Length-weight relationship, condition factors and trophic level of Buffon's river-garfish Zenarchopterus buffonis from coastal waters of Malaysia

<table>
<thead>
<tr>
<th>Journal:</th>
<th>Songklanakarin Journal of Science and Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manuscript ID</td>
<td>SJST-2017-0309.R1</td>
</tr>
<tr>
<td>Manuscript Type:</td>
<td>Original Article</td>
</tr>
<tr>
<td>Date Submitted by the Author:</td>
<td>05-Mar-2018</td>
</tr>
</tbody>
</table>
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| Keyword:         | halfbeak, growth pattern, condition factor, feeding habit, Malaysian coastal waters |
Type of Article (Original Article)

Length-weight relationship, condition factors and trophic level of Buffon's river-garfish
Zenarchopterus buffonis from coastal waters of Malaysia

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Abstract

Length weight relationship (LWR), condition factors and trophic level of *Zenarchopterus buffonis* from the coastal waters of Malaysia were conducted between November 2013 and March 2014. Three hundred individuals of *Z. buffonis* ranging between 8.7–16.0 cm total length and 3.67–22.19 g body weight were investigated in this study. The length-weight relationship demonstrated that the parameter *b* values at Sungai Likas, Tanjung Belungkor, Langkawi, Klang and Matang were 3.3114, 3.0534, 2.5442, 2.2018 and 2.8998 respectively, suggesting positive and negative allometric growth pattern for this species. Specimens from Matang recorded the lowest mean condition factor, *K* (0.2292±0.0578) whereas Tanjung Belungkor displayed the highest value (0.6556±0.0526). Matang was discovered to display the lowest relative condition factor, *K*n (0.0330±0.2336) whereas Klang had the highest *K*n value (3.5097±0.4232). Trophic level for *Z. buffonis* was analyzed based on 84 specimens. Gut content analysis revealed that *Z. buffonis* consume primarily on insects (57%), followed by plant materials (33%) and crustaceans (10%). The calculated TROPH values (1–3.2) signified that *Z. buffonis* has an omnivorous feeding habit. This study provides the pioneer description of LWR parameters, condition factors and diet preference for *Z. buffonis*, which would be beneficial for the sustainable fishery management in Malaysian coastal waters and neighbouring provinces.

Keywords: halfbeak, growth pattern, condition factor, feeding habit, Malaysian coastal waters

1. Introduction

*Zenarchopterus buffonis* which typically known as halfbeak fish exists in both tropical and subtropical regions (Collette, 2004). It is also reported that *Z. buffonis* is widely
distributed in Indo-West Pacific region, ranging from India, Malay Peninsula to northern Australia (Collette & Su, 1986). *Z. buffonis* can be mostly found at the surface levels in coastal waters, estuaries and rivers to hunt mainly insects (Rainboth, 1996).

Increase in length and weight of fish is a result of conversion of the food material consumed into development of muscle mass by the nutritional process (Farzana & Saira, 2008). LWR plays a great role in fisheries science and stock assessment because it provides a valid evaluation of fish’s average weight at a given length class by applying a mathematical relationship between them (Mir et al., 2012). Carlander (1969) reported that the body weight increases exponentially as length increases in fish, with the \( b \) value is normally near to 3.0 and may range between 2.5 and 3.5. The fish possesses an isometric growth if the \( b \) value is 3.0 and remains when the shape and thickness of the fish are consistent. If the fish grows allometrically, the body weight of fish increases at slower \((b<3.0)\) or faster \((b>3.0)\) respective to the growth in length.

The Fulton condition factor (\( K \)) is most typically used by fishery researchers to access the plumpness and health (Mir et al., 2012) of fish, assuming that the fish is in better condition when it is heavier at a given length. Relative condition factor (\( Kn \)) considers variations like those related with food items and feeding habits, sexual maturity (Le Cren, 1951) and the investigation on \( Kn \) can be useful in analyzing the fatness of fish, hence allowing a fish culturist to examine the body weight of fish with reference to a standard calculated body weight (Kurup & Samuel, 1987).

