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Assessment of Suitability of Kerian River Tributaries Using Length-weight Relationship and Relative Condition Factor of Six Freshwater Fish Species

Mohd-Shafiq Zakeyudin[1] Mansor Mat Isa[1,2*] Che-Salmah Md Rawi[1] Amir-Shahruddin Md Shah[1]

Abu-Hassan Ahmad[1]

1. School of Biological Sciences, Sciences University of Malaysia, 11800 Minden, Penang, MALAYSIA

2. Centre for Marine and Coastal Studies, Sciences University of Malaysia, Muka Head, 11060, Teluk Bahang, Penang, MALAYSIA

*E-mail of the corresponding author: drmansor@usm.my)

Abstract

The length-weight relationship and condition factor of six freshwater fish species were conducted monthly at selected rivers of Kerian River Basin from May 2008 to May 2009. The fish species studied were *Devario regina*, *Labiobarbus* sp., *Puntius binotatus*, *Rasbora sumatrana*, *Acantopsis choironrhycos* and *Cyclocheilichthys apogon*. The value of fish growth (b) shows that *D. regina* (b = 3.256), *P. binotatus* (b = 3.911), *R. sumatrana* (b = 3.642) and *C. apogon* (b = 3.623) had positive allometric growth, while *Labiobarbus* sp. (b = 2.898) and *A. choironrhycos* (b = 2.427) had negative allometric growth. The mean *Kn* varied from 1.003 ± 0.109 (*A. choirorhynchos*) to 1.873 ± 0.203 (*R. sumatrana*). Of all the fish species, only mean *Kn* of *R. sumatrana* showed significant difference among the sampling sites, at P < 0.05, suggesting the fish growth in the Kerian River basin was in a good condition.

Keywords: Length-weight relationship, condition factor, freshwater, Kerian River Basin, Malaysia

1. Introduction

Length-weight relationship (LWR) is a key factor in investigation of biology and management of fish species (Odat 2003, Thomas *et al*. 2003, Frota *et al*. 2004, Abdurahiman *et al*. 2004, Golam & Tawfeequa 2006, Ayoade & Ikulala 2007, Samat *et al*. 2008, Jamabo *et al*. 2009, Offem *et al*. 2009). This information is important to evaluate the general health parameters of fish species (fatness, breeding and feeding states) and their suitability to the environment (Schneider *et al*. 2000, González-Gándara *et al*. 2003, Farzana & Saira 2008) as well as provides clues to environmental changes and sustainable management of the stock (Samat *et al*. 2008, Efitre *et al*. 2009). The b value from the growth equation ($W = a L^b$) indicates the rate of weight gain relative to growth in length (Frota *et al*. 2004).

Suitability of an aquatic habitat for fish growth is determined by the value of relative condition factor, which higher value indicates better habitat suitability in term of food availability and other requirements, for optimum fish growth (Samat *et al*. 2008, Abowei 2009). The condition factor determines the period of gonadal maturation, and also attributed to sexual and active spawning sizes (El-Agami 1988, Hadi 2008, Shalloof & Salam 2008, Mansor et al. *in press*). Reproduction results in lower value of condition factor ($K < 1$) marked the fish loses its weight after spawning period (Froese 2006).

Sachidanandamurthy & Yajurvedi (2008) proved that deterioration in water quality directly or indirectly affects fish physiology and growth. High water pH causes alkalosis, damaging skin, browning of gills areas and increasing mucus production. High ammonia increases the toxicity of water, causing ammonia poisoning to the fish, with symptoms such as red streaking on the body and gills may appear pale in colour. These types of diseases reduce or inhibit fish growth, affecting the value of growth coefficient (b). This paper aims to provide information on length-weight relationship and the relative condition factor of six freshwater fish species at selected rivers in Kerian River Basin. In addition, we used this data to determine more productive river and the factors may contribute to the growth of fish including river characteristics and physical-parameters.

2. Materials and Methods

2.1. Sampling Area

The Kerian River Basin is located at the northern part of Malaysia (5° 9' – 5° 21'N and 100° 36.5'–100° 46.8'E) and has a population of approximately 190,000 in a catchments area of 1418 km^2 (Yap 1990). Kerian River Basin is a formation of Kerian River with a number of tributaries that can supply water to thousands of people (Che-Salmah *et al*. 2004). This river consists of various tributaries of Kerian River and Selama River from the upstream and meets at the middle of the basin then flowing westward to the Strait of Malacca. Kerian River starts from the hilly headwaters in Mahang River, Kedah while the Selama River originates from hilly areas in Selama, Perak (Che-Salmah *et al*. 2001). Seven sampling sites were selected for this study namely Mahang, Kangar, Selama, upper of Kerian, middle of Kerian (Selama), Serdang and Bogak Rivers (Fig. 1). General characteristics of sampling sites were given in Table 1.

