 principal rays (9+8 branched rays), forked, both lobes of unequal length, upper lobe length longer than lower lobe. Predorsal scaled with 11-13 scales. Lateral line complete with 31-32+2-3 pored scales. Lateral line scales in transverse row ½ 7/1/3-3 ½.

Genus *Tor* Gray

Tor Gray, 2:96 (type species: *Cyprinus tor* Hamilton)

Tor tor (Hamilton)

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

Tor barakae Arunkumar & Basudha 2003:274(valid)

Material examined: PUCMF 13054/14022/13043

Description

Body moderate to large, elongated and laterally compressed. Dorsal profile of body ascends from tip of snout to dorsal-fin origin. Body depth greatest at dorsal-fin origin.

Ventral profiles of body from tip of snout to base of anal fin slightly concave with highest cancavity at pelvic-fin origin. Head moderate, slightly shorter than depth, dorsal profile more sharply arched than ventral profile; lips thick and fleshy with continuous labial fold across lower jaw; mouth small, gape does not extend below eyes, orbit moderate, located in upper half of lateral side of head. Presence of 2 pairs of barbel; 1 rostral and 1 maxillary barbel; rostral barbel extent beyond corner of mouth. Several tubercles present from 13-16 in anterior partion of lateral side of head under snout. Dorsal fin with 3 simple 8-9 ½ branched rays, distal margin convex, last unbranched ray stiff, first branched ray longest, absence of dark blotch or spot. Pectoral fin with 1 simple, 14-15 branched rays, acuminate, almost reaching pelvic-fin origin, absence of dark spot. Pelvic fin with 1 simple, 8 branched rays, last simple ray longest, absence of dark spot, distal margin reaching vent but not reaching anal-fin origin and acuminate. Anal fin with 3 simple, 5 ½-6 branched rays, acuminate, first branched ray longest, distal margin reaching caudal-fin base. Caudal fin with 9-10+9 principal rays, deeply forked, lobes equal without any dark bars or spot. Lateral line complete with 21-23+2 pored scales. Lateral line in transverse row ½ 3-4/1/2-3 scales. Predorsal region with 8-11 scales. Circumpeduncular scales 12.

Family PSILORHYNCHIDAE

Genus *Psilorhynchus* McClelland

Psilorhynchus McClelland, 1939: 300-428 (type species: *Cyprinus balitora* Hamilton, 1822).

Key to the species of the genus *Psilorhynchus*:

1	Lateral line scale 30-32. Presence of indistinct V shaped vertical bar in the caudal fin...........................	*Psilorhynchus kaladanensis*
-	Lateral line more than 32..	2
2	Lateral line scale 39-41. Mid lateral body with 9-12	

indistinct small dark brown round markings forming

a lateral stripe.. *Psilorhynchus khopai*

Psilorhynchus kaladanensis Lalramliana, Lalnuntluanga and Lalronunga

Material examined: PUCMF 12056/14046

Description

Body small, elongated and compressed. Head also depressed dorsoventrally. Dorsal profiles of body ascend from snout to dorsal-fin origin, then sloping towards caudal peduncle region. Ventral profile of body flattened from tip of snout to base of caudal fin. Depth of body greatest at dorsal-fin origin; orbit moderate, ovoid shape, located slightly at posterior portion of head. Snout rounded absence of transverse groove on dorsum portion but bordered by longitudinal groove on ventral side. Minute pointed conical tubercles cover entire surface of snout and rostral cap regions. Dorsal fin with 3 simple 9 branched rays; presence of dark brown row spot across centre of fin. Anal fin with 2 simple, 6 branched rays; hyaline. Pectoral fin with 1 simple, 10 branched rays; horizontally placed, adpressed, fin not reaching pelvic-fin origin. Pectoral-fin base with cluster of dark brown melanophores. Pelvic fin with 2 simple, 7 branched rays, its origin posterior to dorsal-fin origin. Presence of dark pigment pores between lateral lines forming an indistinct lateral streak. Caudal fin with 10+9 principal rays (9+8 branched); presence of distinct triangular spot at mid base portion and slightly elongated dark mark at base of lower lobe region. Presence of an indistinct V shaped vertical bar across caudal-fin center and dark brown oblique bar at anterior portion. Caudal fin deeply emarginated, lobes of unequal length, upper lobe longer than lower lobe. Lateral line complete with 30-32 scales.

Psilorhynchus khopai Lalramliana, Solo, Lalronunga & Lalnuntluanga

Material examined: PUCMF13013/ 13014/ 14056

Description

Body small, compressed and elongate. Dorsal profile of body gently rising from tip of snout to origin of dorsal fin then sloping steeply towards caudal peduncle. Body depth greatest at dorsal-fin base. Ventral surface flattened from lower jaw to caudal-fin base. Head depressed; wider than deep, eyes ovoid, moderately large, not visible from ventral view, located at middle of head length. Mouth inferior, snout rounded without transverse groove, ventral surface bordered by longitudinal groove on each side. Rostral cap and upper lip fused, separated by deep groove. Lower lip soft, not continuous with upper lip around corner of mouth. Lower jaw covered by thick squarish soft tissue layers (cushioned), papillated, continuous with skin of isthmus and connected with rostral cap by narrow strip of skin around corner of mouth. Mid-lateral body with 9–12 indistinct small dark brown round markings, arranged in a longitudinal row, giving appearance of a faint brown lateral stripe. Dorsal fin with 3 simple, 8 branched rays. Anal fin with 3 simple, 6 branched rays, long, adpressed fin tip not reaching caudal-fin base. Pelvic fin with 2 simple 7 branched rays, its fin origin vertical through or slightly posterior to, dorsal-fin origin; pectoral fin rays 7-8 simple, 9 branched rays. Principal caudal fin rays 9 + 9. Caudal fin forked, upper lobe slightly longer than lower lobe. Lateral line scale rows 39-41, mid-lateral body with 9–12 indistinct small dark brown round markings forming a lateral stripe, 14–17 predorsal scale rows. Scales absent on mid-ventral region between pectoral fins. Belly region between pelvic and pectoral fin without scales

Family COBITIDAE

Genus *Lepidocephalichthys* Bleeker

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

Key to species of the genus *Lepidocephalichthys*:

1	Caudal fins reticulated absence of dark stripe in male specimen...	*Lepidocephalicthys guntea*
-	Absence of caudal fin reticulation.................................	2
2	Presence of 6-7 caudal dark bars. Presence of prominent dark stripe along the side in male...............	*Lepidocephalicthys berdmorei*

Lepidocephalichthys berdmorei (Blyth)

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

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

Material examined: PUCMF 14026/12057

Description

Body moderate to large, elongated, absence of scales on dorsal and ventral side. Dorsal profile of body ascends from tip of snout to dorsal-fin origin. Body depth greatest at dorsal-fin origin. Caudal peduncle very deep, resulting to almost uniform body depth distribution from head to caudal-fin base. Ventral profiles of body almost straight from head to pelvic fin. Head small without scales. Snout rounded; dark stripe extent from tip of snout through the eye or just below, extending to opercle which may be faint in some specimen; anterior rostral barbel long. Presence of 7-14 irregular dark spot on lateral side, but never form bars. Presence of several dark spot on head but absence of bars. Dorsal fin with 3 simple, 6 ½ branched rays, distal portion convex with presence of dark reticulation. Pectoral fin with 1 simple, 7 branched rays, presence of dark streak, margin not reaching pelvic-fin origin. Dorsal-fin origin posterior to pelvic-fin origin. Pelvic fin with 1 simple, 6 branched rays, margin reaching anal-fin origin. Anal fin with 3 simple, 5 ½ branched rays, presence of dark reticulation, fin margin not reaching caudal-fin origin. Caudal fin with 8+8 principal caudal rays, truncate or rounded, presence of large dark spot at upper caudal-fin base, centered on 5 and 6 rays, spanning up to 7 ray. Caudal fin has 6-7 dark, regularly spaced bars. Presence of 4-6 predorsal dark bars and 3-6 postdorsal dark bars.

***Lepidocephalichthys guntea*.** (Hamilton)

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

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

Material examined: PUCMF 12069

Description

Body small to moderate, elongated. Dorsal profile of body ascends from snout tip to dorsal-fin base and almost become straight towards dorsal-fin origin thereafter gently sloping towards caudal fin.Ventral profile of body also ascends from tip of snout to base of pectoral fin thereafter remaining constant to caudal-fin base. Scales absent on head, presence of large dark spots on head, 3 pairs of barbels present, variable in size. Snout rounded dark stripe extent from tip of snout under orbit extending to opercle. Presence of 3-7 predorsal and 3-6 post dorsal dark bars with dark bar always present on dorsal-fin origin. Presence of 8-13 dark spot or blotches along lateral side in female but presence of single very prominent dark stripe on side. Dorsal fin with 3 simple, 6 ½ -7 branched rays, distal margin convex, presence of dark reticulation. Dorsal-fin origin posterior to pelvic-fin origin.

Pectoral fin with 1 simple, 7 branched rays, fin not reaching pelvic-fin origin. Pelvic fin with 1 simple, 6 branched rays, fin not reaching vent or anal-fin origin. Anal fin with 3 simple, 5 ½ branched rays, reticulate dark blotch present, margin not reaching caudal-fin origin. Caudal fin with 8-9+8 principal rays, rounded or truncate, presence of dark spot on base of upper caudal portion usually spanning ray 2-7. Presence of 5-6 dark reticulate caudal thin bars.

Family BALITORIDAE

Genus *Balitora* Gray

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

Key to species of the genus *Balitora*:

1	Lateral line scale complete with 63-64 pored scale. Presence of 6-8 regularly large dark blotches along the back. Anal fin 3 simple 5 ½ branched ray.........	*Balitora* cf. *burmanicus*
-	Pectoral fins cover pelvic fin origin............................	2
2	Pectoral fins cover pelvic fin origin. Lateral line complete with 62-66 pored scale.	*Balitora* sp.1
-	Lateral line complete. Pectoral fins do not cover pelvic fin origin..	3
3	Lateral line complete with 62-65 pored scale. Pectoral fins do not cover pelvic fin origin. Anal fin 2 simple 5 ½ branched rays.	*Balitora* sp.2

Balitora* cf. *burmanicus Hora

Balitora brucei burmanicus Hora, 1932: 291(Meekalan, Myanmar)

Balitora burmanica Kotellat, 1988: 495(valid)

Material examined: PUCMF 14036

Description

Body small, moderately elongated and ventrally depressed. Head and abdomen ventrally flattened. Top of head covered by elongated unculi. Dorsal profile of body ascends from tip of snout to predorsal region and almost becomes straight at dorsal-fin origin.Ventral profile of body from snout to base of anal-fin origin flattened thereafter gently sloping towards caudal-fin origin. Snout rounded. Orbit moderate to large, located towards posterior portion of head. Jaws covered by horny sheath, lip papilated. Body depth greatest at dorsal-fin origin. Body entirely covered by scales with longitudinal keels except on belly portion in front of anal-fin origin. Presence of usually 6-8 regularly large dark blotches along back of body. Dorsal and pelvic-fin origin vertically parallel to each other. Dorsal fin with 3 simple, 8 ½ -9 branched rays, second branched ray longest, distal margin convex. Presence of dark streak along interradial membrane of dorsal fin. Pectoral fin with 8-9 simple, 10-11 branched rays, rounded, fin margin almost reaching base of pelvic-fin origin. Pelvic fin with 2 simple, 8 ½ -9 ½ branched rays, 4 branched ray longest, triangular shaped, presence of dark streak along interradial membrane, margin almost reaching vent. Anal fin with 3 simple, 5 ½ branched rays, convex, presence of faint dark streak along interradial membrane. Caudal fin with 10+9 principal rays, lobes unequal, lower lobe longer than upper lobe, slightly emarginate, presence of two rows of vertical dark bar. Lateral line complete with 63-64+2-3 scales. Lateral line scale in transverse row 8/1/5-7. Barbels 3 pairs, 2 rostral barbels and 1 short maxillary barbel. Predorsal portion scaled with 19-20 scales. Circumpeduncular scale 16-18.

***Balitora* sp.1**

Material examined: PUCMF 13083

Description

Body slightly elongated, depressed ventrally. Dorsal profile of body ascends slightly from tip of snout to predorsal region and almost become straight at dorsal-fin origin. Depth of body greatest at dorsal fin origin. Ventral profiles of body flattened from tip of snout to base of anal-fin origin thereafter gently sloping towards caudal fin. Head large, ventrally flattened, covered by minute tubercles. Orbit small to moderate, positioned at distal part of head. Snout rounded; covered by tubercles, inter orbital space wide. Jaws covered by horny sheath; lip papilated. Barbels present in 3 pairs, 2 rostral barbels; outer barbel very short and 1 maxillary barbel. Dorsal fin with 2-3 simple, 8-9 branched rays, rounded, presence of dark streak in interradial membrane, distal margin convex. Pectoral fin with 9-10 simple 10-12 branched rays, rounded, presence of dark streak in interradial membrane, margin covers pelvic-fin origin. Pelvic fin with 2 simple, 9-10 branched rays, triangle shaped, second branched ray longest, presence of dark streak in interradial membrane, fin margin almost reaching vent portion. Anal fin with 2 simple 5-6 branched rays, short, second branched ray longest, fin margin reaching caudal peduncle and not reaching caudal-fin origin. Caudal fin with 10+9 principal rays, lobes unequal, lower lobe longer than upper lobe, presence of three rows of vertical dark bars. Body covered by scales with longitudinal keels with exception on ventral portion from snout to anal-fin origin. Lateral line complete with 62-66+2 scales. Lateral line scale in transverse row 7-8/1/7. Predorsal scale 18-19. Presence of usually 6-7 large dark blotches along back or dorsal region.

***Balitora* sp.2**

Material examined: 12068

Description

Body small to moderate, elongated, depressed ventrally. Dorsal profile of body ascends slightly from tip of snout to dorsal-fin base thereafter gently sloping towards caudal peduncle. Ventral profile of body from snout tip to anal-fin base flattened and almost straight towards caudal-fin base. Head large, depressed dorsally and flattened ventrally, minute tubercles presents; several irregular faint dark blotches present on dorsal side. Orbit size moderate, located in distal portion of head. Snout rounded but centre tip portion pointed. Presence of 6-7 irregular dark blotches surrounded by pale dark brown area on back. Barbels present in 3 pairs, 2 rostral barbels, outer one very short and 1 maxillary barbel; lip portion papillated. Entire body portion to anal-fin origin covered by scales with longitudinal keels. Dorsal fin with 2-3simple, 8 ½ branched rays, distal margin convex, first branched ray longest. Pectoral fin with 9-10 simple, 10-12 branched rays, rounded, presence of dark streak along interradial membrane. Pectoral fin not reaching pelvic-fin origin. Pelvic fin with 2 simple, 9 branched rays, triangular, second branched ray longest, presence of dark streak along interradial membrane, fin margin almost reaching vent. Anal fin with 2 simple, 5 ½ branched rays, short, second branched ray longest, presence of dark streak along, interradial membrane, fin margin not reaching caudal-fin base . Caudal fin with 10+9-10 principal rays, both lobes unequal, lower lobe longer than upper lobe, emarginate, presence of 3 rows of vertical dark bar. Lateral line complete with 62-65+2-3 pored scales. Lateral line scale in transverse row 7-8/1/6-7. Predorsal region scaled with 18-19 scales. Circumpeduncular scale 20.

Family NEMACHEILIDAE

Genus *Acanthocobitis* Peters

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

Acanthocobitis cf. *botia*

Material examined: PUCMF 15008

Description

Body moderate, long, elongated, more compressed towards posterior end. Dorsal profile of body almost straight but ascends slightly from snout to dorsal-fin base and thereafter gently sloping down towards caudal peduncle. Ventral profiles of body from snout to caudal peduncle slightly concave with highest concavity point at pelvic-fin origin. Body depth greatest at dorsal-fin origin. Head almost cylindrical, from nape to behind nasal pit almost straight, thereafter it suddenly slopes down. Barbels present in 3 pairs; 1 pair of maxillary barbel and 2 pairs of rostral barbels, inner rostral barbel longest. Presence of median interruption in lower lip. Orbit large, located in anterior centre of head. Presence of deep slit in cheek extending from base of rostral barbel to margin of eyes. Dorsal fin with 3 simple, 12 branched rays, third branched ray longest, presence of 5 oblique longitudinal lines or row narrow bands. Dorsal-fin origin anterior to pelvic-fin origin. Pectoral fin with 1 simple, 10 branched rays, rounded, second branched ray longest, fin margin not reaching pelvic-fin origin. Pelvic fin with 3 simple, 6 branched rays, rounded, third branched ray longest. Anal fin with 3 simple, 5 ½ branched rays, second branched ray longest, rounded, fin margin reaching caudal-fin origin. Caudal fin with 9+8 principal rays, emarginate, presence of 5 rows of transverse dark bars. Lateral line complete with 80 cephalic pores. Body covered by minute scales both dorsally and ventrally except on lateral side behind operculum just before cephalic pore region.

Genus *Physoschistura* Banarescu & Nalbant

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

***Physoschistura* sp.**

Material examined: PUCMF 14035/14057

Description.

Body small, elongated and cylindrical in cross section up to anal-fin origin. Dorsal profile of body ascends evenly from tip of snout to dorsal-fin origin, then slanting slightly towards caudal peduncle up to vertical level of anal-fin origin. Ventral profiles of body almost flat from tip of snout to anal-fin origin thereafter sloping gently towards caudal-fin base. Head slightly depressed, dorsolateral part mottled dark brown; orbit located in anterior part of head. Snout rounded. Barbel present in 3 pairs, 2 rostral and 1 pair of maxillary barbels; inner rostral barbel longest. Dorsal fin with 3 simple, 8 ½ branched rays, presence of 1-2 rows of faint dark blotch, distal margin slightly convex. Pectoral fin with1 simple, 10-11 branched rays, margin almost reaching pelvic-fin origin, second branched ray longest. Pelvic fin with 1 simple, 7 branched rays, second branched ray longest, distal margin reaching vent but not reaching anal-fin origin. Anal fin with 3 simple, 5 ½ branched rays, 2 branched ray longest, distal margin reaching caudal-fin origin. Caudal fin with 9+8 principal rays (8+7 branched ray), forked, upper and lower lobe of equal length. Presence of 2 V shaped dark brown bars across distal margin of caudal fin. Presence of both ventral and dorsal adipose crest on posterior part. Lateral line incomplete, reaching anal-fin origin with 55-63 pores. Presence of 10-13 dark brown bars in body.

