

## **CHECKLIST OF FISHES FROM HULU TERENGGANU HYDROELECTRIC PROJECT: A FUTURE PERSPECTIVE**

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### **ABSTRACT**

Hulu Terengganu Hydroelectric Project (HTHP) involved the construction of two new dams which led to the creation of Puah Reservoir with 60 km<sup>2</sup> surface areas and Tembat Reservoir (1.3 km<sup>2</sup>). As a result, there are changes of the existing physicochemical water quality properties from the lotic condition to lentic, which indirectly impact the presence of aquatic organisms, especially fishes at the proposed project areas. The purpose of this paper is to provide the existing fish checklist and conservation status related to future perspective on fisheries management via public stocking. Multiple fishing gears such as long line, different mesh size of gillnets, cast net, and electro-shocker were used in this study covering prior construction, during construction and operation phase of development. No protected fish species under Terengganu Fish Act was sampled during the study. A total of 29 fish species were recorded with cyprinids as the dominant fish family caught in HTHP. The presence of Tilapia (*Oreochromis* spp.) an introduced fish species especially at Puah Reservoir is alarming as it showed the changes in the existing fish biodiversity. Such human induced activities should be prohibited to ensure that local fish species are not affected. Future public stocking by Department of Fisheries (DoF) or locals will affect the existing fish diversity in this newly operated water reservoirs.

**Keywords:** fish biodiversity, conservation status, fisheries management, future perspective.

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## INTRODUCTION

Most reservoirs were constructed for hydroelectric power, water supply for domestic and irrigation and flood control. These reservoirs also contribute to food sources for the local community as well as recreational fisheries for tourists (Yusoff *et al.*, 1995). According to Li and Xu (1999), after impoundment, there are significant changes in fish fauna diversity because of changes in the hydrological regimes and biological conditions. Most of the fish colonizing reservoirs in Malaysia are riverine species as the absence of natural lakes has pre-empted the evolution of true lacustrine fish species (Yusoff & Gopinath 1995).

The documentation of freshwater fish diversity at Tembat Forest Reserve has begun since 2005 by Shah *et al.* (2005) at Sungai Tembat and Sungai Terengganu Mati. The study reported 26 species of fishes belonging to seven families and 19 genera. A study by Rovie-Ryan *et al.* (2008) on fish species from Sungai Tembat and Sungai Ketiar, reported 219 specimens representing eight families and 22 species. Recently, Shah *et al.* (2015) studied the distribution of fishes at Sungai Terengganu Mati and Sungai Tembat within Kenyir covering the upper, within (inundated area) and downstream zones of the proposed project areas and reported a total of 36 species from both tributaries with *Poropuntius smedleyi* as the most dominant species representing 36.8% and 61.3% at Sungai Terengganu Mati and Sungai Tembat, respectively. Meanwhile, Aisah *et al.* (2015) conducted a series of fish rescue program during the diversion of Sungai Puah and impoundment of Puah Dam. The rescue activities recorded 20 species with *Mystacoleucus obtusirostris* being the most abundant species (92%). On the other hand, a research done by Shahril *et al.* (2015) at Sungai Tembat near the ongoing construction of Tembat Dam, reported the dominance of three species; which were *Hemibagrus gracilis* (44%), *Tor tambra* (22%), and *Neolissochilus soroides* (19%).

The construction of Puah and Tembat hydroelectric dam in Tembat Forest Reserve, Hulu Terengganu has begun since 2010 by Tenaga Nasional Berhad (TNB). This project is also known as Hulu Terengganu Hydroelectric Project (HTHP), which created the Puah Reservoir and Tembat Reservoir. Once

completed, these hydroelectric plants will generate a total of 265MW electricity at peak per annum via national grid. The characteristic of each reservoir is summarised in Table 1.