2.2. Determination of River Physico-chemical Parameters

In this study, the following parameters were measured to describe the condition of Kerian River tributaries. *In situ* physico-chemical readings were taken at each sampling site. Dissolved Oxygen (DO) content and temperature (°C) were estimated using YSI meter (Model 55), conductivity (µS/cm), total dissolved solids (TDS) (mg/L) and salinity (ppt) were measured using Hach meter (Model CO150), pH was measured using Hach Sension 1 meter, velocity and depth of a river were estimated using velocity meter and width of a river was measured using a measuring tape.

2.3. Fish Sampling

Sampling was conducted from May 2008 to May 2009 using various fishing gears, such as cast, scoop and insect nets. At each sampling site, fishes were sampled 20 times per 1 hour by the cast net. The scoop and insect nets were used while sampling on hard substrates; boulder, cobble and river bank areas. Collected fishes were kept in an ice chest during transportation to the laboratory. The fishes were identified to the lowest possible taxon using standard taxonomic keys (Mohsin & Ambak 1983, Kottelat *et al*. 1993, Rainboth 1996, Ambak *et al*. 2010), then preserved in 10% formalin for later works.

The fishes, positioned on their left sides, were measured; total length (TL), standard length (SL) in centimetre and weight (W) in gram (Frota *et al*. 2004). Total length was measured from anterior mouth to the tip of the longest caudal fin rays. From anterior mouth part to the end of caudal peduncle was the standard length. The fish was weighed on an electronic scale.

2.4. Length-weight Relationship

The length-weight relationship (LWR) was estimated using the following formula; $W = a\,L^b$ (Le Cren 1951, Pauly 1983); where W is the weight of fish in grams, L is the total length (TL) of fish in cm, *a* is constant and *b* is slope of regression line. The values of *a* and *b* were estimated through a logarithmic transformation; $\log W = \log a + b \log TL$, the least square linear regression (Froese 2006). Value of *b* is an index of growth type of fish (isometric or allometric) and useful for fish classification (Smith 1996), indicating isometric growth (the fish has an equal increment of both length and weight parameters) ($b = 3$), the light group or negative allometric growth ($b < 3$), heavy group or positive allometric growth with ($b > 3$) (Smith 1996, Odat 2003, Thomas *et al*. 2003, Ayoade & Ikulala 2007, Samat *et al*. 2008, Jamabo *et al*. 2009, Laghari *et al*. 2009, Offem *et al*. 2009).

2.5. Relative Condition Factor (Kn)

The formula for relative condition factor is Kn = W/W' (Le Cren 1951); where W is the observed weight of individual fish (g) and W' is the expected weight of fish (g), which can be determined using the following formula: W' = aL^b (Le Cren 1951); the values of Kn are used to compare the well being, healthiness of fish between species, between rivers or different sampling sites in the Kerian River Basin.

All data on length-weight relationship of different species were subjected to regression analysis. The result of Kn values for each species were analyzed using One-way ANOVA to determine the significance values of well being of fish among sampling sites of the Kerian River Basin at P = 0.05. When significant F values were indicated, they were subjected to multiple mean comparison analysis using the Tukey test at P = 0.05.

3. Results and Discussion

Various fish sizes of many species were captured because more than one sampling gear was used in this study. The small fishes were sampled using the insect net, while the cast net was capable of capturing a large number of specimens, ranging from small to large sizes. An electric shocker was extremely indiscriminate in its catch. Dissolved Oxygen content in various rivers had large variation, ranging from 3.77 mg/L in Bogak River to 8.34 mg/L in Selama River. Values of pH fluctuated from 5.64 in Bogak River to 6.22 in Mahang River. The water temperature was the highest in Bogak River (28.29°C) and the lowest in Mahang River (21.82°C). The highest conductivity was recorded in Bogak River (246.47 µS/cm), followed by Serdang River (40.9 µS/cm). However, in other rivers, the values fall within small range (16.51 – 27.02 µS/cm). The TDS content was extremely high in Bogak River (126.19 mg/L), while the content of TDS in other rivers ranged from 8 mg/L (Mahang River) to 18.45 mg/L (Serdang River). The velocity ranged from 0.13 m/s (Bogak River) to 0.80 m/s (upper of Kerian River). A low concentration of salinity was recorded in Bogak River (1.50 ppt) (Table 2).