The key role of feeding studies for fisheries biology was discovered the last decade by using trophic level to determine the consequences of fishing on the equilibrium of ocean food chain (Pauly, Christensen, Dalsgaard, Froese, & Torres, 1998). Trophic levels estimation is valuable to quantify the impact of fishing on the environment and ocean ecosystem because it
permits the development of modern techniques to the study of marine food chains (Pauly et al., 2000).

Several studies on *Z. buffonis* has been conducted, such as mating behaviour (Kottelat & Lim, 1999); habitat preferences (Ikejima, Tongnunui, Medej, & Taniuchi, 2003) description on pharyngeal jaw apparatus and diets (Abidin, Hashim, Das, & Ghaffar, 2015) and morphometric variations of population from Indonesian waters (Syafullah, 2015). However, documented information on the LWR and trophic values of this particular fish species in Malaysian waters is still lacking.

It is important to know the biological diet and other physiological adaptations to achieve high degree of resiliency in the harsh environment of Malaysian coastal waters. Food resources for this species have been depleted due to several factors such as coastal zone destruction, chemical pollution from the urban areas and rapid deforestation. Due to restricted food items available in their habitat, this fish species has shifting diets ranging from herbivory to insectivory, which makes them known as opportunistic surface feeder. The objectives of present study are to describe the LWR, condition factors and trophic level of *Z. buffonis* from the Malaysian coastal waters.

2. Materials and Methods

2.1 Field sampling and laboratory preparation

A total of 300 halfbeak fish were collected from five sites in Malaysia, namely, Sungai Likas in Sabah; Tanjung Belungkor in Johor; Langkawi in Kedah; Klang in Selangor; and Matang in Perak (Table 1). Fresh samples were stored in a deep freezer (−4°C) for subsequence observation. The left side of specimens was photographed using a Canon G12 with 3648 × 2736 pixel dimension images. Some individuals were saved for diet studies.
order to avoid further digestion of the gut content, 4% (w/v) formaldehyde was injected directly into each gut of fish.

2.2 Length-weight relationship

The mathematical relationship between total length and total weight of *Z. buffonis* was estimated according to LWR analysis (\(W=al^b\)) (Abdallah, 2002), where, \(W\) = total body weight of fish (g), \(L\) = total length of fish (cm), \(a\) is the regression intercept of the regression curve and \(b\) is the regression coefficient. The total length of the fish sample (from tip of upper jaw to the tip of caudal fin) was measured to the closest 0.01 cm using a digital caliper (Fisherbrand™ Traceable™, ±0.03mm). Whole body weight of fish was recorded on a digital balance (Shimadzu, AUW220D) to an accuracy of 0.01 g.

2.3 Condition factor \((K)\) and Relative condition factor \((Kn)\)

Fulton (1904) proposed the application of a mathematical formula that would evaluate the condition factor \((K)\) of fish:

\[
K = \frac{W}{L^3} \times 100
\]

Where, \(W\) = whole body wet weight (g), \(L\) = total length in centimetre (cm) and 100 is a factor to bring the value \(K\) close to unity. Relative condition factor \((Kn)\) is computed according to empirical LWR and is calculated by the formula:

\[
Kn = \frac{W}{al^b}
\]

Where, \(W\) = observed weight of fish whereas \(al^b\) = calculated weight of fish. The difference between \(K\) and \(Kn\) is that the former is measuring the deviation from a hypothetical ideal individual whereas the latter measures the deviation of an individual from average weight for length (Saha, Vijayanand, & Rajagopal, 2009).
2.4 Trophic level analysis