**Table 1** Hulu Terengganu Hydroelectric Project (HTHP) reservoir characteristic.

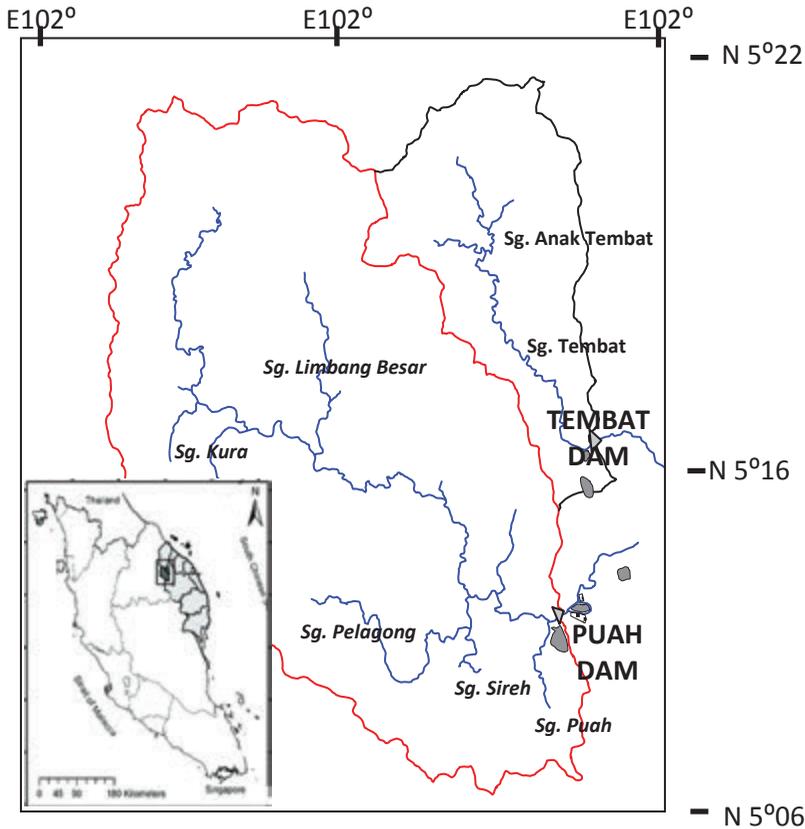
<b>Reservoir</b>	<b>Puah</b>	<b>Tembat</b>
Inflow rivers	Sg. Terengganu Mati, Sg. Limbang, Sg. Kura, Sg. Sirih	Sg. Anak Tembat, Sg. Tembat
River order	5 <sup>th</sup>	4 <sup>th</sup>
River distances (km)	20 (before impoundment)	14 (before impoundment)
Catchment areas (km <sup>2</sup> )	410	101
Surface areas (km <sup>2</sup> )	60	1.3
Average depth (z m)	22	7
Riparian flow	1.0 m <sup>3</sup> /sec	0.5 m <sup>3</sup> /sec

The objective of this study is to characterise the present status of the fish species that been recorded in Puah Reservoir and Tembat Reservoir based on their conservation status and postulated their future perspective. This study is part of the large joining program by TNB Research Sdn. Bhd. (TNBR) together with Universiti Kebangsaan Malaysia (UKM) and Universiti Sains Malaysia (USM) to monitor fish community changes in Hulu Terengganu area before and during construction phases and also during the operation of this electric hydropower project once the construction completed.

## MATERIALS AND METHODS

### Study Site

Generally, the study areas are located within Hulu Terengganu catchment area which consists of two main rivers; namely Sg. Terengganu Mati and Sg. Tembat, and their tributaries, (Figure 1). The study was conducted at both rivers, from 2002 till 2016. This paper presents the results from three sampling zones, i.e. riverine, transition and lacustrine zones of Puah Reservoir and Tembat Reservoir.



**Figure 1** Catchment areas, main river tributaries of Puah Reservoir and Tembat Reservoir before impoundment.

### Specimen Collection

Various types of fishing gears which includes electro-shocker, multiple sizes of gill nets, cast net and long lines were used for sampling. However, electric-shocker was used only to collect fishes in the riffles and shallow zones with depth less than 1 meter. Electrocutted fishes were obtained with the help of scoop nets. For gillnets and long lines, two sets of nets and lines were set-up for 48 hours before moving to other sampling stations, whereas castings using two nets were carried out for 1 hour per location at deeper riverine sections.

The specimens collected were sorted, counted and identified up to the species level based on keys in Kottelat *et al.* (1993) and Rainboth (1996), whereas species nomenclature followed Kottelat (2013). Measurement of total length (cm) and weight (g) for each specimen was also recorded. After identification and data gathering, a few selected specimens representing each species were

preserved in 5% formalin as voucher specimens and archived at School of Biological Sciences, Universiti Sains Malaysia (USM).

## RESULTS

A total of 29 fish species from nine families were recorded from 2002 till 2016 study. Most of these fish species are classified as a riverine species and the species recorded are summarised in Table 2. Puah Reservoir recorded the highest diversity of fishes with 29 species, while Tembat Reservoir only recorded 25 species (Table 2). In the present sampling, none of the protected fish species under Terengganu Fisheries Act such as Asian arowana (*Scleropages formosus*) or Jullien's golden carp (*Probarbus jullieni*) were caught in both reservoirs.