Devario regina, *Labiobarbus* sp., *Puntius binotatus*, *Rasbora sumatrana*, *Acantopsis choirorhynchos* and *Cyclocheilichthys apogon* were common in the river basin hence selected for this study (Table 3). The lengths of fish species captured ranged from 4.3 to 23.5 cm, while their weights fluctuated from 1.0 to 135.0 g. *D. regina* was the most abundant species sampled (n = 124). However, this species was the smallest species, ranging from 4.3 to 10.8 cm. *Labiobarbus* sp. (6.3 to 23 cm and 3 to 135 g) and *A. choirorhynchos* (7.8 to 23.5cm and 4 to 50g) were the largest fish among the fish species sampled (Table 3).

There was a significant relationship between the total length and weight of all six fresh water species in the Kerian River ($P < 0.001$). High values of regression coefficient (R^2) from the result showed a strong correlation between the length and weight of all fish species (Table 3). Similarly, the strong correlation of these two parameters was recorded by Ayoade and Ikulala (2007) and Jamabo et al. (2009), stating that an increase in weight is directly proportionate to an increase in length for a normal fish. The *b* values (2.427 – 3.911) in this study were in normal range for the growth of most fishes. Generally, most fishes scored *b* values from 2 to 4 (Samat *et al*. 2008, Jamabo *et al*. 2009).

D. regina, *P. binotatus, R. sumatrana* and *C. apogon* experienced a positive allometric growth ($b > 3$), indicating most of fishes in this area live in healthy environment condition (Table 3). However, *Labiobarbus sp.* and *A. choirorhynchos* had a negative allometric growth ($b < 3$). The variation in food supplies could be contributed to the different size of species. However, dorso-ventrally compressed body of *A. choirorhynchos* was one of the reasons to have *b* value less than 3. The inherited body shape of this species suggests that it tends to grow longer than its weight (Farzana & Saira 2008).

Base on our result, most fishes in the Kerian River Basin experienced a positive allometric growth, suggesting the space area and food supply were sufficient throughout the year (Farzana & Saira 2008, Samat *et al*. 2008). The *b* value, which represents the body form is related to the ecological and biological factors such as Dissolved Oxygen content in the water, food supply, spawning conditions and other factors such as sex and age of fish (Shukor *et al*. 2008, Offem *et al*. 2009). Generally, suitable ranges of water pH and DO for the fish are 6.5-9 and more than 5 mg/L, respectively (Othman *et al*. 2002). Except in Bogak River, all sampling sites provided suitable habitats for all fish species, since DO contents in the water were within the optimal range for fish growths. According to Interim National Water Quality Standards (INWQS) (Lawson 1995), only tolerant species can adapt to live in water with DO lower than 5 mg/L. Aerobic decomposition of organic matter by microbes reduces the oxygen level in the water which probably it was happened in Bogak River (Othman *et al*. 2002). In this case, most fishes that live in such water have adapted well by having their modified morphologies.

The growth pattern of the various fish species showed that the fish with longer body are heavier in weight (Table 4). Based on the values of the slope (b) (Table 4), *D. regina* (b = 3.256), *P. binotatus* (b = 3.911), *R. sumatrana* (b = 3.642) and *C. apogon* (b = 3.623) were categorized into heavy group (b > 3), while *Labiobarbus* sp. (b = 2.898) and *A. choirorhynchos* (b = 2.427) were classified into light group.

The mean Kn varied from 1.003 ± 0.109 (*A. choirorhynchos*) to 1.873 ± 0.203 (*R. sumatrana*). The highest mean Kn values for *D. regina*, *R. sumatrana*, *P. binotatus*, *Labiobarbus* sp., *A. choirorhynchos* and *C. apogon* were 1.14 ± 0.257 (Kangar), 1.873 ± 0.203 (Mahang), 1.131 ± 0.212 (upper of Kerian), 1.076 ± 0.155 (Serdang), 1.003 ± 0.109 (middle of Kerian) and 1.317 ± 0.208 (Bogak), respectively. Of all fish species, only *R. sumatrana* showed significant different in mean Kn values among the sampling sites ($F_{2,75}$ = 120.818, $P < 0.05$). The Tukey test resulted in significant differences of mean Kn values between Mahang River (1.873 ± 0.203) and upper of Kerian River (1.079 ± 0.152), and between Mahang River and Serdang River (1.073 ± 0.231) ($P < 0.05$).

