Comparison of Length-Weight Relationship and Condition Factor of Three Fish Species between Regulated and Natural Rivers

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ABSTRACT: Batang Rajang and Batang Baleh are two of the main rivers located in Sarawak, Malaysia. Both rivers used to be a natural river system. However, after the impoundment of Bakun Hydroelectric dam in 2004, the flow regime in Batang Rajang was transformed into a regulated flow. This change in flow regime had a potential to leave some impacts on the fish community. Therefore, this study utilizes the Length-Weight Relationship (LWR) together with condition factor (K) to determine the impact of regulated flow towards the fish community by comparing it to the natural flow regime. Prior to this study, no attempt has been conducted to compare the growth pattern of these species that are present in both river systems. The main objective of this study was to record and compare the differences in LWR of these species between Batang Rajang and Batang Baleh. The species selected for this study are *Barbonymus schwanenfeldii*, *Cyclocheilichthys armatus* and *Parachela oxygastroides*. Samples were collected using gill net from various mesh sizes. The formula used for the LWR is log W= log a + b log$L$. The results showed that individuals from all three species that lived in natural river showed a clear single LWR curve, meanwhile individuals that lived in regulated river showed scattered LWR curve. The LWR and K factor of *B. schwanenfeldii, C. armatus* and *P. oxygastroides* differ between Batang Rajang and Batang Baleh indicating regulation of river flow has impact on the fish community.

KEYWORDS: Length-Weight Relationship; Condition factor; *Barbonymus schwanenfeldii; Cyclocheilichthys armatus; Parachela oxygastroides*

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INTRODUCTION

Batang Rajang and Batang Baleh are two of the main rivers located in Sarawak. Although both rivers used to be natural rivers, Batang Rajang was transformed into a regulated flow after the impoundment of Bakun Hydroelectric Dam in 2004. The change in flow regime was thought to have a great potential on leaving impacts towards the fish community. Kiernan et al. (2012) stated that flow is very important and is the major variable in determining all biotic composition.

The length-weight relationship provides a good assessment tool to investigate the situations between these river systems. Hamid et al. (2015) and Khristenko & Kotovska (2017) reported that LWR is widely used by fishery researcher to predict the wellbeing of fishes between groups spatially or temporally in natural population. The main objective of this study was to record and compare the differences LWR of fish of the same species between Batang Rajang and Batang Baleh.

BACKGROUND THEORY

According to Wotton (1991), fish showing b value > 3 indicates that it is becoming heavier in comparison to its length, meanwhile b value < 3 indicates that it is becoming lighter in comparison to its length. Finally, if b value remains exactly at 3, the fish is retaining an isometric growth. Barnham and Baxter (2003) proposed K factor values as follows: K= 0.80 -very poor, K= 1.00 -poor, K= 1.20 -average, K= 1.40 -well-proportioned and 1.60 -excellent.

METHODOLOGY

Field sampling was carried out from Feb 2016 to Oct 2016. In Batang Rajang sampling was done along the stretch below the dam starting from Long Bangu (N2°46'17.6" E114°1'57.9") to Segaham (N2°46'39.6" E114°56'5.1") and includes one tributary called Sg Tebawan (N2°47'2.3" E113°56'55"). Meanwhile, sampling in Batang Baleh was done at upstream of Mengiong River (N1°35'35.3" E113°26'15.6") to Sebatu and (N1°37'16.2" E113°30'39.4") includes one tributary called Sg Entuloh (N1°31'22.1" E113°27'1.1"). The fish samples were collected using monofilament gill net of various mesh sizes. Fish were identified using identification keys from Kottelat et al. (1993). Three selected species chosen for this study are *Barbonymus schwanenfeldii, Cyclocheilichthys armatus* and *Parachela oxygastroides.* The length was measured using a ruler and the body mass was weighed using electronic balance (Shimadzu ELB 300 series).

LWR and K factor was carried out using the equations:

$$\text{Log } W = \log a + b \log L \text{ (Keys, 1928)} \quad (1)$$

where, W is weight, L is length, a and b are constant estimated by regression analysis.

$$K = 100W/L^3 \text{ (Pauly, 1983)} \quad (2)$$

where, W is weight, L is length and K is Condition factor.

