# FISH AND FISHING GEARS OF THE BANGKAU SWAMP, INDONESIA

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**Abstract**
This study contributes to the knowledge of traditional fishing gears and the weight-length relationship of fish species from the Bangkau Swamp, Indonesia. Although the use of fishing gears in Bangkau swamp complies with the local regulation but still, some weaknesses have been identified and the options for improvements are being proposed. The length-weight relationship of three dominant fish species, *Channa striata*, *Trichogaster trichopterus*, and *T. pectoralis* were analyzed. The *b* values ranged from 1.531 to 2.646, with $R^2$ values ranged from 0.814 to 0.917 indicating negative allometric growth pattern; the species becomes leaner as the length increases. The food availability and temperature may have an effect on the growth pattern since the fishes were sampled in dry season. To the best our knowledge, this study is the first reference on WLR for swamp fish in the Bangkau village.

**Keywords:** Freshwater fish; fishing gear; weight-length relationship; Bangkau Swamp; South Kalimantan.

## 1 | INTRODUCTION

The Bangkau Swamp is one of the prominent fishing areas in South Kalimantan, Indonesia. It is estimated having ichthyomass more than 1.5 tons $ha^{-1}$ $year^{-1}$ (Rahman 2005) and more than 34 fish species are found in this area (Mashuri *et al.* 1998). Like many other similar water bodies in other countries (e.g. Galib *et al.* 2010; Samad *et al.* 2010) this water body plays an important role in meeting fish protein requirements adjacent areas- not only for Hulu Sungai Selatan (HSS) district but also for South Kalimantan province (Herliwati and Rahman 2011). The villagers use different types of fishing gears such as gillnet, stage-trap, hand-lines and portable lift net to harvest fishes from the swamp. All the fishing gears are being developed by villagers to catch fishes selectively and thereby to maintain sustainability of fish production from this valuable wetland. However, this wetland is vulnerable to open access since fishing activity is also done by

fishermen from neighboring villages. This makes sense freshwater fishes of this swamp have long been the major source of income for local people. Thus, the Bangkau Swamp fishery is of great concern to the local government, local organization, university, and fisheries experts globally (Pomeroy 1995; Yunita 2010; Slamat *et al.* 2012; Rukmini *et al.* 2013).

Few studies have already been conducted on different aspects of the Bangkau Swamp fisheries including agro-poultry and fisheries (Mashuri *et al.* 1998), eco-biological reproduction of snakehead (*Channa striata*; Bijaksana 2006), food habits and bio-limnology habitat of climbing perch (*Anabas testudineus*; Ansyari *et al.* 2008), characteristic of hinterland swamp and fish diversity (Yunita 2010), eco-biology of *Beje* fisheries (Herliwati and Rahman 2011), genetic conservation of climbing perch (Slamat *et al.* 2012), natural food of climbing perch larvae (Rukmini *et al.* 2013), and restocking of snakehead (Bi-

jaksana *et al.* 2015). Meanwhile the various aspects (e.g. fishing gears and catch composition) of capture fishery are still unevaluated which is very important in managing sustainable fisheries (Galib *et al.* 2009a, 2009b).

Fishing in the Bangkau Swamp is open throughout the year and the catch trend has been declined in the last few years due to over fishing (Herliwati and Rahman 2011). Fishing is carried out by both fishers from Bangkau village and beyond. Consequently, some species of fish became rare and the size of fish is becoming smaller than as usual. This situation is further being exacerbated with the use of electric and potassium by few people to collect fish quickly. This will actually threaten fish and other aquatic species especially because of their applications near the spawning and nursery grounds. This eventually threatens fishers' livelihoods. Facing this situation, the local government through Fisheries Department of HSS district has been promoting and socializing responsible fishing programmes through fisheries extension and other relevant events as well as introducing fish farming business (e.g. climbing perch and snakehead) to the villagers. At the same time, the Faculty of Marine and Fisheries of the Lambung Mangkurat University, South Kalimantan also pays attention to make traditional fishing methods more eco-friendly through gear modification, skills of gear placement, or swamp fish behavioral assessment as well as re-stocking models for several important fish species of high commercial importance. However, it is also necessary to analyze existing fishing gears and catch details to ensure better fisheries management for the swamp through providing recommendations.

