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Ichthyofauna checklist (Chordata: Actinopterygii) for indicating water quality in Kampar River catchment, Malaysia

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Abstract. *Ng CKC, Ooi PAC, Wong WL, Khoo G. 2018. Ichthyofauna checklist (Chordata*: *Actinopterygii) for indicating water quality in Kampar River catchment, Malaysia. Biodiversitas 19*: *2252-2274.* The limnological habitats are receptors of pollution, thus local fish species richness is a plausible biological indicator to reflect the quality of a particular water body. However, database on species occurrence that corresponds with the water physico-chemistry constituents is often not available. The problem is compounded by the lack of species identification description to assist those working on river and freshwater resource conservation projects. This paper attempts to fill the gaps in the context of Kampar River drainage. Based on sampling exercises conducted from October 2015 to March 2017, an annotated list with visual data for 56 species belonging to 44 genera and 23 families is presented. The water physico-chemistry data is also summarized with the corresponding visual data of limnological zones studied. The species diversity results are further compared with other local drainages and the correlation between area size and their relationship is expressed by $y = 17.627e^{0.0601x}$. This paper provides species-level identification information for front line practice and demonstrates how the fish taxonomy discipline can be adapted for practical application in freshwater resource monitoring and management.

Key words: biological indicator; freshwater fish; species diversity; water quality.

Abbreviations: Dissolved Oxygen (DO); Ammoniacal Nitrogen (AN); Total Suspended Solids (TSS); Turbidity (TUR); Iron (FE); Nitrite (NO_2-N); Nitrate (NO_3-N); Phosphate (PO_4); Sulphate (SO_4). Oxygen Demand at 20°C for 5 days (BOD_5); Chemical Oxygen Demand (COD).

INTRODUCTION

Aquatic ecosystems, such as rivers, are often subject to natural and anthropogenic pollution. Hence, limnological studies, including fish diversity can serve as a useful parameter for monitoring river health (Karr 1981; Angermeier and Karr 1994; Grossman et al. 1998; Breine et al. 2004; Noble and Cowx 2007; Sedeño-Díaz and López 2012; Eick and Thiel 2013; Mostafavi et al. 2015). However, those familiar with biological indicator literature are bound to notice the gap between theory and practice. Previous and current works are largely confined to concepts, theoretical studies and the correlations between fish-based biological indices (e.g. richness, evenness) and their environments. While scientific evidences of fish community usefulness and success in reflecting freshwater quality are plentiful, most papers stop short on showing the stakeholders how the species-level biological units can be practically identified. Hence the advantages are somewhat not fully realized and this has arguably restrained the progress of adopting biological indicators. Moreover, the unfortunate reality is that a majority of government agency officers, researchers, conservation activists and community-based action groups lack the species identification references that correspond with water quality data - and here lies the critical gap.

In a developing country such as Malaysia and many other countries in Asia, the discipline of species taxonomy is not a priority in most universities, museums and research institutions. In terms of fish taxonomy, many experts in the field consider our region is still in the discovery and exploratory stage (Kottelat and Whitten 1996; Chong et al. 2010; Ng et al. 2017). Like many countries in Asia, the lack of institutional and funding support in Malaysia has acutely affected ichthyological studies and caused ichthyologist scarcity although the country hosts exceedingly rich aquatic biodiversity. Additionally, anthropogenic pollution notwithstanding, Malaysia is periodically threatened by natural forcings such as strong El Niño event which reduces the volumetric flow and concentrates pollutant constituents in the rivers (Ng et al. 2018). Hence, there is a need for a concise and practical approach to assess the river in a timely manner. Clearly, two questions that beg to be asked are, how can fish-based indicator be successfully applied under such mounting constraints and predicaments, and how can the non-taxonomist, non-ichthyologist, activists or stakeholders readily adopt fish as biological indicator to monitor freshwater resources?

For concerns mentioned and to enable freshwater resource conservation initiatives to begin and thrive, firstly there must be an informative list that enumerates every species found in the particular drainage for quick reference. Prompted by the gaps, this study had two objectives. The first objective was to identify fish species found in the studied zones and produce a species reference for

monitoring water quality. It was carried out with practical interest to assist researchers of other fields, front line activists and government agencies who are keen to adopt freshwater ichthyofauna as biological indicator to monitor freshwater quality. The second objective was the primary scientific interest of investigating the species composition characteristics in various limnological zones. This deepens the understanding of species biogeography in adjacent or other regional drainages in the country. The findings may be useful to researchers operating in those drainages for building their own species list for monitoring water quality by the local stakeholders.

MATERIALS AND METHODS

Study area

Kampar River (4° 24' 1.2234" N, 101° 9' 41.724" E) was selected for this study as it is a typical Malaysian limnological representation of environment, social and economic importance (Figure 1). Kampar River is the key freshwater source for 93,084 population residing in the 699.8 km^2 Kampar district (DOS 2010) that consists of sub-districts namely Jeram, Gopeng, Lawan Kuda, Kampar, Kopisan, Kota Baharu, Kuala Dipang, Mambang Diawan, Malim Nawar, Tronoh Mines and Sungai Siput (S). Therefore, it is crucial that Kampar River's ecological integrity is monitored consistently to ensure the population continues to enjoy clean freshwater supply, in particular zone B where freshwater is extracted by a local water treatment plant. Its fluvial geomorphological character can be described as dendritic with highland tributaries, namely Geruntum, Ulu Kampar, Geroh and Dipang that originate from Titiwangsa Mountainous Range's western foothill region, feeding into the 35 km length main river. Geographically, it is located in the southern region of Kinta Valley in the state of Perak and the catchment covers an approximate area of 400 km^2 with altitudes ranging from 2068 m above sea level (asl) at the highest point and 26 m asl at the lowest point. The region experiences tropical mesothermic microclimate with annual rainfall between 1827 mm to 3403 mm and daily temperature that ranges from 24ºC to 32ºC (MNRE 2011).

Fish sampling

The species sampling exercise was conducted on monthly basis during daytime over a period of 18 months, from October 2015 to March 2017, on 25 m transects along each sampling location stratified to zone A, B, C and D (Figure 1). Specimens were captured using hand nets (mesh size 5 mm), 0.5 m diameter bubu (traditional one-way funnel trap), 2.5 m diameter cast nets (mesh size 15 mm), and baited hooks and lines. To respect the local indigenous custom, no voucher specimens were deposited. Individuals encountered were released unharmed at point of capture after identification and photography of their morphological characters and pigmentation patterns. Only freshly caught adults were photographed to ensure their live pigmentation composition were recorded.

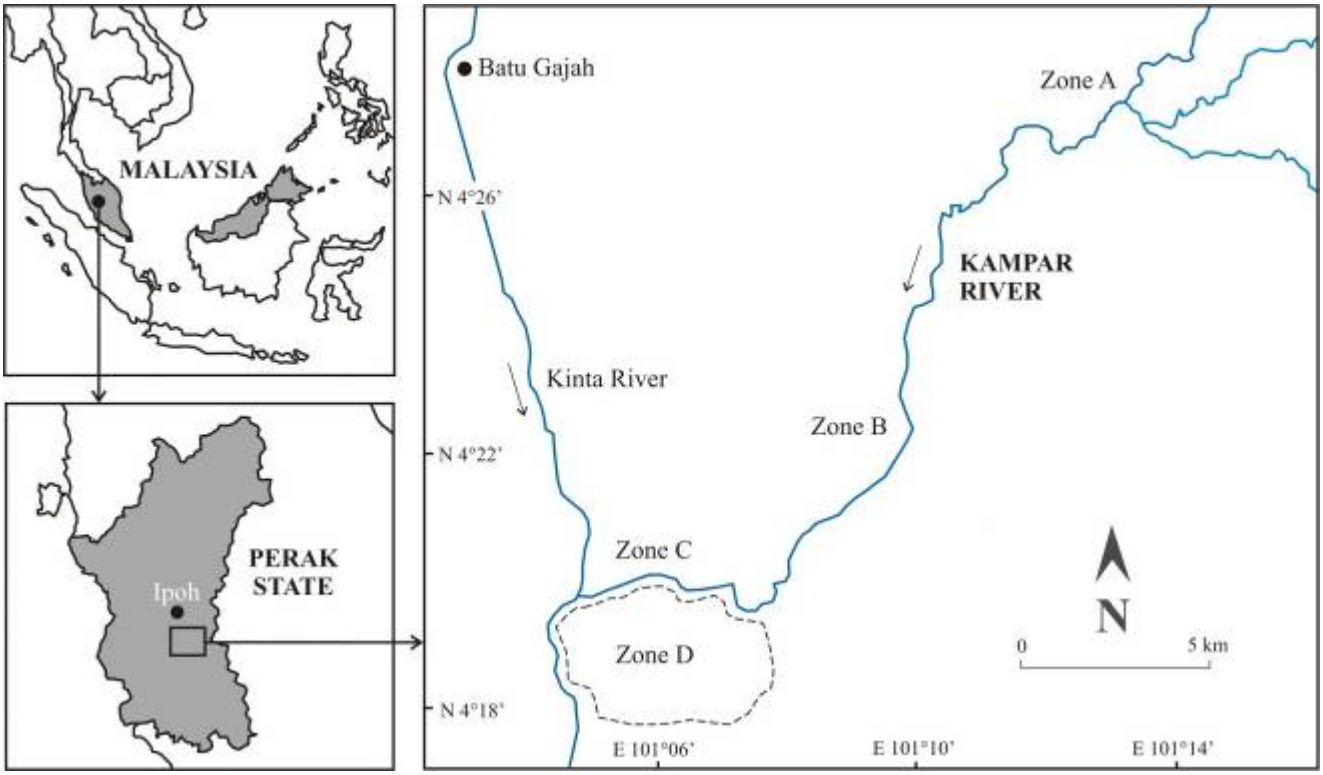

Figure 1. Map and location of sampling zones in Kampar River, Perak State, Malaysia

Taxonomy reporting

All species names were crosschecked with Catalog of Fishes (Eschmeyer et al. 2017) for the latest valid binomial nomenclatures. The genera and species arrangement is in alphabetical order and family systematic ranking follows Nelson et al. (2016). Species that are currently affected by taxonomic uncertainty or could not be identified with confidence were recorded with open nomenclature terms "aff." and "cf." following Lucas (1986) and Bengtson (1988) in taxonomic statements. As the checklist is targeted for a wide audience of users of different skill levels, the most prominent features of the species were focused in identification description. Supplementary commentaries were also provided to assist the user identify habitats where the species may be typically encountered and the precautions when identifying some particular species.

Water quality sampling

To ascertain the water physico-chemistry values of each limnological zone for correlating with species occurrences, the corresponding monthly water quality testing exercises were carried out. The HACH model DR890 mobile colorimeter was deployed to measure in-situ Dissolved Oxygen (DO), Ammoniacal Nitrogen (AN), Total Suspended Solids (TSS), turbidity (TUR), iron (FE), nitrite (NO_2-N), nitrate (NO_3-N), phosphate (PO_4) and sulphate (SO_4). Water pH was measured with Mettler Toledo's pH meter and a thermometer was used to measure temperature. Water samples were also collected and sent to Kenep Laboratories (M) Sdn Bhd, which is a MS ISO/IEC 17025 accredited laboratory, for testing Biochemical Oxygen Demand (BOD_5) at 20°C for 5 days and Chemical Oxygen Demand (COD) parameter.

RESULTS AND DISCUSSION

A total of 2,441 individuals representing 23 families, 44 genera and 56 species were encountered. Zone C registered the lowest number of species while zone D recorded the highest number of species. However, this should not be misconstrued as zone D was the least ecologically impaired among all zones studied. In fact, zone D was a heavily disturbed area and many species encountered were introduced species and these are typically regarded as negative biological indicators. A total of 16 introduced species were recorded in the zones. Zone A recorded the highest percentage of native species occurrence (99.7%) followed by zone B (65.9%) and zone C (33.3%). As expected, species from Cyprinidae (21 species) were numerically most abundant in Kampar River catchment, followed by Clariidae (four species), Osphronemidae (four species) and Channidae (four species). The species presence in zone, rank abundance and sympatric occurrences of native and introduced species in each zone are highlighted in Table 1, Figure 2 and 3. The morphology of each species is shown in Figure 4-9.

Table 1. Species encountered in studied zones. Marking "+" and "*" denote species presence and introduced species respectively.