RESULT AND DISCUSSION

A total of 508 individuals from the three species were collected for this study. All three species belong to the family Cyprinidae from genera *Barbonymus, Cyclocheilichthys* and *Parachela*. The number of individuals collected for each species were as follows; Batang Rajang- *B. schwanenfeldii* (N=59), *C. armatus* (N=67) and *P. oxygastroides* (N=50), Batang Baleh- *B. schwanenfeldii* (N=160), *C. armatus* (N=50) and *P. oxygastroides* (N=122). All 3 species in Batang Rajang showed negative allometric growth where b values < 3.00. *C. armatus* showed the highest b value among the three species (b=2.31), followed by *B. schwanenfeldii* (b=1.61) and *P. oxygastroides* (b=1.57).

Meanwhile, in Batang Baleh one out of three species showed positive allometric growth pattern, *C. armatus* scored the highest b values at 3.31, followed by *B. schwanenfeldii* (b=2.80) and *P. oxygastroides* (b=2.40) (Table 1). The condition factor for all 3 species in Batang Rajang was higher compared to Batang Baleh. *B. schwanenfeldii* scored the highest K at 1.56, followed by *P. oxygastroides* (K=1.33) and *C. armatus* (K=0.64). Meanwhile, for Batang Baleh *B. schwanenfeldii* scored the highest K at 1.14, followed by *P. oxygastroides* (K=1.00) and *C. armatus* (K=0.62) (Table 1).

Individuals living in the regulated river (Batang Rajang) do not follow the traditional growth curve. Based on the results, more scattered growth curve was shown by all 3 species that lived in Rajang as compared to the growth curve in Batang Baleh (Figure 1). Since the flow regime fluctuate less due to the impoundment, the fish behaviors are no longer dictate by natural causes (Bun & Arthington, 2002). Fish living in Batang Rajang shows more than one growth curve. This suggests that the new environment enables each individual to grow at their own pace. Lester et al. (2004) mentioned several factors that are associated with potential somatic growth in fish include foraging time, processing capacity of the digestive tract, quality and quantity of the food, prey-predator relationship and reproduction. There is a possibility that non-fluctuating environment provides more leverage for the fish to find food. Another possible explanation that could be related with the phenomenon is the break of spawning cue. Fish spawning activities in river floodplain are strongly dependent on the inundation of water level as the cue (Bun & Arthington, 2002 and Agostinho et al.,

2008). Without any reproductively cues to alarm the community, the reproduction activities are not uniformed among individuals. Lester et al. (2004) also mentioned that fish eventually diverted the energy investment for somatic growth to reproduction when it is sexually matured. Therefore, there are high possibility that non-uniformed energy spends by each individual resulted in the scattered growth curve in Batang Rajang.

The fish in Batang Rajang showed sign of adaptation towards the new environment. All 3 species studied showed higher condition factor compared to individuals in Batang Baleh, although all have *b* values < 3.00. Based on the fact that K factor is derived from the fish length and weight, this suggests that individuals in Batang Rajang adopt different growth strategy and managed to stay in good condition. Although low K factor was observed for *P. oxygastroides* in Batang Rajang (K=0.64), the same trend was also observed for the same species in Batang Baleh. Froese (2006) stated that great variations of length to weight can occur between species. This is due to the thin morphology of the fish as compared to *B. schwanenfeldii* and *C. armatus*. Steep slope was observed in the *P. oxygastroides* linear plot in Batang Baleh. This is most probably a pseudo-trend instead of a true-trend, which only represent a part of the growth of the species. Most of the *P. oxygastroides* samples collected were about the same length with low standard deviation (21.4 ± 1.1) cm. The SD for this species is much lower compared to other two species that showed SD ≥ 2.0. Thus, more samples from different live stages (juvenile-adult) are required to give a clear representation of the species LWR analysis.

Table 1. The Result of LWR of three species in Batang Rajang and Batang Baleh.

Species	N	Area	R^2	*a*	*b*	Mean K	Mean BW (g)	Mean TL (cm)
Barbonymus schwanenfeldii	59	Rajang	0.55	0.13	1.61	1.56 ± 0.74	84.0 ± 50.7	17.7 ± 3.9
	160	Baleh	0.90	1.68	2.80	1.14 ± 0.12	126.4 ± 76.9	21.3 ± 4.6
Cyclocheilichthys armatus	67	Rajang	0.67	1.03	2.31	1.33 ± 0.50	83.88 ± 41.9	18.3 ± 3.4
	50	Baleh	0.95	2.39	3.31	1.00 ± 0.10	62.53 ± 30.03	18.0 ± 2.5
Parachela oxygastroides	50	Rajang	0.44	0.59	1.57	0.64 ± 0.22	16.3 ± 7.62	13.6 ± 2.0
	122	Baleh	0.71	1.40	2.40	0.62 ± 0.05	61.16 ± 8.86	21.4 ± 1.1

