

Feeding Ecology and Length-weight Relationship of Indian Glass Barb, *Laubuka laubuca* (Hamilton 1822) at Maguru Oya Stream (Deduru Oya River Tributary), Sri Lanka

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Abstract

Laubuka laubuca (Hamilton 1822) is a poorly studied freshwater fish found in South and Southeast Asia. This study was conducted to investigate the feeding habit and length-weight relationship of *L. laubuca* at Maguru Oya Stream, Sri Lanka. Gut contents of 180 fish were analysed, and food particles identified were categorised into 15 broad taxonomic groups. Relative abundance of each food category was calculated for 1-3, 3-5 and >5 cm length classes. Trophic niche breadth, food electivity index and Fulton's condition factor of *L. laubuca* were calculated. Length-weight relationship was determined using the expression, $W = aL^b$. *Laubuka laubuca* was a euryphagous-planktivorous fish and it showed a size dependent feeding pattern. Young fish had significantly broader ($P < 0.05$) trophic niche breadth than that of adults. According to food electivity indices *L. laubuca* preferred euglenoids, rotifers, insect larvae, crustacean larvae, arachnid larvae and macrozoobenthos which were highly abundant in stream habitat. *Laubuka laubuca* showed a positive allometric growth pattern with length-weight relationship of $\log W = -2.3684 + 3.3528 \log TL$. Due to high availability of preferred food items in its habitat and positive allometric growth *L. laubuca* could be categorised under least concern category in the IUCN Red List.

Introduction

Indian glass barb, *Laubuka laubuca* (Hamilton 1822) (Cyprinidae) (Junior synonym, *Chela laubuca*; Kottelat 2013; Froese and Pauly 2016) is a freshwater fish found in Sri Lanka and many other Asian countries (Froese and Pauly 2016). It inhabits the upper and middle depth water layers of streams, small rivers, ponds, flood plains and reservoirs (Vishwanath 2010; Indra et al. 2011; Froese and Pauly 2016). *Laubuka laubuca* is exploited as a tropical aquarium fish due to its small size, yellowish fins, blue-green iridescent body colour and hardiness (Kulabtong et al. 2012). It comprises an important component of riverine fisheries of India (Sugunan 1995), Bangladesh (Hossain et al. 2009; Hossain et al. 2012) and Nepal (Oo 2002). Ethnic groups in Nepal and northern India consume *L. laubuca* in sun dried form (Sarmah et al. 2014; Thapa 2016).

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Other than for human consumption *L. laubuca* is suitable to produce feed for cultured aquatic organisms as its flesh consists of more than 21% protein (Singh et al. 2012). *Laubuka laubuca* is currently not exploited as a food fish in Sri Lanka, despite its high abundance of lentic and lotic water bodies distributed across the country (De Silva and Sirisena 1987; Amarasinghe 1990; Manchanayake and Madduma Bandara 1999; Amarasinghe and Weerakoon 2009; Amarasinghe et al. 2016). According to Schiemer et al. (2001), Villanueva et al. (2008) and Amarasinghe et al. (2014) exploitation of small indigenous species including *L. labauca* would pose little or no impact on the trophic dynamics of reservoir ecosystems of Sri Lanka. However, no studies are reported on the biological aspects of *L. laubuca* in the lotic habitats of Sri Lanka. Most of the riverine habitats in Sri Lanka are among the highly threatened ecosystems, and existence of fish communities in these habitats are severely threatened by anthropogenic activities (Pethiyagoda 2006).

Previous studies on *L. laubuca* report morphometric and meristic characters (Kulabtong et al. 2012), length-weight relationship and form factor (Hossain et al. 2011; Hossain et al. 2012; Kaushik et al. 2015). The knowledge about trophic status of *L. laubuca* in stream habitats is important due to the fact that this species is grouped into vulnerable category in Red Data Lists in some countries such as Bangladesh (IUCN Bangladesh 2014) perhaps due to data deficiency. Therefore, the present study was conducted to study the trophic ecology, length weight relationship and condition factor of *L. laubuca* at Maguru Oya Stream (a tributary of Deduru Oya River), Kurunegala, Sri Lanka.