Family / Species	Local name	Zone			
		A	B	C	D
Notopteridae					
Notopterus notopterus	Belida		+		
Cyprinidae					
Barbodes cf. *rhombeus*	Tebal sisik	+	+		+
*Barbonymus gonionotus**	Lampan jawa		+	+	+
Barbonymus schwanenfeldii	Lampan		+		
Crossocheilus oblongus	Selimang	+			
Cyclocheilichthys apogon	Cemperas	+	+		
*Cyprinus carpio**			+	+	+
Danio albolineata		+			
*Esomus metallicus**					+
Hampala macrolepidota	Sebarau	+	+		
*Hypophthalmichthys nobilis**	Kap kepala besar		+		+
*Labeo rohita**	Rohu			+	+
Labiobarbus leptocheilus	Kawan	+	+		+
Leptobarbus hoevenii	Jelawat siam	+	+		+
*Leptobarbus rubripinna**	Jelawat		+	+	+
Mystacoleucus obtusirostris	Sia	+	+		+
Neolissochilus soroides	Tengas kejor	+			
Osteochilus vittatus	Terbol	+	+		
Poropuntius smedleyi	Tengas daun	+			
Puntigrus partipentazona			+		+
Rasbora vulgaris	Seluang	+	+		+
Toxabramis cf. *houdemeri**					+
Balitoridae					
Balitoropsis zollingeri		+			
Homalopteroides smithi	Susoh batu	+			
Serrasalmidae					
*Piaractus brachypomus**	Pacu		+		+
Loricariidae					
*Pterygoplichthys disjunctivus**				+	+
Sisoridae					
Glyptothorax schmidti	Depu	+			
Siluridae					
Silurichthys schneideri	Gemang	+			
Clariidae					
Clarias aff. *batrachus*	Keli kayu	+	+		
*Clarias gariepinus**	Keli afrika	+	+	+	+
Clarias leiacanthus	Keli	+			
Clarias nieuhofii	Keli limbat	+			
Pangasiidae					
*Pangasianodon hypophthalmus**	Patin		+	+	+
Bagridae					
Hemibagrus capitulum	Baung		+	+	
Mystus singaringan	Baung tikus		+	+	+
Aplocheilidae					
Aplocheilus panchax	Kepala timah		+		+
Poeciliidae					
*Poecilia reticulata**	Gupi		+		
Synbranchidae					
Monopterus javanensis	Belut		+	+	+
Mastacembelidae					
Mastacembelus favus	Tilan	+			
Ambassidae					
Parambassis siamensis	Seriding				+
Pristolepididae					
Pristolepis fasciata	Patong		+		+

Cichlidae					
*Cichla monoculus**					+
*Mayaheros urophthalmus**					+
*Oreochromis aureus**	Tilapia		+	+	+
*Oreochromis niloticus**	Tilapia				+
Eleotrididae					
Oxyeleotris marmorata	Ketutu		+		+
Anabantidae					
Anabas testudineus	Puyu		+	+	+
Helostomatidae					
Helostoma temminckii	Temakang				+
Osphronemidae					
Betta pugnax	Sepilai batu	+			
*Trichopodus pectoralis**	Sepat siam			+	+
Trichopodus trichopterus	Sepat ronggeng				+
Trichopsis vittata	Karim		+		+
Channidae					
Channa gachua	Haruan kedak	+			
Channa lucius	Bujuk				+
Channa micropeltes	Toman				+
Channa striata	Haruan		+	+	+

Taxonomic accounts

Family NOTOPTERIDAE

***Notopterus notopterus* (Pallas 1769)**

Common name: Bronze Featherback

Local name: Belida

Native range: Southern India, Myanmar, Thailand, Sumatra and Java and Malay Peninsula.

Etymology: *Notopterus*: Greek, noton = back + Greek, pteron = wing, fin

Description: Body knife-like compressiform, finely scaled body, large membranous opercular flap, terminal mouth, concave head profile, small dorsal fin, caudal fin pointed and continuation from anal fin.

Comments: Inhabits turbid still deep ponds, wetlands and slow flowing canals. Rarely found in the main rivers.

Family CYPRINIDAE

***Barbodes* cf. *rhombeus* (Kottelat 2000)**

Common name: Spotted Barb

Local name: Tebal sisik

Native range: Mekong Basin, Chao Phraya Basin, Maeklong Basins and peninsular Kra Isthmus of Thailand.

Etymology: *Barbodes*: Latin, barbus = barbel + Greek, oides = similar; *rhombeus*: Latin, rhombeus = rhombus, equilateral geometry.

Description: Body compressiform with scales, terminal mouth, dorsal-fin spine finely serrated, caudal fin forked and prominent blotch at dorsal fin anterior base.

Comments: Inhabits clear or turbid fast, slow and stagnant waters. Observed to feed on some plants, aquatic arthropods and macroinvertebrates. This species is associated with the "catch-all" *Puntius* complex and work is still in progress to clarify its identity. Some members of the complex have been reassigned to new genera *Dawkinsia, Haludaria* and *Pethia* (Pethiyagoda et al. 2012) and *Barbodes* (Kottelat 2013). Currently, members of *Barbodes* are typically told apart by apomorphic markings on the body. Specimens found in Perak have been frequently cited as *B. binotatus* (Hashim et al 2012; Ikhwanuddin et al. 2017) but we hesitate to adopt the same as there are pending taxonomic issues that are well explicated in Roberts (1989: 60-61). *B. binotatus* was described from a holotype of Javan origin and the species is likely to be restricted to Java, Bali, Lombok and Sumatra (Kottelat 2000). Out of 41 species listed in the *Barbodes* genus which are mostly found in the Philippines, Borneo and Indonesia, *B. rhombeus* occurring in Kra Isthmus of Thailand (Kottelat 2013) may be the closest congener to specimens found in Perak. Farinordin et al. (2017) also highlighted recently that they found two morphological forms of scale below the lateral line in "*B. binotatus*" encountered in tributaries of Kenyir Lake, Terengganu. This opens up the possibility of specimens found in Perak could be *B. rhombeus* or an un-described species. Until the uncertainty is resolved, we are citing this species as *B.* cf. *rhombeus* to highlight the possibilities.

***Barbonymus gonionotus* (Bleeker 1849)**

Common name: Silver Barb

Local name: Lampam jawa

Native range: Java.

Etymology: *Barbonymus*: Latin, barbus = barbel + Greek, anṓnumos = anonymous; *gonionotus*: Greek, gōnía = angle + Greek, noton = back

Description: Body strongly compressiform with dorsal profile arched, head small, mouth terminal, caudal fin forked with light orange anal and pelvic fin.

Comments: Not native to peninsula Malaysia. The species was first introduced for aquaculture in Sungai Terengganu and Sungai Perak (Chong et al. 2010). Currently it is widespread throughout southeast Asia.

***Barbonymus schwanefeldii* (Bleeker 1854)**

Common name: Tinfoil Barb

Local name: Lampam sungai

Native range: Throughout Sundaic and mainland Southeast Asia namely Cambodia, Vietnam, Thailand, Malay Peninsula, Borneo and Indonesia.

Etymology: *Barbonymus*: Latin, barbus = barbel + Greek, anṓnumos = anonymous; *schwanefeldii*: in honour of H. W. Schwanefeld.

Description: Scaled body, strongly compressiform with dorsal profile arched, head small, mouth terminal, caudal fin forked with submarginal stripe on orange/red caudal lobes.

Comments: Inhabits slow water lakes and rivers. The scientific name is often misspelled as *B. schwanenfeldii* (with an extra "n") in many reports.

***Danio albolineata* (Blyth 1860)**

Common name: Pearl Danio

Local name: (none)

Native range: Myanmar, Laos, Thailand throughout Malay Peninsula to Sumatra.

Etymology: *Danio*: Bengalese, dhani = small; *albolineata*: Latin, *albus* = white + *lineatus* = lined.

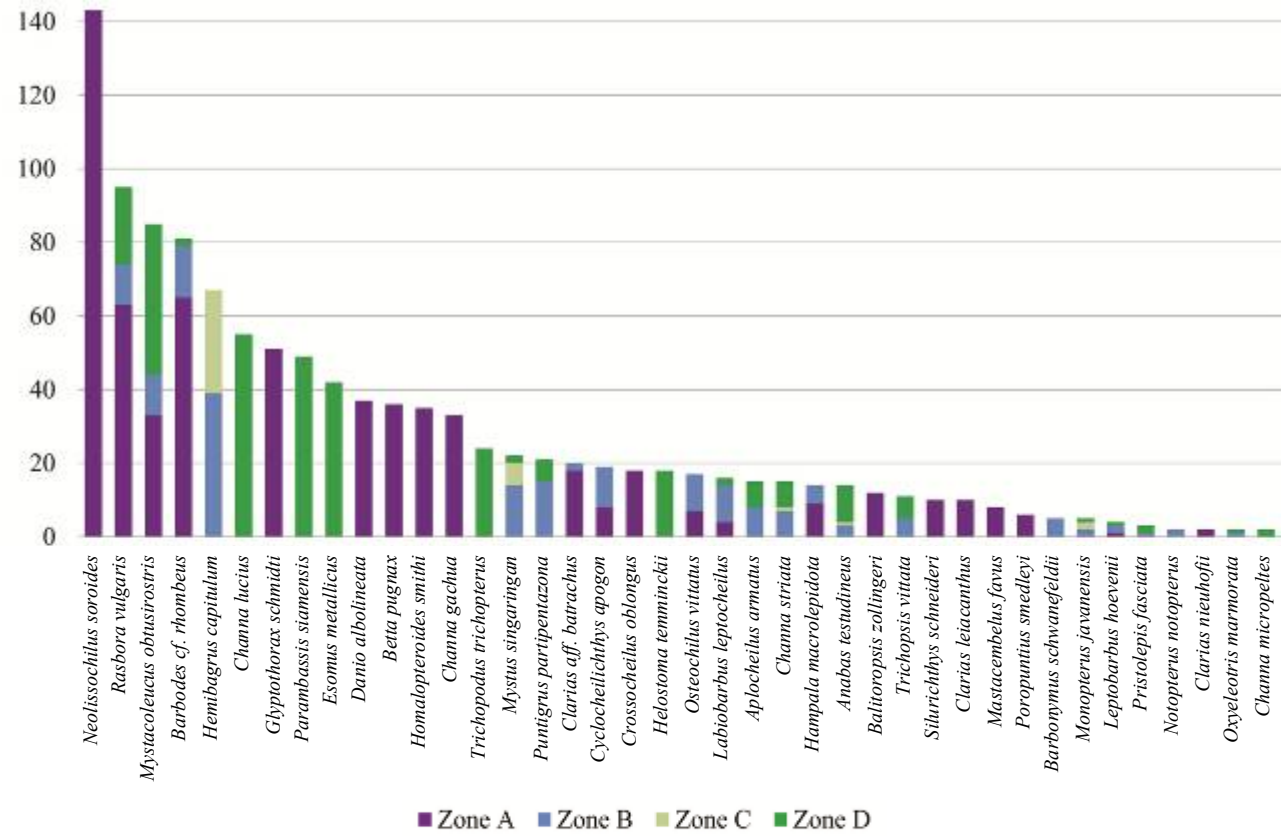

Figure 2. Rank abundance, diversity and sympatric occurrences in native species population among studied zones