## 2 | METHODOLOGY

### 2.1 | Study site

The study was conducted at Bangkau village which is about 17 km from Hulu Sungai Selatan district of South Kalimantan province (Figure 1), located at 02°43'S and 115°13'E. The village consists mostly of wetland area with extremely high fluctuation of water level, varies from 0.5 – 6.5 m. About 615.5 ha of the area of this village are being used for fisheries followed by agricultural crop production (360 ha) and residential area (10 ha). There are about 1,600 people live in the 20 km$^2$ wetland area. The area of the wetland varies with the level of rainfall. During rainy season (October-March), the wetland is entirely flooded and the fishes become difficult to catch. Inversely, during the dry season (April-September) the wetland is covered by very dense vegetation and the fish are being concentrated on the sludge holes or backwater and allow fishers to catch them. This regular changing from water area to high plant biomass is an important factor in regulating high production of freshwater fishes in the wetland. Fishing activities usually start from February and contin-

ues up to October. Rukmini *et al.* (2013) reported that the water productivity of Bangkau Swamp is classified as moderate and reported plankton abundance from 0.1 - $40 \times 10^6$ cell m$^{-3}$. There are six species of plankton *i.e. Mougeotia* sp., *Coconeis* sp., *Keratella* sp., *Chlorococcum* sp., *Brachionus* sp., and *Navicula* sp. are abundantly found in the swamp which are also natural food sources for fish. This research was carried out for a period of six months from July to November 2014.
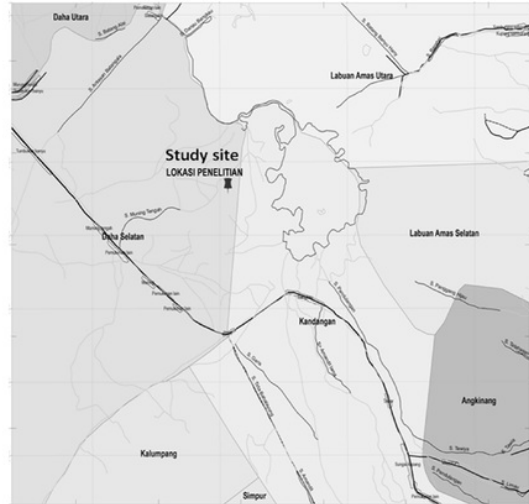


**FIGURE 1** Map showing the location of Bangkau Swamp in HSS District, South Kalimantan Province, Indonesia.

### 2.2 | Statistical analysis

During the research, the catches were counted, identified up to species using taxonomy and key identify fish (Saanin 1986). Total length and weight of each individual fish have been measured by using standard measuring scale (up to the nearest mm) and digital balance (up to the nearest 0.01 g) respectively. The weight-length relationship (WLR) was calculated using the equation $W = _aL^b$ (Ali *et al.* 2013); where $W$ is the total weight in g, $L$ is the total length in cm, $a$ is constant and $b$ is exponent. The parameters $a$ and $b$ were estimated by linear regression of the transformed equation: $\log W = \log a + b \times \log L$. Additionally, the coefficient correlation of $r$ was estimated, and the $b$-value for each species was compared to the hypothetical value of 3 (Oscoz *et al.* 2005); where $b > 3$ represents positive allometric growth (*i.e.* weight increases more than length), $b < 3$ represents negative allometric growth (*i.e.* length increases more than weight) and $b = 3$ represents isometric growth (i.e. both length and weight are increasing at the same rate). Frota *et al.* (2004) reported that the parameter '$b$' of the WLR equation, also known as allometry coefficient has an important biologi-

cal meaning, indicating the rate of weight gain relative to growth in length.