Genus *Schistura* McClelland

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

Key to species of the genus *Schistura*:

1 Lateral line incomplete with 46-65 pores. Presence of

11-16 transverse black bars on the body...................... *Schistura nebeshwari*

- Lateral line incomplete with less than 46 pores............ 2

2 Lateral line incomplete with 27-38 pores. Presence of 20-23 transverse black bars on the body..................... *Schistura porocephala*

- Lateral line complete.. 3

3 Lateral line complete with 85-100 pores. Presence of 9-11 transverse dark bars on the body.......................... *Schistura koladynensis*

- Transverse black bars on the body less than 9............ 4

4 Lateral line complete with 74-83 pores. Presence of 6 dark brown saddles forming globular shaped bars....... *Schistura scyphovecteta*

- Presence of 6-7 dark bars broader than interspace on the body.. 5

5 Lateral line complete with 82-95 pores. Presence of 6-7 dark bars broader than interspace on the body. Presence of 2 vertical rows of black spot across the caudal fin... *Schistura andrewi*

Schistura koladynensis Lokeshwar & Vishwanath

Material examined: PUCMF 13064/14041/12032

Description

Body small to moderate, elongated, almost cylindrical, slightly compressed anteriorly and more compressed posteriorly. Dorsal profile of body slightly ascends from tip of snout to dorsal-fin origin thereafter becoming straight to end of caudal peduncle. Ventral profiles of body from tip of snout to anal-fin origin straight and thereafter slightly sloping towards caudal peduncle. Head depressed, almost as broad as high at nape but ascend slightly towards occiput region. Snout rounded, orbit small and located at upper half of lateral side of head. Mouth moderately arch, lips fleshy, presence of median interruption in lower lip and median incision in upper lip. Barbel presence in three pairs, 2 rostral and 1 maxillary barbels; outer rostral barbel longer than inner rostral barbel, reaching corner of the mouth. Dorsal fin with 1 simple, 8-8 ½ branched rays, second branched ray longest, distal margin convex, presence of 2 to 3 rows of dark spot in transverse section. Pectoral fin with 1 simple, 10-11 branched rays, rounded, reaching only about one third distances from tip of snout to pelvic-fin base, presence of dark streak in interradial membrane. Pelvic fin with 1 simple, 7 branched rays, sub-acuminate, 3 branched ray longest, presence of two rows of dark spot, its fin origin posterior to dorsal-fin origin, distal margin reaching vent but not reaching anal-fin origin. Anal fin with 3 simple, 5 ½ branched rays, short, third branched ray longest, presence of one raw of dark spot, distal margin not reaching caudal-fin origin. Caudal fin with 10+9 principal rays, presence of basicaudal bar, 4-5 vertical rows of dark bar, deeply forked, lobes sub-equal. Body entirely covered by embedded scales. Lateral line complete, straight, with 85-100 pores. Presence of 9-11 transverse dark bars on the body.

Schistura porocephala Lokeshwor & Vishwanath

Material examined: PUCMF 13001

Description

Body moderately small, elongated, slightly depressed anterior to dorsal-fin origin, and compressed posteriorly. Dorsal profile of body almost straight, but slightly elevated at dorsal-fin origin. Head depressed, short, triangular and absence of scales. Snout rounded and long. Barbels three pairs, inner rostral barbel, outer rostral and maxillary barbels, reaching halfway to lateral margin of operculum. Anterior distal margin of dorsal fin convex, posterior margin slightly truncated. Dorsal-fin with 3 simple, 7 ½ branched rays, 2-3 rows of black spots on dorsal fin. Anal fin with 3 simple, 5 ½ branched rays, nearly reaching caudal-fin base.

Pectoral fin with 1 simple, 10-11 branched rays, oval in shape, fin margin not reaching pelvic fin origin. Pelvic fin with 1 simple, 7 branched ray, its origin anterior to dorsal fin origin, 1-2 rows of black spots present. Caudal fin with 10+9 principal rays (9+8 branched rays), slightly emarginate, subequal, upper lobe little longer than lower, presence of 5-6 rows of black spots. Body completely covered with embedded scales except on belly in front of anal-fin origin. Lateral line incomplete with 28-37 pores; 17–23 thin olivaceous dark bars on body against yellowish cream background.

Schistura nebeshwari Lokeshwor & Vishwanath

Material examined: PUCMF -130026

Description

Body small to moderate size, elongated, cylindrical in dorsal. Body slightly depressed anterior to dorsal-fin origin, compressed posteriorly and lateral side but almost flat in ventral side. Dorsal adipose crest present on caudal peduncle. Dorsal profile of body ascends from tip of snout to predorsal region then become straight towards end of caudal-fin base. Presence of 13–16 dark bars on body; complete prominent black basicaudal bar and presence of lower jaw with shallow median notch. Presence of inflated cheek and absence of suborbital flap. Head depressed, short, triangular in dorsal aspect. Snout slightly pointed in lateral aspect and long. Dorsal fin with 3 simple, 8½ branched rays, second branched ray longest, presence of dark spot at dorsal-fin base and presence of dark streak in interradial membrane. Dorsal-fin origin slightly anterior to pelvic-fin origin. Anal fin with 3 simple, 5½ - 6 ½ branched rays, triangle, second branched ray longest, presence of dark streak, absence of dark spot and almost reaching caudal-fin base. Pectoral fin with 1 simple, 9 branched rays, sub-acuminate, third branched ray longest, reaching midway to pelvic-fin origin. Pelvic fin with 1 simple, 7 branched ray, sub-acuminate, third branched ray longest and absence of dark spot. Caudal fin with 8-9+8 principal rays, deeply emarginate, lobes subequal, lower lobe little longer than upper one. Lateral line incomplete, with 47–65 pores, reaching vertical through anus or middle of anal-fin base. Barbels presence in three pairs, inner rostral barbel longer than outer barbel and reaching corner of mouth; maxillary barbel reaching margin of eye vertical through posterior.

Schistura scyphovecteta Lokeshwor & Vishwanath

Material examined: PUCMF 130027/14060

Description

Body relatively small, moderately elongated, cylindrical in cross-section at dorsal-fin origin, compressed posteriorly to caudal-fin base. Dorsal profile of body ascends evenly from tip of snout to dorsal-fin origin, thereafter sloping gently towards caudal-fin base. Ventral profile of body straight from tip of snout to anal-fin origin then slightly sloping towards caudal peduncle. Head slightly depressed, moderately elongated without any tubercles. Snout rounded in lateral aspect. The species have 5-6 brown stripes along lateral line superposed by bar pattern. Barbel presence in three pairs, inner rostral barbel short and not reaching corner of mouth; outer one reaching base of maxillary barbel. Maxillary barbel almost reaching vertical through posterior margin of eye. Dorsal fin with 3 simple 7-7 ½ branched rays, sub acuminate, second branched ray longest, absence of dark spot but presence of dark streak in interradial membrane. Pectoral fin with 1 simple, 10 branched rays, subacuminate, reaching two-thirds distance to pelvic-fin origin, third and fourth branched rays longest. Pelvic fin with 1 simple, 7 branched rays, sub-acuminate, second branched ray longest, its fin origin posterior to dorsal-fin origin. Anal fin with 3 simple, 5 ½ branched rays, second branched ray longest, sub-acuminate, not reaching caudal-fin base. Caudal fin with 8-9+8 principal rays, deeply emarginate, lobes unequal, lower lobe little longer than upper one, presence of basicaudal bar. Absence of adipose crests in caudal peduncle both dorsally and ventrally. Body completely covered with minute deeply embedded cycloid scales except on chest and belly anterior to anal-fin origin. Lateral line is complete, with 74–83 pores. Axillary pelvic fin lobe well developed.

Schistura andrewi Solo, Lalramliana, Lalronunga & Lalnuntluanga

Material examined: PUCMF 14001/14002/15007; MZUBM/F. 140001–140003

Description

Body elongate; dorsal profile rising evenly from tip of snout to level of eye, gradually ascending to dorsal-fin origin, then sloping gently to end of caudal peduncle. Body somewhat cylindrical anterior to dorsal-fin origin, then becoming increasingly compressed towards caudal-fin base. Dorsal profile of body almost flattened and straight from snout tip to anal-fin origin, thereafter sloping gently towards caudal-fin base. Head long, depressed; ascend deeply from tip of snout to interorbital region, then ascend gently towards occiput region. Presence of small median incision in upper lip and median interruption in lower lip. Barbel's presence in 3 pairs; 2 rostral and 1 maxillary covered, with unculi. Snout rounded. Sub-orbital flap present in male specimen. Mouth subterminal, large and moderately arched. Orbit large, ovoid and positioned near top of head, slightly anterior towards snout, visible in dorsal and lateral view not in ventral view. Presence of long axillary pelvic lobe. Dorsal fin with 2 simple, 8½ branched rays, its origin anterior to pelvic-fin origin; its distal margin convex; presence of dark spot at dorsal-fin base and two rows of black spots horizontally across dorsal fin; last unbranched ray shorter than first branched ray. Pectoral fin with 1 simple, 9-10 branched rays, second branched ray longest, sub-acuminate, absence of dark spot. Pelvic fin with 1 simple, 6 branched rays, sub-acuminate, second branched ray longest, its fin insertion posterior to dorsal-fin origin, midway between snout tip and caudal-fin base. Anal fin with 2 simple, 5½ branched rays, sub-acuminate, first and second branched ray longest, its origin slightly closer to caudal-fin origin than pelvic-fin origin and margin just reaching caudal-fin origin. Caudal fin with 10+9 principal rays, deeply emarginate with two vertical rows of black spots across fin; its lobes sub-equal. Caudal peduncle 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. Lateral line complete with 82–95 pores. Presence of 6–7 broad, black bars on body, wider than interspace.

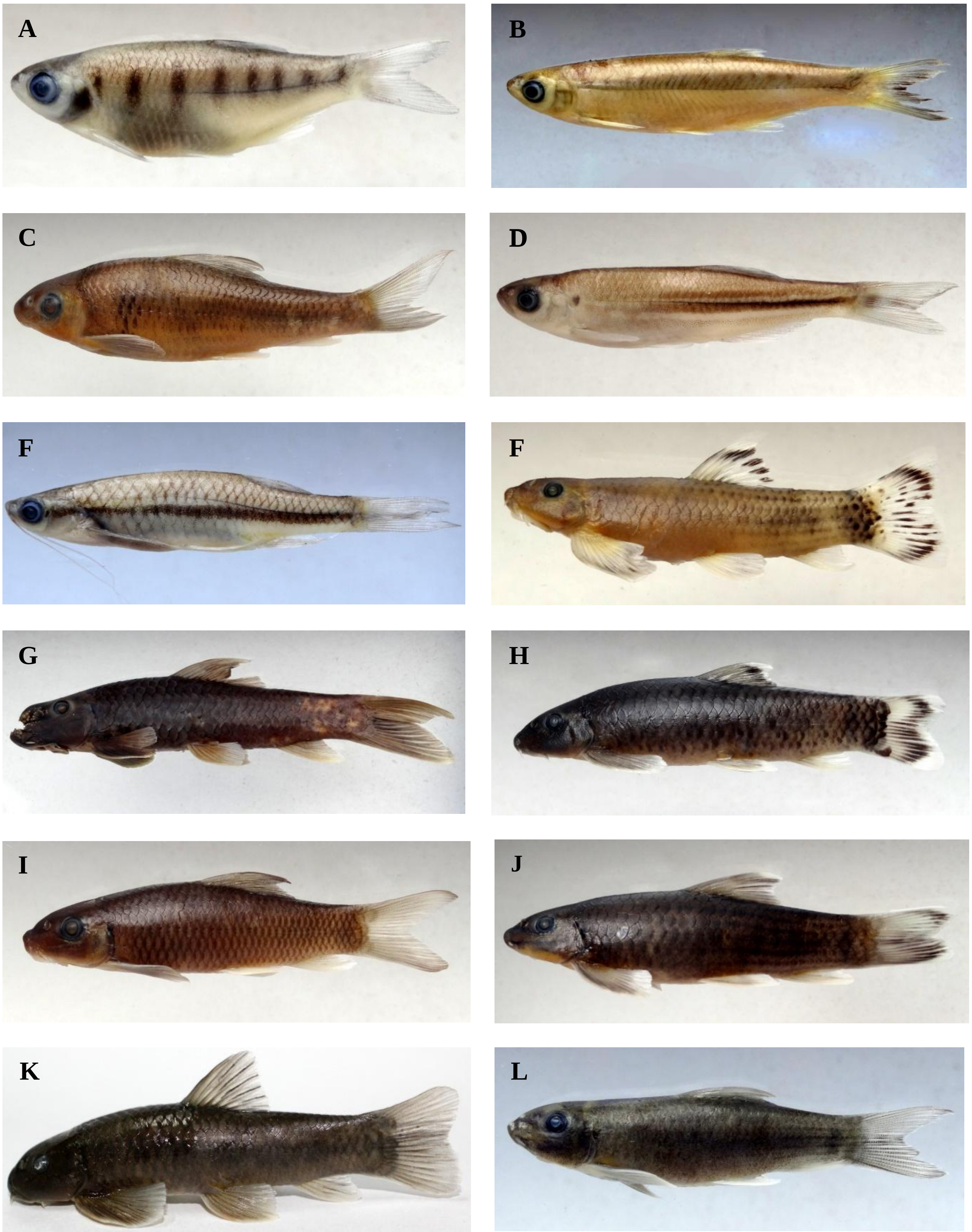

Figure 5.1 A) ***Opsarius profundus*****; B)** ***Cabdio morar*****; C)** ***Crossocheilus*** **cf.** ***burmanicus*****;D)** ***Devario aequipinnatus*****; E)** ***Esomus danrica*****; F)** ***Garra flavatra*****; G)** ***Garra*** **cf.** ***gotyla*****; H)** ***Garra lissorynchus*****; I)** ***Garra nigricollis*****; J)** ***Garra rakhinica*****; K)** ***Garra*** **cf.** ***vittatula*****; L)** ***Garra khawbungi*****.**

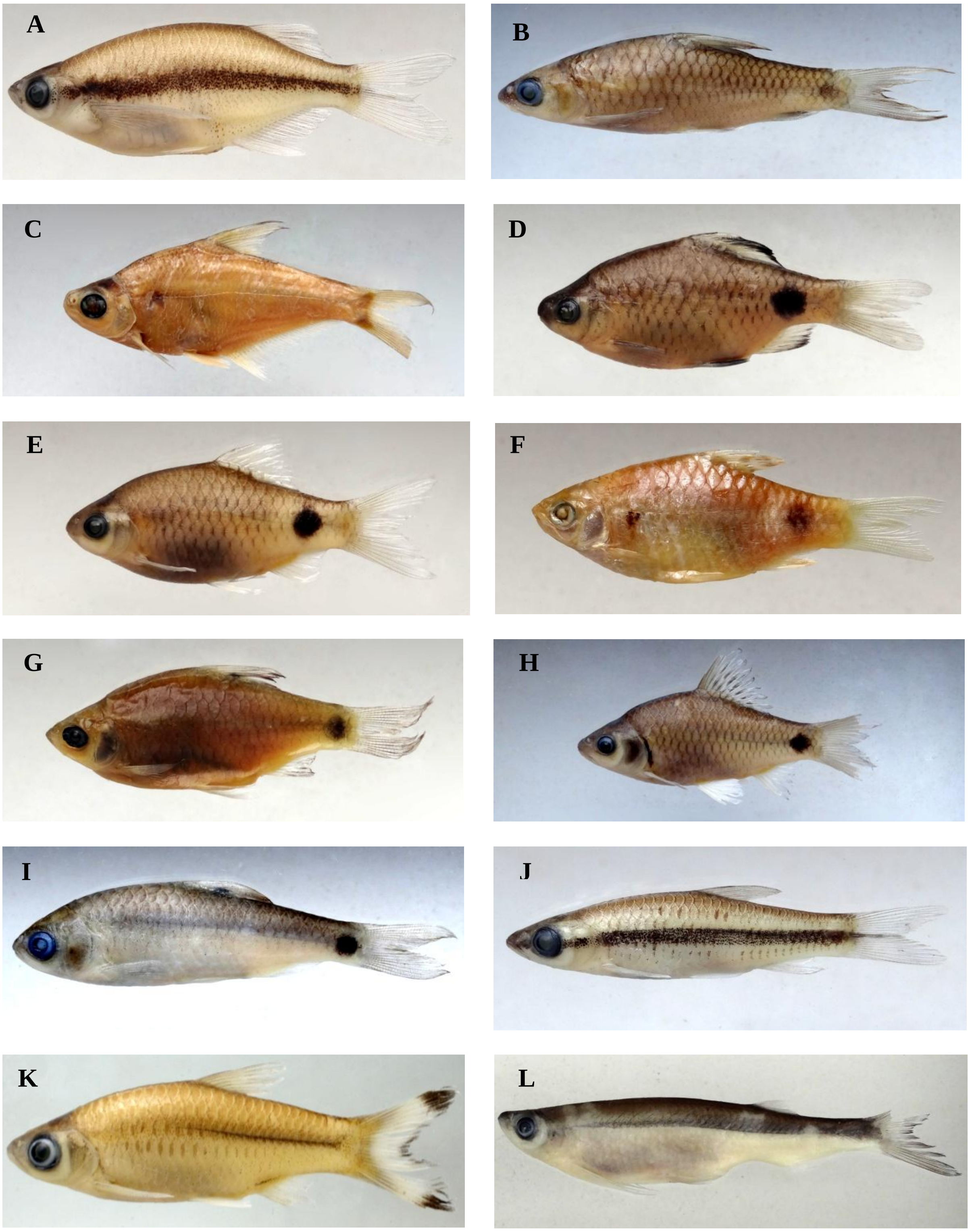

Figure 5.2 A) *Laubuka* cf. *laubuca*; B) *Neolissochilus* sp; C) *Osteobrama* cf. *cunma*; D) *Pethia conchonius*; E) *Pethia expletiforis*; F) *Pethia* sp; G) *Puntius sophore*; H) *Puntius chola*; I) *Puntius* sp; J) *Rasbora daniconius*; K) *Rasbora rasbora*; J) *Salmostoma* sp.