The mean Kn values for all the fish species were greater than one in each sampling sites (Table 5), indicating fishes were in better condition. The gonad developed gradually until the maturation stage (Samat *et al*. 2008). The weight per unit length of fish is greater when it grows rapidly. The mean Kn values of less than one represent slow growth of fish. Overcrowding, parasite, disease and low productivity may attribute to the lower Kn value. Froese (2006) and Samat *et al*. (2008) stated that a larger part of the energy is transferred for other activities such as growth and emptying of ovaries.

The mean Kn values of *R. sumatrana* showed a significant different ($P < 0.05$) among the Mahang, upper of Kerian and Serdang rivers. According to our results, Kn values of the Mahang river was significantly different with both the upper of Kerian and Serdang rivers, but Serdang River was not significantly different with upper of Kerian River. Mahang River had the highest mean value of Kn, reflecting high food availability in this river. The presence of fruit trees along Mahang River presumably provided additional food sources for fish compared to other rivers. Shukor *et al*. (2008) suggested that *R. sumatrana*, which swims near the water surface, has more opportunity to pick up any terrestrial insects and detritus falling on the water surface. In fact, larger rivers and limited food availability in Serdang and upper of Kerian Rivers increased the competition among fishes and predation, that could trigger linear b values.

There was no significant difference in the mean Kn values of *D. regina* among the Mahang, Kangar and Selama rivers (see Table 5). Partially shaded by the riparian vegetation, fast flowing water, sandy and hardy substrate types of these rivers are the most preferable habitats for this fish (McClure *et al*. 2006). A streamlined body with a superior mouth enables this species to get food sources from the water surface. Insects are the main diet of all *Danio* species. *C. apogon* preferred poor quality in Bogak River as its main habitat because slow moving water was suitable for its morphology. This species fed on detritus, the main food for most fishes living in this river (Yap 1988). Substrate types also play an important role to distinguish fish adaptation. It is assumed that *A. choirorhynchos* is an active burrower. Only a few numbers of individuals of this species were found in Mahang, upper of Kerian and Serdang rivers.

4. Conclusion

In this study, all the selected rivers were productive to certain fish species. Based on the Kn values, Kangar River is considered as the best habitat for *D. regina*, while Mahang River for *R. sumatrana*, upper of Kerian River for *P. binotatus*, Serdang River for *Labiobarbus* sp., middle of Kerian River for *A. choirorhynchos* and Bogak River for *C. apogon.* The physico-chemical parameters and characteristics of the rivers played an important role in determining the growth type of fish and their adoptions to certain rivers. In addition, availability of food sources could possibly influenced the growth performances of fishes.

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References

Abowei, J.F.N. (2009), "The abundance, condition factor and length-weight relationship of *Cynoglossus senegalensis* (Kaup, 1958) from Nkoro River Niger Delta, Nigeria", *Advance Journal of Food Science and Technology* **1**(1), 57-62.

Abdurahiman, K.P., Harishnayak, T., Zacharia, P.U., Mohamed, K.S. (2004), "Length-weight relationship of commercially important marine fishes and shellfishes of the southern coast of Karnataka, India", *NAGA*, *ICLARM*, **27**(1&2), 9-14.

Ambak, M.A., Mansor, M.I., Mond-Zaidi, Z., Mazlan, A.-G. (2010), "*Fishes of Malaysia*". Publisher Universiti Malaysia Terengganu. 344 pp.

Ayoade, A.A., Ikulala, A.O.O. (2007), "Length-weight relationship, condition factor and stomach contents of *Hemichromis bimaculatus, Sarotherodon melanotheron* and *Chromidotilapia guentheri* (Perciformes: Cichlidae) in Eleiyele Lake, Southwestern Nigeria", Revista de Biologia Tropical **55**(3-4), 969-977.

Che-Salmah, M.R., Abu-Hassan, A., Ameilia, Z.S. (2001), "Preliminary distribution of Ephemeroptera, Plecoptera and Trichoptera (EPT) in Kerian River Basin, Perak, Malaysia", *Pertanika Journal of Tropical Agricultural Science* **24**(2), 101-107.

Che-Salmah, M.R., Abu-Hassan, A., Ameilia, Z.S. (2004), "Odonate communities (Odonata: Insecta) in a tropical river basin, Malaysia", *Wetland Sci*ence **1**, 1-9.