## 3 | RESULTS

### 3.1 | Fishing gears

A total of eight commonly used fishing gears in the Bangkau village were investigated. These fishing gears were locally known as *Banjur, Lalangit, Pengilar, Tempirai, Hancau, Lunta, Lukah,* and *Rengge* (Figure 2).
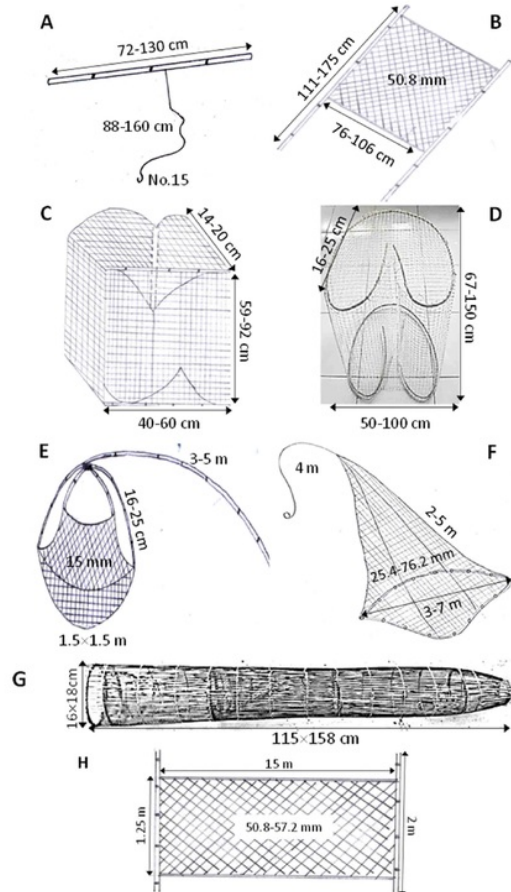


**FIGURE 2** The fishing gears used in Bangkau swamp. Banjur (stage lines, A); Lalangit (horizontal gillnet, B); Tempirai (stage trap, C); Pengilar (basket trap, D), Hancau (portable lift net, E), Lunta (cast net, F), Lukah (fish trap, G), and Rengge (gillnet, H).

*Banjur* (stage lines) is consists of 72 – 130 cm long bamboo with 15 hooks and 88 – 160 cm long nylon rope. The distance between rope and hook is about 25 cm. The frog (*Rana cancrivora*) is used as bait in this fishing gear. Target species are *Channa striata* and *Mystus nemurus*. The

average size of *Banjur* in the study area seemed larger than *Banjur* operated in other geographical areas, e.g. Martapura sub-district.

*Lalangit* (horizontal gillnet) is made of monofilament nylon with 50.8 mm mesh size that is attached between two 111 – 175 cm long bamboo laths with opening distance of 76 – 106 cm. In practice the fisher supply rice bran over the net to attract the fish. This net deployed in the morning and retrieved every 1 – 2 hours. *C. striata, Anabas testudineus, Trichogaster pectoralis* are often caught by *Lalangit*. The average size of *Lalangit* seems to be typically larger than that of *lalangit* operated in Sungai Batang-Martapura sub district.

*Pengilar* (basket trap) is made of wire of 40 – 60 cm long, 14 – 20 cm wide and 59 – 92 cm high. It has the entrance and exclusion openings at the opposite side. *Pengilar* is placed vertically and moored at the pole that is planted at the bottom. Target fish species include *Helostoma temminckii, T. pectoralis* and *Monopterus albus*.

*Tempirai* (stage trap) is similar to *Pengilar* but bigger in the size. It is made of heart-shaped wire, generally 50 – 100 cm long, 16 – 25 cm wide, 67 – 150 cm high and 5 cm wide opening. A small trap door either on the left or right side allows removal of catches. The snail (*Achani*ta sp.) is used as bait and placed inside the trap. The trap is set in the riverbank, swampy area or paddy field before sunset and retrieved the next morning or mounted on a high tide and removed after low tide. Major species caught are *T. trichopterus* and *M. albus* are often getting caught in the fisher's trap. The average size of *Tempirai* is typically larger than that of *Tempirai* used in Sungai Batang-Martapura sub district (Ahmadi *et al.* 2014)

*Hancau* (portable lift net) is consisted of *tampuatar* (3 – 5 m long bamboo), *rangau* (bamboo lath of 155 – 182 cm and diameter of 2 cm for connecting between nets) and *tabulilingan* (buffer). The size of the net is about 1.5 m² with 15 mm mesh size. In principle, *Hancau* is operated by the way of waiting for the fish to gather in the area nets for 25 – 30 minutes and lifted afterward. Mostly *T. trichopterus* are trapped in this net.

*Lunta* (cast net) is a circular net with small weights distributed around its edges. The net is cast or thrown by hand in such a manner that it spreads out on the water and sinks. This technique is called net casting or net throwing. Fish are caught as the net is hauled back in. It is made of monofilament nylon net of 25.4 – 76.2 mm mesh size. Total length of the net is about 2 – 5 m long and has a radius which ranges from 3 – 7 m. Weights (approximately 4.5 kg) are in form of iron rings (diameter: 3.2 cm) distributed around the edges. When the net is full, a re-

trieval clamp, which works like a wringer on a mop, closes the net around the fish. The net can be cast from a boat or from the riverbank. Commonly caught fishes with *Lunta* include *C. striata*, *A. testudineus*, *T. pectoralis* and *T. trichopterus*.