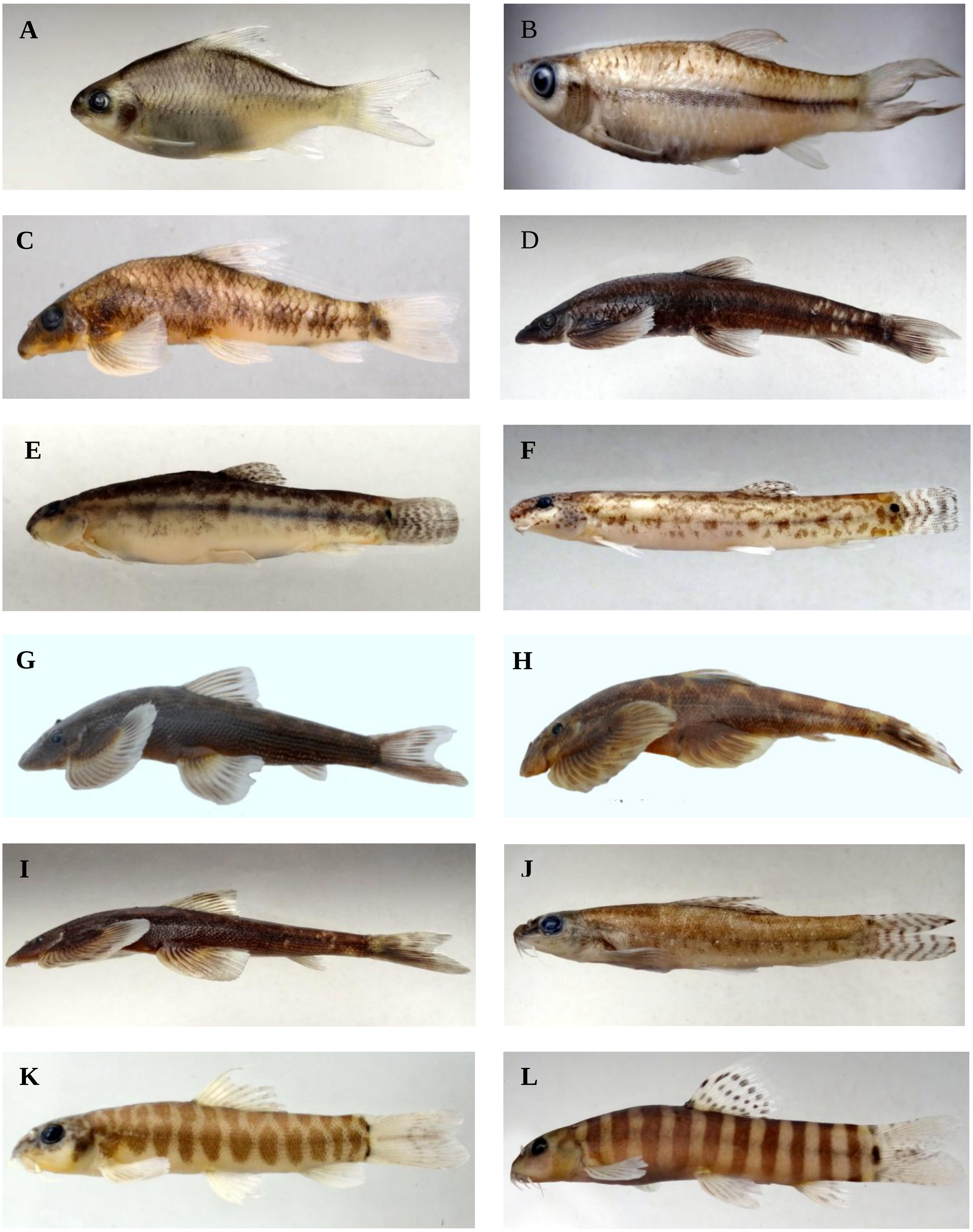

Figure 5.3 A) *Semiplotus modestus*; B) *Tor tor* ; C) *Psilorhynchus kaladanensis*; D) *Psilorhynchus khopai*; E) *Lepidocephalichthys guntea*; F) *Lepidocephalichthys berdmorei*; G) *Balitora* cf. *burmanicus*; H) *Balitora* sp.1; I) *Balitora* sp.2; J) *Acanthocobitis botia*; J) *Physoschistura* sp. K) *Schistura koladynensis*.

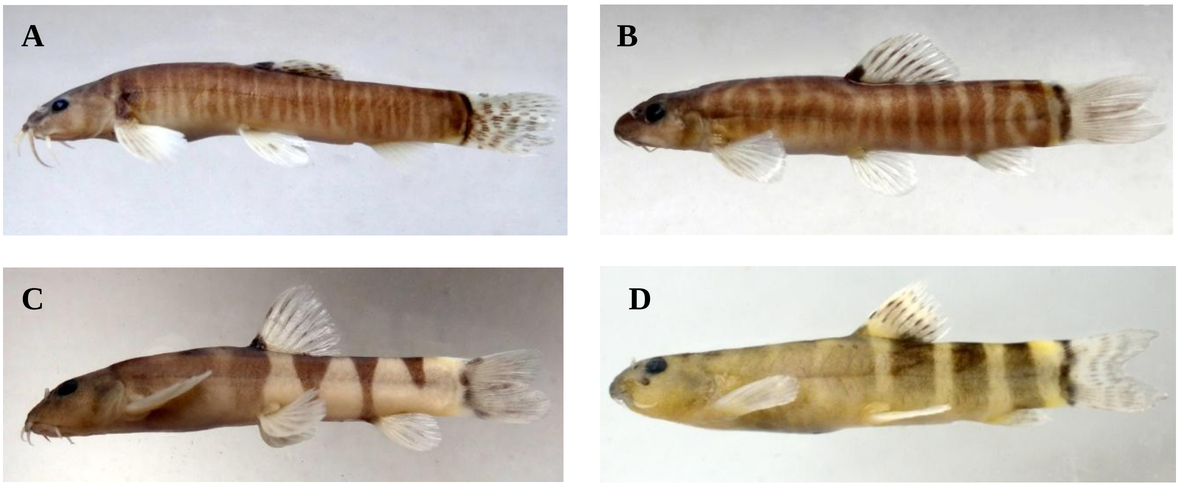

Figure 5.4 A) A) ***Schistura porocephala*****; B)** ***Schistura nebeshwari*****; C)** ***Schistura scyphovecteta*****; D)** ***Schistura andrewi***

5.2 New species description

5.2.1 ***Psilorhynchus khopai*****,** Lalramliana, Beihrosa Solo, Samuel Lalronunga & Lalnuntluanga, 2014

Type material. Holotype: **PUCMF** 13013, 63.2 mm SL; India: Mizoram: Tuisi River, a tributary of Kaladan River in the vicinity of Khopai village, Saiha District, 22°10'38"N, 93°02'45"E; Beihrosa Solo & Samuel Lalronunga, 16 November 2012. Paratypes: PUCMF 13014 (6), 57.4–83.7 mm SL; PUCMF 13014/CS (2), 63.8–70.2 mm SL (cleared and stained); same data as holotype.

Diagnosis. *Psilorhynchus khopai* belongs to *P. homaloptera* species group and differs from its congeners in having the following combination of characters: mid-lateral body with 9–12 indistinct small dark brown round markings arranged in a longitudinal row, giving appearance of a faint brown lateral stripe; 7–9 unbranched pectoral fin rays; 3 unbranched dorsal and anal fin rays; 9 + 9 principal caudal fin rays; forked caudal fin; 14–17 predorsal scale rows; 39–41 lateral-line scale rows; adpressed anal fin tip not reaching caudal fin base; and, in life, a faint gold stripe along dorsal midline with 4–5 black spots between dorsal fin and caudal fin base.

Description. Biometric data are given in Table 1. Head depressed; body small, compressed and elongate. Dorsal profile gently rising from tip of snout to dorsal-fin origin then sloping steeply towards caudal peduncle, body depth greatest at dorsal-fin base. Ventral surface flattened from lower jaw to caudal-fin base. Head wider than deep, eye ovoid, moderately large, not visible from ventral view, located middle of head length. Mouth inferior, snout rounded without transverse groove, ventral surface bordered by a longitudinal groove on each side. Tubercles minute, conical with pointed tips over entire surface of snout rostral cap, skin fold lateral to mouth, lateral and dorsal surface of head, along dorsal surface of unbranched and anteriormost branched pectoral-fin rays, more prominent in males. Rostral cap and upper lip fused, separated by deep groove. Lower lip soft, not continuous with upper lip around corner of mouth. Lower jaw covered by thick squarish soft tissue layers (cushioned), papillated, continuous with skin of isthmus and connected with rostral cap by narrow strip of skin around corner of mouth. Pre-epiphysial fontanelle moderate, rod-shaped, extending posteriorly middle of orbit. Post-epiphysial fontanelle similar in size and shape to pre-epiphyseal fontanelle, almost reaching posterior margin of orbit anteriorly. Five infraorbital bones (IO1-5); IO1-3 plate-like; IO1 biggest; IO4-5 greatly reduced in width. Gill membranes joined to isthmus. Fifth ceratobranchial with 4 rod or needle-like pharyngeal teeth, arranged in single row. Branchiostegal rays 3, all long and slender. Swim bladder coated by thick peritoneal membrane. Anterior chamber large, partially enclosed in bony cavity anteriorly by lateral process of the 2nd vertebral centrum and laterally by outer arm of os suspensorium; posterior chamber greatly reduced. Dorsal fin with iii, 8 (9) rays. Anal fin with iii, 6 (9) rays. Principal caudal fin rays 9 + 9 (9), dorsal procurrent rays 6 (2), ventral procurrent rays 5 (2). Pelvic fin rays ii, 7 (9); pectoral fin rays vii, 9 (2) or viii, 9 (6) or ix, 9 (1). Pectoral fin horizontally placed, adpressed fin tip reaching two-third between pectoral fin origin and pelvic fin origin. Pelvic-fin origin vertical through, or slightly posterior to, dorsal-fin origin. Anus positioned between pelvic fins. Anal fin long, adpressed fin tip not reaching caudal-fin base. Caudal fin forked, upper lobe slightly longer than lower lobe. Scales cycloid and large, radii directed posteriorly. Lateral-line scale rows 39 (2) or 40 (5) or 41 (2), plus 1–2 on base of caudal-fin; transverse scale rows from dorsal fin origin to pelvic-fin origin 3.5/1/2 (7) or 2.5 (2); scale rows around caudal peduncle 10 (9), arranged irregularly; pre-dorsal scale rows 14 (1), 15 (3), 16 (4) or 17 (1); scales between anus and anal-fin origin 11(2) or 12 (7). Scales absent on mid-ventral region between pectoral fins. Belly region between pelvic and pectoral fin without scales. Vertebrae 40 (1) or 41 (1), consisting of 27 (1) or 28(1) abdominal and 13 (2) caudal.

Coloration. In 70% alcohol, body light brownish dorsally and light creamish ventrally. Brown stripe along dorsal midline from occiput to caudal fin base, most prominent from dorsal fin origin to caudal base. No dark spot on dorsal midline between occiput and dorsal fin origin. Mid-lateral body with 9–12 indistinct dark brown and round markings arranged in a longitudinal row and giving appearance of a faint brown lateral stripe; markings most prominent along posterior half of the body. Ventral surface of body without pigment. Anteriormost pectoral and pelvic fin rays with weak scattering of light brown melanophores along interradial membranes of unbranched rays. Dorsal fin without obvious pigmentation, but with a weak scattering of dark brown melanophores along interradial membranes. Anal fin with a faint interrupted bar across anterior half of fin, formed by a dense scattering of melanophores around last unbranched and three anteriormost branched rays. Caudal fin hyaline, formed by a dense scattering of melanophores along the surface of the principal rays; pigmentation most prominent along lower lobe. In life, body background colour light brown to grayish, a faint gold stripe along dorsal midline with 4–5 black spots between dorsal-fin insertion and caudal-fin base, Blotches along lateral body obscure, usually black in colour. Fin pigmentation most prominent in pectoral, pelvic, anal fin and along lower lobe of caudal fin. Dorsal fin hyaline.

Distribution and habitat. Known from the type locality, Tuisi River, a tributary of Kaladan River drainage (Fig. 3). It is found in moderate- to fast-flowing portions of the river with sparse vegetation and a substrate of pebble, sand, gravel and small boulder (Fig 4). Associated species captured with *P. khopai* include *Glyptothorax* sp., Garra sp., Schistura sp. and *Batasio convexirostrum*.

Etymology. Named after Khopai, a small village near the type locality. A noun in apposition.

Remarks: Yazdani *et al*. (1990) assigned a new and separate generic name *Psilorhynchoides* for *P. homaloptera* and *P. pseudecheneis*, 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 & Kotellat, 2007; Conway, 2011; Conway *et al*., 2013). Therefore, *Psilorhynchus* is still preferred for these species. *P. khopai* is proposed to be a member of the *P. homaloptera* species group (Conway, 2011) as it poses a greater number of unbranched pectoral-fin rays (vii–ix) and lateral-line scale rows (39–41). Among members of *P. homaloptera* species group, *P. khopai* is most similar to *P. rowleyi* in having a dome-shaped rostral cap, similar numbers of lateral-line scale rows, total vertebrae and principal caudal fin rays; however, *P. khopai* is distinguished by having a smaller eye (18.4–20.9 % HL vs. 21.7–31.5), forked caudal fin (vs. emarginated), more unbranched dorsal and anal fin rays (iii vs. ii), adpressed anal fin tip not reaching caudal fin base (vs. reaching caudal fin base) and a faint gold stripe along dorsal midline with 4–5 black spots between dorsal fin and caudal fin base (vs. absent). The pre-dorsal scale rows of *P. khopai* are varied in number (14–17) and arranged irregularly, acondition similar to *P. arunachalensis* (Nebeshwar *et al*., 2007) and *P. pseudecheneis* (Conway *et al*., 2012). However, *P. khopai* is distinguished from *P. arunachalensis* in having fewer principal rays in the upper lobe of caudal-fin (9 vs. 10), fewer lateral-line scale rows (40–41 vs. 46–48) and the absence of blotches or a spot on the dorsal midline between the occiput and dorsal fin origin (vs. present); and from *P. pseudecheneis* in having fewer lateral-line scale rows (40–41 vs. 46–48), more circumpeduncular scale rows (10 vs. 8) and lacking highly modified cycloid scales forming a series of large flap-like structures between the insertion of the pectoral- and pelvic-fins (vs. present). Further, *P. khopai* is distinguished from *P. homaloptera* in having higher principal caudal fin rays in the lower lobe of caudal-fin (9 vs. 8), longer snout (52.7–55.3 % HL vs.

48.0–51.3), narrower inter-orbital (39.9–45.4 % HL vs. 45.8–49.1) and a dome-shaped rostral cap (vs. slightly pointed); and from *P. microphthalmus* in having fewer principal caudal fin rays in the upper lobe and more principal caudal rays in the lower lobe (9 + 9 vs. 10 + 8), more predorsal scales (14–17 vs. 12–13), smaller eye (18.4–20.9 % HL vs. 21.2–24.0) and absence of four black occelus-like markings on the occiput (vs. present). The number, shape and size of branchiostegal ray is an important diagnostic character. *P. khopai* possess three branchiostegal rays, all long and slender. This distinguishes the species from all members of the *P. balitora* species group where the anteriormost branchiostegal ray is reduced or absent. Furthermore, *P. khopai* is distinguished from members of the *P. balitora* species group in having more lateral-line scale rows (39–41 vs. 29–36). *P. khopai* is distinguished from members of the *P. nudithoracicus* species group in having more vertebrae (39–41 vs. 34–36), more unbranched pectoral-fin rays (7–9 vs. 4–6), fewer branched dorsal-fin rays (8 vs. 9) and, with the exception of *P. robustus* and *P. tenura*, fewer principal caudal-fin rays on the upper lobe of the caudal-fin (9 vs. 10). It differs from *P. robustus* in lacking a large dark blotch situated posterodorsal to opercular opening (vs. present), deeper head (46.6–55.8 % SL vs. 41.0–45.5) and shorter snout (48.8–53.4 % HL vs. 50.0–56.4); and from *P. tenura* in having more predorsal scales (14–17 vs. 11–12), wider head (73.0–84.9 % HL vs. 67.2–71.0) and wider inter-orbital (39.9–45.4 % HL vs. 31.6–34.8). Kar & Sen (2007) listed *P. gracilis* (now *P. nudithoracicus*) from Barak River drainage and *P. balitora* from both the Kaladan and Barak river drainages of Mizoram without mentioning where the collections were deposited. *P. sucatio* is also known from tributaries of the Barak River drainage of Mizoram (Ng & Lalramliana, 2010). Our collections from tributaries of the Barak River drainage include *P. nudithoracicus* and *P. sucatio* whereas *P. balitora* has neither been collected from the Barak River nor Kaladan River drainages. However, *P. khopai* is distinguished from *P. sucatio* in having fewer principal rays on the upper lobe of the caudal fin (9 vs. 10), more number of unbranched pectoral fin rays (7–9 vs. 4–5), more number of vertebrae (40–41 vs. 34–37), wider head (73.0–84.9 % HL vs. 59.1–64.4), deeper head (46.6–55.8% HL vs. 39.5–44.6), smaller eye (17.4–20.9 % HL vs. 23.9–26.7, smaller inter-orbital (39.9–45.4 % HL vs. 48.1–53.8) and wider mouth (33.7–37.2 % HL vs. 22.5–26.2).