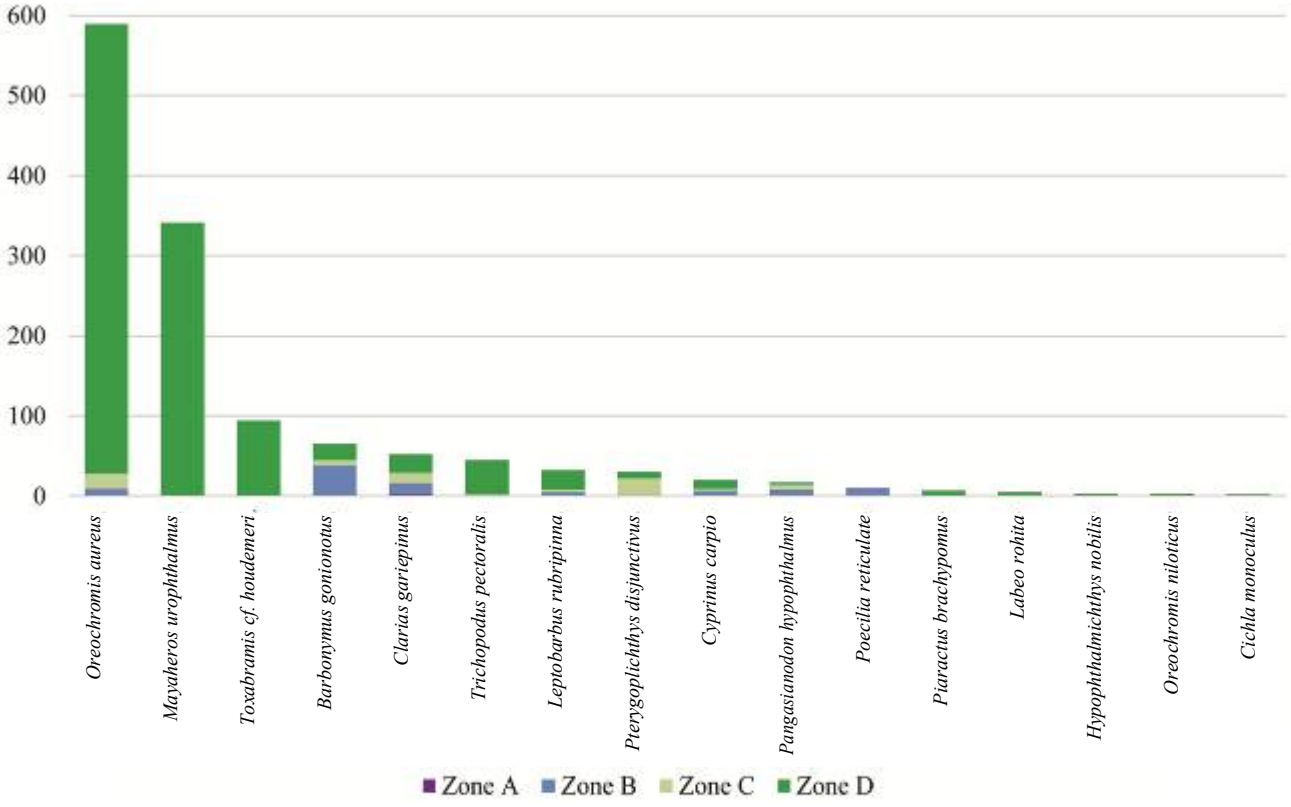

Figure 3. Rank abundance, diversity and sympatric occurrences in introduced species population among studied zones

Description: Caudal fin forked, terminal mouth, incomplete lateral line, two pairs of barbels, maxillary barbels extending beyond pectoral base, rostral barbels extending beyond eye, iridescent blue and orange coloration in life.

Comments: Found in small flowing clear streams (width < 2m) in oil palm plantation along the hillsides.

***Crossocheilus obscurus* Tan & Kottelat 2009**

Common name: Siamese Algae Eater

Local name: Selimang

Native range: Sumatra and Malay Peninsula.

Etymology: *Crossocheilus*: Greek, krossós = fringe + Greek, cheílos = lip; *obscurus*: Latin, obscurus = obscure, unclear, indistinct.

Description: Scaled body, mouth inferior, caudal fin forked, mid-lateral stripe from operculum to caudal fin. *C. obscurus* can be distinguished from the closest congener *C. oblongus* by displaying faded or unclear mid-lateral stripe in mature individuals (vs. sharp mid-lateral stripe).

Comments: Typically found foraging among pebbles and rocks in hillside clear fast flowing streams and rapids.

***Cyclocheilichthys apogon* (Valenciennes 1842)**

Common name: Beardless Barb

Local name: Cemperas

Native range: Myanmar, Thailand, Malay Peninsula to Indonesia

Etymology: *Cyclocheilichthys*: Greek, kyklos = round + Greek, cheílos = lip + Greek, ichtys = fish; *apogon*: Greek, a = without + Greek, pogon = chin, beard

Description: Fine ridges and folds across top and sides of head, small black spot on scale bases form longitudinal rows along body, mouth terminal, no barbel, caudal fin forked and caudal peduncle ocellated.

Comments: Usually found shoaling in slow moving or stagnant water in ex-tin mining lakes, canals, ditches and swamps.

***Cyprinus carpio* Linnaeus 1758**

Common name: Common Carp

Local name: Kap

Native range: Basins of Black, Caspian and Aral seas in Europe

Etymology: *Cyprinus*: Latin, cyprinus = carp; *carpio*: latinized form of carp which was used by the Romans and Celtics.

Description: Scaled overall dark greenish fusiform body, two pairs of barbels, caudal fin forked, terminal mouth and typically with enlarged rounded abdomen.

Comments: Not native to peninsula Malaysia. Care must be taken during identification process because it is a polytypic species having several variant forms to adapt to artificial breeding or environmental influences. Wildtype inhabits turbid well vegetated large rivers and lakes.

***Esomus metallicus* Ahl 1924**

Common name: Striped Flying Barb

Local name: Seluang janggut

Native range: Salween, Mae Klong, Chao Phraya and Mekong basins in Indochina.

Etymology: *Esomus*: Latin, e = out of + Greek, sôma = body, presumably referring to long maxillary barbels; *metallicus*: Latin, metallum = metal, presumably referring to its reflective scales.

Description: An obvious lateral band beginning from behind the eye and extending to the base of the caudal fin, caudal fin forked, lateral line does not extend to the anal fin (in some cases it does not even reach ventral fin base), terminal mouth and extra long maxillary barbels extending past pelvic base.

Comments: This species is regarded as non native to peninsula Malaysia by Lim and Tan (2002). It can be found shoaling in large numbers in ex-tin mining lakes and still water swamps.

***Hampala macrolepidota* Kuhl & van Hasselt 1823**

Common name: Jungle Perch

Local name: Sebarau

Native range: Throughout Sundaic and mainland Southeast Asia namely Cambodia, Vietnam, Thailand, Malay Peninsula, Borneo and Indonesia.

Etymology: *Hampala*: Javanese, hampala is the vernacular name for the genus; *macrolepidota*: Greek, makrós = long + Greek, lepdotos = scaled

Description: Scaled fusiform body, mouth terminal, one pair of barbels, caudal fin forked, an obvious black bar between the dorsal and pelvic fins and submarginal stripe on orange/red caudal lobes.

Comments: Observed to swim in groups in well-oxygenated, clear rapids and torrent rivers. It is prized as food and sport fish by the locals.

***Hypophthalmichthys nobilis* (Richardson 1845)**

Common name: Bighead Carp

Local name: Kap kepala besar

Native range: China.

Etymology: *Hypophthalmichthys*: Greek, hypo = under + Greek, ophthalmos = eye + Greek, ichthys = fish; *nobilis*: Latin, nobilis = noble, or celebrated.

Description: Large scaled body with small scattered black spots, mouth terminal slanting upwards, lower jaw extends slightly over upper jaw, without barbel, caudal fin forked and numerous keels extending from pelvic base to anus.

Comments: Not native to peninsula Malaysia. It is a popular food fish that is extensively farmed. Feral population typically inhabits large and deep lakes.

***Labeo rohita* (Hamilton 1822)**

Common name: Rohu

Local name: Kap india

Native range: Pakistan, Nepal, India, Bangladesh, Sri Lanka and Myanmar.

Etymology: *Labeo*: Latin, labeo = with large lips; *rohita*: Sanskrit, rohita = blood or reddish carp.

Description: Slightly reddish/brownish fins, scaled body, caudal fin forked, blunt snout, lips papillose and terminal mouth with maxillary barbels concealed in lateral groove.

Comments: Not native to peninsula Malaysia. Extensively bred by the local aquaculture farms and escapee population inhabits large pond and deep lakes with semi-aquatic vegetation.

***Labiobarbus leptocheilus* (Valenciennes 1842)**

Common name: (none)

Local name: Kawan

Native range: Indochina, Malay Peninsula, Sumatra, Borneo and Java.

Etymology: *Labiobarbus*: Latin, labium = lip + Latin, barbus = barbel; *leptocheilus*: Greek, lepto = fine or thin + Greek, cheilos = lip, edge or margin.

Description: Body with noticeable longitudinal stripes formed by small black mark on each scale, mouth terminal, caudal fin forked with long dorsal fin.

Comments: A pelagic fish that inhabits clear flowing waterways and feeding on organic detritus, benthic algae, phytoplankton, periphyton, small crustaceans and aquatic insect larvae.

***Leptobarbus hoevenii* (Bleeker 1851)**

Common name: Sultan Fish

Local name: Jelawat

Native range: Thailand, Malay Peninsula, Borneo, Sumatra and Java.

Etymology: *Leptobarbus*: Greek, leptós = slender + Latin, barbus = barbel; *hoevenii*: in honour of Jan van der Hoeven.

Description: Scaled plain colored fusiform body, a black blotch behind opercle, caudal fin forked, mouth terminal, two pairs of barbels, lateral line ending below middle of caudal base and head straight to slightly concave profile.

Comments: A pelagic fish that inhabits clear running waters and intolerant to low dissolved oxygen level. It feeds on plant-based detritus, zooplankton and small macroinvertebrates. This species is often misidentified as *L. rubripinna* and the details of difference is described in Tan and Kottelat (2009: 39-40). Specimens found in Kampar region are most probably escapees from the aquaculture farms.

***Leptobarbus rubripinna* (Fowler 1937)**

Common name: Red-finned Cigar Shark

Local name: Jelawat siam

Native range: Mekong and Chao Phraya basins.

Etymology: *Leptobarbus*: Greek, leptós = slender + Latin, barbus = barbel; *rubripinna*: Latin, rubra = red + pinna = fin.

Description: *L. rubripinna* can be mainly distinguished from congener *L. hoevenii* with anal and caudal fin lobes rounded and reddish (vs. pointed and dark grey).

Comments: Not native to peninsula Malaysia and typically misidentified as *L. hoevenii*. Commonly bred in aquaculture industry as replacement to *L. hoevenii* as a high value food fish (i.e. *L. hoevenii* is becoming rare due to overfishing). Feral population may be found in rivers, lakes and it has a better tolerance to low dissolved oxygen level in waters than *L. hoevenii*.

***Mystacoleucus obtusirostris* (Valenciennes 1842)**

Common name: (none)

Local name: Sia

Native range: Throughout Sundaic and mainland Southeast Asia namely Cambodia, Vietnam, Thailand, Malay Peninsula, Singapore, Borneo and Indonesia.

Etymology: Mystacoleucus: Greek, mystax = whiskered + Greek, iusculus = slightly, or somewhat; *obtusirostris*: Latin, obtusus = blunt + Latin, rostrum = snout or beak.

Description: Most scales with black base, mouth terminal, dorsal-fin with black anterior and distal margins, and caudal fin forked with black distal margin. It has an obscure procumbent predorsal spine pointing towards the snout.

Comments: Inhabits fast rocky streams and well oxygenated swamps. It may be referred to as *M. marginatus* in many reports before it was revised by Kottelat (2013).

***Neolissochilus soroides* (Duncker 1904)**

Common name: Copper Mahseer

Local name: Tengas

Native range: Thailand, Cambodia and Malay Peninsula.

Etymology: *Neolissochilus*: Greek, neos = new + Greek, lissos = smooth + Greek, cheilos = lip; *soroides*: Soro = Javanese name for *Tor soro* + Greek, ides = descendant of, i.e. "like soro"

Description: Scaled bodied, caudal fin deeply forked, cheek with tubercles, mouth terminal and dorsal fin spine not serrated with lateral-line scales 20-24, usually 22, and predorsal scales 8-10. Due to trophic polymorphism *N. soroides* has three mouth types, namely normal, truncated and lobed.

Comments: Only found in well oxygenated and intact forested flowing streams and rivers with sandy and rocky bottoms. This species is often misidentified as *N. hendersoni* which only has lateral-line scales 18-22, usually 20, and predorsal scales 6-8. Moreover *N. hendersoni* has so far only been recorded in northern Malay Peninsula, namely in the regions of Penang, Kedah, Langkawi and Kelantan (Khaironizam et al. 2015). It is also often misidentified as sympatric species *Poropuntius smedleyi* which has lateral-line scales 27-28 and slightly longer caudal fin lobes.

***Osteochilus vittatus* (Valenciennes 1842)**

Common name: Bonylip Barb

Local name: Terbul

Native range: Throughout Sundaic southeast Asia namely Cambodia, Vietnam, Thailand, Malay Peninsula, Singapore, Borneo and Indonesia.