Cyprinidae was the most dominant family representing 60.0% of the total species caught followed by Bagridae (10.0%), Channidae and Mastacembelidae (6.7%) and the remaining species were recorded as singletons (3.3%) (Table 2). Result also indicated that *Poropuntius smedleyi* (Tengas Daun) was the dominant species caught at Puah Reservoir and Tembat Reservoir with 36.8% and 61.3% of total specimen caught, respectively. The other dominant fish species of Puah Reservoir and Tembat Reservoir is blunt-snout barb (*Mystacoleucus obtusirostris*) (5.0%) and river catfish (*Hemibagrus* spp.) (7.1%), respectively.

Out of 29 fish species, only one exotic species i.e. tilapia (*Oreochromis niloticus*) were recorded at Puah Reservoir, while the other species were either classified as native or indigenous species (Table 2). According to IUCN Red List of Threatened Species Database; 21 species are categorized as Least Concern (LC), six species were not evaluated (NE), while two species (*Epalzeorhynchus kalopterus* and *Tor tambra*) are Data Deficient (DD) (Table 2). Twenty one fish species in the list can be consumed while 15 fish species have potential as aquarium fishes, whereas three fish species are important for sport fishing.

**Table 2** Fish species checklist by reservoirs of HTHP and their conservation status.

Taxa Species	Native/ Introduced	IUCN Status	Puah Reservoir	Tembat Reservoir	Usage
<b>Bagridae</b>					
<i>Hemibagrus gracilis</i>	Native	NE	+	+	FF
<i>Hemibagrus capitulum</i>	Native	LC	+	+	SF/F
<i>Leiocassis poecilopterus</i>	Native	NE	+	+	FF
<b>Channidae</b>					
<i>Channa lucius</i>	Native	LC	+	+	FF
<i>Channa striata</i>	Native	LC	+	+	FF
<b>Cichlidae</b>					
<i>Oreochromis niloticus</i>	Introduced	LC	+	-	FF
<b>Clariidae</b>					
<i>Clarias batrachus</i>	Native	LC	+	+	FF
<b>Eleotridae</b>					
<i>Oxyeleotris marmoratus</i>	Native	LC	+	+	AQ/F
<b>Cyprinidae</b>					
<i>Barbodes binotatus</i>	Native	LC	+	+	AQ
<i>Barbonymus schwanenfeldii</i>	Native	LC	+	+	AQ
<i>Cyclocheilichthys apogon</i>	Native	LC	+	+	AQ/F
<i>Crossocheilus oblongus</i>	Native	LC	+	+	AQ
<i>Epalzeorhynchus kalopterus</i>	Native	DD	+	+	AQ
<i>Garra cambodgiensis</i>	Native	LC	+	+	AQ
<i>Hampala macrolepidota</i>	Native	LC	+	+	AQ/S
<i>Labiobarbus festivus</i>	Native	NE	+	+	FF
<i>Lobocheilos rhabdoura</i>	Native	LC	+	+	FF
<i>Mystacoleucus obtusirostris</i>	Native	LC	+	+	FF
<i>Neolissochilus soroides</i>	Native	LC	+	+	AQ/F
<i>Osteochilus waandersii</i>	Native	LC	+	+	FF
<i>Poropuntius smedleyi</i>	Native	NE	+	+	AQ/F
<i>Barbodes lateristriga</i>	Native	LC	+	+	AQ
<i>Rasbora elegans</i>	Native	LC	+	+	AQ
<i>Rasbora paviana</i>	Native	LC	+	+	AQ
<i>Tor tambra</i>	Native	DD	+	+	AQ/S
<b>Mastacembelidae</b>					
<i>Macrogathus circumcinctus</i>	Native	LC	+	-	FF
<i>Mastacembelus unicolor</i>	Native	NE	+	+	AQ/F
<b>Synbranchidae</b>					
<i>Monopterus javanensis</i>	Native	LC	+	-	FF
<b>Pristolepididae</b>					
<i>Pristolepis grootii</i>	Native	NE	+	-	FF

**Notes:** + = present; - = absent; IUCN Status: DD = Data Deficient; LC = Least Concern; NE = Not Evaluated; NT = Near Threatened; AQ = Aquarium Fish; FF = Food Fish; SF = Sport Fish.