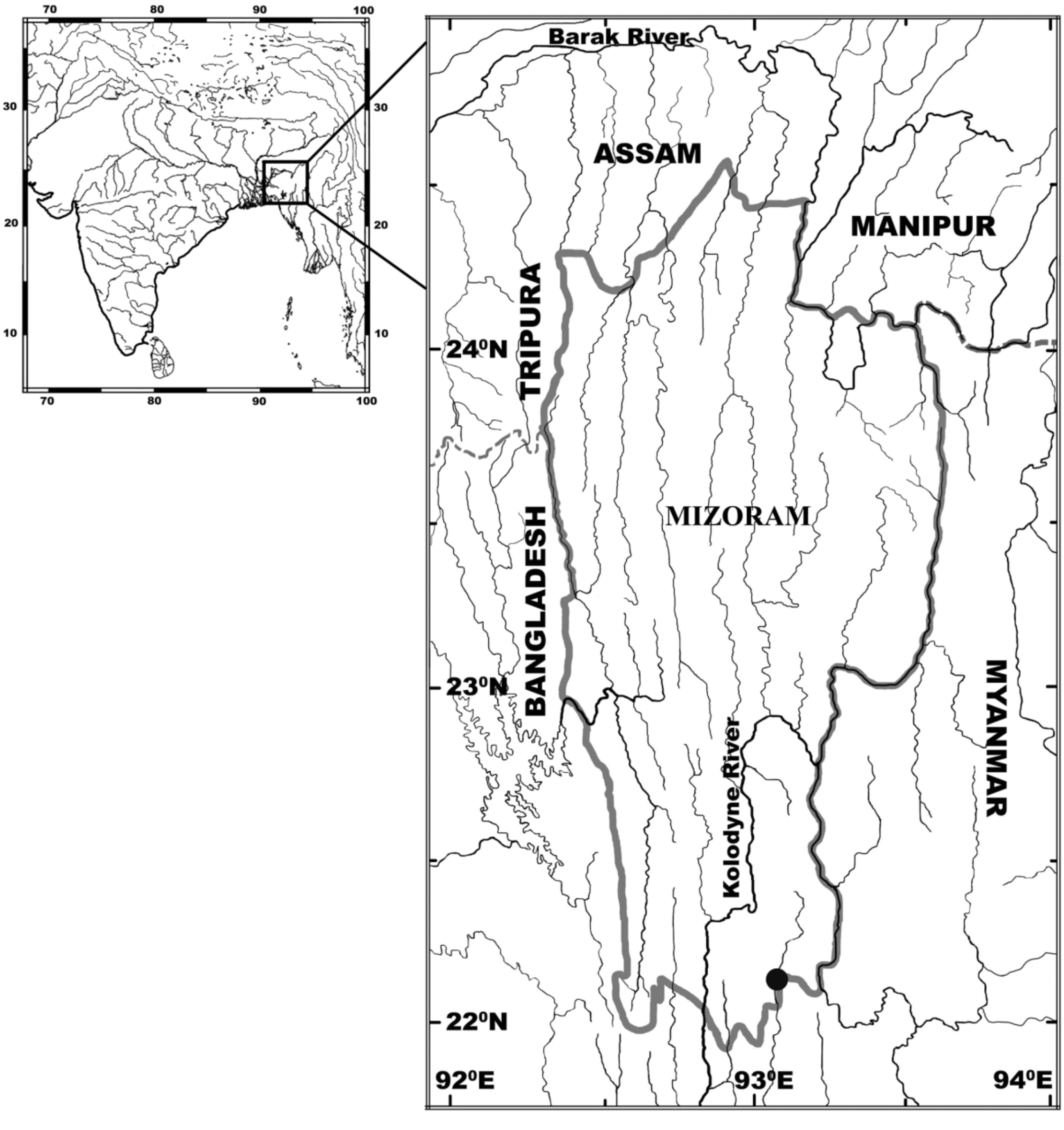

Figure 5.5: Map showing the collection locality of *Psilorhynchus khopai* (circle); n.b., a circle indicates more than a single locality.

TABLE 5.1. Biometric data for *P. khopai* (n=9). Ranges include values of holotype

	holotype	range	mean	SD
Standard length (mm)	63.2	(57.4–83.7)		
In % SL				
Body depth	17.1	13.2–17.1	15.2	1.1
Head length	20.7	18.8–20.8	19.9	0.7
Pre-dorsal length	50.9	43.9–50.9	46.3	2.0
Pre-pectoral length	17.6	16.5–18.6	17.5	0.7
Pre-pelvic length	49.8	43.3–50.6	47.9	2.0
Pre-anal length	77.7	77.7–82.6	79.9	1.5
Distance from snout to anus	56.7	55.8–60.3	58.1	1.4
Distance from anus to anal fin	17.6	17.6–22.3	20.6	1.5
Caudal peduncle length	13.4	12.6–14.5	13.2	0.6
Caudal peduncle depth	8.4	6.8–8.6	7.7	0.6
Caudal peduncle width	4.0	3.3–4.7	3.9	0.5
Pectoral fin length	29.1	24.7–29.1	26.5	1.3
Pelvic fin length	20.9	19.2–22.3	20.9	0.9
Length of last unbranched anal ray	14.3	13.0–17.9	15.3	1.3
Length of last unbranched dorsal ray	23.7	20.1–24.4	22.8	1.4
In % HL				
Head width	73.9	70.5–75.8	73.4	2.2
Head depth	42.0	39.8–43.4	41.6	1.3
Eye diameter	19.6	17.4–20.9	19.4	1.2
Snout length	55.1	52.7–55.3	54.3	1.1
Inter-orbital width	46.4	43.5–46.4	44.9	0.9
Mouth width	33.3	32.6–35.4	33.9	1.3

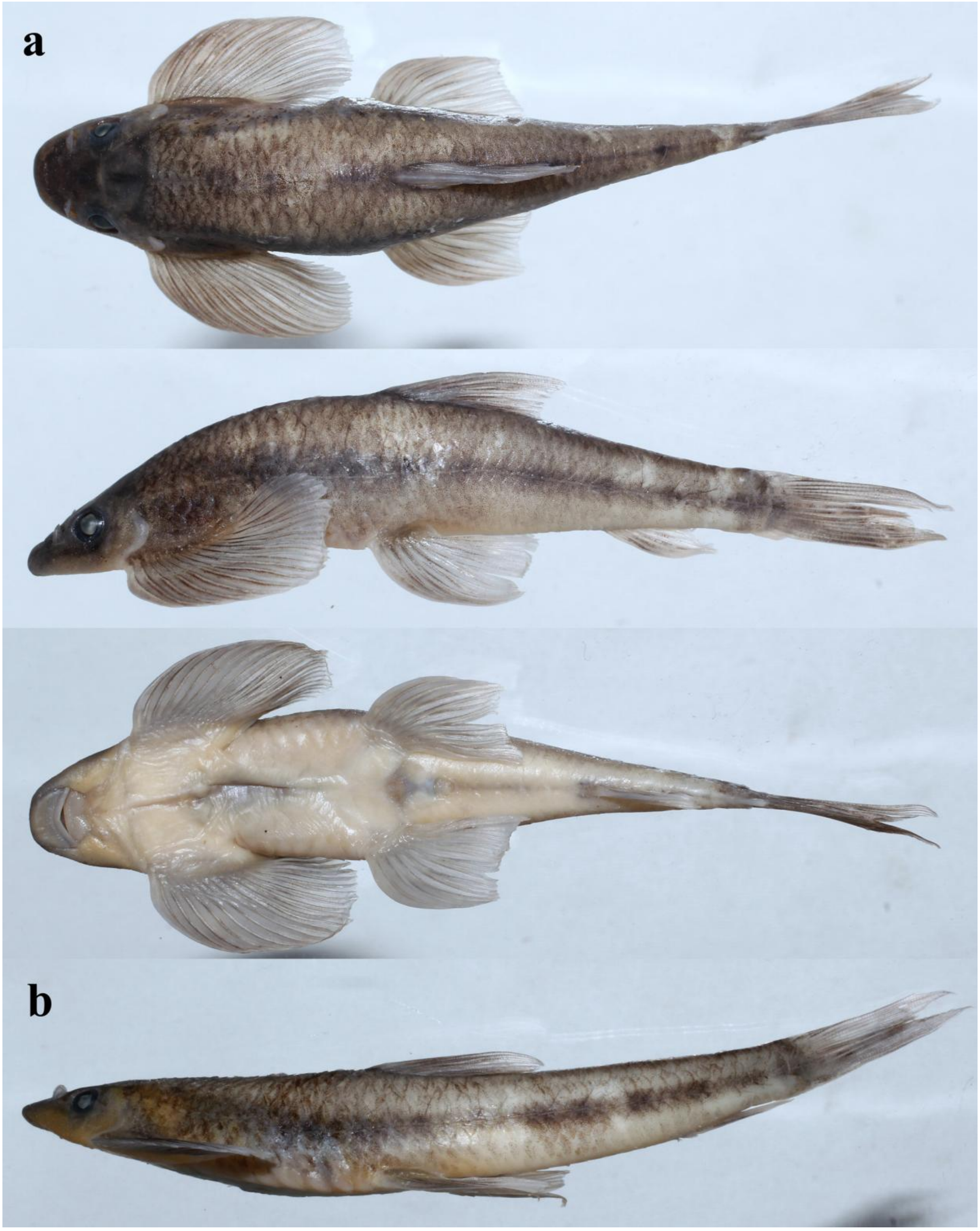

Figure 5.6 *Psilorhynchus khopai*, (a) holotype PUCMF 13013, 63.2mm SL; dorsal, lateral and ventral views. (b) paratype, PUCMF 13014, 68.7 mm SL, lateral view.

Figure 5.7 Live individuals of *Psilorhynchus khopai*, PUCMF 13014, 80.2mm SL; India: Mizoram, Tuisi River.

5.2.2 ***Schistura andrewi*** Beihrosa Solo, Lalramliana, Samuel Lalronunga & Lalnuntluanga, 2014

Type material. Holotype: PUCMF 14001, 50.5 mm SL; India: Mizoram, Mat River, a tributary of Kaladan River in the vicinity of Serchhip, Serchhip District, 23° 20' 04" N; 92° 50' 01" E; Solo *et al*. 20 April 2013. Paratypes: PUCMF 14002 (8), 35.9–44.6 mm SL; MZUBM/F. 140001–140003 (3), 40.1–45.2 mm SL; PUCMF 14003 (4), 36.9–41.3 mm SL (cleared and stained); locality data same as holotype.

Diagnosis. *Schistura andrewi* differs from other species of the genus from the Kaladan basin and its adjacent basins by having the combination of the following characters: long axillary pelvic lobe; complete lateral line with 82–95 pores; 2 unbranched dorsal and anal fin rays; 6–7 broad, wider than interspace, black bars on the body; 2 rows of black spots horizontally across the dorsal fin; a deeply emarginate caudal fin with 2 vertical rows of black spots across the fin, and 9 + 8 branched caudal fin rays; males with a sub-orbital flap; and intestine looped behind the stomach.

Description. Biometric data are given in Table 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 origin of dorsal fin, 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 2.0–2.4 times) wider than long. Lips thick, fleshy (Fig. 2a), covered by furrows. Upper lip with small median incision. Lower lip with median interruption. No median notch on lower jaw. Processus dentiformis present. Inner rostral barbel extending up to ⅓ of distance between snout tip and anterior rim of orbit, outer rostral barbel extending up to ⅔ of distance between snout tip and anterior rim of orbit; maxillary barbel extending vertical through middle of orbit. Barbels covered with unculi. Dorsal fin with 2 simple and 8½ (16) branched rays, its origin anterior to pelvic-fin insertion; its distal margin convex; last unbranched ray shorter than first branched ray. Pectoral fin sub-acuminate, with 11 (5) or 12 (11) rays, its insertion slightly anterior to posterior edge of opercle, adpressed fin tip reaching midway between its insertion and pelvic-fin insertion. Pelvic fin sub-acuminate, shorter than head length, with 8 (16) rays; its insertion posterior to dorsal-fin origin, midway between snout tip and caudal-fin base, adpressed fin tip reaching anus. Axillary pelvic lobe present at pelvic-fin base. Anal fin sub-acuminate with 2 simple and 5½ (16) branched rays, its origin slightly closer to caudal-fin base than pelvic-fin insertion. Caudal fin branched rays 9 + 8 (16). Caudal fin deeply emarginate, its lobes sub-equal. Caudal peduncle 1.2 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 complete with 82–95 pores. Cephalic lateral-line system with 8 supraorbital, 4+9/10 infraorbital, 9 pre-operculom mandibular and 3 supratemporal pores. Intestine with a large loop behind stomach (Fig. 2b) Vertebrae (abdominal + caudal): 21+12 = 34 (3) or 20 + 12 = 33 (1).

Sexual dimorphism. A prominent sub-orbital flap present in males.

Coloration. In 70% alcohol: Body light-yellowish brown with 6–7 wide black bars, usually wider than interspaces (typically 2–3 pre-dorsal, 2 sub-dorsal and 2 post-dorsal); all bars coalesces dorsally and reaching to level of pelvic-fin base ventrally; posteriormost bar coalesce ventrally. Black basicaudal bar complete and well marked. Dorsal surface of head dark brown. Dorsal fin hyaline with a black blotch at base, covering simple and first branched rays; 2 rows of black spots on rays horizontally across the fin; caudal fin hyaline with 2 rows of black spots on rays vertically across the fin. Pectoral, pelvic and anal fin hyaline, with dark markings on inter-radial membrane. Fresh specimens are similar to preserved specimen except for reddish coloration on the caudal peduncle region, dorsal and ventral portions of the caudal fin near the basicaudal bar.

Etymology. The species is named after Andrew Arunava Rao who extends his help to the authors for documentation of fishes in Mizoram. It is a noun in apposition.

Distribution and habitat. The species has been collected only from the Mat River, tributary of Kaladan River, Mizoram, India (Fig. 3). Specimens were collected from a small pool in slow-flowing water. The substrate was composed of sand, gravel and rocks. The species was found associated with *Schistura nebeshwari*, *Olyra* sp. and *Garra* spp.

Comparison: Among all the species of the genus *Schistura* described from the rivers of Mizoram, northeastern India, *S. andrewi* is distinguished, with the exception of *S.*

aizawlensis, *S. koladynensis*, *S. paucireticulata* and *S. scyphovecteta*, in having complete lateral line. It is distinguished from *S. aizawlensis* in having a complete basicaudal bar (vs. dissociated), more branched dorsal-fin rays (8½ vs. 7–7½), presence (vs. absent) of two rows of black spot on dorsal fin and a shorter snout length (27–35 % DHL vs. 38–45); from *S. koladynensis* in having fewer body bars (6–7 vs. 9–11), complete basicaudal bar (vs. dissociated) and absence (vs. present) of a pair of elongated blotches each on dorso-lateral side of snout, extending from base of inner rostral barbel to vertical of nostril ventrally; from *S. paucireticulata* in having fewer body bars (6–7 vs. 8–9), bars not reticulated (vs. bars anterior to dorsal-fin origin forming a reticulated pattern), fewer unbranched dorsal-fin rays (2 vs. 4), fewer branched anal-fin rays (5 vs. 6) and complete basicaudal bar (vs. dissociated); and from *S. scyphovecteta* in having fewer unbranched dorsal-fin rays (2 vs. 4), more branched dorsal-fin rays (8½ vs. 7½), 2 conspicuous horizontal rows of black spots across rays of the dorsal fin (vs. a row of light brown spots) and intestine with a large loop behind the stomach (vs. slightly bent). Kar and Sen (2007) listed *S. carletoni* (Fowler), *S. sikmaiensis* (Hora), and *S. vinciguerrae* (Hora) from rivers of the Barak drainage (Brahmaputra basin), and *S. multifasciata* (Day) and *S. tirapensis* Kottelat from Kaladan basin. Karmakar & Das (2007) listed *S. kangjupkhulensis* (Hora) from Tiau River (Kaladan basin) of Mizoram, India. Since the type locality of *S. carletoni* is the Beas River (Indus basin) of India, *S. kangjupkhulensis, S. sikmaiensis* and *S. vinciguerrae* the Chindwin-Irrawaddy basin, and that of *S. multifasciata* and *S. tirapensis* the Ganga-Brahmaputra basin, it is unlikely that the above-mentioned species would also occur in the isolated Kaladan basin, and those reported species may be due to misidentification. However, *S. andrewi* is distinguished from all these species in possessing a sub-orbital flap in males (vs. no flap). Relative to other species occurring in the nearby adjacent basins (Ganga-Brahmaputra basin and Chindwin- Irrawaddy basin) and those species previously mentioned, *Schistura andrewi* can be distinguished from all the species, with the exception of *S. chindwinica* (Tilak & Husain), *S. ferruginea* Lokeshwor & Vishwanath, *S. gangetica* (Menon), *S. manipurensis* (Chaudhuri), *S. reticulata* Vishwanath & Nebehwar , *S. rubrimaculata* Bohlen & Šlechtová, *S. scaturigina* (McClelland), *S. shebbearei* (Hora) and *S. sijuensis* (Menon), in having sub-orbital flap in males (vs. no flap). It differs from *S. chindwinica* in having fewer bars on the body (6–7 vs. 8–11), small median incision on the upper lip (vs. no incision) and intestine with a large loop behind the stomach (vs. slightly bent); from *S. ferruginea* and *S. manipurensis* in having complete lateral-line (vs. incomplete); from *S. gangetica* in having fewer bars on the body (6–7 vs. 12) and bars anterior to dorsal fin without any break up or reticulation (vs. band anterior to dorsal fin break up and form numerous narrow bands); from *S. reticulata* in having fewer bars on the body (6–7 vs. 17–29) and more branched caudal-fin rays (9 + 8 vs. 8 + 7); from *S. rubrimaculata* in having fewer unbranched dorsal-fin rays (2 vs. 4), fewer unbranched anal-fin rays (2 vs. 3) and presence (vs. absent) of 2 rows of black spots on rays arranged horizontally across the dorsal fin; from *S. scaturigina* in having fewer bars on the body (6–7 vs. 9–12) and a complete basicaudal bar (vs. dissociated); from *S. shebbearei* in having a complete lateral line (vs. incomplete, terminating above the anal fin) and from *S. sijuensis* in having 2 (vs. 1) rows of black spots on rays arranged horizontally across the dorsal fin and non reticulate bars on side of body (vs. bars in front of the dorsal fin origin forming a reticulated pattern).