The guts of 84 individuals of *Z. buffonis* were and the digestive tracts were dissected out and placed in 70% ethanol for a longer preservation. Identified prey items were classified to large taxonomic groups, counted and weighed to the closest 0.01 g. Gut content analysis was performed according to recommendations provided by Stergiou and Karpouzi (2002). Gut contents were examined carefully using a dissecting microscope and evaluated in accordance with occurrence method (Hyslop, 1980). Weight percentage (wt%) and frequency of occurrence ($f_o$) were analyzed for different fish length classes. Composition data were applied to estimate the trophic levels of *Z. buffonis* captured from Malaysian coastal waters. Trophic level helps in indicating the position of animals inside the marine food chain that widely explain aquatic ecosystems (Pauly & Palomares, 2000). TrophLab was used to calculate the TROPH value from the dataset and also its standard error by applying the volume contribution and the trophic level of each prey species to the diet. The trophic level was calculated per length class based on equation below (Pauly et al., 2000):

$$ \text{TROPH}_j = 1 + \sum_{j=1}^{G} DC_{ij} \times \text{TROPH}_j $$

Where TROPH$_j$ represents the fractional trophic level of prey (j), $G$ is the total number of prey species in a gut and DC$_{ij}$ is the fraction of j in the diet of i. Hence this explained the value of trophic level ranges between 2.0 (herbivore) and 5.0 (carnivore) (Pauly & Palomares, 2000). The mean values ($\pm$S.E.) estimated from the equation were input into the MICROCAL ORIGIN 8.0 graphic software (OriginLab, Northampton, MA) (Simon et al., 2009) for acquiring the trophic position pattern according to the fish size class.
### 2.5 Statistical analysis

A non-linear regression was applied to obtain value of $a$ and $b$. A curve fitting was performed by a non-linear repetitive technique using Levenberg-Marquardt and Simplex algorithms to achieve the best convergence $\chi^2$ goodness-of-fit values by using a computer software programme (OriginLab, Northampton, MA). The degree of modification of the model obtained was determined by the coefficient of determination ($r^2$). Student’s t-test (Das, De, & Ghaffar, 2014) was carried out to check whether the $b$ values obtained were differ significantly ($P<0.05$) from 3, signifying the growth pattern of fish: negative allometric ($b>3.0$), positive allometric ($b>3.0$), or isometric ($b=3.0$) (Spiegel, 1991). A statistic significance of 5% ($P<0.05$) was set in all cases.

### 3. Results

#### 3.1 Length-weight relationship

The range of total length, body weight, regression parameters and growth pattern of *Z. buffonis* from each location are summarized in Table 1. It was discovered that *Z. buffonis* from Sungai Likas region the values of exponent $b$ was greater than 3 (Figure 1), and Sungai Likas has the greatest $b$ value than other sampling sites. The value of exponent $b$ was also greater than 3 in Tanjung Belungkor region (Figure 2), indicating a positive allometric growth pattern. Population of *Z. buffonis* in Langkawi, Klang and Matang area showed a negative allometric growth ($b<3$) (Figure 3, 4 and 5). The *Z. buffonis* from Klang waters displayed the lowest $b$ value among all sampling sites.

Analysis of condition factor ($K$) and relative condition factors ($Kn$) of *Z. buffonis* from all sampling sites are presented in Table 2. All of the fish sampled in this study showed the $K$ value is lower than 1.0 and all the values were considered significant ($P<0.05$), with the lowest value in Matang (0.2292±0.0578) and highest in Tanjung Belungkor (0.6556±0.0526).
The relative condition factor ($K_n$) value was lowest in Matang (0.9339±0.2336) and highest in Klang (3.5097±0.4232).

### 3.2 Trophic level analysis

Out of the studied guts, 3% were found empty and 97% contained prey items. Three different families of insects, one family of shrimp and plan materials were identified in this study (Table 3). Insects were the main prey items (57%), followed by plant materials (33%) and crustaceans (10%). Among the identified insect species, weaver ants (Formicidae) and plant materials formed the majority of the diet by weight 7g. Weaver ants also occurred most frequently ($f_o=96$) in fish samples. It was observed that insect were the majority group of the diet by number ($N=124$) and weight ($W=12g$).