Efitre, J., Chapman, L.J., Murie, D.J. (2009), "Fish condition in introduced tilapias of Ugandan crater lakes in relation to deforestation and fishing pressure", *Environmental Biology of Fishes* doi: 10.1007/s10641-009-9461-z (Jan 5, 2012).

El–Agami, A.E. (1988), "Age determination and growth studies of *Gerres oyena* (Forskall 1775) in the Arabian Gulf waters", *Mahasagar* **21**(1), 23–34.

Farzana, Y., Saira, K. (2008), "Length-weight relationship and relative condition factor for the halfbeak *Hemiramphus far* Forsskål, 1775 from the Karachi coast", *University Journal of Zoology, Rajshahi Univ*ersity **27**, 103-104.

Froese, R. (2006), "Cube law, condition factor and weight-length relationship: history, meta-analysis and recommendations", *Journal of Applied Ichthyology* **22**, 241-253.

Frota, L.O., Costa, P.A.S., Braga, A.C. (2004), "Length-weight relationships of marine fishes from the central Brazilian coast", *NAGA, ICLARM* **27**(1&2), 20-26.

Golam, M., Tawfeequa, R. (2006), "Length-weight relationship, condition factor and sex-ratio of freshwater fish, *Rhinomugil corsula* (Hamilton) (Mugiliformes: Mugilidae) from Rajshahi, Bangladesh", *Journal of Biological Science* **14**, 139-141.

González-Gándara, C., Pérez-Diaz, E., Santos-Rodríguez, L., Arias-González, J.E. (2003), "Length-weight relationships of coral reef fishes from the Alacran Reef, Yucatan, Mexico", *NAGA, ICLARM* **26**(1), 14-16.

Hadi, A.A. (2008), "Some observation on the age and growth of *Tilapia zillii* (Gervais, 1848) in Umhfein Lake (Libya)", *Journal of Applied Sciences* **2**, 12–21.

Jamabo, N.A., Chindah, A.C., Alfred-Ockiya, J.F. (2009), "Length-weight relationship of a mangrove prosobranch *Tympanotonus fuscatus var fuscatus* (Linnaeus, 1758) from the Bonny Estuary, Niger Delta, Nigeria", *World Journal of Agricultural Sciences* **5**(4), 384-388.

Kottelat, M., Whitten, A.J., Kartikasari, S.N., Wirjoatmodjo, S. (1993), "*Freshwater fishes of western Indonesia and Sulawesi",* Periplus Editions Limited. p 293.

Laghari, M.Y., Narejo, N.T., Mahesar, H., Lashari, P.K., Abid, M. (2009), "Length-weight relationship and condition of indigenous catfish, *Rita rita* (Hamilton) from cemented ponds University of Sindh, Jamshoro", Sindh University *Research Journal (Science Series)* **41**(2), 47-52.

Lawson, T.B. (1995), "*Fundamentals of aquacultural engineering*", Chapman and Hall. New York. 357 pp.

Le Cren, E.D. (1951), "The length-weight relationship and seasonal cycle in the gonad weight and condition in the perch (*Perca fluviatilis*)", *Journal of Animal Ecology* **20**, 201-219.

Mansor, M.I., Nur-Ili-Alia, D., Wan-Ahmad-Afzan, W.M., Amir-Shah-Ruddin, M.S. & Ng, W.K. (in press), "Biological aspects of the sleeper goby, *Butis gymnopomus* (Bleeker, 1853), from the Merbok estuary, Kedah, Malaysia", *Ichthyological Research*.

McClure, M.M., McIntyre, P.B., McCune, A.R. (2006), "Notes on the natural diet and habitat of eight danionin fishes, including the zebrafish *Danio rerio", Journal of Fish Biology* **69**, 553-570.

Mohsin, A.K.M., Ambak, M.A. (1983), "*Freshwater fishes of Peninsular Malaysia*", Publisher Universiti Pertanian Malaysia. 284pp.

Odat, N. (2003), "Length-weight relationship of fishes from coral reefs along the coastline of Jordan (Gulf of Aqaba)", *NAGA, ICLARM*, **26**(1), 9-10.

Offem, B.O., Samsons, Y.A., Omoniyi, I.T. (2009), "Length-weight relationship, condition factor and sex ratio of forty six important fishes in a tropical flood river", *Research Journal of Fisheries and Hydrobiology* **4**(2): 65-72.