Materials and Methods

The study site

Sampling was conducted at three sampling sites each with 2 km distance apart at Maguru Oya Stream, Kurunegala District in North Western Province, Sri Lanka (Fig. 1). Maguru Oya Stream is one of the first order streams of Deduru Oya River which is the fourth largest river in the island. The average depth and width of sampling sites varied from 0.78- 0.90 m and 7.2- 8.3 m, respectively. The estimated terrain elevation above sea level of this freshwater stream is 82 m.

Sampling and preservation of fish

Fish were sampled using a cast net (mesh size 5 mm) at three selected sampling sites (A, B, C; Fig. 1) at Maguru Oya Stream. Sampled fish were immediately preserved in 10% formalin and brought to the laboratory for further analysis. The individual weight (digital balance; Sartorius, BS-223 S, Germany) to the nearest 0.01 g and total length (vernier caliper; Mitutoyo) to the nearest 1 mm were measured and fish were categorised into three different length classes as 1-3, 3-5 and >5 cm. They were then stored separately in a refrigerator at the temperature of 2 °C until the gut content analysis was carried out. In total, 180 fishes were collected for the gut content analysis from the three sampling sites.

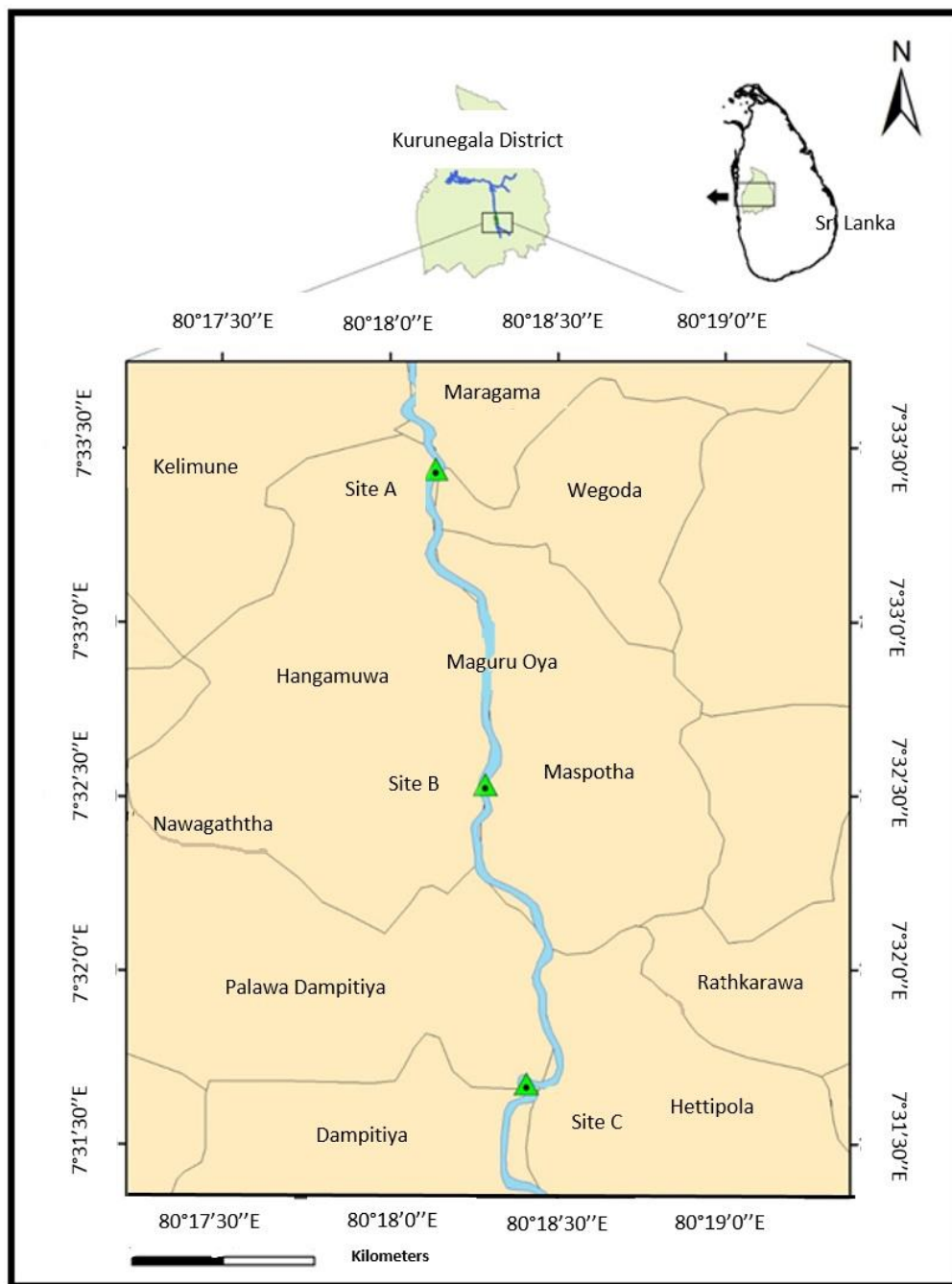


Fig.1. The locations of three sampling sites (A, B and C) for Indian glass barb, *Laubuka laubuca* at Maguru Oya Stream.

Length-weight relationship

The relationship between length and weight was calculated using the expression: $W = aL^b$, where, W is the total body weight (g), L the total length (mm), and the log-transformed version, $\log W = \log a + b \log L$ where $\log a$ and b are intercept and slope, respectively. The slope of the relationship (b) was compared with cube value using Student's t-test to investigate whether *L. laubuca* exhibits isometric ($b=3.0$), positive allometric ($b>3.0$), or negative allometric ($b<3.0$) growth.

Fulton's condition factor

The Fulton's condition factor (K) was calculated according to formula, $K = (W/ L^3) \times 100$ (Pauly 1983).

Gut content analysis

Individual fish were dissected and as cyprinids do not have well-developed stomach, the contents of the first one third of the gut were considered as recently ingested food. These gut contents were transferred to a fixed volume of distilled water. One milliliter of this suspension was transferred to the Sedgwick rafter cell for quantitative determination of gut contents. The gut content was examined using a light microscope at the magnifications of x10 and x40 and components of gut content were identified up to generic level using standard keys (Abeywickrama and Abeywickrama 1986; Fernando and Weerawardhena 2002). Relative volume of each food item was determined using arbitrarily a *Pinnularia* cell as the standard, and expressed as percentage bio-volume of total food items in the gut contents (Hynes 1950). Individual food items identified were categorised into 15 broader taxonomic groups.