Etymology: *Osteochilus*: Greek, osteon = bone + Greek, cheilos = lip; *vittatus*: Latin, vitta = ribbon, band or stripe.

Description: Scaled bodied with some orange/red scale bases, caudal fin deeply fork, mouth terminal, lateral side of upper lip thick with many folds and long dorsal fin.

Comments: Found in turbid streams, rivers and wetlands, and has tolerance to low dissolved oxygen level in waters. Bony but prized as food fish by the locals.

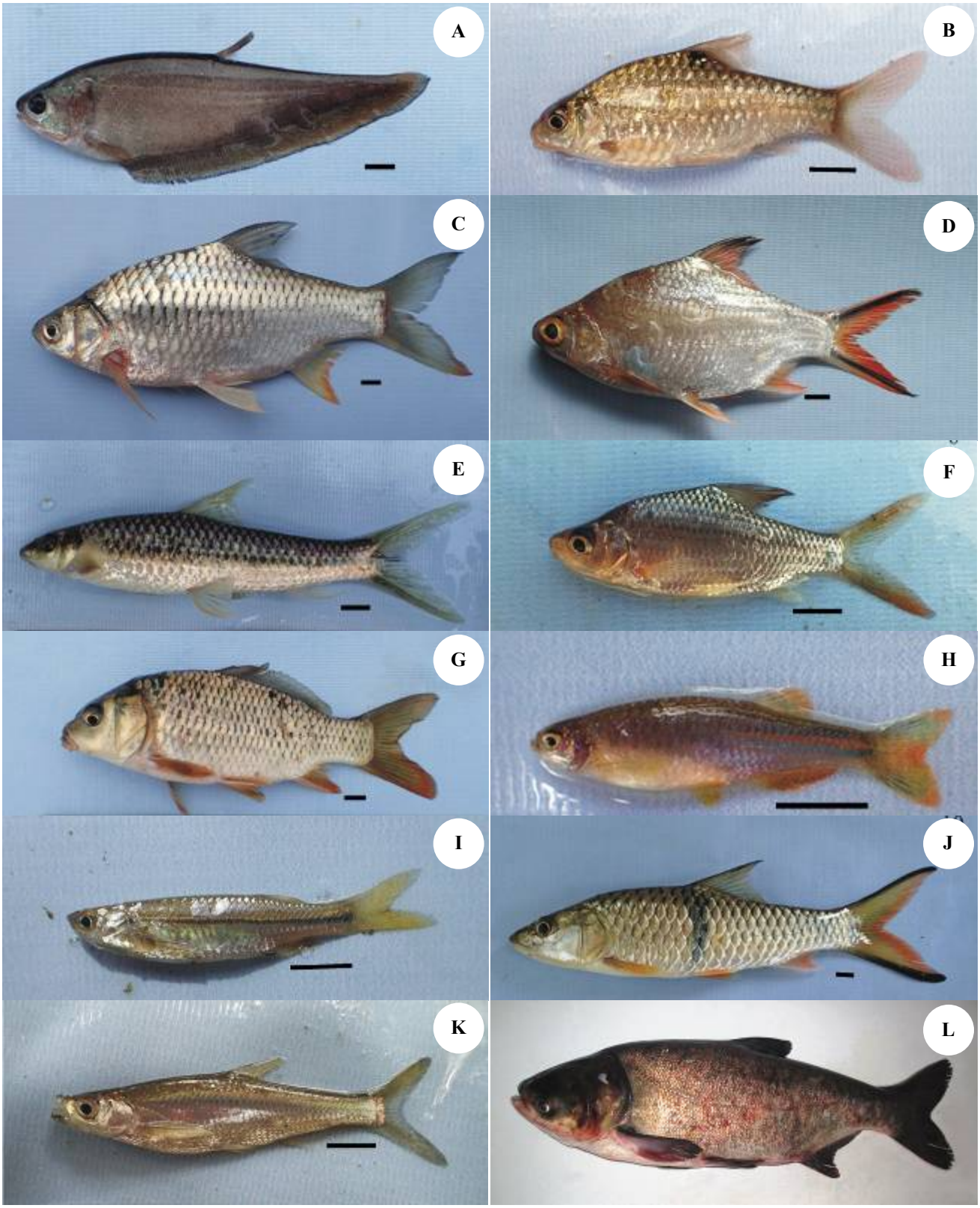

Figure 4. A. *Notopterus notopterus;* B. *Barbodes* cf. *rhombeus*; C. *Barbonymus gonionotus*; D. *Barbonymus schwanefeldii;* E. *Crossocheilus obscurus*; F. *Cyclocheilichthys apogon*; G. *Cyprinus carpio*; H. *Danio albolineata*; I. *Esomus metallicus*; J. *Hampala macrolepidota*; K. *Toxabramis* cf. *houdemeri*; L. *Hypophthalmichthys nobilis.* Bar = 1 cm

***Poropuntius smedleyi* (de Beaufort 1933)**

Common name: (none)

Local name: Tengas daun

Native range: So far the species is only reported in Malay Peninsula (type locality: Johor).

Etymology: *Poropuntius*: Greek, poros = porous + Greek, punctum = pointed; *smedleyi*: in honour of Norman *Smedley.*

Description: Scaled bodied, caudal fin deeply forked and mouth terminal. Appears similar to *N. soroides* but with slightly longer caudal fin and dorsal fin spine serrated. This species can also be distinguished by lateral-line scales 27-28 compared to *N. soroides* with lateral-line scales 20-24.

Comments: Inhabits well oxygenated and intact forested flowing streams and rivers with sandy and rocky bottoms. This species is often misidentified as a species from the *Neolissochilus* genus.

***Puntigrus partipentazona* (Fowler 1934)**

Common name: Tiger Barb

Local name: Pelampung jaring

Native range: Mekong, Mae Khlong and Chao Phraya basins in Thailand and Malay Peninsula.

Etymology: *Puntigrus*: Greek, punctum = pointed + Latin, tigris = tiger; *partipentazona*: Latin, partīre = apart, divide up + Greek, penta = five + Latin, zōna = band or belt.

Description: Scaled bodied, caudal fin deeply forked and mouth terminal. Broad black bars on body with one across the eye, and red/orange pelvic, dorsal and caudal fins.

Comments: Found in still water or very slow flowing water in the weedy marginal zones of ponds, lakes and wetland.

***Rasbora vulgaris* Duncker 1904**

Common name: Malayan Rasbora

Local name: Seluang

Native range: Endemic to Malay Peninsula (Lumbantobing 2014).

Etymology: *Rasbora*: Indian = fish; *vulgaris*: Latin = common.

Description: Scaled elongated bodied, mouth terminal with a symphseal knob that fits into a depression in the maxilla, gape not larger than eye diameter, barbels absent, and caudal fin deeply forked with caudal peduncle ocellated with a metallic dark green spot. Lateral pigmentation features follow Kottelat (2005) and Lumbantobing (2014) under the *Lateristriata* subgroup.

Comments: Inhabits hillside streams, rivers and also lowland wetlands with sandy-gravel substrate. It is highly adaptable to fast, slow and still waters. This species is sometimes misidentified as its closest congener *R. paviana*.

***Toxabramis* cf. *houdemeri* Pellegrin 1932**

Common name: Silver blade-minnow

Local name: Pimpin

Native range: Southern China, Hainan Island and northern Vietnam (Chen et al. 1987)

Etymology: *Toxabramis*: Greek, toxotes = archer + abramis = referring to original placement in Abramidinae family; *houdemeri*: in honor of Fernand Édouard Houdemer who collected the type in a market in Hanoï, Vietnam.

Description: Scaled slender body, laterally compressed, keel extending from anal fin base to between the pectoral-fin base, serrated dorsal spine, mouth slightly superior, barbels absent, and caudal fin deeply forked.

Comments: Not native to peninsula Malaysia. Large feral groups can be found in wetlands heavily disturbed by aquaculture activities. Speculated to be introduced together with aquaculture carps population from China. Observed sold in the fresh market as food species and as live feeder fish in the aquarium industry.

Family BALITORIDAE

***Homalopteroides smithi* (Hora 1932)**

Common name: (none)

Local name: Susoh batu

Native range: Mekong, Mae Khlong and Chao Phraya basins in Thailand and Malay Peninsula.

Etymology: *Homalopteroides*: Greek, homalos = flat + Greek, pteron = wing + Latin, oides = likeness; *smithi*: in honour of Hugh M. Smith.

Description: Depressiform, caudal fin lunate, inferior mouth with pectoral fin extending beyond pelvic fin origin.

Comments: Small individuals are widespread but never abundant among smooth rocks and pebbles in fast flowing shallow hillside streams and rivers. Observed to feed on aquatic macroinvertebrates present in organic detritus trapped among the rocks.

***Balitoropsis zollingeri* (Bleeker 1853)**

Common name: Black Lizard Loach

Local name: Puting beliung

Native range: Laos, Vietnam, Cambodia, Thailand, Malay Peninsula, Borneo and Indonesia.

Etymology: *Balitoropsis*: Balitora = a genus of fish + Greek, opsis = appearance, resemblance; *zollingeri*: in honour of Heinrich Zollinger.

Description: Depressiform, caudal fin lunate, inferior mouth with pectoral fin not reaching the origin of the pelvic fin.

Comments: Previously grouped under the *Homaloptera* genus and it is often found sympatrically with *Homalopteroides smithi* thus misidentification is possible.

Family SERRASALMIDAE

***Piaractus brachypomus* (Cuvier 1818)**

Common name: Red-bellied Pacu

Local name: Pacu

Native range: Amazon and Orinoco basins in South America.

Etymology: *Piaractus*: Greek, piar = fat, greasy + Greek, arktos = to bear; *brachypomus*: Greek, brachy = short + Greek, pōma = lid, operculum.

Description: Strongly compressiform, body finely scaled, mouth terminal, two rows of teeth on upper and lower jaw, small adipose fin, caudal fin truncated with red/orange belly, pectoral, pelvic and anal fin.

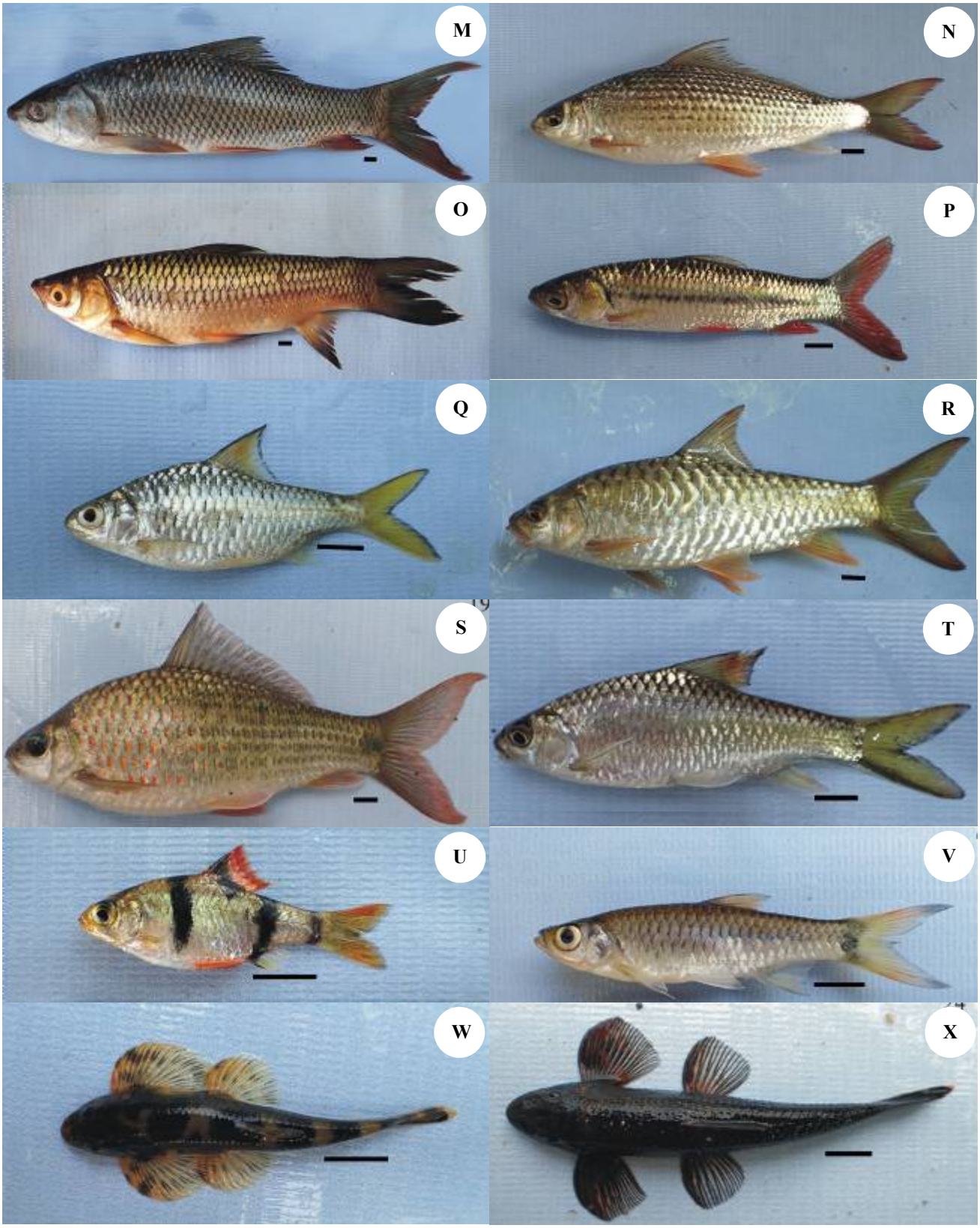

Figure 5. M. *Labeo rohita;* N. *Labiobarbus leptocheilus*; O. *Leptobarbus hoevenii*; P. *Leptobarbus rubripinna*; Q. *Mystacoleucus obtusirostris*; R. *Neolissochilus soroides*; S. *Osteochilus vittatus;* T. *Poropuntius smedleyi*; U. *Puntigrus partipentazona*; V. *Rasbora vulgaris*; W. *Homalopteroides smithi*; X. *Balitoropsis zollingeri.* Bar = 1 cm.