## DISCUSSIONS

According to Welcomme (1985), there is a positive correlation between the diversity of fish species with the total river length and size of the river catchment areas. As a result, bigger river catchment areas with the longer river have higher fish diversity and are more productive in term of weight caught. This is in agreement with our study as Puah Reservoir which has the bigger catchment areas and longer rivers recorded higher fish diversity compared to Tembat Reservoir (Table 1).

The dominance of cyprinids in both study sites are in agreement with the reports published from other reservoirs in Malaysia: Chenderoh, 55% (Ali, 1996); Temengor (Zakaria-Ismail & Lim, 1995); Kenyir, 57% (Yusoff *et al.*, 1995); Timah Tasoh, 37% (Shah *et al.*, 2006); Ahning, 60% (Shah & Ali, 2002) and Bukit Merah (Mohd Shafiq *et al.*, 2014). The dominance of cyprinids is the characteristic of Asian freshwater fish fauna due to their ability to adapt and survive in the freshwater habitats (Welcomme, 1985; Rainboth, 1996).

Public fish-stocking activity by Department of Fisheries (DoF) or reintroduction of other indigenous species by local people in future will increase the number of fish species at both reservoirs. The introduction of exotic species such as Java barb (*Barbonymus gonionotus*), Jullien's golden carp (*Probarbus jullieni*), giant gourami (*Osphronemus goramy*) and giant snakehead (*Channa micropeltis*) had been observed in Temengor Reservoir and Pergau Reservoir (Ambak & Jalal, 2006; Shah *et al.*, 2016). The presence of some small-sized exotic species at Puah catchment area in the small pond near the abandon contractor basecamp before inundation should be treated with caution. This alien fish species may have been introduced by workers in the area. This fish species has been used as fish-bait for fishing forest snakehead (*Channa lucius*) and hampala barb (*Hampala macrolepidota*). There is a possibility that this exotic fish species may escape into the Puah Reservoir and establish a new species colony.

The Global IUCN Red List status of fishes recorded in this study may not show the actual local conservation status of fishes in Malaysia. For example, there are a lot of studies on *Tor* spp. that ranging from taxonomy, biodiversity, genetic, nutrition and also aquaculture (Siti Shapor *et al.*, 2007; Walton *et al.*, 2017). Therefore, the relevant government agency and academicians need to engage with the IUCN Red List assessors update the present fish conservation status in Malaysia.

Most of the fish recorded in both reservoirs were formerly riverine species and were dependent on forest products such as ripe fruits, seeds, forests litter, as well as terrestrial and aquatic insects for food. Thus, these natural food sources are severely limited when the natural rivers were inundated, which led to high inter-

species and intra-species competition to occupy the existing lotic environment. It has been noted that species such as *Tor* spp. and *Neolissochilus* spp. cannot adapt to the lentic conditions, thus are limited to the lotic habitats (Ambak & Jalal, 2006). Besides that, the changes from lotic to the lentic environment also led to the loss of existing breeding and spawning ground of fishes, which directly increased pressure to fishes for survival at limited lotic environment. These riverine species tend to concentrate in the littoral and riverine portions of the newly develop reservoirs zone. Luckily, the pressure from fishing activities is minimised as the access to both areas had been closely monitored and controlled by the Department of Wildlife and National Parks (PERHILITAN). Nevertheless, existing larger sized cyprinids, snakeheads and catfish will slowly diminished, and the smaller cyprinids, notably *Barbonymus schwanenfeldii* and *Labiobarbus festivus*, will become dominant. Consequently, there will be a reduction in the number of fishes captured later, as the average size of fish caught (same species) will be reduced. This is based on similar phenomena observed in Temengor Reservoir (Shah *et al.* 2016).

## CONCLUSIONS

Fishes of Puah Reservoir and Tembat Reservoir are classified as riverine species which prefer to live in a lotic environment. The changes in the environment from lotic to lentic will alter the composition of the existing fish species due to inter/intra-species competition for food and space (for breeding and spawning). It has been hypothesized that several fish species will be replaced by other indigenous species through public fish-stocking activities by DoF or local people, based on experience from Temengor Reservoir and Pergau Reservoir. Without fishing activity pressure, the changes of fish composition and community in Puah Reservoir and Tembat Reservoir will take a longer time to show the impact. Therefore, a long-term study is needed to monitor the changes of existing fish biodiversity and well-being of the fish population.

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