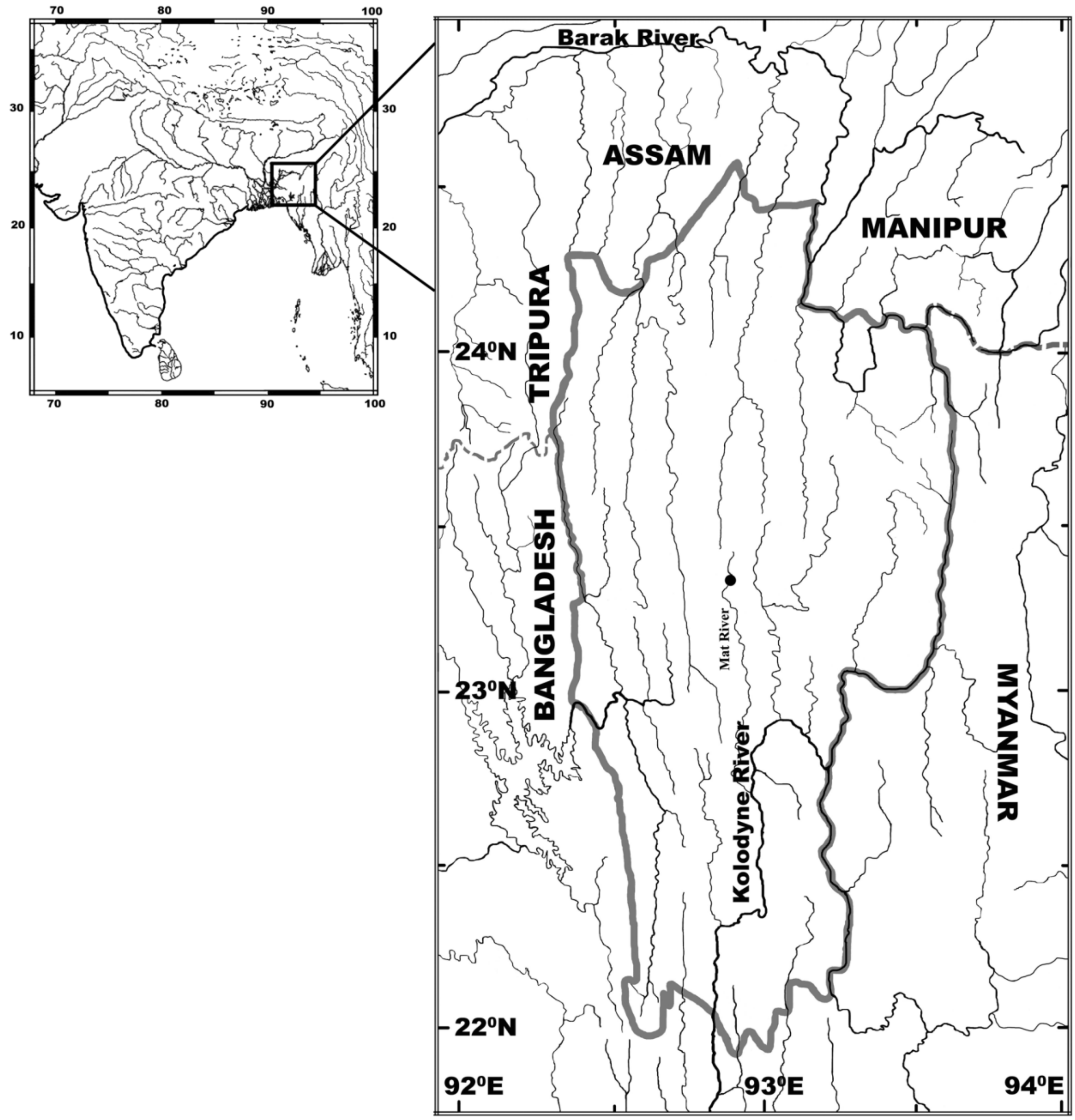

Figure 5.8: Map showing the collection locality of *Schistura andrewi* (circle); circle indicates more than a single locality.

TABLE 5.2 Biometric data for *Schistura andrewi* (n=16).

	holotype	range	mean	SD
Standard length (mm)	50.5	35.9–50.5		
In % standard length				
Dorsal head length	19.8	19.6–21.2	20.6	0.6
Lateral head length	23.4	21.5–24.5	22.9	0.7
Pre-dorsal length	50.9	49.9–53.6	51.7	1.0
Pre-pelvic length	55.8	50.7–57.1	53.3	1.8
Pre-anus length	71.7	69.1–73.3	71.7	1.4
Pre-anal length	77.8	74.7–80.2	77.6	1.3
Head depth at occiput	13.1	11.8–13.6	12.6	0.5
Body depth at dorsal fin	18.8	15.9–18.8	17.3	0.9
Body depth at anal fin	16.0	14.0–16.4	15.1	0.8
Depth of caudal peduncle	13.9	11.7–14.0	12.8	0.6
Length of caudal peduncle	15.8	13.8–16.2	14.8	0.6
Head width at eye	13.1	10.9–13.1	11.9	0.5
Maximum head width	15.4	13.2–15.4	14.2	0.6
Body width at dorsal fin origin	15.6	12.9–15.6	14.3	0.9
Body width at anal fin origin	10.1	8.9–10.5	9.8	0.5
Height of dorsal fin	15.4	14.3–16.9	15.3	0.7
Length of upper caudal fin rays	22.6	20.1–23.1	21.6	0.9
Length of lower caudal fin rays	23.8	21.7–24.2	23.2	0.8
Length of median caudal fin rays	13.3	12.1–14.0	12.8	0.6
Length of anal fin	17.6	15.7–18.1	17.3	0.7
Length of pelvic fin	20.8	17.4–20.8	18.9	0.9
Length of pectoral fin	23.4	19.1–23.5	21.7	1.3
In % dorsal head length				
Snout length	34	27–35	32	2.0
Eye diameter	20	20–23	22	1.4
Interorbital width	31	26–33	30	2.1

Figure 5.9 *Schistura andrewi***,** holotype PUCMF 14001, 50.5mm SL, lateral, dorsal and ventral view.

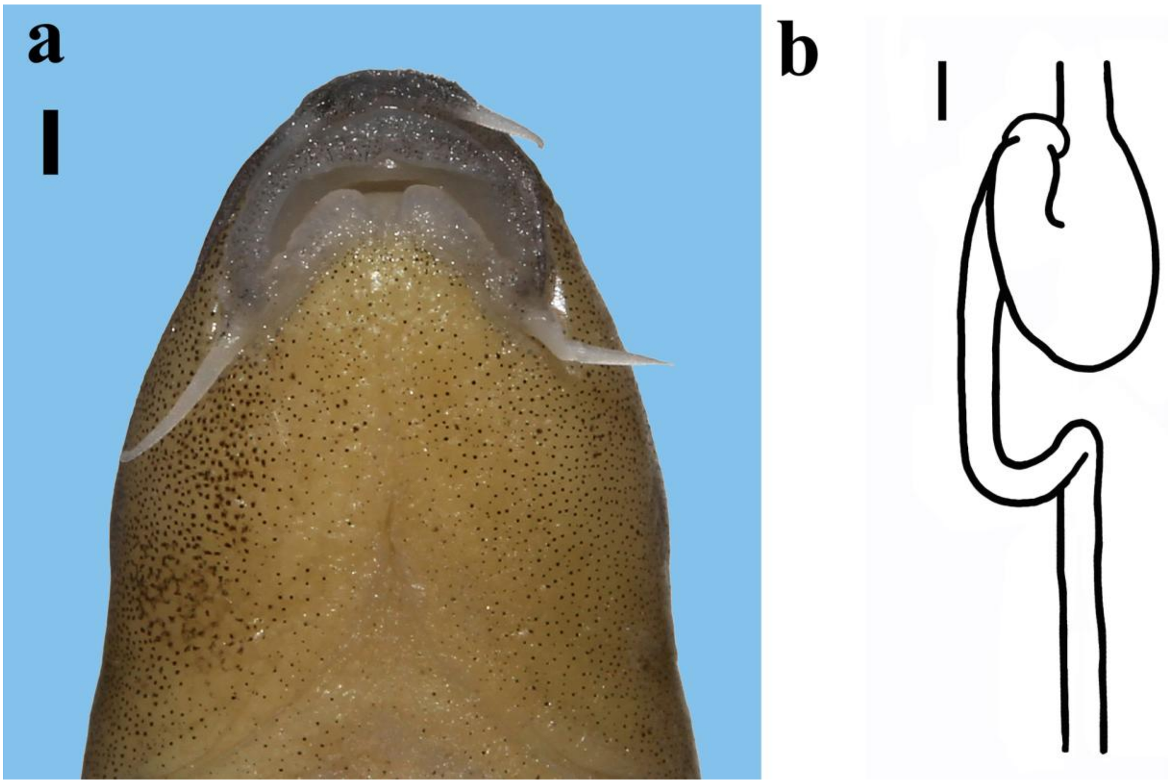

Figure 5.10 *Schistura andrewi*, a)paratype, PUCMF 14002,43.1mm SL, ventral view of head; b) paratype, PUCMF 14003,41.3 mm SL, digestive tract. Scale bars = 1mm.

5.3 Fish diversity

From the work carried out on the diversity of the order Cypriniformes fish from the Kolodyne drainage of Mizoram, 40 species of fish were recorded belonging to 5 families, and 21 genera. Out of the 5 families, Cyprinidae turns out to be the most dominant family accounting for a total of 26 species (65 %), followed by the family Nemacheilidae which account for a total of 7 species representing 17.5 %. The family Balitoridae contribute 7.5% followed by Psilorhynchidae and Cobitidae by contributing only 2 species each which constitute only 5 % of the overall species collected. The distribution of Cypriniformes under different families and genus collected are shown below (percentage wise):

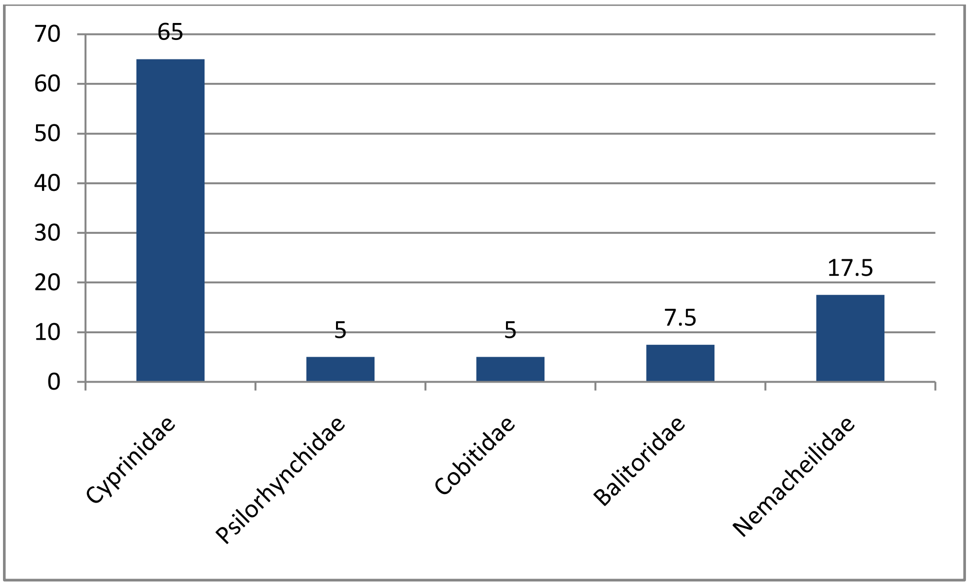

Figure 5.11 Family wise distribution of Cypriniformes (in %)

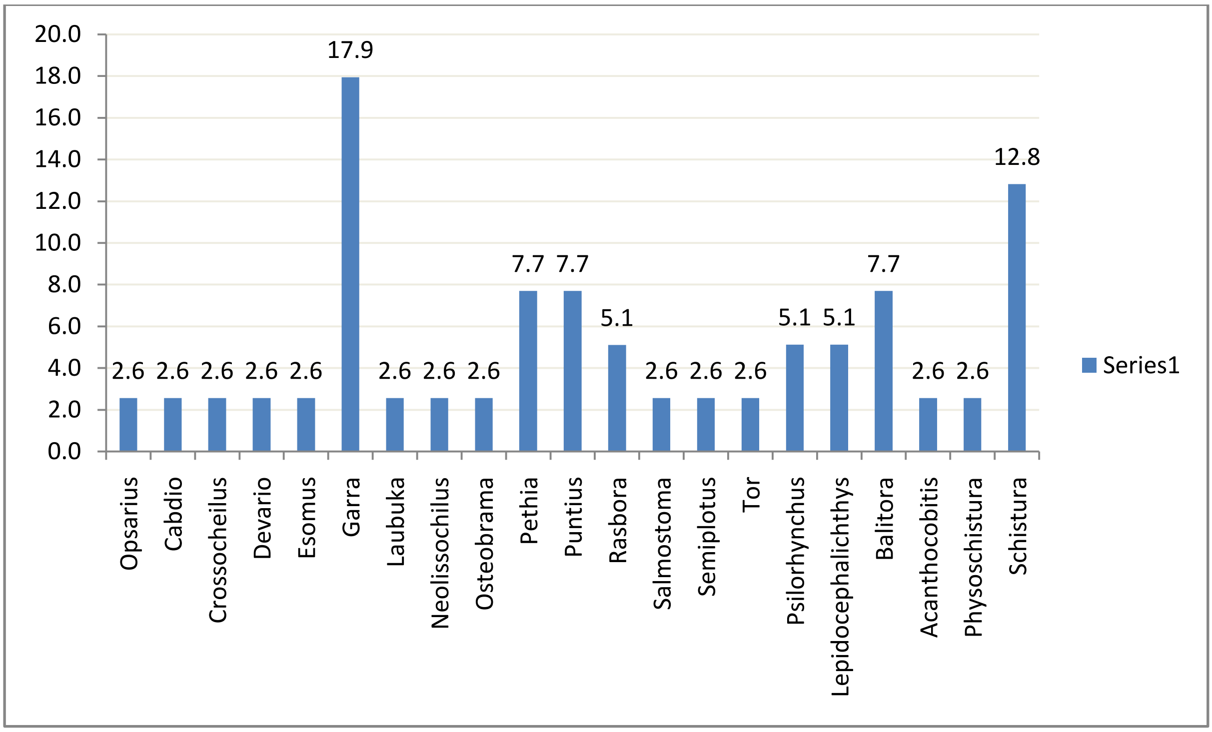

Figure 5.12 Genus wise distribution of Cypriniformes (in %)

From the study carried out, the genus *Garra* account for the highest number of species with a total of 7 species followed by the genus *Schistura* which account for a total of 5 species only. The genus *Pethia, Puntius* and *Balitora* are represented by 3 species each. The genus *Rasbora, Psilorhynchus* and *Lepidocephalichthys* are represented each by 2 species only. There are several genera which contribute only just one species each such as *Opsarius, Cabdio, Salmostoma, Crossocheilus, Devario, Esomus, Laubuka, Osteobrama, Neolissochilus, Semiplotus, Tor, Acanthocobitis* and *Physoschistura*.

The family *Cyprinidae* is represented by 15 genera out of the overall 21 genera collected and is the most dominant family accounting for 65% followed by the family *Nemacheilidae* which constituted 17.5 %. The family *Balitoridae* comprises of only 7.5% which is followed by both *Cobitidae* and *Psilorhynchidae* representing only 5 % each.

The present study reported the presence of only one species of *Opsarius* viz. *Opsarius profundus,* from all the study sites and the species is of common occurrence throughout the different seasons. The taxonomic identity of the fish have been revealed by Dishma and Vishwanath (2012) and is characterized by the presence of great body depth at dorsal fin origin, incomplete lateral line and presence of 7-10 dark blue bars against background of the body. Earlier report on the presence of *Opsarius* species of fish from Kolodyne drainage of Mizoram includes *Opsarius bendelisis* (Hamilton), *O. dogarsinghi* (Hora), *O. barna* (Hamilton), *O. shacra* (Hamilton) and *O. vagra* (Karmakar & Das, 2007; Kar & Sen, 2007). The presence of *O. barna* from Kolodyne River as mentioned by Kar and Sen (2007) remain doubtful as not a single of *O. barna* have been collected so far from all the study sites which could be due to a mistaken identification of the species.

The present study highlighted the presence of only a single species of *Cabdio* (= *Aspidoparia*) sp. from the Kolodyne River of all the study sites. Earlier reports of Cabdio species of fish from Mizoram include *Cabdio jaya* and *C. morar* (Kar & Sen, 2007; Lalronunga, 2015) from Kolodyne and Barak drainage of Mizoram respectively. The *Cabdio* species from the present study cannot be determined to the species level as it did not resemble either *C. jaya* or *C. morar*. It differs from *C. jaya* in having fewer lateral-line scales (42-44 vs. 52-60) and *C. morar* in having more lateral-line scale (42-44 vs. 38-42). Selim and Vishwanath (2001) mentioned the presence of 7 branch rays in the anal fin of *C. jaya* and 9 branched rays in *C. morar* and *C. ukhrulenis*. However, the *Cabdio* sp. collected have 11-13 branched rays which clearly differentiated from the other groups mentioned above beside the difference in lateral-line scales. The *Cabdio* sp. thus collected seems to be very rare as it was collected only from the Kolodyne River among all the study sites.

The present study revealed the presence of *Crossocheilus* cf. *burmanicus* from five study sites. *Crossocheilus* cf. *burmanicus* from the study sites contains the same number of dorsal fin as *Crossocheilus burmanicus* with 3 simple and 9 branched rays. However, it differs from *Crossocheilus burmanicus* in having fewer lateral line scales (32-33 vs. 39-41).

Mukerji (1932; 1934) was the first author to mention the differences between Burmese and Assamese forms of *Crossocheilus* by mentioning only minor differences. Hora (1936) proposed the sub specific name *burmanicus* for the Burmese form of *Crossocheilus* based on Mukerji (1934) data without mentioning any type specimen in the collection of the Indian Museum and failed to describe it (Menon & Yazdani, 1963). Hora (1938) considers that the form he used for *Crossocheilus* that time as *burmanicus* deserve special status but without giving any description. The presence of *Crossocheilus burmanicus* Hora and *C. latius* (Hamilton-Buchanan) have been reported from the Kolodyne river of Mizoram by Kar and Sen (2007). Lalronunga (2015) in his doctoral thesis also reported the occurrence of *C. latius* from the Barak drainage of Mizoram. The report of *C. burmanicus* and *C.latius* from the Kolodyne river of Mizoram by Kar and Sen (2007) could be a mistaken identity as they were not collected from none of the study sites and the *Crossocheilus* species collected seems to differ from both.

The present study highlights the occurrence of one species under the genus *Devario*, *Devario aequipinnatus* from all the study sites and its occurrence is regular throughout different seasons. Reports of *Devario* species had been mention by Karmakar and Das (2007) from Kawrawng river of Kolodyne drainage as *Danio aequipinnatus* (McClelland). Kar and Sen (2007) also mentioned the presence of *Devario naganensis* Chaudhuri from the Kolodyne river of Mizoram. Though *Devario naganensis* is listed by both Kar and Sen (2007) and Karmakar and Das (2007) from Kolodyne drainage of Mizoram, it is not included in all our collections from the all the study sites. It is also possible that the previous listing of the species from the drainage may be misidentification as *D. naganensis* has been reported only from the Chindwin basin of Nagaland and Manipur (Talwar & Jhingran, 1991; Vishwanath *et al*., 2007).

The present study reported the occurrence of only one species under the genus *Esomus* viz. *E. danrica.* The occurrence of this species had also been reported from Tlabung, Karnaphuli drainage and Serlui river of Barak drainage from Mizoram (Karmakar and Das, 2007). Lalronunga (2015) also mentioned the presence of *Esomus danrica* from the rivers of Barak drainage, Mizoram.