Othman, M.R., Samat, A., Hoo, L.S. (2002), "The effect of WQI on the distribution of fish in Labu river system in Sub-Langat Basin, Malaysia", *Journal of Biological Science* **2**(1), 28-31.

Pauly, D. (1983), "Some simple methods for the assessment of tropical fish stock", *FAO Technical Paper* 234, 52pp.

Rainboth, W.J. (1996), "*Fishes of the Cambodia Mekong*", FAO 265 pp.

Sachidanandamurthy, K.L., Yajurvedi, H.N. (2008), "A study on growth co-efficient and relative condition factor of the major carp (*Catla catla*) in two lakes differing in water quality", *Applied Ecology and Environmental Research* **6**(3), 33-47.

Samat, A., Shukor, M.N., Mazlan, A.G., Arshad, A., Fatimah, M.Y. (2008), "Length-weight relationship and condition factor of *Pterygoplichthys pardalis* (Pisces: Loricariidae) in Malaysia Peninsula", *Research Journal of Fisheries and Hydrobiology* **3**(2), 48-53.

Schneider, J.C., Laarman, P.W., Gowing, H. (2000), "Length-weight relationship", *Manual of fisheries survey method* **2**, 1-16.

Shukor, M.N., Samat, A., Ahmad, A.K., Ruziaton, J. (2008), "Comparative analysis of length-weight relationship of *Rasbora sumatrana* in relation to the physicochemical characteristics in different geographical areas in Peninsular Malaysia", *Malaysian Applied Biology* **37**(1), 21-29.

Smith, K.M.M. (1996), "Length/weight relationship of fishes in a diverse tropical freshwater community, Sabah, Malaysia", *Journal of Fish Biology* **49**, 731-734.

Thomas, J., Venu, S., Kurup, B.M. (2003), "Length-weight relationship of some deep-sea fish inhabiting the continental slope beyond 250m depth along the West Coast of India", *NAGA, ICLARM* **26**(2), 17-20.

Yap, S.Y. (1988), "Food resource utilization partitioning of fifteen fish species at Bukit Merah Reservoir, Malaysia", *Hydrobiologia* **157**, 143-160.

Yap, S.Y. (1990), "A Malaysian Tidal barrage incorporating a fishery component: Perspectives. Reservoir fisheries of Asia", *Proceedings of the 2nd Asian reservoir fisheries workshop*, Hangzhou, People's Republic of China, 15-19 October 1990. p 76-103.

Second Author:
MANSOR MAT ISA, born in Tokai, Kedah, Malaysia on 4th Aug 1955.
Graduated from National University of Malaysia in 1981.
Obtained Ph.D. on Fish Population Dynamics and Management from University College of Swansea,Wales, U.K. in Sept 1993.
Became a Fisheries Officer from 1981 to 1989 at the Fisheries Research Institute, Penang Malaysia.
Appointed a Research Officer at the Fishery Resources Development and Management Department of the Southeast Asian Fisheries Development Center, Chendering, Kuala Terengganu, Malaysia from 1993 to 2005. Joining as a University Lecturer at the Sciences University of Malaysia from 2007 till present.

Table 1. General characteristics of selected rivers in the Kerian River Basin with coordinates.

Name of site	Approximate sampling location	Description of site
Mahang River	5°20'43.70"N 100°46'17.70"E	Small hillstream, steep gradient of a river bank, relatively fast flowing water, partially shaded by fruiting and bamboo trees, sand mining areas and fruit orchards near the river area, sandy and gravel substrates.
Kangar River	5°20'17.17" N 100°46'28.30"E	Small hillstream, shallow gradient of a river bank, oil palm plantation, slow moving water, very shallow, the river is partially shaded by the riparian vegetation, substrates dominated by sand.
Selama River (upstream)	5°15'34.60"N 100°50'42.10"E	Moderate size hillstream, shallow gradient of a river bank, relatively fast flowing water, the river is located in hilly areas, recreation areas, fruit orchard nearby, the main substrates are boulder and cobble, the river is partially shaded by the riparian vegetation such as *Koompassia malaccensis*, *Aglaonema nitidum*, *Chassalia chartacea* and *Bambusa* sp.,
Kerian River (upper)	5°18'48.60"N 100°46'57.30"E	A large hillstream, moderate gradient, cobble, very strong current, *Melastoma malabathricum* dominates the river bank
Kerian River (middle)	5°13'41.50"N 100°41'13.50"E	A large river, steep and unstable bank near the oil palm plantation, the river is near residential areas,
Serdang River	5°11'32.40"N 100°36'57.20"E	Steep gradient of a river bank, exposed directly to sunlight, surrounded by oil palm plantation, the main substrate was sand, only grass as the main vegetation. A small scale of aquaculture was found here, very near to residential areas.
Bogak River	5°2'38.30"N 100°31'13.70"E	Moderate gradient of a river bank, surrounded by oil palm, paddy field plantations and residential areas, exposed directly to sunlight, muddy substrates covered by *Cabomba* sp. and *Salvinia molesta*