The calculated TROPH value for *Z. buffonis* is ranging from 1 to 3.3 with mean value of 3.2±0.55 (Figure 6). Fish with total length of 8 to 13 cm has trophic value of 1.0 to 3.5, while fish with total length of 11.5 to 13 cm has trophic value of 1.0. The diets of the smallest length class consisted entirely insects. The following length class of fish (10.5−12.5 cm) showed that their diet shifted by consuming crustaceans with a great contribution of arthropods. The larger length class of fish (12.5−15.5 cm) demonstrated a wider array of food consumption which comprised of plant materials and insects, indicating that the species have a tendency to be generalist feeders as it grows larger (Figure 7).

### 4. Discussion

The present investigation agrees with earlier studies on different species of halfbeak fish from the same family (Hemiramphidae), where positive ($b>3$) and negative ($b<3$) allometric growth has been reported (Table 4). Various factors may influence the dissimilarity in growth pattern for this species throughout seasons and years, for example
salinity, climate, food, and sexual maturity (Sparre, 1992). Therefore, ecosystem health that associates with human exploitation involving aquaculture fish farming and logging activities could be another factor and this would disturb the ecological balance of this area.

The greatest exponent $b$ value of this $Z. \text{buffonis}$ in Sungai Likas indicated that it provided a more favorable environment with abundance of food availability, thus the fish population has better growth than other regions of coastal water of Malaysia. Coastal area of Klang has the lowest $b$ value. Klang might be a relatively less healthy and disadvantageous as a result of illegal logging activities that may disturb the water quality especially sedimentation, dissolved oxygen, temperature and pH (Mashhor, 2010). Hamzan, Zaini, Ibrahim, and Ariffin (2015) proposed that the natural environment and the water quality of coastal waters of Klang was deteriorated because of increasing waste disposal into upstream catchment activities from industrial and construction regions. These phenomena may have caused detrimental influence on the ecosystem health hence resulting in poor growth for $Z. \text{buffonis}$.

Hile (1936) suggested that the allometric coefficients ($b$) for an optimal fish might vary in the range of 2.5–4.0 and $Z. \text{buffonis}$ from coastal waters of Malaysia is in conformity with the typical $b$ values (2.5–3.5) even though it may vary significantly within this range (Froese, 2006). Pervin and Mortuza (2008) stated that higher $b$ values give impression of the overall condition of appetite and gonad composition of fish.

The $K$ values for $Z. \text{buffonis}$ were less than 1, with an average condition factor of $Z. \text{buffonis}$ in Sungai Likas, Tanjung Belungkor and Langkawi were similar (0.6007–0.6556). Other species of hemiramphids also showed a relatively low (less than 1) condition factor value, such as $\text{Hemiramphus archipelagicus}$ from Karachi Coast, Pakistan has a range of condition factor value of 0.197–0.257 (Tabassum et al., 2015). In this study, the $K$ values of Tanjung Belungkor were higher compared to the other four habitats, indicating that the body
specimens in Tanjung Belungkor were fatter and had thicker bodies than the other populations. This may be due to several factors, such as sex (Muchlisin et al. 2010) and maturity (Doddamani & Shanbouge, 2001), spawning (Al-Daham & Wahab, 1991), and effects of pollutants (Bakhoun, 1999).