*Lukah* (fish trap) is an elongated tube-shaped fishing gear made of bamboo (115 – 158 cm long) of 16 – 18 cm diameter. There is one entry funnel mounted on the inside of conical-shape for fish to enter and tapering inside to about 2.5 cm in diameter, called *hinjap* (one-way valve, made of elastic rattan; there are 2-3 *hinjap* installed about 35 – 40 cm one to other), and the other side is covered with cork-stopper so that the fish that have entered cannot escape. The traps are deployed in the swamp in densely vegetated areas of slow or no current in the morning and retrieved in the afternoon. They are either submerged partly at an oblique angle of approximately 15º or lowered to the bottom weighted by a sandbag depending on the depth of water. Mostly *C. striata*, *A. testudineus*, *Helostoma temminckii*, *T. pectoralis*, and *M. albus* are trapped in *Lukah*. The average size of *Lukah* is slightly smaller than that of *Lukah* used in Sungai Batang-Martapura sub district.

*Rengge* (gillnet) is typically made of monofilament nylon with 50.8 – 57.2 mm mesh size. It is about 15 m long and 1.25 m high, equipped with weights at the bottom and floats at the top, and is moored at the two poles that are planted at the bottom of each end. However, installation of *Rengge* can vary depending on the fish caught and its habitat. Mostly *A. testudineus* and *T. pectoralis* are trapped in this gear.

### 3.2 | Fish fauna

A total of 188 specimens belonged to 7 species of 6 families were collected throughout the research period (Table 1). The fish catch composed of *Trichogaster trichopterus* (31.38 %), *T. pectoralis* (20.74 %), *Anabas testudineus* (17.02 %), *Helostoma temminckii* (12.23 %), *Channa striata* (11.17 %), *Monopterus albus* (5.85 %) and *Mystus nemurus* (1.60 %) with total length and body weight varied from 50 to 570 mm and 1 to 1500 g respectively.

The WLR for three species i.e. *C. striata*, *T. trichopterus* and *T. pectoralis* showed that the *b* values were significantly lower than critical isometric value (*b* < 3), indicating negative allometric growth pattern in all species. All estimated *b*-values in the WLR equation were within the range 1.531 and 2.646, with $R^2$ values ranged from 0.814 to 0.917. A strong relationship between length and weight of fish were observed (Figure 3). No significant difference was observed between the slopes of the species (*P* > 0.05).
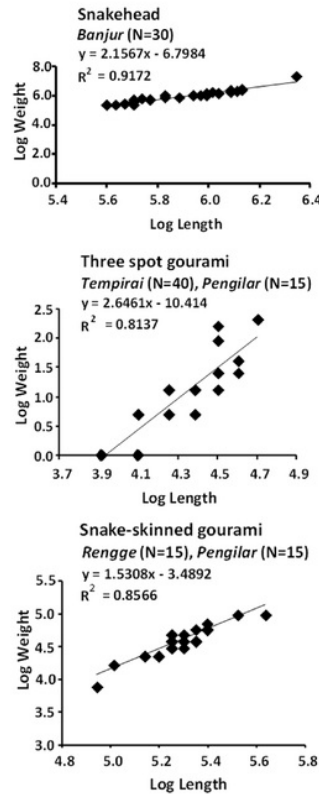


**FIGURE 3** The relative growth curves (negative allometric; length-weight relationship) for three fish species sampled from Bangkau Swamp using the selected fishing gears.

## 4 | DISCUSSION

Diversity and intensity of fishing gears used in a water body play a key role in maintaining status of fish biodiversity and can be a significant threat to fish fauna (Chaki *et al.* 2014; Galib 2015; Joadder *et al.* 2015; Galib *et al.* 2016). All the gears described in this study demonstrate the simplicity of its design and fabrication and represent their ease of operation. The fishers are always humble to share their traditional indigenous knowledges as well as receptive to new ideas. In our investigation, *Banjur* is considered the most effective gear for snakeheads. *Tempirai* and *Hancau* are the least preferred fishing gears and primarily used to capture small fishes (< 100 mm). The escape gaps and trap density of *Tempirai* and *Lukah* are still not clear at present. *Hancau* fishers understand that the mesh size they are using at present is detrimental to sustainability of catches. Net fishers acknowledged that net length and mesh sizes were an issue and in all villages the idea of defining standards length and mesh sizes. Meanwhile, the operation of *Lunta* were more often lim-

ited within marsh vegetated habitat and targeted fish species. Basically, the fishing gears used in the study area comply with the local regulation. By-catch is insignificant as all the harvested fishes were being sold which means that the benefits are widely spread. Thus, this represents that the improvements of the selected fishing gears were necessarily done.