The present study from various sites revealed the presence of at least 7 *Garra* species contributing to 17.9 % of the overall genus which accounts for the largest number of species collected under one genus. The species includes *Garra flavatra, Garra* cf. *gotyla, Garra* cf. *lissorynchus, Garra nigricolis, Garra rakhinica, Garra* cf. *vittatula and Garra khawbungi.* Of these, *Garra flavatra* seems to be of rare occurrence as they were collected from just one study site i.e Tuisi River of Khopai. *Garra nigricollis* also seems to be rare as the specimen had been collected from only two study sites. Some species of *Garra* such as *Garra rakhinica* and *Garra* cf. *vittatula* turns out to be very common in occurrence as was found in all the study sites. *Garra rakhinica, G. flavatra* and *G. nigricollis* are originally described and reported its distribution restricted in Rakhine, Yoma (Myanmar). A closer inspection reveals that there is a chance of connection of Rakhine and Kaladan basin at Sittwe, Myanmar. Therefore, the specimens identified as *G. rakhinica, G. flavatra* and *G. nigricollis* expand their distributional range. This study holds the first ever report of the three species in Indian rivers. Two new species of *Garra* have also been described recently from Tuipui and Tiau river of Mizoram by Arunachalam *et al*. (2014) and named *Garra khawbungi* and *Garra tyao*. *Garra khawbungi* is closely related to *Garra nigricollis* but differs from it by having more lateral line scales, fewer predorsal scales, fewer caudal fin rays, presence of a transverse groove on snout and absence of a black band across the posterior margin of the head and between right and left side of pectoral fin bases. After carefully studying the description the reported new species, *Garra tyao*, from Tiau River (Tyao River, as given in the original description) of Kaladan basin (Arunachalam *et al*., 2014) seemingly belongs to *G. rakhinica*. Though unable to examine the type specimens of *Garra tyao*; however, from the original description of *Garra tyao* no distinct variation is observed between *G. tyao* and *G. rakhinica*. The diagnostic characters of *Garra tyao* from *G. rakhinica*, given by Arunachalam *et al.* (2014), are that *G. tyao* have more number of lateral line scales (31 vs. 27–29 in *G. rakhinica*), fewer branched caudal-fin rays (9+8 vs. 10+9 in *G. rakhinica*) and the presence (vs. absent in *G. rakhinica*) of 'W'- shaped dark band on the caudal fin. The higher count of the lateral line scales in *G. tyao* is attributed to the difference in the counting method in which Kullander and Fang (2004) counted only scales on the body for *G.rakhinica* whereas Arunachalam *et al.* (2014) followed Hubbs & Lager (1964), and the difference in caudal-fin rays is attributed to the method of counting of fins as Kullander and Fang (2004) counted and gave the principal caudal rays for *G. rakhinica* whereas Arunachalam *et al.* (2014) presented the branched caudal rays for *G. tyao.* Besides, the presence (vs. absent in *G. rakhinica*) of 'W'- shaped dark band on the caudal fin is attributed to the difference in color description by the authors. A closer inspection of the caudal fin photograph (Fig. 5C of Arunachalam *et al.* 2014) is exactly similar to the color of the caudal fin of *G. rakhinica* defined by Kullander and Fang (2004). Besides, an important diagnostic character of *G. rakhinica,* the blackish horizontal stripe from base of anterior barbel to preopercle is not mentioned in the description of *G. tyao* but can be clearly seen in the photograph (Fig. 5A of Arunchalam *et al.* 2014). Therefore, keeping in mind the aforesaid account of the overall similarity between the two nominal species, *G. tyao* is considered here a junior synonym of *G. rakhinica.*

Several reports of *Garra* species had been recorded from different locations of Mizoram by different authors. Lalronunga *et al*. (2013) described *G. dampaensis* from Seling River (tributary of Karnaphuli River) within Dampa Tiger Reserve. The species have a dark streak near the free margin of the dorsal fin, W-shaped band on the caudal fin and is among the *Lissorhynchus* complex of Menon (1964). Kar and Sen (2007) reported the presence of 4 species of *Garra* from Kolodyne river namely *Garra annandalei* Hora, *Garra gotyla gotyla* (Gray), *Garra naganensis* and *Garra* sp. Four species of *Garra* were also reported from Mizoram by Karmakar and Das (2007) and their report is almost similar to that of Kar and Sen (2007) with the exception of *Garra lissorhynchus.* The inclusion of *Garra naganensis* from Kolodyne River by Karmakar and Das (2007) remain doubtful as none of the species collected from the study sites resemble the species mentioned by them.

Hamilton described *Chela* as the first division under the genus *Cyprinus*. Silas (1985) considered *Laubuka* Bleeker and *Chela* Hamilton to be similar as opposed to Kotellat (2011) who considered *Laubuka* Bleeker to be senior. Subsequent authors such as Banarescu (1968), Talwar and Jhingran (1991) followed Silas (1985). Pethiyagoda *et al*. (2008) reviewed the former genus thereby differentiating *Laubuka* from *Chela* by using the lateral line scales of 31-37+1-2 vs. 56-61+3-4 and consider the genus *Chela* to be a monotypic species. *Laubuka* species are widely present and distributed across South East Asia, India, Sri Lanka, Bangladesh and Myanmar and mentioned four species of *Laubuka* such as *L. lankensis*, *L. insularis*, *L. varuna* and *L. ruhuna* to be endemic to Sri Lanka and *L. fasciata* to be endemic to the Western Ghats of India (Silas, 1985; Talwar & Jhingran, 1991). Shaji and Easa (2003) also mentioned a species under the genus *Laubuka* that shows striking differences compare to typical *L. laubuka* from Kerala, India. In the present study, only one species under the genus *Laubuka*, viz. *Laubuka* cf. *laubuca* had been collected from 3 study sites. Kar and Sen (2007) listed *Chela* (= *Laubuka*) *laubuca* (Hamilton-Buchanan) from Kolodyne river of Mizoram. Lalronunga (2015) also reported the presence of *Laubuka laubuca* from Barak drainage of Mizoram. It is unfortunate that we could not collect *Laubuka laubuca* from Kolodyne River drainage, and further, the collected materials of Kar and Sen (2007) is not available to study. However the *Laubuka* sp. collected in this study is markedly differs from *L. laubuca* in having a broad longitudinal dark stripe along the flank (vs. absent in *L. laubuca*)

The present study highlighted the presence of *Neolissochilus* sp. from Mat River and though is commonly available on the site of collection; it seems rare in other study sites. The *Neolissochilus* sp. collected from Mat river shares certain similarities with *Neolissochilus hexagonolepsis* but however differs from it in having fewer lateral line scales (23-25 vs. 28-32) and presence of 6-9 minute serrations in last unbranched ray of dorsal fin, the characters not encountered in either *Neolissochilus* or *Tor* species.

Neolissochilus hexagonolepis (McClelland) is originally named as *Barbus hexagonolepis* McClelland and its synonyms includes *Barbus dukai* (Day), *Barbus hexagonolepis* (Hora) .The species is distinguished by the presence of a group of horny tubercles on cheeks and the lower lip is separated from the jaw with horny covering and distributed throughout Eastern Himalayas, Assam, Burma, Sikkim, Nepal and Pakistan (Tilak, 1972). *Neolissochilus* sp. is considered to be available in small numbers through the eastern Himalayas in India, Bangladesh and Myanmar (Menon, 2004). Shrestha (2003) recorded the species from Nepal; and Dahanukar *et al*. (2004) highlighted the need for conservation.

The present work reported the occurrence of only one species under the genus *Osteobrama* herein mentioned as *Osteobrama* cf. *cunma. Osteobrama cunma* had been mentioned from Karnaphuli River, Mizoram by Karmakar and Das (2007), Kar and sen (2007). It was originally described by Hamilton- Buchanan (1822) in his 'Fishes of India'. The species have been collected from only Kolodyne River and the presence of just one specimen highlighted its rare occurrence from the study site. The *Osteobrama* species collected has fewer dorsal fin rays compare to *Osteobrama cunma* species i.e. 3 simple and 8 ½ branched rays' vs. 3 simple and 9 branched rays, more pectoral fin rays i.e. 1 simple and 15 branched rays vs. 1 simple and 12 branched rays.

The genus *Puntius* had been recognized as 'catch all' genus by several authors (Kortmulder, 1972; Schut *et al*., 1984; Kullander & Fang, 2005; Kullander, 2008) and contains some 220 nominal species out of which about 120 species is considered to be valid (Pethiyagoda *et al.*, 2012). There are altogether three different species of *Puntius* collected throughout the study period viz, *P. sophore*, *P. chola* and *Puntius* sp. The genus *Puntius* turn out to be rare compare to *Pethia* and were collected only from a few study sites which includes two sites for *P. sophore* and one study site each for *P. chola* and *Puntius* sp. Simultenously, The present study listed three species under the genus *Pethia* namely *P. conchonius*, *P. expletiforis* and *Pethia* sp., the taxonomic status of which is yet to be identified. Out of the three species mentioned above, *P. conchonius* is widely distributed in all the study sites and shows dominant presence followed by *P. expletiforis* which is present in 5 study sites but the unidentified *Pethia* sp. shows its presence in only one study site. As a result of this, Pethiyagoda *et al*. (2012) segregated the genus *Puntius* into five different genera based on their different lineages viz. *Dawkinsia, Dravidia, Pethia, Puntius* and *Systomus*. The genus *Pethia* is distinguished from its congeners by the presence of last unbranched dorsal fin ray stiff, serrated, a black blotch on the caudal peduncle, frequent presence of black blotches, spots or bars on sides of the body, infraorbital 3 deep, partially overlapping preoperculum; absence of rostral barbel and absence or presence of minute maxillary barbels. Kar and Sen (2007) reported 6 species of *Puntius* from Mizoram out of which, 4 species were from the river Kolodyne and include *P. conchonius.* Karmakar and Das (2007) listed *Puntius chola* (Hamilton-Buchanan), *P. conchonius* (Hamilton-Buchanan), *P. shalynius* Yadani & Talukdar and *P. ticto ticto* (Hamilton-Buchanan). Out of the *Puntius* genera they mentioned, only *P. chola* was collected from Karnaphuli drainage whereas the other three were collected from rivers of Kolodyne drainage. Lalronunga (2015) listed *Pethia conchonius, Puntius sophore* and *P. chola* from Barak drainage of Mizoram. *Pethia expletiforis* has been described as new species from Ka-ao River, Kolodyne drainage of Mizoram (Dishma & Vishwanath, 2013). The present study listed two species under the genus *Rasbora*, viz. *Rasbora daniconius* and *R. rasbora* with *R. daniconius* being collected from 3 study sites and *R. rasbora* from 2 study sites only. The abundance of *Rasbora* species collected from the study sites were low and may become threatened in the near future if proper conservation strategies are not adopted effectively.

Rasbora has also been considered taxonomically as a ‘catch all’ species due to lack of unique diagnostic characters (Brittan 1954). Brittan (1954) in his first and comprehensive revision of the genus *Rasbora* recognized three subgenera namely *Rasbora*, *Rasboroides* and *Megarasbora* and further classified the genus *Rasbora* into eight species complexes such as, *lateristriata*, *sumatrana-eleganas*, *caudimaculata*, *trifasciata*, *argyrotaenia*, *daniconius*, *einthovenni* and *pauciperforata*. Brittan's classification of *Rasbora* species complex have been used and revised by many authors after him and created several new genera such as *Boraras*, *Brevibora*, *Horadandia*, *Kotellatia*, *Rasboroides*, *Trigonopoma* and *Trigonstigma* for some lineages within *Rasbora* (Kottelat & Vidthayanon, 1993) and despite the creation of many new genera, many worker still recognized a larger assembly along the *Rasbora* lineages. The species under the genus *Rasbora* has been considered to be widely distributed (Hora & Mukherji, 1935) and only four species of the genus are known so far from India (Vishwanath & Laisram, 2004b) . A new species, *Rasbora ornatus* under the genus *Rasbora* has been described from Manipur (Vishwanath & Laisram, 2004b). Two species of *Rasbora* viz. *R. daniconius* and *R. rasbora* had been listed from Mizoram (Karmakar & Das 2007; Kar & Sen, 2007; Lalronunga, 2015).

The present work highlighted the presence of one species under the genus *Salmostoma* herein mentioned as *Salmostoma* sp. which is collected from only one study area i.e. Kolodyne. *Salmostoma* is the generic name given by Swainson (1839) for type species *Cyprinus bacaila* Hamilton-Buchanan. Due to the disputing taxonomic status of the genus *Chela*, several workers had revised the genus and Banarescu (1969) put all the larger *Chela* within a specific range of gillrakers under one genus *Salmostoma* Swainson comprising of twelve species.

Semiplotus modestus species have been collected from majority of the study sites with the exception of Sala River and this species had been described from Akyab (now Sittwe), Kaladan basin in Myanmar by Day (1870). There are only four species described under the genus *Semiplotus* so far (Vishwanath & Kosygin, 2000a) and the other three species with the exception of *S. modestus* includes, *S. semiplotus* (McClelland) from Brahmaputra in Assam of Barak drainage, India, *S. cirrhosus* Chaudhuri from Putao plains in Myanmar and *S. manipurensis* Vishwanath and Kosygin from Manipur (Vishwanath, 2014). Both *S. cirrhosus* and *S. manipurensis* are from Chindwin-Irrawaddy basin whereas *S. modestus* is so far collected only from Kolodyne drainage and is endemic to it requiring proper conservation.

In the present study, *Tor tor* species have been collected from all the study sites throughout different seasons and this prove the species to be widely distributed and of common occurrence. *Tor tor* had been reported from Mizoram by some authors (Karmakar & Das, 2007; Kar & Sen, 2007; Lalronunga, 2015).

Tor tor (Hamilton-Buchanan) was originally described as *Cyprinus tor* by Hamilton-Buchanan (1822) from the Mahananda River, Bengal and reported on the 'Fishes of Ganges' from, India. The species is known to be widely distributed in several countries and is native to India, Bangladesh, Bhutan, Nepal, Myanmar and Pakistan (Desai, 2003). Five valid species under the genus Tor have been listed from different parts of India namely *Tor tor*, *T. putitora*, *T. khudree*, *T. progenius* and *T. kulkarni* (Menon, 1992; 1999). Jayaram (2010) taxonomic re description of the genus *Tor* revealed the presence of at least nine valid species. The occurrence of *Tor* species is so far known in India from different riverine system such as Narmada, Ganges, Brahmaputra and Indus (Desai, 2003). *Tor tor* species distribution has also been listed from the tributaries of Godavari and Krishna river system (Jayaram, 2010).

The family Psilorhynchidae is represented by only one genus *Psilorhynchus* which contributes only 5 % of the specimen collected. The present study revealed the presents of two species under the genus *Psilorhynchus* viz. *P. khopai* and *P. kaladanensis* from 4 study sites but totally absent from the river Kolodyne. The genus *Psilorhynchus* McClelland inhabits fast flowing rivers and streams. Rainboth (1983) mentioned that the distribution of the genus is restricted to lowland and high gradient streams of Ganga-Brahmaputra drainage, India and streams of India-Myanmar border. The genus *Psilorhynchus* is characterized by the small body size, small scales, flattened ventral surface, arched dorsal and a high number of pectoral fins (Vishwanath & Manojkumar, 1995). Lalramliana *et al*. (2014b) reported the occurrence of the genus *Psilorhynchus* from Kaladan drainage of North Eastern India. *Psilorhynchus sucatio* (Hamilton-Buchanan) had been listed from Tlawng River, Mizoram (Karmakar & Das, 2007). Kar and Sen (2007) listed *Psilorhynchus balitora* (Hamilton) and *P. gracilis* Rainboth from Kolodyne and Tuirial river of Mizoram. Lalronunga (2015) listed 3 species under the genus *Psilorhynchus* namely *P. homaloptera, P. nudithoracicus and P. sucatio* from Barak drainage of Mizoram. Two new species have been described recently under the genus *Psilorhynchus* viz. *P. kaladanensis* (Lalramliana *et al*., 2015) and *P. khopai* (Lalramliana *et al*., 2014b) from Kolodyne drainage of Mizoram. The occurrence of *P. gracilis* from Kolodyne river of Mizoram as mentioned by Kar and Sen (2007) requires further verification as *P. gracilis* is not collected from a single study site and the *Psilorhynchus* species collected from the study sites includes *P. kaladanensis* and *P. khopai* only.

Loaches under the genus *Lepidocephalichthys* have a wide geographical distribution in Asia, and include several countries such as India, China, Vietnam, Laos, Cambodia, Borneo and Java (Kottelat & Lim, 1992; Menon, 1992; Arunkumar, 2000). *Lepidocephalichthyes* fishes have a bifid suborbital spine and are sexually dimorphic (Nalbant, 2002; Slechtova *et al*., 2007). Several authors' review of *Lepidocephalichthys* included descriptions of new species (Kottelat & Lim, 1992; Menon, 1992; Arunkumar, 2000) but however failed to highlight comparison among them. Morphological characters used to distinguish species have included placement of the dorsal fin in relation to the pelvic fin, shape of the caudal fin, coloration, pattern of scales on the head, length and arrangement of barbels, size and shape of the suborbital spine, and body size (Havird & Page, 2010).

In this study, the family Cobitidae is represented by a single genus *Lepidocephalichthys* which comprises of two species only and the family Cobitidae contributes only 5%. The present study records the presence of *L. berdmorei* and *L. guntea* from some rivers of Kolodyne drainage, Mizoram with *L. guntea* showing more dominance in diversity by showing its presence in 5 rivers against *L. berdmorei* showing occurrence in only 2 rivers. Species under the genus *Lepidocephalichthys* have been reported by few authors from Mizoram. Karmakar and Das (2007) listed *Lepidocephalus* (= *Lepidocephalichthys*) *berdmorei* (Blyth) from Tlawng river, *L. annandalei* Chaudhuri and *L. guntea* from six rivers of Mizoram (Kar & Sen, 2007), *L. guntea* and *L. berdmorei* from three rivers of Barak drainage, Tlawng, Tuivai and Tuirial (Lalronunga, 2015).

Karmakar and Das (2007) placed *L. berdmorei* under the genus *Lepidocephalus*, with which it is often confused with (Deein *et al*., 2014). The genus *Lepidocephalichthys* is distinguished from *Lepidocephalus* in the absence of lateral line vs. presence of complete lateral line, fewer branched dorsal fin rays (6 vs. 8-9), fewer pectoral fin rays (7 vs. 9-13) (Havird *et al*., 2010). Kar and Sen (2007) listing of *L. annandalei* from Tlawng River still remain doubtful in nature and need further confirmation as this species is known from the Ganges Brahmaputra drainage of India.