Relative condition factor ($K_n$) indicates fatness, condition and welfare of fish. $K_n$ value is an important index used to monitor feeding intensity and growth rate of fish and is based on theory that heavier fish at a given length are healthier (Bagenal & Tesch, 1978). The values of $K_n$ which are found to be $>1$ indicates that the well being of the fish is good whereas its value $<1$ reflects that the fish is in bad condition. In the present investigation, it has been found that the $K_n$ was interesting similar ($0.9−1.0$) for all localities except for Klang ($K_n>3.0$). This may due to random collection of fish samples around the year and diverse range of food availability (Sarkar et al., 2013). This is further supported by the similar findings in respect to $K_n$ values for different geographical areas, such as Barilius bendelisis populations exhibited different $K_n$ values at different hill stream areas in India (Singh & Nautiyal, 2017). It can be suggested from the result of the current study that condition of the fish can be considered as good and performing well for all localities from coastal waters of Malaysia.

This study provides an important understanding into dietary and feeding habits of Z. buffonis in Malaysian coastal waters. Most of the guts of Z. buffonis observed in this study were filled with food items and percentage of absence of food was very low. The relatively low percentage of occurrence of empty gut may result from food material availability in the environment, rejection or digestion of food materials in fish gut during struggling to escape from the hook. This halfbeak species in Malaysian waters feed fundamentally on insects (in decreasing order of abundance: Formicidae, Dysticidae and Diptera), followed by plant materials and crustaceans. Diet structure of Z. buffonis exposed that this halfbeak species
often feed at the water surface as revealed by their principally insect in gut content rather than crustaceans and mangrove petal fragments (Abidin et al., 2015). This may be due to vast availability of arthropods on mangrove leaves and trees in the environment.

There were some inherent complications with the gut content analysis, for example the complicatedness in taxonomic identification due to the digestive activity especially along the gut, difficulties in quantifying several components in the food items, including detritus and plankton (Polluning & Pinnegar, 2002). Since gut content analysis is dependent on prey items that fed instantly before capture, hence they describe a limited perspective of the dietary preference in time and area (de la Moriniere et al., 2003). Nevertheless, gut content analysis is a widely applied method to study relationships in diet composition and trophic position (Hyslop, 1980).

The calculated value of trophic level of Z. buffonis indicated that they are omnivorous in nature, which signifies their feeding preferences consists of plant materials (herbivory) to crustaceans and fishes (carnivory). A carnivory feeding preferences were observed for archer fishes (Toxotes chatareus and T. jaculatrix) which have been dwelling the similar habitat in Malaysian water (Simon et al., 2009; Simon & Mazlan 2010). Although no research has been conducted in halfbeak trophic level in Malaysian waters, similar feeding preferences of other halfbeak species have been documented in coastal waters of North Stradbroke Island (Dey et atl. 2011). All these species exhibit similar feeding preferences, namely crustaceans, insects and plant materials and can be considered as omnivores. Trophic levels in halfbeak fishes differ with size. The estimated TROPH values suggested that bigger size or adult halfbeak fish can be either herbivorous or carnivorous. But smaller size or juveniles of halfbeak fish can only be carnivorous and possess a dietary protein restriction as they consume primarily on insects and crustaceans. This ontogenic trophic shift from carnivorous to omnivorous may due to the lack capability of enzymatic digestion of carbohydrates as herbivorous fish adults
(Day et al., 2011). Alimentary tract of juveniles may lack of capability to digest plant items adequately, as trophic shifts likely to correspond with elongation of gut (German & Horn, 2006). Results show that this species of halfbeak fish feed principally on insects rather than crustaceans and plant materials. This is maybe due to vast availability of insects on mangrove leaves in the environment.

Typically for most fish species, the sizes of prey consumed increase correspondingly to size of predator, which is applicable for comparisons within fish species (Stergiou & Karpouzi, 2002). This is because as fish grows, their relative success rate increases as a result of ontogenetic shift in sensory system and swimming efficiency (Juanes & Conover, 1994). In addition, a few studies have also assessed dietary shifts in relation to ontogenic changes in attributes such as mouth gape, pharyngeal morphology, digestive anatomy and nutritional requirement of gastrointestinal development are needed for fish growth (Davis, 2012).