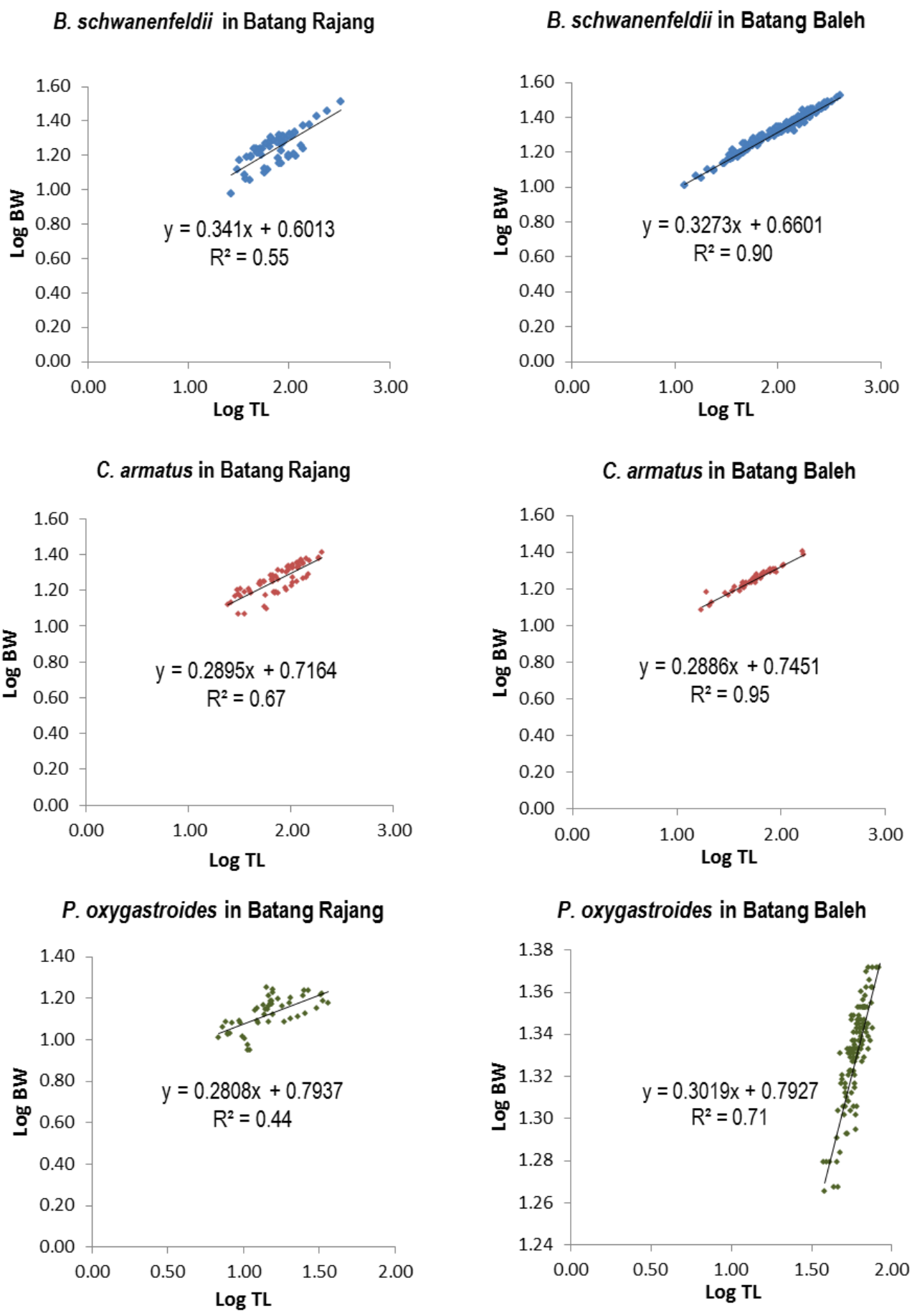

Figure 1. The LWR linear regression plots for three species in Batang Rajang and Batang Baleh.

CONCLUSION

The LWR and K factor of *B. schwanenfeldii, C. armatus* and *P. oxygastroides* differ between Batang Rajang and Batang Baleh. This showed that regulation of river flow has impact on the fish community.

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