The genus *Balitora* comprises of hill stream loaches that can be identified by strongly depressed body, ventrally flattened head and abdomen, uninterrupted lower lip, maxillary barbel at the corner of mouth, presence of 8-10 simple and 10-12 pectoral branched rays; adhesive pads present on ventral surface of anterior pectoral fin 8-11 rays and 3-4 anteriormost pelvic rays (Kotellat, 1988). The family Homalopteridae was divided into two Homalopterinae and Gastromyzontinae by Hora (1932) and he later considered both taxa as families in 1950 which subsequent authors treated them as a single family (Nelson, 1984). Homalopterines and Gastromyzontines form a monophyletic lineage (Sawada, 1982). The family Homalopteridae Bleeker is a synonym of Balitoridae Swainson and the genus *Balitora* Gray includes eight species, five species of them recorded from the Indian and Indochinese areas (Kotellat, 1988). The total number under the genus *Balitora* with the exclusion of synonyms and misidentification comes to 12 valid species and subspecies (Chen *et al*., 2005).

The family Balitoridae is represented a single genus *Balitora* that comprises of three species which accounts for 7.5% of the specimen collected. The three species under the genus *Balitora* includes *Balitora* cf. *burmanicus* and two unidentified *Balitora* sp. *Balitora* cf. *burmanicus* was collected only from Ngengpui River which shows that its presence is not very dominant in the major rivers of Kolodyne drainage within Mizoram. *Balitora* sp.1, which was collected only from Kolodyne river also seems to be a rare species as it share common features with the genus *Balitora* but have a unique feature in its distal margin of pectoral fin reaching pelvic fin origin which is not known so far in the other *Balitora* species. Out of three species under the genus *Balitora* collected, *Balitora* sp.2 turns out to be the most dominant and is collected from 5 study sites.

Few authors have recorded the occurrence of *Balitora brucei* Gray, from Mizoram (Kar & Sen, 2007; Karmakar & Das, 2007; Lalronunga, 2015) but out of the three authors, only Kar and Sen (2007) listed *Balitora brucei* from Kolodyne drainage in addition to Barak drainage whereas the other authors listed the species from rivers of Barak drainage only.

The family Nemacheilidae accounts for the second most dominant family contributing 17.5% comprising of three genera namely, *Acanthocobitis, Physoschistura* and *Schistura.* The genus *Acanthocobitis* and *Physoschistura* are represented by only one species each whereas the genus *Schistura* is represented by 5 species and turns out to be the second most dominant genus.

The genus *Acanthocobitis* is collected from only one study site, Mat River. Considering the long duration of sample collection, only one specimen collected shows the scarcity of *Acanthocobitis* species from the study sites and hence highlight the need for proper conservation.

In the present research carried out, *Physoschistura* species have been collected from only two study sites viz. Ngengpui and Tiau River and the total number of specimen collected were also comparatively few which highlighted the importance of conserving this species. The genus *Physoschistura* was described by Banarescu & Nalbant and designated *Nemachilus brunneana* Annandale from Inle Lake and Ywanghwe valley, Myanmar as its type species (Singh *et al*., 1982). Five species under the genus *Physoschistura* have been recognized (Kottellat, 1990) which includes *Physoschistura shanensis* Hora, *P. rivulicola* Hora, *P. raoi* Hora, *P. brunneana* Annandale and *P. pseudobrunneana* from Indochinese region. Seven species under the genus *Physoschistura* have been recognized and distributed in the Brahmaputra, Salween, Irrawady, upper Mekong and Chindwin drainage of Myanmar (Chen *et al*., 2011). Lokeshwor and Vishwanath (2012a) recently describe a new species, *P. chindwinensis* from Lokchao river of Chindwin drainage, Manipur, India which increases the total species under the genus *Physoschistura* to 8. Recent description of new species under the genus *Physoschistura* includes *Physoschistura tigrinum* (Lokeshwor & Vishwanath, 2012b) from Chindwin basin, Manipur. Lokeshwor *et al*. (2012) described a new species *Physoschistura tuivaiensis* from Tuivai River, Barak drainage of Mizoram and Lalronunga (2015) also listed *Physoschistura tuivaiensis* from three rivers namely Tlawng, Tuivai and Tuirial of Barak drainage, Mizoram. *Physoschistura* sp. collected in this study share certain resemblances with *P. dikrongensis* but differ in some characters such as presence of 3 simple and 5 ½ branch anal fin rays vs. 4 simple and 5 ½ rays; incomplete lateral line with 55-63 pores as against 70-85 pores . Considering the various diagnostic characters with other *Physoschistura* sp., it doesn't share complete similarities with any one of them and this species herein referred to as *Physoschistura* sp. could be destined to become a new species.

The work carried out revealed the presence of 5 species under the genus *Schistura* namely *S. koladynensis, S. porocephala, S. nebeshwari, S. scyphovecteta* and *S. andrewi.* The genus *Schistura* under the family Nemacheilidae comprises of about 190 valid species which are generally small size fish with attractive colouration; presence of medial interruption on the lower lip; arched mouth, presence of a black bar on the caudal fin base and dorsal fin (Kotellat, 1990). Species under the genus *Schistura* are widely distributed in the hill streams of South and Southeast Asia (Kotellat, 2012). There has been hardly any report on taxonomic studies related to the genus *Schistura* genus and earlier report includes *S. tirapensis* and *S. multifasciata* from Kolodyne basin of Mizoram (Kar & Sen, 2007), however, recent developments in the taxonomic studies leads to the descriptions of new species from this area. Recent works on the genus *Schistura* from Kolodyne basin of Mizoram includes *S. koladynensis* (Lokeshwor & Vishwanath, 2012c), *S. porocephala* (Lokeshwor & Vishwanath, 2012d), *S. nebeshwari* and *S. scyphovecteta* (Lokeshwor & Vishwanath, 2013), *S. andrewi* (Solo *et al*., 2014). Lalronunga (2015) reported the occurrence of 7 species of *Schistura* from Barak drainage of Mizoram

Schistura koladynensis has been collected from all the study sites and proved to be a dominant species. The species was first described as new species by Lokeshwor and Vishwanath (2012c) from Kolodyne River, Mizoram and earlier report on *S. tirapensis* and *S. multifasciata* could be due to misidentification or extinction as not a single specimen has been collected from all the study sites during the sample collection. Besides, the above mentioned species were known so far from the Ganga-Brahmaputra basin only and its occurrence in Kolodyne basin in unlikely.

Schistura porocephala is originally described as a new species by Lokeshwor and Vishwanath (2012d) from a stream near Thualthu, that drains to Mat River, a tributary of Kolodyne River, Mizoram. In the present work, *Schistura porocephala* has been collected from four study sites and is of common occurrence in its presence study sites. The species has been distinguished by the presence of 27-38 prominent pores in the cephalic incomplete lateral line system, 20-23 thin dark olivaceous bars on the body, depressed head and body anterior to dorsal fin and an elongated suborbital flap in males (Lokeshwor & Vishwanath, 2012d).

Schistura nebeshwari has been collected from all the sampling sites and proved to be a dominant species considering its abundance throughout different seasons. The species had been described as new species from rivers of Kolodyne drainages, Ka-ao River, Kolchaw River and a stream near Phura village of Saiha district, Mizoram (Lokeshwor & Vishwanath, 2013). The species is identified from other *Schistura* species by the presence of dorsal adipose crest on caudal peduncle, 11-14 olivaceous dark bars on the body, numerous melanophores on dorsal portion of head, presence of basicaudal bar, incomplete lateral line, inflated cheek and presence of three black spots at dorsal fin base (Lokeshwor & Vishwanath, 2013).

Schistura scyphovecteta is also collected from majority of the study sites with the exception of Sala River and is of common occurrence throughout the different seasons. The species is described by Lokeshwor and Vishwanath (2013) from three rivers of Kolodyne drainage within Saiha district. The species is distinguished by the presence of six dark brown saddles that continues to the flank forming globular shaped bars along the lateral line, complete lateral line, two dark spot at dorsal fin base, incomplete black basicaudal bar (Lokeshwor & Vishwanath, 2013)

The work carried out leads to the description of a new species *Schistura andrewi* from Mat River near Serchhip, Serchhip district, Mizoram. The species has been distinguished from other *Schistura* species by the presence of long axillary pelvic lobe, complete lateral line with 82-95 pores, two rows of black spots horizontally across the dorsal fin, and two vertical rows of black spot across the deeply emarginated caudal fin, six to seven broader than interspace black bars on the body (Solo *et al*., 2014).

5.4.1 Assemblage.

The Kolodyne river drainage system of Mizoram comprises of several rivers and out of the selected seven major rivers, 40 species of Cypriniformes fish species were collected belonging to 5 families and 21 genera. From the work carried out, the family Cyprinidae, which consisted of 26 species accounts for the highest percentage of species richness with 65% followed by the Nemacheilidae family consisting of 7 families with 17.5 % of the overall species collected. The family Balitoridae contributed 3 species with 7.5% followed by the families Psilorhynchidae and Cobitidae consisting of 2 species each with 5 % each.

At the genus level, the genus *Garra* contributed the highest species diversity by contributing 7 species which is 17.9% followed by the genus *Schistura* which contributed 5 species and accounts for 12.8%. There are 3 genera which contributed 3 species each namely, *Puntius, Pethia* and *Balitora* which is followed by those genera comprising of only 2 species each namely, *Psilorhynchus*, *Rasbora* and *Lepicocephalichthys*. There are 13 genera comprising of just one species which includes, *Opsarius*, *Cabdio, Devario*, *Crossocheilus, Esomus, Laubuka, Neolissochilus, Osteobrama*, *Salmostoma*, *Semiplotus, Tor, Acanthocobitis* and *Physoschistura*.

In terms of species richness, there are 8 species which were collected from all the study sites throughout all seasons and proved to be quite dominant, viz. *Opsarius profundus, Devario aequipinnatus, Garra rakhinica, Garra* cf. *vittatula, Pethia conchonius, Tor tor, Schistura koladynensis* and *S. nebeshwari*.

There are 11 species belonging to 9 genera, which shows their presence in only one study site and includes, *Garra flavatra*, *Neolissochilus* sp, *Pethia* sp, *Puntius chola*, *Puntius* sp., *Osteobrama* cf. *cunma*, *Balitora* cf. *burmanicus*, *Balitora* sp.1, *Acanthocobitis* cf. *botia* and *Schistura andrewi*.

Among the rivers of the study sites, Mat River have the highest species richness contributing 25 native species of Cypriniformes fish out of which 4 species turns out to be collected from its river only, namely, *Neolissochilus* sp., *Puntius* sp., *Acanthocobitis* cf. *botia* and *Schistura andrewi* which is followed by Tuisi River which contribute 23 species with just one species i.e. *Garra flavatra* collected from the present study site only. The river Tuichang, Kolodyne and Sala contributed 22, 21 and 20 species respectively out of which the Kolodyne River have 3 species namely, *Salmostoma* sp., *Balitora* sp.1 and *Osteobrama* cf. *cunma* that are absence from other study sites whereas Sala River have one unidentified *Pethia* sp. collected from its river that are not found in other study sites. Ngengpui River and Tiau River contribute the least in terms of species richness by contributing 19 species each. Apart from this there are two species found only in the river Ngengpui among the study sites, viz. *Puntius chola* and *Balitora* cf. *burmanicus* which are not found in other study sites.

Species similarity between Kolodyne River and its tributaries are measured using Sorenson's coefficient (SC) which helps in determining community similarities by giving a value between 0 to 1, the closure the value is to 1, the more the communities have in common. The work carried out revealed the highest species overlap between Kolodyne and Mat River which have Sorenson coefficient value of 0.69 which is followed by Kolodyne and Tuisi River which have Sorenson coefficient value of 0.68. Species similarity between Kolodyne and Tuichang River as well as Kolodyne and Tiau River are similar with Sorenson coefficient value of 0.65 which is followed by Kolodyne and Ngengpui River with Sorenson coefficient value of 0.60. Community similarity is the least in Kolodyne and Sala River with Sorenson coefficient value of 0.48.

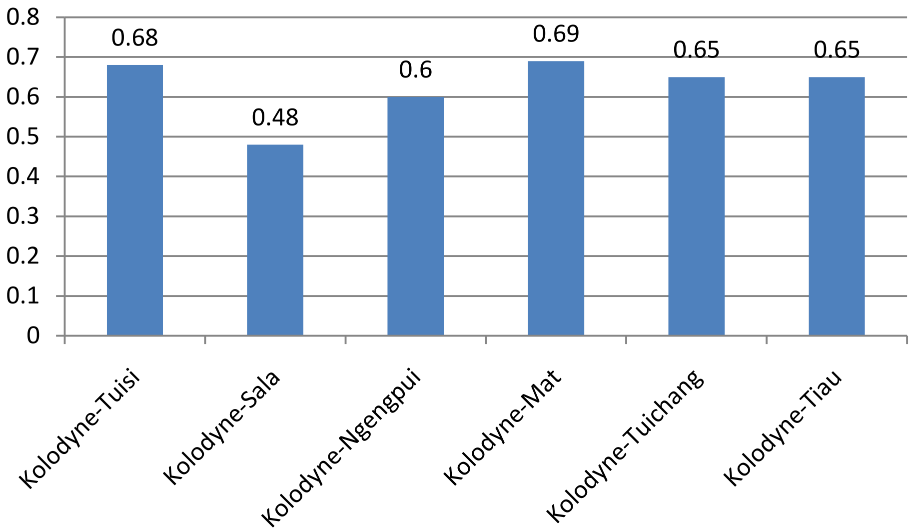

Figure 5.13. Community similarity between Kolodyne River and its tributaries

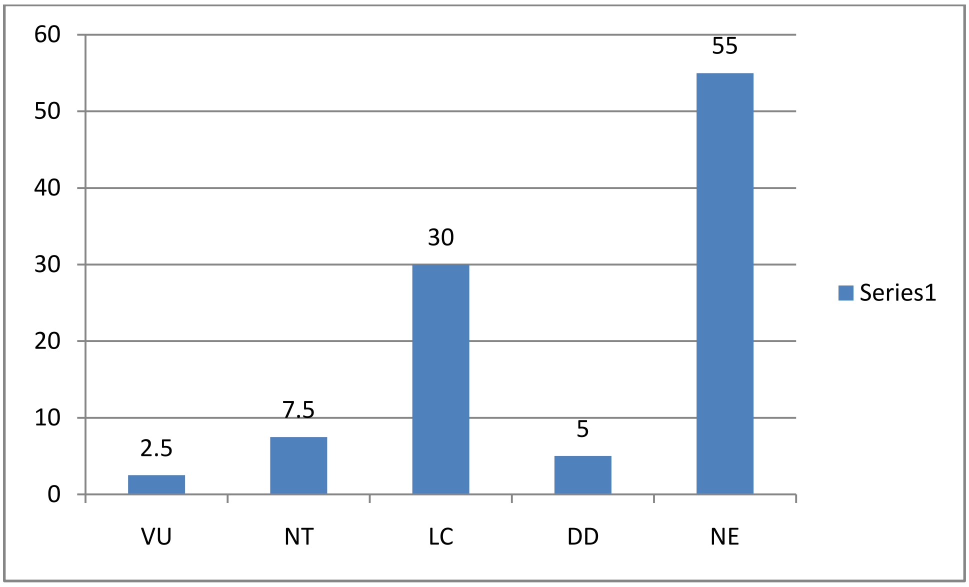

Figure 5.14 IUCN Red list (2015) categories of the fish species collected (in %)

Table 5:3 List of fish species collected, distribution and conservation status as assessed by IUCN Red list (2015) on Kolodyne, Tuisi, Sala, Ngengpui, Mat, Tuichang and Tiau River.

Sl. No	**Order Cypriniformes**	**Name of the rivers**							**IUCN Status**
		Kolodyne	**Tuisi**	**Sala**	**Ngengpui**	**Mat**	**Tuichang**	**Tiau**	
1	*Opsarius profundus*	+	+	+	+	+	+	+	NE
2	*Cabdio* cf.*morar*	+				+			LC
3	*Crossocheilus* cf. *burmanicus*	+		+		+		+	LC
4	*Devario aequipinnatus*	+	+	+	+	+	+	+	LC
5	*Esomus danrica*		+	+	+	+	+	+	LC
6	*Garra flavatra*		+						VU
7	*Garra* cf. *gotyla*	+	+			+	+		LC
8	*Garra* cf. *lissorhynchus*		+	+	+				NE
9	*Garra nigricollis*			+			+		DD
10	*Garra rakhinica*	+	+	+	+	+	+	+	NT
11	*Garra* cf. *vittatula*	+	+	+	+	+	+	+	NT
12	*Garra khawbungi*	+	+	+		+	+	+	NE

13	*Laubuka* sp.			+	+	+			NE
14	*Neolissochilus* sp.					+			NE
15	*Osteobrama* cf. *cunma*	+							LC
16	*Pethia conchonius*	+	+	+	+	+	+	+	LC
17	*Pethia expletiforis*	+	+		+		+	+	NE
18	*Pethia* sp.			+					NE
19	*Puntius sophore*	+	+				+		LC
20	*Puntius chola*				+				LC
21	*Puntius* sp.					+			NE
22	*Rasbora daniconius*		+	+				+	LC
23	*Rasbora rasbora*			+			+		LC
24	*Salmostoma* sp.	+							NE
25	*Semiplotus modestus*	+	+		+	+	+	+	DD
26	*Tor tor*	+	+	+	+	+	+	+	NT
27	*Psilorhynchus kaladanensis*		+		+	+	+		NE
28	*Psilorhynchus khopai*		+			+	+	+	NE

29	*Lepidocephalichthys berdmorei*		+	+					NE
30	*Lepidocephalichthys guntea*	+			+	+	+	+	NE
31	*Balitora* cf. *burmanicus*				+				NE
32	*Balitora* sp.1	+				-	-	-	NE
33	*Balitora* sp.2		+	+		+	+	+	NE
34	*Acanthocobitis* cf. *botia*					+			LC
35	*Physoschistura* sp.				+			+	NE
36	*Schistura koladynensis*	+	+	+	+	+	+	+	NE
37	*Schistura porocephala*	+	+			+	+		NE
38	*Schistura nebeshwari*	+	+	+	+	+	+	+	NE
39	*Schistura scyphovecteta*	+	+		+	+	+	+	NE
40	*Schistura andrewi*					+			NE

(+ = Presence, - = Absence, VU=Vulnerable, NT=Near Threaten, LC=Least Concern, DD=Data Deficient, NE=Not Evaluated).