5. Conclusion

Specimens from Matang recorded the lowest mean condition factor, $K$ (0.2292±0.0578) whereas Tanjung Belungkor demonstrated the highest value (0.6556±0.0526). Matang was discovered to display the lowest relative condition factor, $Kn$ (0.0330±0.2336) whereas Klang had the highest $Kn$ value (3.5097±0.4232). Gut content analysis revealed that Z. buffonis consume primarily on insects (57%), followed by plant materials (33%) and crustaceans (10%). The calculated TROPH values (1−3.2) signified that Z. buffonis has an omnivorous feeding habit. The present study document the fundamental information on LWR parameters, condition factors and diet preference for Z. buffonis collected from Malaysian coastal waters that would be helpful for ichthyologists and environmentalists to enforce adequate management and regulations in ensuring sustainable fisheries and biodiversity conservation, specifically in coastal waters of Malaysia.
Acknowledgments

The authors would like to thank the ichthyology lab technical staff of Universiti Kebangsaan Malaysia and School of Fisheries and Aquaculture Sciences, Universiti Malaysia Terengganu for their dedicated field assistance throughout the sample collection. This research was financed and supported by JSPS COMSEA-UMT Grant 53177. All field sampling and laboratory protocols followed and complied with the current laws of Malaysia.

References


<table>
<thead>
<tr>
<th>Location</th>
<th>Coordinate</th>
<th>n</th>
<th>Total length range (cm)</th>
<th>Body weight range (g)</th>
<th>Growth pattern</th>
<th>$W = aL^b$</th>
<th>$b$</th>
<th>$r^2$</th>
<th>t-test</th>
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</thead>
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<tr>
<td>Sg. Likas</td>
<td>$5°59'34.8''N, 116°06'03.0''E$</td>
<td>52</td>
<td>9.20–13.20</td>
<td>4.08–15.30</td>
<td>PA</td>
<td>$W = 0.0036L^{2.114}$</td>
<td>3.3114</td>
<td>0.9465</td>
<td>2.67, $P&lt;0.05$</td>
</tr>
<tr>
<td>Tg. Belungkor</td>
<td>$1°26'42.5''N, 104°03'47.4''E$</td>
<td>50</td>
<td>7.20–15.00</td>
<td>2.40–23.35</td>
<td>PA</td>
<td>$W = 0.0057L^{3.054}$</td>
<td>3.0534</td>
<td>0.9191</td>
<td>0.27, $P&gt;0.05$</td>
</tr>
<tr>
<td>Langkawi</td>
<td>$6°22'17.8''N, 99°40'18.5''E$</td>
<td>98</td>
<td>12.00–19.30</td>
<td>2.52–16.23</td>
<td>NA</td>
<td>$W = 0.0193L^{2.544}$</td>
<td>2.5442</td>
<td>0.9200</td>
<td>5.11, $P&lt;0.05$</td>
</tr>
<tr>
<td>Klang</td>
<td>$3°00'36.0''N, 101°23.01.6''E$</td>
<td>50</td>
<td>8.70–16.00</td>
<td>3.67–22.19</td>
<td>NA</td>
<td>$W = 0.0034L^{2.018}$</td>
<td>2.2018</td>
<td>0.9029</td>
<td>8.16, $P&lt;0.05$</td>
</tr>
<tr>
<td>Matang</td>
<td>$4°50'37.3''N, 100°37'.37.9''E$</td>
<td>50</td>
<td>12.50–24.00</td>
<td>11.45–40.0</td>
<td>NA</td>
<td>$W = 0.0032L^{2.8998}$</td>
<td>2.8998</td>
<td>0.8367</td>
<td>0.54, $P&lt;0.05$</td>
</tr>
</tbody>
</table>

*PA, positive allometric growth; NA, negative allometric growth

**Table 1** Number of fish samples collected ($n$), range of total length and body weight, t-test value, growth pattern and parameters of LWR of *Z. buffonis* in five different locations in coastal waters of Malaysia
Table 2 Condition factor (mean and SD) and relative condition factor (mean and SD) of *Z. buffonis* for five different locations in coastal waters of Malaysia.