**TABLE 1** Catch composition of different fishing gears used in the Bangkau Swamp.

| Gear type/Local name | English name | Scientific name | Family name | Total catch | Total length (mm) | Weight (g) |
|---|---|---|---|---|---|---|
| **Banjur (stage line)** | | | | | | |
| 1. Haruan | Snakehead | *Channa striata* | Channidae | 15 | 270–570 | 200–1500 |
| 2. Baung | Catfish | *Mystus nemurus* | Bagridae | 3 | 270–410 | 200–800 |
| **Lukah (fish trap)** | | | | | | |
| 3. Haruan | Snakehead | *Channa striata* | Channidae | 2 | 270–300 | 200–220 |
| 4. Papuyu | Climbing perch | *Anabas testudineus* | Anabantidae | 5 | 80–140 | 15–56 |
| 5. Tambakan/ Biawan | Kissing gourami | *Helostoma temminckii* | Helostomatidae | 3 | 130–200 | 50–150 |
| 6. Sepat siam | Snake-skinned gourami | *Trichogaster pectoralis* | Osphronemidae | 2 | 150–190 | 70–100 |
| 7. Belut | Swamp eels | *Monopterus albus* | Synbrancidae | 4 | 260–410 | 17–77 |
| **Tempirai (stage trap)** | | | | | | |
| 8. Sepat | Three-spot gourami | *Trichogaster trichopterus* | Osphronemidae | 40 | 50–110 | 1–10 |
| 9. Belut | Swamp eels | *Monopterus albus* | Synbrancidae | 3 | 350–420 | 24–71 |
| **Pengilar (basket trap)** | | | | | | |
| 10. Tambakan/ biawan | Kissing gourami | *Helostoma temminckii* | Helostomatidae | 20 | 130–250 | 50–200 |
| 11. Sepat siam | Snake-skinned gourami | *Trichogaster pectoralis* | Osphronemidae | 15 | 150–280 | 70–150 |
| 12. Belut | Swamp eels | *Monopterus albus* | Synbrancidae | 4 | 360–410 | 45–77 |
| **Hancau (portable lift net)** | | | | | | |
| 13. Sepat | Three-spot gourami | *Trichogaster trichopterus* | Osphronemidae | 15 | 50–100 | 1–5 |
| **Lalangit (horizontal gillnet)** | | | | | | |
| 14. Haruan | Snakehead | *Channa striata* | Channidae | 2 | 270–290 | 200–220 |
| 15. Papuyu | Climbing perch | *Anabas testudineus* | Anabantidae | 4 | 60–120 | 2–4 |
| 16. Sepat siam | Snake-skinned gourami | *Trichogaster pectoralis* | Osphronemidae | 4 | 140–190 | 50–90 |
| **Rengge (gillnet)** | | | | | | |
| 17. Papuyu | Climbing perch | *Anabas testudineus* | Anabantidae | 20 | 140–210 | 60–170 |
| 18. Sepat siam | Snake-skinned gourami | *Ttrichogaster pectoralis* | Osphronemidae | 15 | 140–220 | 50–120 |
| **Lunta (cast nets)** | | | | | | |
| 19. Haruan | Snakehead | *Channa striata* | Channidae | 2 | 280–310 | 220–310 |
| 20. Papuyu | Climbing perch | *Anabas testudineus* | Anabantidae | 3 | 90–130 | 23–39 |
| 21. Sepat | Three-spot gourami | *Trichogaster trichopterus* | Osphronemidae | 4 | 50–70 | 1–3 |
| 22. Sepat siam | Snake-skinned gourami | *trichogaster pectoralis* | Osphronemidae | 3 | 170–200 | 80–100 |

In addition, there is an interesting indigenous knowledge called *Pulau Berjalan* (walking island) composed of floating aquatic plants (e.g. *Eichornia crassipes*, *Ipomoea aquatic* and *Hydrilla verticillata*) to form an island (or bridge) when they were freely moving on the water surface during high water level season. The size of floating islands with could reach about 200 m$^2$. Due to their very large surface area, during their movement, they occasionally covered a group of swimming fishes. Such fishes will react instantaneously and become panic because of the sudden darkness of the water due to the shading by the island. These fishes will then look for a bright place or

hole because they also need a place to breath to the surface. Based on this theory, fishers in the Bangkau village make square holes just at the middle of this floating island and then over the surface of this square hole, they set up *Lalangit* to catch the fishes. The use of *Banjur* is also a promising option for collecting specimens.