Table 2. The site description and the mean *in situ* reading (±s.d.) by sampling sites during the study period.

Sampling site	Mahang River	Kangar River	Kerian River (upper)	Selama River (upstream)	Kerian River (middle)	Serdang River	Bogak River
DO (mg/L)	8.28 ± 0.17	7.71 ± 0.14	8.14 ± 0.42	8.34 ± 0.85	6.99 ± 0.09	6.69 ± 0.33	3.77 ± 0.46
pH	6.22 ± 0.71	5.95 ± 0.27	5.83 ± 0.74	6.05 ± 0.51	5.80 ± 0.29	6.04 ± 0.20	5.64 ±0.45
Cond (µS/cm)	16.51 ± 0.79	18.6 ± 0.17	22.49 ± 2.99	19.6 ± 0.63	27.02 ± 2.56	40.9 ± 9.70	246.47 ± 143.63
Temperature (°C)	21.82 ± 0.33	23.6 ± 0.57	22.61 ± 0.15	22.4 ± 0.57	23.32 ± 0.77	26.00 ± 1.46	28.29 ± 3.09
TDS (mg/L)	8 ± 0.58	8.63 ± 0.00	10.61 ± 2.25	9.11 ± 0.58	12.25 ± 1.26	18.45 ± 1.50	126.19 ± 68.02
Salinity (ppt)	0	0	0	0	0	0	1.50 ± 0.71
Velocity (m/s)	0.69 ± 0.14	0.49 ± 0.08	0.80 ± 0.08	0.42 ± 0.08	0.65 ± 0.03	0.56 ± 0.07	0.13 ± 0.02
Depth (cm)	46.13 ± 11.09	17.5 ± 7.33	62.25 ± 13.65	62 ± 26.75	400 ± 74.58	32.5 ± 5.26	230 ± 25.32
Width (m)	4.91 ± 1.10	3.64 ± 0.65	2.24 ± 0.14	8.87 ± 0.75	41.15 ± 0.00	12.8 ± 0.30	15.6 ± 0.00

Table 3. Estimated parameters of the length-weight relationship for six selected freshwater fish species in Kerian River. (n: number of samples, min: minimum, max: maximum, *a*: intercept of regression line, *b*: slope of regression line, S.E: Standard Error, Cl: confidence level, R^2: regression coefficient). *Significant at P < 0.01.

Families	Species	n	Total length (cm)		Weight (g)		Ln *a*	*b*	S.E of *b*	95% of Cl	R^2
			min	max	min	max					
Cyprinidae	*D. regina*	124	4.3	10.8	1	16	-5.101	3.256	0.203	3.052-2.461	0.89*
	Labiobarbus sp.	104	6.3	23	3	135	-4.464	2.898	0.130	2.788-3.010	0.96*
	P. binotatus	92	5	12.6	1	32	-6.570	3.911	0.272	3.733-4.249	0.91*
	R. sumatrana	92	5.1	11.6	1	16	-6.041	3.642	0.206	3.363-3.921	0.88*
	C. apogon	35	5.7	14	1	39	-5.948	3.623	0.158	3.385-3.861	0.97*
Cobitidae	*A. choirorhynchos*	56	7.8	23.5	4	50	-3.960	2.427	0.148	2.214-2.640	0.91*

Table 4. Fish grouping in Kerian River based on the value of *b* (slope of the linear equation) and mean condition factor for combined sexes with standard deviation (K ± s.d); *b* < 3: light group (NA, negatively allometric), while *b* > 3: heavy group (PA, positively allometric). R^2: regression coefficient.