Plankton sampling and identification

Plankton in the sampling sites were collected using a plankton net (mesh size: 50 μ m). Immediately after sampling, half of the sample was preserved in Lugol's iodine solution for enumeration of phytoplankton and the rest in 5% formalin for zooplankton analysis. Both phytoplankton and zooplankton were identified up to generic level and their relative volumes were estimated and expressed as percentage of the total food items in the water according to the procedure mentioned under the gut content analysis.

Trophic niche breadth

The Levins' measure of trophic niche breadth (B) of fish was estimated by $B = 1/\sum p_j^2$; where p_j is the proportion of individuals found in or using resource state, or fraction of items in the diet that are of food category j (Levins 1966). B was divided by the total number of resource states after correcting for a finite number of resources as suggested by Hurlbert (1978) for estimating the standardised niche breadth, $B_A = (B - 1) / (n - 1)$ where n = number of possible resource states.

Food electivity index

The food electivity index (E) of fish was estimated using the following formula, $(E) = (r_i - p_i) / (r_i + p_i)$, where r_i is the relative abundance of prey item i in the gut (as a proportion of the total gut contents) and p_i is the relative abundance of the same prey item in the environment (Ivlev, 1961). The index of electivity (E) has a possible range of -1 (strong negative selection or avoidance) via 0 (no selection or random selection) to +1 (strong positive selection) (Durbin 1979).

Statistical analysis

Mean dietary breadth in the three size groups of fish was compared using one-way ANOVA at $\alpha = 0.05$ level of significance. Multi-dimensional scaling (MDS) was used to summarise relative importance of 15 food categories of fish in the three size classes. As proportions of food categories range from very low to fairly high values, data were double square root transformed prior to MDS analysis. One-way ANOVA was performed using the MINITAB (Version 14 for windows) and PRIMER (Version 5.2.9 for windows; Clarke and Gorley 2001) statistical software was used for MDS analysis.

Results

Gut contents of *L. laubuca*

The food items found in the gut contents of *L. laubuca* were categorised into 15 main broader taxonomic groups as shown in Table 1. *Laubuka laubuca* can be considered as a planktivorous fish as it feeds on both phytoplankton and zooplankton.

Table 1. Fifteen food categories and components found in the gut contents of *Laubuka laubuca*.