<table>
<thead>
<tr>
<th>Location</th>
<th>Condition factor (<em>K</em>)</th>
<th>Relative condition factor (<em>Kn</em>)</th>
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<tbody>
<tr>
<td></td>
<td>Mean±SE</td>
<td>Mean±SE</td>
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<tr>
<td>Sg. Likas</td>
<td>0.6045±0.0403</td>
<td>1.0284±0.0658</td>
</tr>
<tr>
<td>Tg. Belungkor</td>
<td>0.6556±0.0526</td>
<td>1.0010±0.0801</td>
</tr>
<tr>
<td>Langkawi</td>
<td>0.6007±0.0656</td>
<td>2.9339±0.2336</td>
</tr>
<tr>
<td>Klang</td>
<td>0.3613±0.0791</td>
<td>3.5097±0.4232</td>
</tr>
<tr>
<td>Matang</td>
<td>0.2292±0.0578</td>
<td>0.9964±0.0937</td>
</tr>
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</table>

Table 3 Prey items observed in 84 guts of *Z. buffonis* from coastal waters of Malaysia, were classified by major categories.

<table>
<thead>
<tr>
<th>Prey category</th>
<th><em>N</em></th>
<th><em>W</em> (g)</th>
<th>%wt</th>
<th><em>n</em></th>
<th><em>fo</em></th>
<th><em>w</em> (g)</th>
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<tr>
<td>Insects:</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Weaver ants (Formicidae)</td>
<td>58</td>
<td>7</td>
<td>33</td>
<td>32</td>
<td>38</td>
<td>0.08</td>
</tr>
<tr>
<td>Diving beetles (Dytiscidae)</td>
<td>42</td>
<td>3</td>
<td>14</td>
<td>27</td>
<td>32</td>
<td>0.04</td>
</tr>
<tr>
<td>Winged insects (Diptera)</td>
<td>16</td>
<td>2</td>
<td>10</td>
<td>22</td>
<td>26</td>
<td>0.02</td>
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<tr>
<td>Plant materials:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mangrove petal fragments</td>
<td>16</td>
<td>7</td>
<td>33</td>
<td>3</td>
<td>4</td>
<td>0.08</td>
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<td>Crustaceans:</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Shrimp (<em>Penaeus sp.</em>)</td>
<td>3</td>
<td>2</td>
<td>10</td>
<td>1</td>
<td>1</td>
<td>0.02</td>
</tr>
<tr>
<td>Total</td>
<td>143</td>
<td>21</td>
<td>100</td>
<td>85</td>
<td>101</td>
<td>0.24</td>
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</tbody>
</table>

*N*: number of individuals of prey category; *W*: total weight; % wt: percent by weight; *n*: number of guts with prey item; *fo*: frequency of occurrence; *w*: total weight of prey category per gut.
For Review Only

Table 4. The population growth form of hemiramphid as reported from various countries