Comments: Not native to peninsula Malaysia and it is bred in aquaculture farms as food species. Feral population often found in low dissolved oxygen and turbid waters in slow flowing rivers and wetlands. Often sympatric with other introduced species.

Family LORICARIIDAE

***Pterygoplichthys disjunctivus* (Weber 1991)**

Common name: Vermiculated Sailfin Catfish

Local name: Bandaraya

Native range: Madeira basin in Bolivia and Brazil.

Etymology: *Pterygoplichthys*: Greek, pteryx = wing, fin + Greek, hoplon = weapon + Greek, ichthys = fish; *disjunctivus*: Latin, disjunctivus = disjoin, separated.

Description: Strongly despressiform, vermiculated pattern on ventral surface, mouth inferior, armored skin, caudal fin lunate and large dorsal fin.

Comments: Not native to peninsula Malaysia and introduced by the aquarium hobbyist industry. It is widespread in slow flowing rivers and wetlands with low oxygenated and turbid waters. It also has the capability of thriving in mesohaline conditions.

Family SISORIDAE

***Glyptothorax schmidti* (Volz 1904)**

Common name: (none)

Local name: Depu

Native range: Sumatra and Malay Peninsula.

Etymology: *Glyptothorax*: Greek, glyptes = carver + Greek, thorax = chest; *schmidti*: patronym could not be identified, probably in honour of ichthyologist Petr Yulevich Schmidt or biologist Johannes Schmidt.

Description: Depressiform, scaleless, caudal fin forked, barbels four pairs, uniformly dark body with prominent pale mid-dorsal and midlateral stripes, and thoracic adhesive apparatus present on ventral side. It can be further distinguished from other Sundaic congeners by referring to Ng and Kottelat (2016).

Comments: Ubiquitous and inhabits the benthic zone of well oxygenated torrential stream and river. The thoracic adhesive apparatus is adapted to adhere to rock surface to prevent the fish from being swept off by strong currents. It is often sympatric with *Balitoropsis zollingeri* and *Homalopteroides smithi*.

Family SILURIDAE

***Silurichthys schneideri* Volz 1904**

Common name: (none)

Local name: Gemang darat

Native range: South-eastern Thailand, northern Malay Peninsula and northern Sumatra.

Etymology: *Silurichthys*: Greek, silouros = catfish + Greek, odoús = tooth + Greek, ichthys = fish; *schneideri*: in honour Gustav Schneider.

Description: Without scales, exceptionally small dorsal fin, caudal fin rounded, mouth terminal and two long barbels. The species propel itself with wavelike flexure of long anal fin, normally termed as “ribbon fin”.

Comments: Found in slow flowing microhabitats with submerged decaying tree stumps or other organic debris.

Family CLARIIDAE

***Clarias* aff. *batrachus* (Linnaeus 1758)**

Common name: Walking Catfish

Local name: Keli kayu

Native range: Restricted to Sundaic region

Etymology: *Clarias*: Greek, chlaros = lively; *batrachus*: Greek, batrachos = frog-like, perhaps referring to its amphibious ability

Description: Mouth, scaleless dark body with numerous minute white spots, four pairs of barbels with thick fleshy bases, caudal fin rounded, dorsal fin extending to caudal peduncle and supraoccipital process more or less triangular.

Comments: Nocturnal and active by night. The species inhabits still swamps, canals and ditches with soft substrate of organic decaying material and soil sediment. Rarely found in the main rivers. The taxonomic identity of this species remains unclear and the authorities hypothesized that there may be four valid species of Javanese, Indian, Indochinese or Sundaland origins. Currently, the authorities have classified specimens from the Malay Peninsula and Borneo to be *C.* aff. *batrachus* "Sundaland" until the uncertainty is resolved (Ng and Kottelat 2008; Lee and Sulaiman 2015).

***Clarias gariepinus* (Burchell 1822)**

Common name: African Catfish

Local name: Keli afrika

Native range: Africa and Middle East

Etymology: *Clarias*: Greek, chlaros = lively; *gariepinus*: in honour of its type locality Gariep River (now known as Orange River) in South Africa.

Description: Scaleless body usually with irregular dark blotches on light grey background, white ventral surface, mouth terminal, caudal fin rounded, dorsal fin extending to caudal peduncle and supraoccipital process pointed.

Comments: Not native to peninsula Malaysia but widespread due to its tolerance to heavily polluted waters. It is extensively bred by the local aquaculture industry as food species. Feral population inhabits rivers and wetlands with soft muddy substrate.

***Clarias leiacanthus* Bleeker 1851**

Common name: Forest Walking Catfish

Local name: Keli mata kati

Native range: Throughout Sundaic and mainland Southeast Asia namely Cambodia, Vietnam, Thailand, Malay Peninsula, Singapore, Borneo and Indonesia.

Etymology: *Clarias*: Greek, chlaros = lively; *leiacanthus*: Greek, leios = smooth + Greek, akanthus = spine, thorn.

Description: Scaleless dark brown body marked with vertical rows of yellowish spots, mouth terminal, four pairs of barbels, caudal fin rounded and dorsal fin extending to caudal peduncle.

Comments: Individuals are commonly found in forested

or semi-disturbed freshwater or peat swamps and slow streams. It is often sympatric with *C.* aff. *batrachus* and *C. nieuhofii*.

***Clarias nieuhofii* Valenciennes 1840**

Common name: Slender Walking Catfish

Local name: Keli limbat

Native range: Throughout Sundaic and mainland Southeast Asia namely Cambodia, Vietnam, Thailand, Malay Peninsula, Singapore, Borneo, Philippines and Indonesia.

Etymology: *Clarias*: Greek, chlaros = lively; *nieuhofii*: in honour of Johan Nieuhof.

Description: Appearance resembles *C. leiacanthus* but possesses elongated eel-like body.

Comments: *C. nigricans* described in eastern Borneo (Ng 2003), *C. pseudonieuhofii* described in western Borneo (Sudarto et al 2004) and *C. gracilentus* described in Vietnam (Ng et al. 2011) were reported to be superficially resembled *C. nieuhofii.* Currently these anguilliform species are grouped under the "*C. nieuhofii"* taxonomic complex.

Family PANGASIIDAE

***Pangasianodon hypophthalmus* (Sauvage 1878)**

Common name: Iridescent Shark, Sutchi Catfish

Local name: Patin

Native range: Mekong, Chao Phraya and Mae Klong basins.

Etymology: *Pangasianodon*: Assamese, pangas = name of *Pimelodus pangasius* in India + Greek, an = without + Greek, odon = tooth; *hypophthalmus***:** Greek, hypo = below + Greek, ophthalmus = eyes.

Description: Scaleless body, mouth terminal, caudal fin forked, anal fin extending to caudal peduncle.

Comments: Not native to peninsula Malaysia but widespread in rivers due to escapees from the aquaculture industry. Due to its potamodromous nature, the species can be found in low oxygenated and turbid down or upriver but never in shallow fast waters. Attempt to cross breed non-native *P. hypophthalmus* and native *Pangasius nasutus* has successfully produced a hybrid for the aquaculture industry (Hassan et al. 2011), thus species identification of *P. hypophthalmus* may be inconsistent due to hybrids that may exist in the wild.

Family BAGRIDAE

***Hemibagrus capitulum* (Popta 1904)**

Common name: (none)

Local name: Baung

Native range: Southern Thailand, Sumatra, Malay Peninsula and Borneo.

Etymology: *Hemibagrus*: Greek, hemi = partial, half + Portuguese, bagrus = catfish; *capitulum*: Latin, capit = head + Latin, ulum = small.

Description: Scaleless body, depressed head, mouth terminal, four pairs of barbels, caudal fin deeply forked with upper lobe of caudal fin filamentous, and with adipose fin.

Comments: Usually found in downriver where water is lowly oxygenated and turbid. It is also valued as a food fish and bred by the aquaculture industry. Often misidentified as *H. nemurus* or *H. fortis* in many references and literature until Ng and Kottelat (2013) clarified their taxonomical status and localities; *H. nemurus* only occurs in Java Island.

***Mystus singaringan* (Bleeker 1846)**

Common name: (none)

Local name: Baung tikus

Native range: Throughout Sundaic mainland Southeast Asia namely Cambodia, Vietnam, Thailand, Malay Peninsula, Borneo and Indo-Malay archipelago.

Etymology: *Mystus*: Greek, mystax = whiskered; *singaringan*: Indonesian, *s*ingaringan = vernacular name for this species.

Description: Scaleless light yellow body, depressed head, mouth subterminal, caudal fin deeply forked, extended adipose fin, four pairs of barbels with maxillary barbels reaching beyond anal fin.

Comments: Usually inhabits slow and turbid down rivers and wetlands with soft muddy substrate.

Family APLOCHEILIDAE

***Aplocheilus armatus* (van Hasselt 1823)**

Common name: Blue Panchax

Local name: Kepala timah, Mata lalat

Native range: Pakistan, Nepal, Sri Lanka, India, Bangladesh, throughout Sundaic southeast Asia and Indo-Malay archipelago.

Etymology: *Aplocheilus*: Greek, aploe = simple + Greek, cheilos = lip; *armatus*: Latin, armatum = armed, armoured.

Description: Scaled body, mouth terminal, caudal fin rounded and a white spot on top of head.

Comments: Inhabits still freshwater and hypersaline waters of shallow vegetated canals, paddy fields, water pockets and ditches. It is a larvivorous fish with a reputation as biological control for mosquito larva.

Family POECILIIDAE

***Poecilia reticulata* Peters 1859**

Common name: Guppy

Local name: Gapi

Native range: Northern South America, coastal drainages Guyana, Suriname, of Venezuela, Trinidad, Tobago and the Brazilian states of Amapá and Pará.

Etymology: *Poecilia*: Greek, poikilos = variegated, embroidered; *reticulata*: Latin, reticulum = fine mesh, grid.

Description: Top of head scaled, caudal fin rounded and mouth terminal. The species displays sexual dimorphism where male has obvious color patterns and a slender modified anal fin (gonopdium) while the female is larger and colorless.

Comments: Not native to peninsula Malaysia. It is a larvivorous fish and it can tolerate polluted waters in lakes, ponds, canals and ditches.