Food category	Abbreviations	Food components
Blue green algae	BG	<i>Dactylococopsis</i> , <i>Lyngbya</i> , <i>Merismopedia</i> , <i>Microcystis</i> , <i>Oscillatoria</i>
Green algae	GA	<i>Pediastrum</i> , <i>Closterium</i> , <i>Cosmarium</i> , <i>Spirogyra</i> , <i>Ulothrix</i> , <i>Scendesmus</i>
Euglenoids	EG	<i>Euglena</i> , <i>Trachelomonas</i> , <i>Cryptoglena</i>
Golden brown algae	GB	<i>Centritractus</i> , <i>Fragilaria</i>
Diatoms	DT	<i>Synedra</i> , <i>Tabellaria</i> , <i>Achanthes</i> , <i>Navicula</i> , <i>Pinnularia</i> , <i>Nitzschia</i>
Filamentous algae	FA	<i>Melosira</i> , <i>Tribonema</i> , <i>Ulothrix</i>
Unidentified algae	UA	-
Protozoans	PZ	<i>Cryptomonas</i> , <i>Peranema</i> , <i>Paramecium</i>
Rotifers	RT	<i>Tintinnopsis</i> , <i>Brachionus</i> , <i>Philodina</i> , <i>Lecane</i>
Cladocerans	CD	<i>Daphnia</i> , <i>Diaphnosoma</i> , <i>Moina</i> , <i>Bosmina</i> , <i>Ceriodaphnia</i> , <i>Chydorous</i>
Copepods	CP	<i>Calchas</i> , <i>Cyclops</i> , <i>Eucyclops</i> , <i>Thermocyclops</i>
Aquatic insect larvae	IL	Diptera, Ephemereptera, Plecoptera, Hemiptera larvae
Crustacean larvae	CL	Shrimp larvae (zoea and mysis)
Arachnid larvae	AL	Aquatic mites
Macrozoobenthos	MB	Nematodes, Annelids

Relative importance of food categories

Relative importance of each food category, expressed as percentage proportions (% p_i) in the gut content of *L. laubuca* is given in Table 2. Relative importance of some food categories increased (e.g., diatoms, protozoans, copepods, crustacean larvae, arachnid larvae, and macrozoobenthos) with increasing body size while some food categories (e.g., blue green algae, green algae, golden brown algae, filamentous algae, rotifers and cladocerans) decreased with increasing length of fish.

Table 2. Mean \pm SE of relative importance (% P_i) of 15 food categories recorded in the gut contents of three different length classes of *Laubuka laubuca* in Maguru Oya.

Food category	Length class		
	1-3 cm	3-5 cm	>5cm
BG	14.3 \pm 0.6	7.4 \pm 0.2	0.2 \pm 0.0
GA	3.2 \pm 0.4	2.8 \pm 0.1	1.1 \pm 0.1
EG	7.8 \pm 0.3	3.5 \pm 0.4	4.4 \pm 0.6
GB	0.9 \pm 0.2	0.4 \pm 0.2	0.1 \pm 0.0
DT	3.8 \pm 0.4	4.1 \pm 0.4	9.7 \pm 0.6
FA	1.5 \pm 0.4	1.2 \pm 0.2	0.3 \pm 0.1
UA	1.6 \pm 0.15	0.7 \pm 0.1	0.2 \pm 0.0
PZ	0.1 \pm 0.0	0.1 \pm 0.0	0.2 \pm 0.0
RT	2.0 \pm 0.1	0.8 \pm 0.0	0.9 \pm 0.0
CD	38.3 \pm 0.8	11.9 \pm 0.5	1.0 \pm 0.6
CP	0.9 \pm 0.3	1.1 \pm 0.1	1.2 \pm 0.01
IL	11.8 \pm 0.3	32.9 \pm 2.1	18.3 \pm 0.6
CL	4.4 \pm 0.1	16.4 \pm 0.7	30.1 \pm 1.5
AL	5.3 \pm 0.1	12.0 \pm 0.2	12.7 \pm 1.0
MB	3.5 \pm 0.3	4.1 \pm 0.3	19.4 \pm 1.9

Blue green algae - BG, Green algae - GA, Euglenoids - EG, Golden brown algae - GB, Diatoms - DT, Filamentous algae- FA, Unidentified algae - UA, Protozoans - PZ, Rotifers - RT, Cladocerans - CD, Copepods - CP, Aquatic insect larvae - IL, Crustacean larvae - CL, Arachnid larvae - AL and Macrozoobenthos - MB

In the MDS plot, stress value is 0.01 (Clerk and Gorley 2001) showing that the dietary habits of different length classes of *L. laubuca* were well separated in the two dimensional MDS plot (Fig. 2).