The body shape of all species analyzed displays a negative allometric growth, which means that length of fish increases more than weight. From family Channidae, similar observations were found for *Parachanna obscura* (Olurin and Savage 2011), *Channa maurulius* (Rathod *et al.* 2011) and *C.* diplogramma (Ali *et al.* 2013) but contrary with the result from *C. striata* in Thailand (Satrawaha and Pilasamorn 2009) and *C. punctatus* in India (Khan *et al.* 2012). From family Osphronemidae, both species *Trichogaster Sota* in India (Paswan *et al.* 2012) and *Trichopodus trichopterus* in Iran (Jafaryan *et al.* 2014) were more or less similar to our findings. In case of *Anabas testudineus* (family Anabantidae), positive allometric was reported (Rahman *et al.* 2015). However, Kumar *et al.* (2013) recorded a negative allometric growth similar to the present study. In fish, the weight is considered to be a function of length (Weatherley and Gill 1987), and the fish length is the best indicator of production efficiency (Ghorbani *et al.* 2012). The WLR are not constant over the entire year and vary according to factors such as food availability, feeding rate, gonad development and spawning period (Bagenal and Tesch 1978), temperature and salinity (King 1996), inherited body shape (Yousuf and Khurshid 2008) and fecundity (Lawson 2011). In this study, the pattern of negative allometric growth may be attributable to the food availability and temperature since the fishes were sampled in dry season (July-September). LWR may help to develop sustainable management strategies in this region.

For further researches, evaluation of the effectiveness and efficiency of the selected traditional fishing gears from this area is of high importance. More researches are also required on the gear selectivity through modification of the net/trap shapes and sizes or by applying the 'pocketing method' to evaluate the escape gaps and trap density of *Tempirai, Pengilar* and *Lukah*, among others. The use of '*mince teabag*' baits containing local ingredients is a promising option for *Banjur, Hancau, Lalangit, Tempirai* or *Pengilar*. A '*teabag*' baiting method has been effective in the cod longline fishery (Anon 2005) and crab pot fishery such as the Green crab *Carcinus maenas* (Behrens Yamada *et al.* 2006) and the blue swimming crab *Portunus pelagicus* (Vazquez Archdale *et al.* 2008). Research on the luring of fish schools by underwater sound is also interesting option, especially when the wetland is entirely flooded by water and the fishes are difficult to catch. The use of an audio fishing lure system for attracting fish is being developed. The success of field recording of underwater sound has been reported for the payao fishing in Philippines (Babaran *et al.* 2008). In Taiwan, researchers used aversive underwater sound to drive fish from intake areas (Wu *et al.* 2009). A *donburi* fishing method that uses sound generated underwater to attract fish has been applied in Kagoshima Prefecture of Japan (Yan *et al.* 2010). Fish behavior control methods using underwater sound in marine ranching in Japan are also being developed (Anraku *et al.* 2006). The use of fishing traps with LED (Light Emitting Diode) underwater lamps in swamp waters may provide a great challenge for us (Ahmadi 2012, 2014; Ahmadi and Rizani 2013) since there are no reports on its application in this region, so far. Thus, phototactic responses in the swamp fishes are still in question mark. By doing these suggestions, it meant that more detailed data are needed to analyze the factors leading to this variation, and the results are still open for discussion.

## 5 | CONCLUSIONS

Although the use of fishing gears in Bangkau Swamp complies with the local regulation but some weaknesses of the traditional fishing gears have been identified. The present study shows that the *b* values of species analyzed were significantly lower than critical isometric value, indicating negative allometric growth; the species becomes leaner as the length increases. To the best knowledge of the authors, this study is the first reference on WLR for three fish species in Bangkau Swamp. More references on WLR for other native species are required to give clear indication of their effects and make management recommendations.

## ACKNOWLEDGMENTS

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**I & R** primary data collection; **I, R & A** data analysis; **A** manuscript preparation.

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