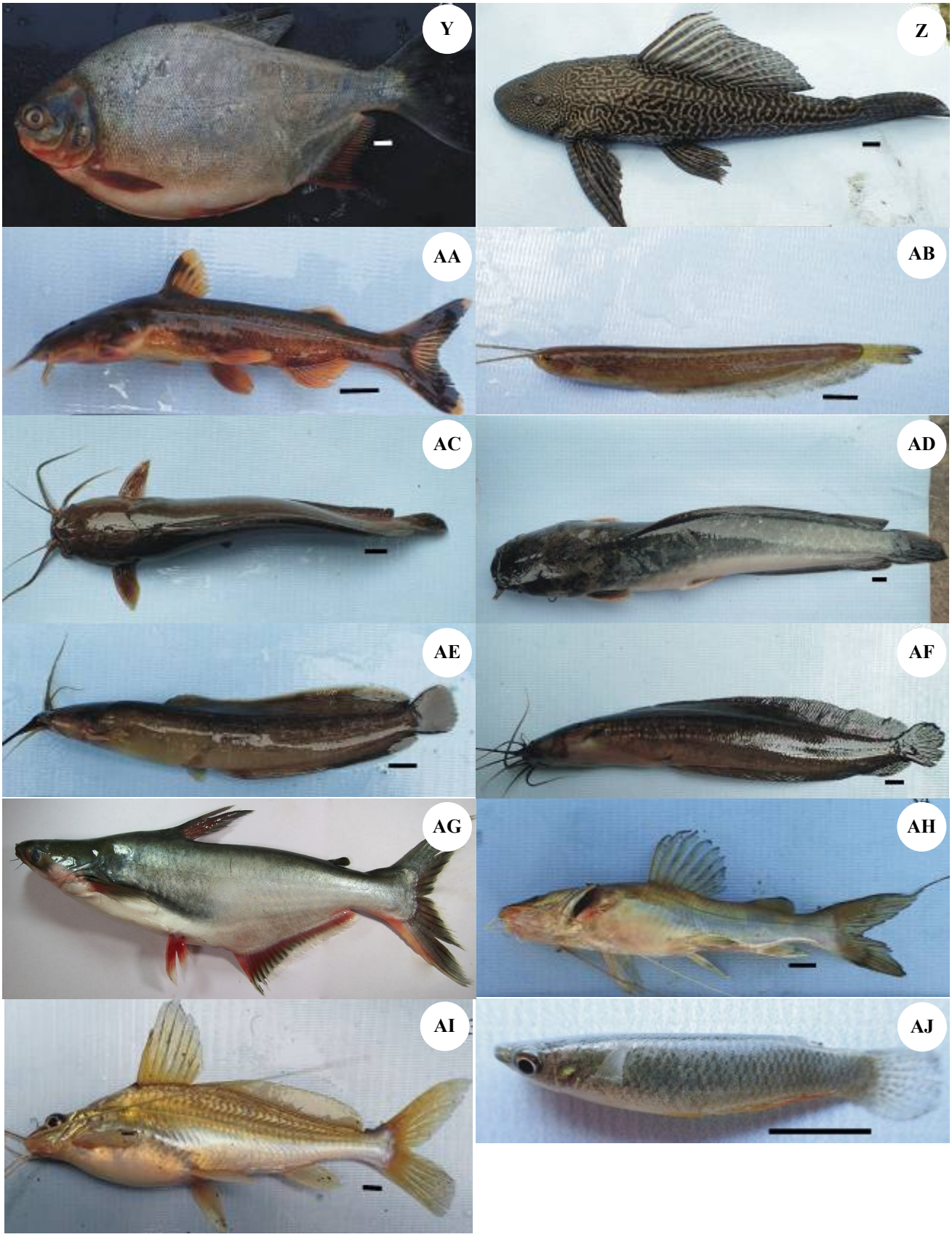

Figure 6. Y. *Piaractus brachypomus;* Z. *Pterygoplichthys disjunctivus*; AA. *Glyptothorax schmidti*; AB. *Silurichthys schneideri*; AC. *Clarias* aff. *batrachus*; AD. *Clarias gariepinus*; AE. *Clarias leiacanthus*; AF. *Clarias nieuhofii*; AG. *Pangasianodon hypophthalmus*; AH. *Hemibagrus capitulum*; AI. *Mystus singaringan*; AJ. *Aplocheilus armatus*. Bar = 1 cm

Family SYNBRANCHIDAE

***Monopterus javanensis* La Cepède 1800**

Common name: Rice Field Eel

Local name: Belut sawah

Native range: Sundaic southeast Asia from Fujian (China) to Indo-Malay archipelago.

Etymology: *Monopterus*: Greek, monos = one + Greek, pteron = fin; *javanensis*: denoting Java Island.

Description: Anguilliform scaleless body, gill openings at ventral, mouth terminal, pectoral and pelvic fin not present, caudal fin pointed and continuation from anal fin.

Comments: Inhabits shallow water with muddy substrate. In previous papers, this species was commonly cited as *M. albus*. However, a study found *M. albus* to be genetically divided into three clades, namely China-Japan, Ryukyu Islands, and southeast Asian clades (Matsumoto et al. 2010). Until their taxonomic statuses are clarified, Kottelat (2013) proposes that the southeast Asian population should be cited as *M. javanensis* and the China-Japan species population should be cited as *M. albus*. Species found in Ryukyu Islands in Japan has not been described and named yet; currently it is simply referred to as the "Ryukyuan" population.

Family MASTACEMBELIDAE

***Mastacembelus favus* Hora 1923**

Common name: Tire Track Eel

Local name: Tilan

Native range: Thailand to the Malay Peninsula.

Etymology: *Mastacembelus*: Greek, mastax = mouth + Greek, emballo = to throw in; *favus*: Latin, favus = honeycomb

Description: Anguilliform body, body scales minute, a row of short dorsal spines (33-37), anal spine present, short flexible and fleshy snout, no pelvic fin, body pattern extending to abdomen, caudal fin pointed and continuation from anal fin.

Comments: Inhabits slow unpolluted waters with sandy/rocky substrate. The species is usually misidentified as *M. armatus* in many reports. In some reports, it may be cited as *M. armatus* var. *favus.* However, Roberts (1986) clarified that *M. armatus* has many distinctions from *M. favus*. He also warns that the two species may be sympatric in some Thai localities but not in Malay Peninsula. Kottelat (2013) recognizes *M. armatus* and *M. favus* as two valid species.

Family AMBASSIDAE

***Parambassis siamensis* (Fowler 1937)**

Common name: Glassperch

Local name: Seriding

Native range: Mekong, Mae Khlong , Chao Phraya basin in Indochina, Thailand and Malay Peninsula. Population in Singapore and Indonesia are introduced (Roberts 1994; Ng et al. 1993; Ng & Lim 1997)

Etymology: *Parambassis*: Greek, para = near + Greek, anabasis = ascending; *siamensis*: denoting Siam, or Thailand.

Description: Body strongly compressiform, mouth terminal, caudal fin forked, eye preorbital bone with serration on ridge and edge, deep notch on dorsal fin, notable black blotch at spinous dorsal fin and entire body appears translucent.

Comments: Inhabits still water or very slow flowing water in the weedy marginal zones of lower rivers, ponds, ditches, canals, lakes and wetland.

Family PRISTOLEPIDIDAE

***Pristolepis fasciata* (Bleeker 1851)**

Common name: Malayan Leaffish

Local name: Patung

Native range: Sundaic southeast Asia and Malay-Indo archipelago.

Etymology: *Pristolepis*: Greek, pristis = saw + Greek, lepis = flake, scale; *fasciata*: Latin, fascia = band, strip, stripe.

Description: Body strongly compressiform, mouth terminal, caudal fin rounded, lateral line interrupted.

Comments: Inhabits turbid still vegetated ponds, wetlands and slow flowing canals. Rarely found in the main rivers.

Family CICHLIDAE

***Cichla monoculus* Spix & Agassiz 1831**

Common name: Peacock Cichlid

Local name: (none)

Native range: Brazil, French Guiana, Guyana and Suriname.

Etymology: *Cichla*: Greek, kichle = wrasse; *monoculus*: Latin, mono = one + Latin, culus = eye.

Description: Scaled compressiform body, mouth terminal, discontinued lateral line, caudal fin truncated, ocellated on posterior end of hypural plate and three broad bars with some black spots on yellowish body.

Comments: Not native to peninsula Malaysia. It was first introduced by anglers as game fish into mining pools of Batu Gajah and Air Kuning in Perak (DOF 2007). It is now widespread in lakes and wetlands. The taxonomic diversity and ecological behaviours of cichlid fishes from Middle America and Africa are extensively discussed by Rican et al. (2017).

***Mayaheros urophthalmus* (Günther 1862)**

Common name: Mayan Cichlid

Local name: (none)

Native range: México, Belize, Nicaragua, Honduras and eastern Guatemala,

Etymology: Mayaheros: Maya = Mesoamerican Mayan people + Mayan, heros = hero; *urophthalmus*: Greek, oura = tail + Greek, ophthalm = relating to eye.

Description: Compressiform scaled body, mouth terminal, branchiostegal membrane pink/orange, seven (sometimes eight) bars on body and dark blotch on truncated caudal fin base.

Comments: Not native to peninsula Malaysia. An euritopic species that can tolerate a wide range of environment in lowland freshwater lakes, canals, wetlands and brackish biotopes.

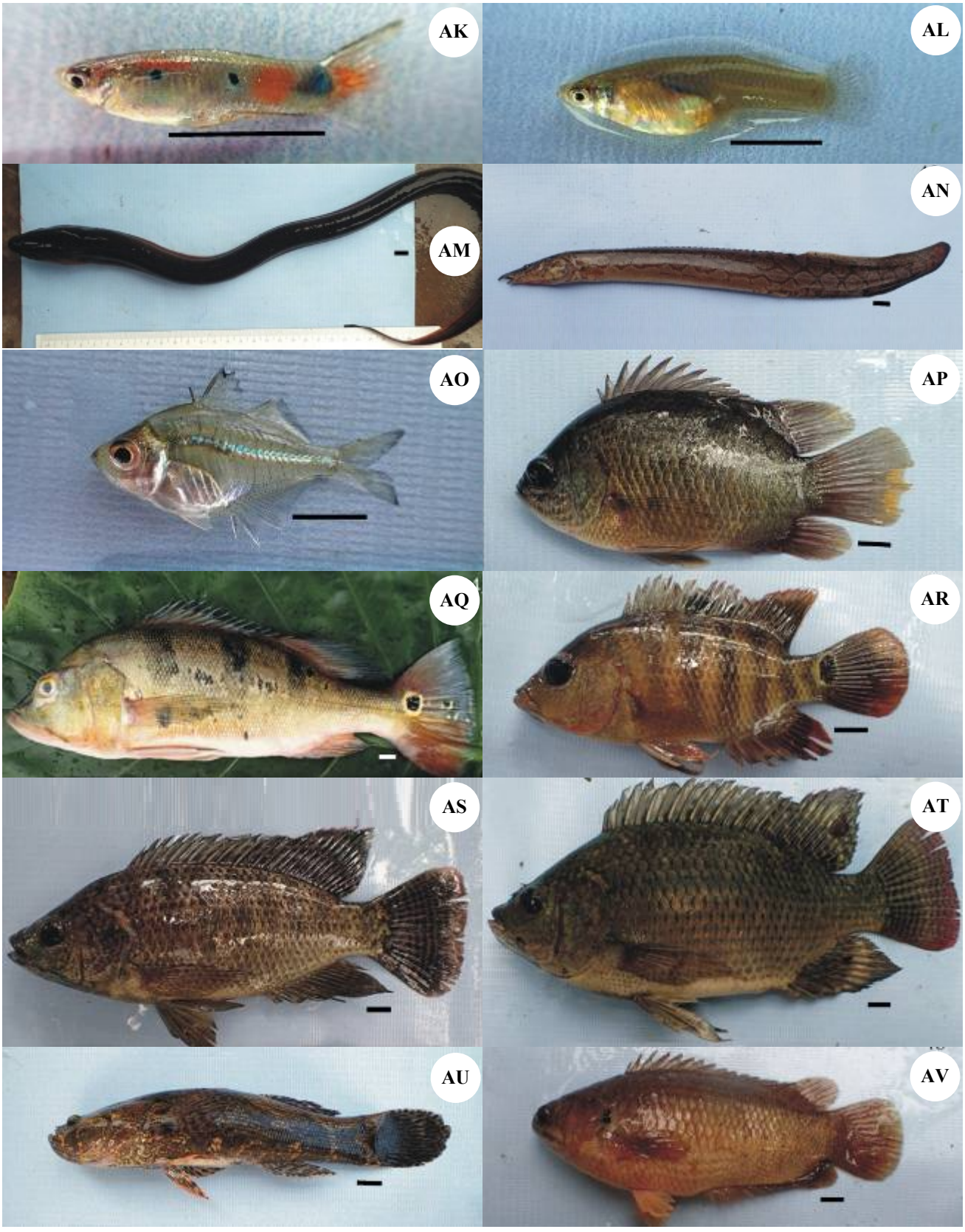

Figure 7. AK. *Poecilia reticulata* (male.; AL. *Poecilia reticulata* (female.; AM. *Monopterus javanensis*; AN. *Mastacembelus favus*; AO. *Parambassis siamensis*; AP. *Pristolepis fasciata*; AQ. *Cichla orinocensis*; AR. *Mayaheros urophthalmus*; AS. *Oreochromis aureus*; AT. *Oreochromis niloticus*; AU. *Oxyeleotris marmorata*; AV. *Anabas testudineus.* Bar = 1 cm

***Oreochromis aureus* (Steindachner 1864)**

Common name: Blue tilapia

Local name: Tilapia

Native range: Northern and Western Africa, and the Middle East.