Fig. 2. Two dimensional MDS plot of relative importance of dietary composition of three different length classes of *Laubuka laubuca* (A, B, and C letters represent the three different study sites; 1-3, 3-5 and >5 represent three length classes).

Trophic niche breadth

Mean \pm SE of trophic niche breadths of *L. laubuca* are given in Table 3. The values were significantly different among different length classes while niche breadth decreased with increasing length of fish.

Table 3. Mean \pm SE for niche breadth values for three length classes of *Laubuka laubuca*.

Length class	Site A	Site B	Site C	Average
1cm-3 cm	2.14a \pm 0.05	2.11a \pm 0.03	2.09a \pm 0.06	2.11 \pm 0.05
3cm- 5 cm	2.08b \pm 0.02	2.03b \pm 0.06	2.04b \pm 0.03	2.05 \pm 0.02
> 5 cm	1.87c \pm 0.01	1.88c \pm 0.01	1.84c \pm 0.02	1.88 \pm 0.01

Means with different superscripts in different columns are significantly different (one-way ANOVA, $P < 0.05$).

Food electivity index

Euglenoids, rotifers, insect larvae, crustacean larvae, arachnid larvae and macrozoobenthos were positively selected and green algae, diatoms, filamentous algae and copepods were negatively selected by *L. laubuca* (Fig. 3).

Golden brown algae, unidentified algae and cladocerans were negatively selected by the fish grouped into the largest length class while the same food categories were positively selected by fish grouped into smaller length classes.

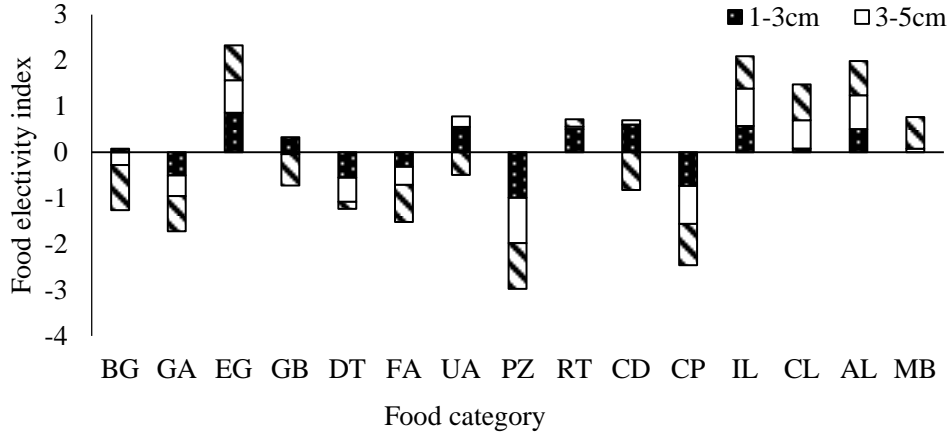


Fig. 3. Ivlev's electivity indices for food categories of three different length classes of *Laubuka laubuca*.

Length-weight relationship and condition factor

The length and weight of *L. laubuca* in Maguru Oya Stream ranged from 18.9- 58.5 mm and 0.02- 1.86 g, respectively. The length weight relationship of *L. laubuca* was $\log W = - 2.3684 + 3.3528 \log L$ ($R^2=0.98$, $P<0.05$) with W in mg and L in mm (Fig. 4). It had a positive allometric growth pattern with a significant difference from cube value (Student's t test, $t = 0.7722$; $p < 0.05$) and the body condition factor was $0.76 \text{ mg} \cdot \text{mm}^{-3}$.