Fish species	Group	Growth pattern	$W = aL^b$
D. regina	Heavy	PA	$W = 0.013TL^{3.252}$
Labiobarbus sp.	Light	NA	$W = 0.028TL^{2.864}$
P. binotatus	Heavy	PA	$W = 0.05TL^{3.811}$
R. sumatrana	Heavy	PA	$W = 0.011TL^{3.301}$
A. choirorhynchos	Light	NA	$W = 0.019TL^{2.427}$
C. apogon	Heavy	PA	$W = 0.002TL^{3.623}$

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Table 5. Mean relative condition factor with standard deviation (Kn ± s.d) and growth performance of six species collected from seven sampling sites in the Kerian River Basin.

Fish species		Sampling sites						
		Selama	Kangar	Mahang	Upper of Kerian	Serdang	Middle of Kerian	Bogak
D. regina	*Kn*	1.033±0.2133	1.14±0.257	1.027±0.156				
	TL(cm)	(4.3-10.5)	(4.9-9.7)	(6.1-10.8)	NA	NA	NA	NA
	W(g)	(1-12.9)	(1-11)	(2-16)				
	b	2.882	3.574	3.212				
R. sumatrana	*Kn*			1.873±0.203*	1.079±0.152*	1.073±0.231*		
	TL(cm)	NA	NA	(6.7-10.5)	(6.6-11.6)	(5.1-10.5)	NA	NA
	W(g)			(2-14)	(3-16)	(1-13)		
	b			3.770	3.095	3.538		
P. binotatus	*Kn*				1.131±0.212	1.052±0.219		
	TL(cm)	NA	NA	NA	(6.4-9.7)	(5-12.6)	NA	NA
	W(g)				(3-12)	(1-32)		
	b				3.133	3.507		
Labiobarbus sp.	*Kn*					1.076±0.155	1.034±0.084	1.048±0.136
	TL(cm)	NA	NA	NA	NA	(6.3-23)	(8.5-16.2)	(6.5-11)
	W(g)					(4-135)	(6-34)	(3-13)
	b					3.037	2.533	2.889
A. choirorhynchos	*Kn*						1.003±0.109	
	TL(cm)	NA	NA	NA	NA	NA	(16.8-23.5)	NA
	W(g)						(16-50)	
	b						2.678	
C. apogon	*Kn*							1.317±0.208
	TL(cm)	NA	NA	NA	NA	NA	NA	(5.7-14)
	W(g)							(1-39)
	b							3.629

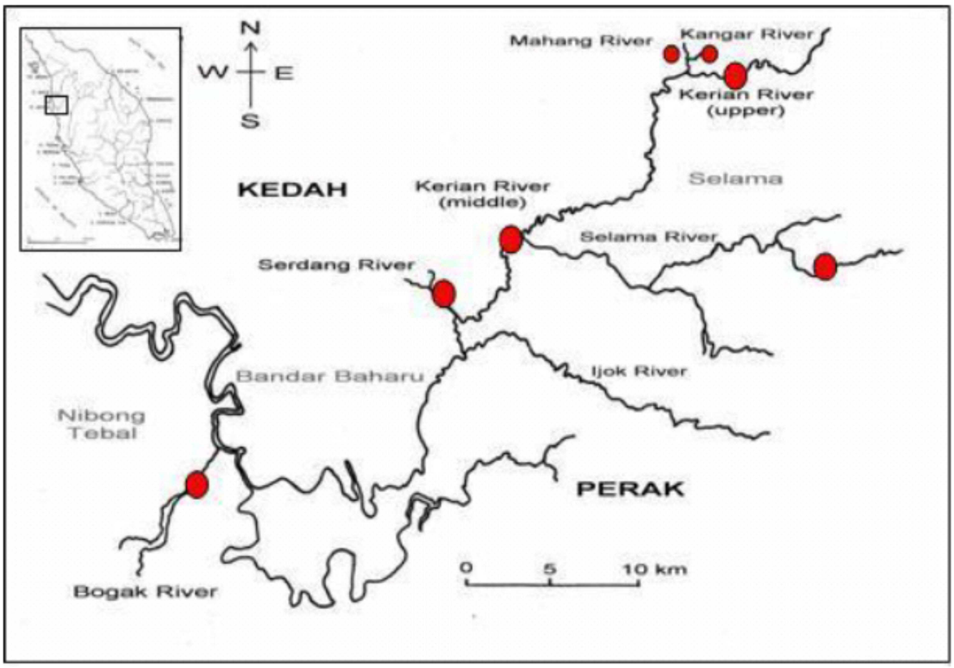

Fig. 1. The map of Kerian River Basin (inset square) in the northern of Peninsular Malaysia. Red circles representing sampling sites.