<table>
<thead>
<tr>
<th>Families</th>
<th>Species</th>
<th>Number of fishes collected</th>
<th>Total length range (cm)</th>
<th>$a$</th>
<th>$b$</th>
<th>$r^2$</th>
<th>Locality</th>
<th>Growth pattern</th>
<th>Author(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemiramphidae</td>
<td>Hyporhamphus unifasciatus</td>
<td>201</td>
<td>4.4 – 22.0</td>
<td>0.008</td>
<td>2.760</td>
<td>0.899</td>
<td>Mexico</td>
<td>NA</td>
<td>González Acosta et al. (2004)</td>
</tr>
<tr>
<td>Hemiramphidae</td>
<td>Hemiramphus far</td>
<td>69</td>
<td>22.0 – 44.5</td>
<td>0.329</td>
<td>1.831</td>
<td>0.848</td>
<td>New Caledonia</td>
<td>NA</td>
<td>Kulbicki et al. (2005)</td>
</tr>
<tr>
<td>Hemiramphidae</td>
<td>Hemiramphus brasiliensis</td>
<td>34</td>
<td>12.9 – 36.4</td>
<td>0.002</td>
<td>3.172</td>
<td>0.977</td>
<td>Grand Cul-de-Sac Marin Bay, Guadeloupe</td>
<td>PA</td>
<td>Bouchon-Navaro et al. (2006)</td>
</tr>
<tr>
<td>Hemiramphidae</td>
<td>Hyporhamphus roberti roberti</td>
<td>94</td>
<td>7.0 – 17.2</td>
<td>0.001</td>
<td>3.540</td>
<td>0.967</td>
<td>Curucá Estuary, Brazil</td>
<td>PA</td>
<td>Giarrizzo et al. (2006)</td>
</tr>
<tr>
<td>Hemiramphidae</td>
<td>Chriodorus atherinoides</td>
<td>165</td>
<td>10.2 – 26.0</td>
<td>0.004</td>
<td>3.300</td>
<td>0.988</td>
<td>La Carbonera lagoon, Mexico</td>
<td>PA</td>
<td>Bonilla-Goméz et al. (2013)</td>
</tr>
<tr>
<td>Hemiramphidae</td>
<td>Hyporhamphus affinis</td>
<td>12</td>
<td>13.5 – 27.5</td>
<td>0.001</td>
<td>3.575</td>
<td>0.970</td>
<td>New Caledonia</td>
<td>PA</td>
<td>Kulbicki et al. (2005)</td>
</tr>
<tr>
<td>Hemiramphidae</td>
<td>Hyporhamphus intermedius</td>
<td>103</td>
<td>10.5 – 14.3</td>
<td>0.002</td>
<td>2.860</td>
<td>0.943</td>
<td>Tian-e-zhou Oxbow Yangtze River, China</td>
<td>NA</td>
<td>Wang et al. (2012)</td>
</tr>
<tr>
<td>Hemiramphidae</td>
<td>Zenarchopterus dispar</td>
<td>36</td>
<td>10.3 – 13.7</td>
<td>-</td>
<td>3.494</td>
<td>0.805</td>
<td>Pidie Jaya, Indonesia</td>
<td>PA</td>
<td>Fadhil et al. (2016)</td>
</tr>
<tr>
<td>Hemiramphidae</td>
<td>Zenarchopterus buffonis</td>
<td>300</td>
<td>7.2 – 24.0</td>
<td>0.007</td>
<td>2.802</td>
<td>0.905</td>
<td>Malaysia</td>
<td>NA</td>
<td>Present study</td>
</tr>
</tbody>
</table>

* $a$ is the intercept, $b$ is the allometric regression coefficient and $r^2$ is correlation coefficient.
Figure 1 Length-weight relationships of *Z. buffonis* in Sg. Likas and regression line represents non linear fit of fish and circles represent individuals.
Figure 2 Length-weight relationships of *Z. buffonis* in Tg. Belungkor and regression line represents non linear fit of fish and circles represent individuals.
Figure 3 Length-weight relationships of *Z. buffonis* in Langkawi and regression line represents non linear fit of fish and circles represent individuals.
Figure 4 Length-weight relationships of *Z. buffonis* in Klang and regression line represents non linear fit of fish and circles represent individuals.
Figure 5 Length-weight relationships of *Z. buffonis* in Matang and regression line represents non linear fit of fish and circles represent individuals.
Figure 6 Trophic level-size relationship of *Z. buffonis* (circles represent mean trophic level estimated by TrophLab program and bars represent variants of prey items)
Figure 7 Number of food items ingested by *Z. buffonis*. n: number of fish in each length class (excluding empty gut).