Etymology: *Oreochromis*: Greek, oreos= mountain + chromis = fish; *aureus*: Latin, aurum = golden.

Description: Compressiform scaled dark body, mouth terminal, caudal fin truncated, metallic blue cheek.

Comments: Not native to peninsula Malaysia and introduced by the aquaculture industry. Feral population inhabits shallow waters in wetland with sandy substrate which the males require to build spawning pits.

***Oreochromis niloticus* (Linnaeus 1758)**

Common name: Nile tilapia

Local name: Tilapia

Native range: Northern and eastern Africa.

Etymology: *Oreochromis*: Greek, oreos= mountain + chromis = fish; *niloticus*: denoting Nile River.

Description: Compressiform scaled dark body, mouth terminal, small vertical stripes throughout depth of truncated caudal fin.

Comments: Not native to peninsula Malaysia and introduced by the aquaculture industry. It is also often misidentified as sympatric species *O. aureus*.

Family ELEOTRIDIDAE

***Oxyeleotris marmorata* (Bleeker 1852)**

Common name: Marble Goby

Local name: Ketutu

Native range: Throughout Sundaic southeast Asia namely Cambodia, Vietnam, Thailand, Malay Peninsula, Borneo and Indonesia.

Etymology: *Oxyeleotris*: Greek, oxys = sharp + Greek, eleos = bewildered; *marmorata*: Latin, marmorō = marble.

Description: Fine scaled body with mottled pattern, mouth terminal, lower jaw projecting, head broad and flattened, caudal fin rounded and with two separate dorsal fins.

Comments: Found in ponds, lakes and swamps. Not usually found in running rivers and fast rapids.

Family ANABANTIDAE

***Anabas testudineus* (Bloch 1792)**

Common name: Climbing perch

Local name: Puyu

Native range: Widespread throughout India, throughout Sundaic southeast Asia namely Cambodia, Vietnam, Thailand, Malay Peninsula, Borneo and Indonesia.

Etymology: *Anabas*: Greek, anabasis = climbing up; *testudineus*: Latin, testudo = tortoise + Latin, ineus = made from.

Description: Scaled body, mouth terminal, caudal fin rounded, with operculum serrated with spines, dark spot on opercle posterior margin and caudal peduncle. Color in life ranges from green, olive, light brown to dark.

Comments: Occurs in muddy, turbid, stagnant water bodies. It is an obligate air breather with a distinct ability to survive in hypoxic waters or for several days out of water. Several species may be confused under the name *A. testudineus* and awaiting further clarification (Kottelat 2013).

Family HELOSTOMATIDAE

***Helostoma temminckii* Cuvier 1829**

Common name: Kissing gourami

Local name: Temakang

Native range: Widespread throughout Sundaic southeast Asia namely Cambodia, Vietnam, Thailand, Malay Peninsula, Borneo and Indonesia.

Etymology: *Helostoma*: Greek, helo = nail + Greek, stoma = mouth; *temminckii*: in honour of Coenraad Jacob Temminck.

Description: Scaled body strongly compressed laterally, caudal fin indented and mouth terminal with brown-colored protrusible thick lips.

Comments: While the variety offered by the fishkeeping hobby industry is typically pinkish, the wildtype is usually dark green. It is associated with moderately turbid and clear water habitats with submerged vegetation.

Family OSPHRONEMIDAE

***Betta pugnax* (Cantor 1849)**

Common name: Penang Betta

Local name: Sepilai batu

Native range: Malay Peninsula and Singapore.

Etymology: *Betta*: Malay, betah = persistent, or resolute; *pugnax*: Latin, pugnax = combative.

Description: Head rhombic when viewed dorsally, greenish to bluish iridescent spots on the scales and operculum, mouth terminal and caudal fin broadly lanceolate.

Comments: Usually found in peripheries of stagnant water pockets in hillside streams with overhanging riparian vegetation and rocky sandy substrate. Taxonomic and distribution account of *B. pugnax* and other species in the *Betta* genus is discussed and described extensively in Tan and Tan (1996) and Tan and Ng (2005) .

***Trichopodus pectoralis* Regan 1910**

Common name: Snakeskin gourami

Local name: Sepat siam

Native range: Mekong and Chao Phraya basins in Cambodia, Laos, Thailand, Vietnam and Myanmar.

Etymology: *Trichopodus*: Greek, tricho = hair + Greek, podus = leg; *pectoralis*: Latin, pectus = pectoral, breast.

Description: Mottled lateral stripe across body, mouth terminal, caudal fin slightly emarginated, long filamentous pelvic fin ray extending posteriorly to caudal fin.

Comments: Not native to peninsula Malaysia. Capable of breathing atmospheric air and can tolerate turbid and low oxygenated water in stagnant ponds and swamps.

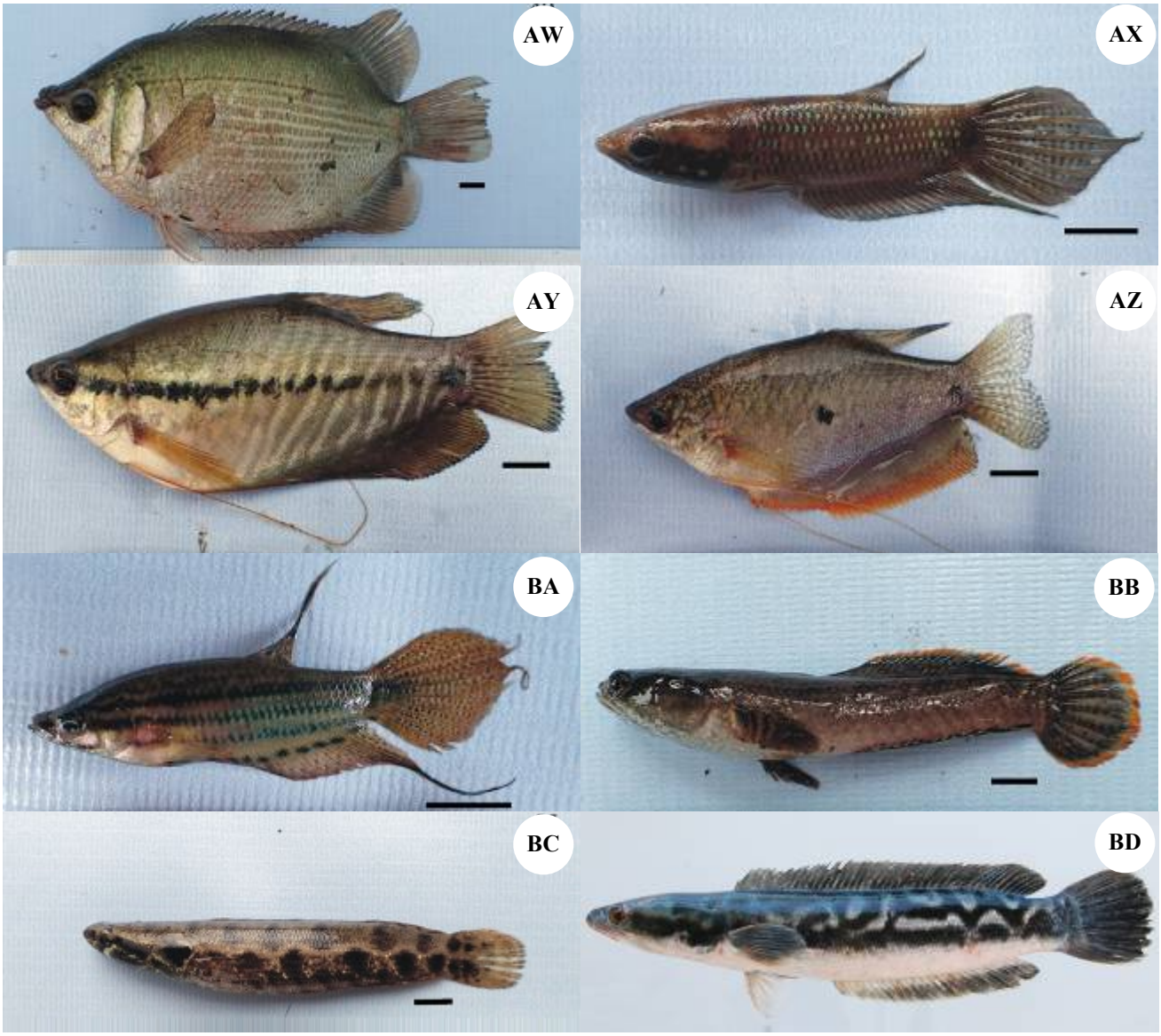

Figure 8. AW. *Helostoma temminckii*; AX. *Betta pugnax*; AY. *Trichopodus pectoralis*; AZ. *Trichopodus trichopterus*; BA. *Trichopsis vittata*; BB. *Channa gachua*; BC. *Channa lucius*; BD. *Channa micropeltes*. Bar = 1 cm

***Trichopodus trichopterus* (Pallas 1770)**

Common name: Three spot gourami

Local name: Sepat ronggeng

Native range: Widespread throughout the Sundaic mainland southeast Asia and Malay Peninsula.

Etymology: *Trichopodus:* Greek, tricho = hair + Greek, podus = leg; *trichopterus*: Greek, tricho = hair + Greek, pterón = wing.

Description: Mouth terminal, two spots on the body, caudal fin slightly emarginated, long filamentous pelvic fin ray with orange spotted anal and caudal fin.

Comments: Found in low oxygenated lowland ponds, lakes and swamps. Not usually found in running rivers and fast rapids. It is often sympatric with other species from the Osphronemidae family.

***Trichopsis vittata* (Cuvier 1831)**

Common name: Croaking Gouramy

Local name: Karim

Native range: Widespread throughout the Sundaic mainland southeast Asia and Indo-Malay archipelago.

Etymology: *Trichopsis*: Greek, *tricho* = hair + Greek, ópsis = appearance; *vittata*: Latin, vittatus = stripe, band.

Description: Body usually with three lateral stripes, mouth terminal, caudal fin broadly lanceolate and long filamentous pelvic fin ray.

Comments: Commonly found in lowland swamp habitat with dense vegetation.

Family CHANNIDAE

***Channa gachua* (Hamilton 1822)**

Common name: Dwarf Snakehead

Local name: Haruan kedak

Native range: Sundaic mainland southeast Asia and Indo-Malay archipelago.

Etymology: *Channa*: Latin, channe = referring to a form of sea perch; *gachua*: Bengali, gachua = vernacular name for this species.

Description: Scaled body, mouth terminal, red/orange margin on long dorsal, anal and rounded caudal fin.

Comments: Usually found in slow moving waters in hillside streams with overhanging riparian vegetation and rocky sandy substrate. Conte-Grand et al. (2017) reported that species commonly cited as *Channa gachua* in many papers may be erroneous. This species is involved in a complex of two widespread phylogenetic lineages. They propose that the true *C. gachua* belongs to the western lineage that covers Bangladesh, India, Nepal, Sri Lanka and Myanmar (Rakhine region). They also suggest that specimens should be cited as *C. limbata* if they are encountered in eastern lineage which covers Myanmar towards Vietnam, southern China, Thailand, peninsular Malaysia and Indonesia. Until further detailed studies emerge to conclusively validate the eastern lineage, this paper continues to adopt *Channa gachua.*

***Channa lucius* (Cuvier 1831)**

Common name: Forest Snakehead

Local name: Bujuk

Native range: Widespread throughout Tenasserim mountain range in Myanmar east to the Mekong and south to the Indo-Malay archipelago.