5.4.2 Conservation and threat status

The fish species collected falls within five categories according to IUCN red list 2015 such as Vulnerable (VU), Near threaten (NT), Least concern (LC), Data deficient (DD) and Not evaluated (NE). All of the Cypriniformes encountered in the present study reported the occurrence of native species only and invasive species have not been collected so far from the study areas.

According to the IUCN red list 2015 categories, majority of the fish species, which is 55% of the overall specimen collected, turns out to be under not evaluated (NE) category indicating the lack of information on these species. This highlighted the need for more work to assess the fish diversity for future references as well as to understand the importance of conservation as many species which falls within this group could be facing endangered or extinction in the near future.

Following not evaluated category, least concern (LC) category come to be next with 30 % of the entire species collected. Under this category, those species which are abundance in population as well as threat of extinction remains far are grouped. However, among the species collected under the least concern category, some species are available in few numbers and collected from just few study site or sites and to mention a few, *Cabdio* cf. *morar*, *Osteobrama* cf. *cunma*, *Puntius chola*, *Rasbora rasbora*, *Salmostoma* sp. and *Acanthocobitis* cf. *botia*.

Near threaten category accounts for only a few numbers and consisted of 7.5%. Under this category, only three species were collected namely, *Garra rakhinica*, *Garra* cf. *vittatula* and *Tor tor*. Though this group doesn't qualify for threaten category, their numbers have been considerably reduce and if proper conservation steps are not taken, they are at risk of becoming threaten in the near future.

Data deficient category was represented by just 5% and comprises of only two species viz. *Garra nigricollis* and *Semiplotus modestus*. Data deficient category is one which is indicated by the availability of little or no information on the abundance and distribution of species; it highlighted the need for more studies on these species.

Among the IUCN categories encountered in the present study, vulnerable category turns out to be the least with just only 2.5% and represented by only one species i.e. *Garra flavatra* collected from Tuisi River only. This group are represented by high risk of endangerment and continuing decline of population in the wild and require immediate conservation strategy to increase their number.

Dudgeon *et al*. (2006) reported that freshwater fish species are declining throughout the whole world. Similarly, Moyle and Leidy (1992) mentioned more than 20% of the world's 10000 freshwater fish species recorded to become extinct, threatened or endangered in the early 1900s. According to IUCN 2009 red list, 27% of freshwater fish species are categorised as either extinct or threatened. Several factors are responsible for the decline of freshwater biodiversity which includes eutrophication, damming of rivers, habitat loss or habitat destruction, species invasion, overharvesting and climate change (Allan & Flecker, 1995).

5.4.3 Conservative measures taken for fish diversity in the study area

In the present study, all of the study sites were carefully studied about the availability of conservation strategies adopted by the locals towards fish conservation. The role of the local peoples through Village Councils and other NGO's were carefully determined to understand the extent of conservative approach taken in each of the study sites. In all of the study sites, meetings were held with the Village Council members' as well as the leaders of NGOs such as, Young Mizo Association (YMA), Mara Thyutlia Py (MTP) etc. towards improving fish conservation in their rivers. Some of the methods usually selected towards fish conservation include declaring of a few kilometres within a selected river as protected area for fishing, avoidance of fishing by any means during breeding season, protection of the rivers from use of poisonous toxic chemicals as well as illegal use of dynamos etc.

The conservation efforts undertaken yielded positive results in two of the study sites namely Tuisi River near Khopai village and Kolodyne River at the vicinity of Lungbun. The conservation methods applied at Kolodyne River near Lungbun village include declaring 1km stretch within the river as protected area from fishing by all means throughout all seasons whereas other areas is still permissible for fishing. However, the use of poisonous chemicals, dynamos, bombs etc. is strictly prohibited throughout all seasons of the year in any part of the river that comes under their area of jurisdiction.

In Tuisi River near vicinity of Khopai village, 2 km within the river is declared as protected area from fishing as well as any other activities that may interfere with fish conservation. However, other areas of the river is permitted for fishing activities by legal means but prohibited from illegal fishing which includes the use of poisonous chemicals, dynamos, bombs etc. The conservation strategy applied is aim at conserving and increasing the fish population as well as fish diversity of a river. It also aims to increase endless supply of young fingerlings from protected site of a river to permissible areas for fishing in the coming years which will generate economic prosperity for the locals.

Conservation measures on fish have been going on in some parts of Mizoram, the famous one have been fish conservation undertaken by the locals of Darzokai at Kolodyne River near their village which covers a stretch of 2 km. It serves as a tourist attraction site where the fishes are not permitted for fishing or other commercial purposes but well taken care of by feeding and offering protection in its natural habitat. The conservation effort undertaken is also supported by the Fishery Dept. Govt of Mizoram thereby creating awareness among the locals regarding the importance of fish conservation in its natural habitat. The areas beyond the protected part of the river is permitted for fishing by legal means, but fishing by means of poisonous chemicals, dynamos, bombs etc. are considered illegal and strictly prohibited . Defaulters are dealt accordingly with fines and punishment to send out warnings to those who attempt illegal fishing in the protected part of a river. The conservation effort is aimed at conserving fish diversity in its natural habitat for recreational and sustainable purposes.

The conservation methods if applied successfully will leads to the conservation of fish diversity in several parts within the state of Mizoram. Several fish species are still awaiting discovery and conservation of fish is the first step towards protection of fish species from becoming extinct in the near future. Besides, conservation of fish will help in the sustainable development of fish population in its natural habitat which will generate more income from fishing, protect fish diversity and help the local people economically.

CHAPTER 6

SUMMARY AND CONCLUSION

6.1. Summary and Conclusion

The freshwater fish constitute one of the most diverse groups among the vertebrates and have great potential in terms of economic contribution as well as maintaining diversity in the ecosystem. The hill stream fishes of the north-eastern part of India harbours a great diverse group of fishes, but due to lack of Icthyological surveys and studies taken up in the past, the extent of fish diversity could not be completely verified and many species are still left to be discovered. Recent development on the studies of fish diversity by some workers from these areas leads to the discovery and description of several new species. The Kolodyne drainage and its tributaries within Mizoram are still lacking scientific exploration and only few work have been carried out on fish diversity so far, therefore, keeping that in mind the present work have been carried out to reveal the fish diversity of the areas for proper scientific documentation as well as for future references which will contribute a lot towards the conservation of several fish species that are facing threats.

The present work carried out reported the occurrence of at least 40 species of Cypriniformes fish belonging to 5 families and 21 genera.

The family Cyprinidae contributes the highest number of fish with 26 species belonging to 15 genera (65%) followed by the family Nemacheilidae with 7 species under 3 genera (17.5%) of the overall species collected. The other families such as Psilorhynchidae, Cobitidae and Balitoridae are represented by one genus each.

In terms of genus, *Garra* contributes the largest number with 7 species of fish accounting to 17.9% followed by the genus *Schistura* with 5 species accounting 12.8%. Three genera namely *Pethia, Puntius* and *Balitora* contribute 3 species each which represents 7.7%. The genera *Rasbora, Psilorhynchus* and *Lepidocephalichthys* contribute two species each and accounts for 5.1 % each. There are other several genera which contribute one species and representing only 2.6% of the overall species such as *Opsarius, Cabdio, Crossocheilus, Devario, Esomus, Laubuka, Neolissochilus, Osteobrama, Salmostoma, Semiplotus, Tor, Acanthocobitis* and *Physoschistura*.

The present work on Cypriniformes fish diversity leads to the description of 2 new species namely, *Psilorhynchus khopai* from Tuisi river and *Schistura andrewi* from Mat river. Further studies on these study sites are likely to yield more new species in the near future and more exploration is required to assess the fish diversity. Besides, the study reported the occurrence of *Garra flavatra, G. rakhinica* and *G. nigricollis* for the first time in Indian rivers. The present study further observed *Garra tyao*, which was decribes as a new *Garra* species by Arunachalam *et al*. (2014) from Tyao River shares similarities with *Garra rakhinica* on closure inspection thereby considered being the junior synonym of *Garra rakhinica*.

The study areas comprises of some species whose taxonomic status are not yet fully understood and further studies are required for these species identification namely, *Physoschistura* sp., *Pethia* sp., *Puntius* sp., *Cabdio* sp., *Balitora* sp. 1, *Balitora* sp. 2, *Osteobrama* cf. *cunma* etc. Further studies are likely to yield new species description from some of these species.

The work carried out also highlighted the occurrence of some dominant species which are present in all the study sites during the sample collection and those species includes *Opsarius profundus, Devario aequipinnatus, Garra rakhinica, Garra* cf. *vittatula, Pethia conchonius, Schistura koladynensis* and *S. nebeshwari*. However, some species are not widely distributed and very rare in its occurrence and were collected from only one or two study sites which includes *Cabdio* sp., *Garra flavatra*, *Garra nigricollis*, *Balitora* sp. 1, *Balitora* cf. *burmanicus*, *Neolissochilus* sp., *Rasbora rasbora*, *Puntius chola*, *Puntius* sp., *Pethia* sp., *Acanthocobitis botia*, *Osteobrama* cf. *cunma*, *Salmostoma* sp., *Physoschistura* sp. and *Schistura andrewi*.

According to IUCN red list (2015) category of the fish specimen collected from the study areas, 55% are represented by Not Evaluated which is followed by 30 % Least Concern and another 7.5% are under threatened category. Data Deficient and Vulnerable categories are represented by 5% and 2.5% respectively. The fact that 55% of the fish species from the study areas turns out to belong to Not Evaluated category revealed how much species of fish species are still not properly studied to assess conservation status and without understanding the real critical condition face by a fish species, conservation strategy could face hurdles and thereby affect fish conservation in the Kolodyne drainage.

Conservation of fish have been undertaken in at least two of the study sites, Kolodyne River near Lungbun village covering a distance of 1 km and Tuisi River at the vicinity of Khopai village which covers a distance of 2 km . The areas declared as fish conservation areas are strictly conserved and protected from fishing and other activities throughout all seasons of the year whereas other parts of the river not covered by protected area are permitted for fishing by legal means. However, the use of poisonous chemicals, dynamos, bombs etc. which are considered illegal fishing methods are strictly prohibited in any part of the river throughout the whole year.

The work carried out highlighted the need for the conservation aspects of fish diversity on the Kolodyne drainages of Mizoram. Due to lack of scientific documentation on the various study sites, it is very difficult to ascertain the exact fish diversity as well as the extent of threatened and rate of extinction. The description of new species from majority of the study sites in the recent years by some authors revealed that there are still many fish species awaiting discovery and if proper conservation measure is not taken immediately, some species are facing immediate threats of extinction. Keeping this in mind, proper scientific study for documentation is taken up in the present study and for future references which will ultimately assist in the conservative measures.

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APPENDICES

Appendix I: Comparative material for new species description

Psilorhynchus homaloptera ZSI F 11792/1, holotype, 55.1 mm SL and ZSI F11796/1, 4 paratypes, 53.4–58.3 mm SL; India: Nagaland, Keleki stream.

Psilorhynchus pseudecheneis: ZSI F1929/2, 4 paratypes, 76.1–84.4 mm SL; Eastern Nepal: Dudhkosi River, Solokhumbu District. Additional data from Conway *et al*. (2013).

Psilorhynchus rowleyi: ZSI F 13461/1, 1, 75.5 mm SL; Myanmar: Kora, Vernay-Hopwood Upper Chindwin Expedition, 1935. Additional data from Shangningam *et al*. (2013).

Psilorhynchus nudithoracicus: PUCMF 2050, 5, 46.2–58.1 mm SL; India: Mizoram, Barak drainage (Brahmaputra basin), Teirei (Tributary of Tlawng River), Saikhawthlir.

Psilorhynchus sucatio: PUCMF 2021, 14, 51.5–62.9 mm SL; India: Mizoram, Barak drainage (Brahmaputra basin), Teirei (Tributary of Tlawng River), Saikhawthlir.

Published information used for comparison: Arunachalam & Muralidharan (2008) for Psilorhynchus tenura, Conway & Kotellat (2007) for *P. robustus*, Nebeshwar *et al*. (2007) for *P. arunachalensis* and Vishwanath & Manojkumar (1995) for *P. microphthalmus*.

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, 2344'54" N 9245'27" 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 kangjupkhulensis: MUMF 3007 (3), 42.8–46.3 mm SL; India: Manipur: Chandel District: Chindwin- Irrawaddy basin: Khujairok, Moreh.

Schistura koladynensis: PUCMF 12019 (5), 47.6–74.5 mm SL; India: Mizoram, Kaladan River, in the vicinity of Kawlchaw, Lawngtlai, 22°23'48''N 92°57'47''E; Lalronunga & Vanlalmalsawma, 24 April 2012. PUCMF 12021 (4), 55.8–62.8 mm SL; India: Mizoram, Kaladan 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 maculosa: ZSI FF 4973, holotype, 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; Lalronunga *et al*., 20 April 2013; ZSI FF 4974 (3), paratypes, 56.9–69.0 mm SL; MZUBM/F. 130021- 130023 (3), paratypes, 46.4–71.0 mm SL; PUCMF 13010 (8), paratypes, 33.9–76.0 mm SL; 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.

Schistura manipurensis: Uncatalogued (3), 48.7–50.9 mm SL; India: Manipur: Chandel District: Chindwin- Irrawaddy basin: Khujairok, Moreh.

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

Schistura nebeshwari: PUCMF 13024 (10), 37.6–50.5 mm SL; India: Mizoram, Maisa River, in the vicinity of Maisa Village; Lalramliana, 08 December 2011. PUCMF 13025 (9), 43.8–69.9 mm SL; India: Mizoram, Tuisi River, in the vicinity of Khopai village; Lalramliana *et al*., 07 March 2012. PUCMF 13026 (19), 30.8–65.0 mm SL; India: Mizoram, Tuisi River, in the vicinity of Khopai village; Lalronunga *et al*., 16 November 2012. Additional data from Lokeshwor & Vishwanath (2013b).

Schistura paucireticulata: PUCMF 13020 (9), 41.7–52.7 mm SL; India: Mizoram, Tuirial River, in the vicinity of Tuirial Village; Vanlalmalsawma, 26 March 2013. Additional data from Lokeshwor *et al*. (2013).

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

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

Schistura scyphovecteta: PUCMF 13027 (11), 24.2–52.3 mm SL; India: Mizoram, Tuisi River, in the vicinity of Khopai village; Lalronunga *et al*., 16 November 2012. Additional data from Lokeshwor & Vishwanath (2013b).

Schistura sikmaiensis: MUMF 11220–11222 (3), 63.4–74.6 mm SL; India: Manipur: Chindwin-Irrawaddy basin: Senalok.

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

Published information used for comparison: Bohlen & Šlechtová (2013) for *S. rubrimaculata*; Hora (1935) for *S. shebbearei*; Lokeshwor & Vishwanath (2013c) for *S. ferruginea*; Menon (1987) for *S. carletoni*, *S. gangetica*, *S. sijuensis* and *S. tirapensis*.

Appendix II: List of publications

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

2). 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.

Appendix III: List of paper published in conference/symposium

1). Solo, B., Lalnuntluanga and Lalramliana (2016).Occurrence of *Oreochromis mossambicus* in rivers of Mizoram: A boon or a bane? In: Lalramnghinglova, H.,Vanramliana and Lalthanzara, H. (eds). *Current trends of biodiversity research in Mizoram*. 89-99pp.

2). Solo, B., Lalnuntluanga and Lalramliana (2013). Investigation on the current status of ornamental fish Diversity in Mizoram, Northeastern, India. In: *Bioresources and Traditional Knowledge of Northeast India*. 161-164pp.

Appendix IV: List of seminar/symposium/conference/workshops attended

1). *National seminar on issues of wildlife conservation in India with special reference to Mizoram* organized by Department of Environment Science, Mizoram University and Department of Zoology, Pachhunga University College, sponsored by Environment & Forest Department, Govt. of Mizoram and Mizoram University held on 24th - 25th April, 2014 at Mizoram University, Aizawl, Mizoram.

2). *Workshop on capacity building in effective management of intellectual property rights (IPRS) in Biotechnology by universities and research institutes in Mizoram* Sponsored by Department of Biotechnology, Govt. of India, organized by Biotech Consortium India

Limited (BCIL), New Delhi held on 27th-28th August, 2015 at Pachhunga University College, Aizawl, Mizoram.

3). *Two days workshop on current trends of biodiversity research in Mizoram* organized by Department of Environmental Science, Mizoram University and Department of Zoology, Pachhunga University College, sponsored by CSIR, New Delhi held on 20th-21st March, 2015 at Pachhunga University College, Aizawl, Mizoram.

4). *One day state level research monitoring and sensitization workshop* organized by Project Committee, Pachhunga University College held on 9th Nov, 2015 at Pachhunga University College, Aizawl, Mizoram.

5). *One day seminar on Animal Welfare and Ethics* organized by Department of Pharmacy, Ripans in association with Committee for the purpose of Control and Supervision of Experiments on Animals (CPCSEA) on 6th June, 2013 at Regency Hotel, Aizawl, Mizoram.

6). *Three days Hands on training on DNA barcode* organized by Department of Zoology Pachhunga University College, sponsored by Institutional Biotech Hub (DBT India) and STAR College Scheme (DBT India), held on 14th-16th March, 2013 at Pachhunga University College, Aizawl, Mizoram.

7). *One Week Course on Applied Statistics* organized by Human Resource Development Centre, Mizoram University, Sponsored by UGC from 7th-12th September, 2015 at Mizoram University, Aizawl, Mizoram.

8). *Advocacy Workshop on Bird Conservation in Mizoram* organized by Indian Bird Conservation Network BNHS, Mumbai and Pachhunga University College with support from the Mizo Academy of Sciences held on the 21st February, 2014 at Pachhunga University College, Aizawl, Mizoram.

9). *One Day Seminar on Genetically Modified Crops and Food Security* organized by Mizo Academy of Sciences and Government Zirtiri Residential Science College, supported by Directorate of Science and Technology, Government of Mizoram and National Council for Science and Technology Communication, Department of Science and Technology, New Delhi held on 23rd January, 2014 at Zirtiri Residential Science College, Aizawl, Mizoram.

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

11). *Sensitization Workshop on Basic Sciences-2016* organised and sponsored by Directorate of Science & Technology, Govt. of Mizoram held on 2nd February, 2016 at Serchhip, Mizoram.