Etymology: *Channa*: Latin, channe = referring to a form of sea perch; *lucius*: Latin, lucius = light.

Description: Scaled body, mouth terminal, caudal fin rounded, a series of black blotches on body and oblique bars on abdomen.

Comments: Commonly found in lowland swamp habitat with dense vegetation and submerged large woody debris and snag.

***Channa micropeltes* (Cuvier 1831)**

Common name: Giant Snakehead

Local name: Toman

Native range: Widespread throughout the Sundaic mainland southeast Asia and Indo-Malay archipelago.

Etymology: *Channa*: Latin, channe = referring to a form of sea perch; *micropeltes*: Greek, mikros = small + Greek, pelte = shield.

Description: Scaled body, mouth terminal, caudal fin rounded, blue, green, purple or pink patterns along with black irregular lateral stripes on body (juveniles have two clear stripes) and prominent canine teeth.

Comments: Occurs in deep pond, lakes and wetlands.

***Channa striata* (Bloch 1793)**

Common name: Striped Snakehead

Local name: Haruan

Figure 9. BE. *Channa striata*. Bar = 1 cm

Native range: Pakistan, Peninsula India, Sundaic mainland southeast Asia and Indo-Malay archipelago.

Etymology: *Channa*: Latin, channe = referring to a form of sea perch; *striata*: Latin, striatus = striped.

Description: Scaled body, mouth terminal, caudal fin rounded, faint chevron bars on body with white ventral surface.

Water quality results and visuals

A total of 144 water samples were extracted from October 2015 to March 2017 in the four studied zones to examine the monthly water physico-chemistry variances. Visual data for physical quality of each zone and the corresponding water physico-chemistry values are presented in Figure 10, 11, 12 and 13.

Discussion

Not only a checklist is a valuable reference for species identification, a site specific checklist is also the most basic data that reflects the characteristics of local species composition for comparison with other localities. As such, the data of this study is placed into broader context by considering some previous researches in adjoining drainages to deepen the understanding of species biogeography. The discussion may be useful to researchers operating in those drainages for building their own species list for monitoring water quality.

Whilst this study recorded 23 families, 44 genera and 56 species, literature review reveals that 1) Ikhwanuddin et al. (2017) recorded 11 families, 23 genera and 26 species in Pelus River catchment; 2) Farinordin et al. (2017) recorded a collective total of 14 families, 23 genera and 25 species in Sah River, Chepor River and Tambun River located in western Ipoh; and 3) Hashim et al. (2012) recorded 33 families, 71 genera and 107 species in Perak River catchment. This implies that Kampar River catchment (400 km^2) harbours a higher level of species diversity compared to upper Pelus River (170 km^2) and the mentioned river catchments (46 km^2) located western Ipoh. This is to be expected and consistent with the "area" hypothesis first proposed by MacArthur (1969). Biogeographically, the level of species richness tends to increase in proportion to the size of watershed as there are more lentic and lotic heterogeneity to drive allopatric and sympatric speciation processes (Lohman et al. 2011). Correspondingly, Perak River catchment (11,900 km^2) recorded a much higher diversity.

Figure 10. Zone A is located in 4° 27' 11.3322", 101° 13' 14.3256" and the environment may be typically characterised by riverbanks that are stable and protected by natural vegetation. There is a mix of riffles, shallow and deep pools to provide habitat heterogeneity complexity in the lotic system. The mean average water physico-chemistry values (n=36, mean±SD) measured were DO = 8.97±0.86 mg/L; BOD_5 = 7.03±2.65 mg/L; COD = 21.36±6.80 mg/L; pH = 7.09±0.31; TSS = 43.36±129.39 mg/L; TUR 68.35±206.23 FAU; AN = 0.0250±0.0243 mg/L; FE = 0.2386±0.4233 mg/L; NO_2-N = 0.0053±0.0029 mg/L; NO_3-N = 6.54±3.09 mg/L; PO_4 = 0.7081±0.9339 mg/L; and SO_4 = 5.14±6.65 mg/L.

Figure 11. Zone B is located in 4° 22' 42.744", 101° 9' 42.4794" and the environment may be typically characterised by evidences of past channel incising, aggrading and some recovery. Vegetation gaps existed along the riparian area. No pool or riffle was observed in the slow flowing lotic system. The mean average water physico-chemistry values (n=36, mean±SD) measured were DO = 7.62±0.61 mg/L; BOD_5 = 6.86±2.46 mg/L; COD = 19.50±3.60 mg/L; pH = 6.94±0.31; TSS = 29.19±32.66 mg/L; TUR 44.14±44.29 FAU; AN = 0.0353±0.0305 mg/L; FE = 0.4714±0.4787 mg/L; NO_2-N = 0.0051±0.0033 mg/L; NO_3-N = 4.47±1.94 mg/L; PO_4 = 0.2061±0.1074 mg/L; and SO_4 = 1.69±1.77 mg/L

The evidence from this study combined with other studies discussed implies that the relationship between area size and species diversity in said catchments can be expressed by exponential trend line $y = 17.627e^{0.0601x}$ (Figure 14). This can be taken as the ichthyofaunal benchmark for guiding future inventory studies in nearby or distant drainages in Malaysia or other tropical regions with similar fluvial dentritic and geomorphological characteristics. The trend line may be refined in the future when more inventory records at alpha, beta and gamma levels are available in the region.

Besides empirical outputs, it would be constructive to discuss how a species list should be enriched with visual outputs for river conservation applications. Since fish-based studies pertaining to molecular, ecological, conservation, aquaculture and water quality indication analysis are becoming prevalent, a checklist needs to reach out to the widest audience. Whenever possible, full color

Figure 12. Zone C is located in 4° 20' 3.6378", 101° 5' 20.3352" and the environment may be typically characterised by riparian clearings and channel straightening. Steep banks and failures were prominent. Sediment deposition, sandy and muddy substrates have caused the channel to be shallow in certain parts.The mean average water physico-chemistry values (n=36, mean±SD) measured were DO = 6.80±0.59 mg/L; BOD_5 = 7.25±3.02 mg/L; COD = 21.17±0.19 mg/L; pH = 7.06±0.32; TSS = 43.22±29.14 mg/L; TUR 57.42±37.65 FAU; AN = 0.0608±0.0483 mg/L; FE = 0.5944±0.3666 mg/L; NO_2-N = 0.0164±0.0097 mg/L; NO_3-N = 5.12±2.38 mg/L; PO_4 = 0.2294±0.0961 mg/L; and SO_4 = 2.19±1.78 mg/L.

Figure 13. Zone D is located in 4° 19' 31.9044", 101° 5' 24.9684" and the environment may be typically characterised by lentic systems, mostly isolated ponds and lakes. The region is heavily disturbed by anthropogenic activities. The mean average water physico-chemistry values (n=36, mean±SD) measured were DO = 6.01±2.10 mg/L; BOD_5 = 5.39±2.26 mg/L; COD = 18.80±3.40 mg/L; pH = 7.26±0.39; TSS = 23.03±12.17 mg/L; TUR 30.67±15.94 FAU; AN = 0.1542±0.2090 mg/L; FE = 0.3856±0.2826 mg/L; NO_2-N = 0.0166±0.0236 mg/L; NO_3-N = 7.01±2.49 mg/L; PO_4 = 1.23±1.01 mg/L; and SO_4 = 1.31±1.70 mg/L.

photographs should be provided for every species to help distinguish species from their morphological and pigmentation patterns. The standard textual dichotomous keys and descriptions are often too complex for non-ichthyologists to grasp and without photographic aid, it may discourage the use of fish as biological indicators. Moreover, non-ichthyologists typically have no access to holotypes or reference specimens archived in museums, and taxonomists are normally too few or too busy to assist.

There are already far too many checklists and ichthyofaunal reports that are published without visual supplements and taxonomic errors may cause confusions when they are perpetuated in subsequent publications. This is well highlighted and discussed by Iglésias et al. (2010). In the Sundaic region where the level of biodiversity is exceptionally high, species and their congeners may exhibit very close resemblances and identification errors are possible. It is critically important to provide accurate

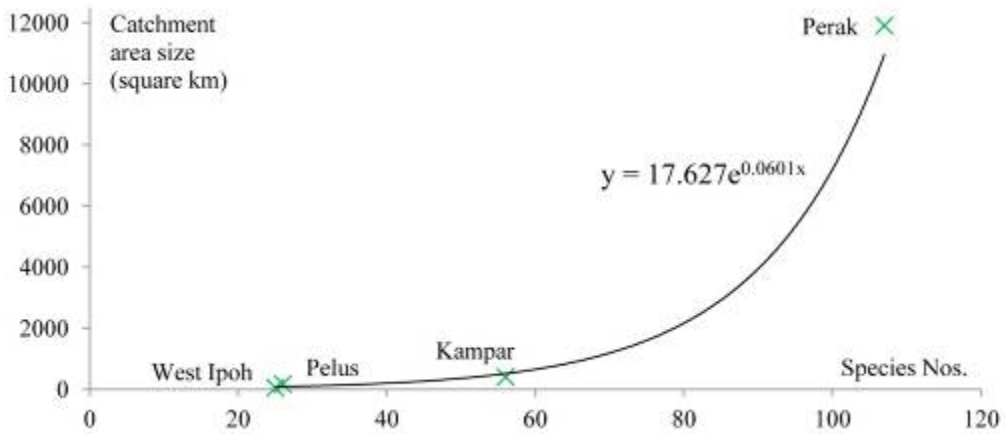

Figure 14. Exponential curve expressing the relationship between catchment area size and species diversity in adjoining drainages

photographic documentation of fresh specimens to enable reassessment by experts so that identification mistakes may be conveyed to the author(s) in a timely manner. In the advent of cheaper and better cameras and the proliferation of online journals, printing cost is no longer an issue for papers that are supplemented with color images. This may also improve the understanding and stimulate discussion on pigmentation, pattern and morphological variation caused by phenotypic polymorphism that normally occurs in fishes encountered at different limnological regions. It should be recognized that a scientific report is openly published for sharing data and to invite scrutiny as a way for quality control. When published, the visual representation of species will be much more widely scrutinized than specimens deposited in faraway museums.

The data presented herein has two limitations. Firstly, as mentioned earlier, the studied region is still in exploration and discovery phase in terms of ichthyology. The check list enumerated herein is preliminary at best and the variety of species is expected to increase as more lateral and longitudinal surveys along the main river and tributaries that feed into Kampar River are carried out in the future. Future studies should include night sampling to unveil nocturnal species for refining the checklist. Secondly, some species taxonomic statuses and valid scientific names are still unsettled and problematic although they were described long ago, such as *Barbodes* cf. *rhombeus*, *Channa gachua*, *Clarias* aff. *batrachus* and possibly *Anabas testudineus* that are involved in complexes. However, this does not mean that the taxonomic statuses of other species are stable. Revision shocks in fish taxonomy are common and non-ichthyologists should not to be distracted by emerging nomenclature and taxonomic problems. Contentious identification issues take time to be resolved and they are inevitable in the field of taxonomy. Such concerns should be left to trained ichthyologists to monitor as they have a professional duty to validate and update the literature with the most current and valid species scientific names. It should be stressed that there is currently no universal criteria or platform for updating and crosschecking valid scientific names in a real time manner. Taxonomic nomenclatural consistency for all fish species is an elusive ambition, a fact well understood by ichthyologists. Therefore it is always important to refer to the most current reviews or species descriptions published by the authorities to communicate species identity.

Last but not least, it should be stressed that the approaches presented in this paper is not intended to replace the expertise of ichthyologists and taxonomists. Although their numbers may be few in our region, every effort should be made to consult them whenever possible for counterchecking species identity to ensure only accurate reports are published.

In conclusion, we show how fish diversity can be investigated, enumerated and transformed into direct application for monitoring purposes. Report presented herein also contains concise details of water quality ranges of each limnological zone. Identification descriptions and images are also provided to further assist the stakeholders who are interested to apply fish as bioindicator for freshwater resource monitoring and management. Although this study so far has only been on a small scale, the approaches and outcomes reported in this paper are valuable in a global context. If similar taxonomic references that correspond with water-physico-chemistry data are provided and practically advanced by researchers, globally, more stakeholders and policymakers may apply and support freshwater fish as biological indicator for monitoring freshwater resources reliably.

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