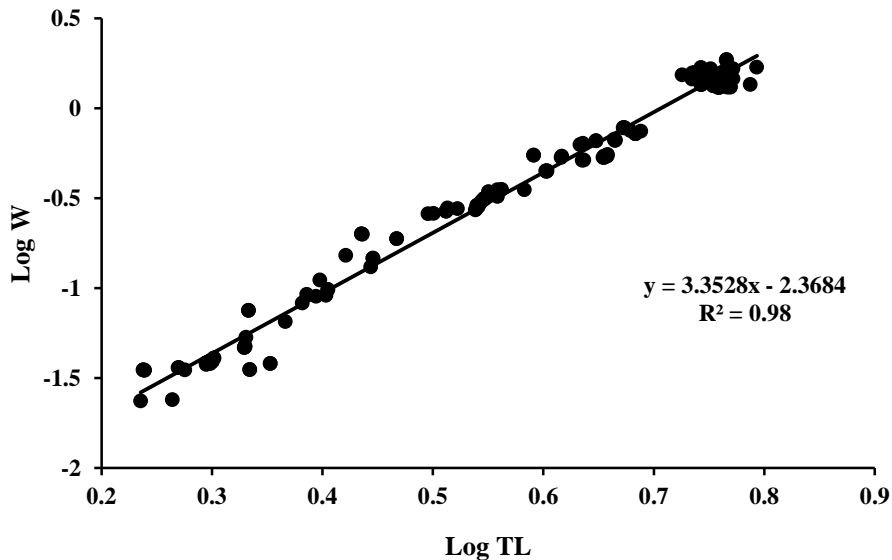


Fig. 4. The relationship of Log weight (W) and Log total length (TL) of *Laubuka laubuca* at Maguru Oya Stream.

Discussion

Laubuka laubuca can be considered as a euryphagous-planktivorous fish as its diet contained a wide range of planktonic organisms, including algae, copepods, cladocerans, crustacean larvae, arachnid larvae, insect larvae and planktonic nematodes and annelids. Euryphagous fish species are more successful in maintaining larger populations compared to stenophagous species (Amisah and Agbo 2008). Therefore, the broad spectrum of food items ingested by *L. laubuca* may make it possible to maintain large populations in habitats where it occurs.

Three length classes of *L. laubuca* were grouped into three clusters based on gut contents showing its size-dependent dietary shift. Fish grouped into smaller length classes mainly fed on algae, cladocerans and insect larvae. The dependence of young stages of freshwater fish species on algae and cladocerans for their nutrient requirement has been previously observed by Lazzaro (1987). Juveniles of two spot barb, *Puntius bimaculatus* (Bleeker 1863) inhabited in small creeks in Sri Lanka also consumed high amount of algae compared to their adults (De Silva et al. 1977). Because algae have no escape mechanisms, filter-feeding young fish require no specific capture strategies to utilise them as food (Lazzaro 1987). Cladocerans (*Daphnia*, *Diaphanosoma*, *Moina*) may be preferred over copepods and rotifers by smaller fish due to their comparatively lower swimming speed (Vijverberg et al. 2001), and slow prey avoidance response (Lazzaro 1987). Mosquito fish, *Gambusia holbrooki* in Lake Nainital in India also showed higher preference for cladocerans than copepods (Singh and Gupta 2010).

Insect larvae were found in relatively higher proportion in the diet of *L. laubuca* irrespective of its length class as previously observed for *Belontia signata* (Gunther 1861), *Puntius tittैया* Deraniyagala 1929, *Pethia nigrofasciata* (Gunther 1868) (Wikramanayake and Moyle 1989) and *Puntius dorsalis* (Jerdon 1849) (De Silva et al. 1996). Other than insect larvae, adult fish also fed on crustacean larvae, arachnid larvae and macrozoobenthos. The relative proportions of these food categories increased with body size of fish. The low relative importance of these food categories in the gut contents of fish smaller than 3 cm showed selective feeding behaviour of *L. laubuca* during juvenile stages.

The trophic niche breadth of *L. laubuca* was significantly broader in juveniles than that of adults. This indicates that adult *L. laubuca* is relatively specialised, whereas young stages with wider niche breadth are typically generalists. However, adult *L. laubuca* consumed a comparatively higher amount of diatoms, which are highly abundant in Sri Lankan freshwaters (Silva 2006). Diatoms consisted of a major part of the food in stream living fish in Sri Lanka including, *P. bimaculatus*, *Pethiya cumingi* (Gunther 1868) (Wikramanayake and Moyle 1989) and *P. nigrofasciata* (De Silva and Somarathna 1994). The highest length (58.5 mm) and weight (1.86 g) of *L. laubuca* recorded in the present study were highly comparable with that of the same parameters recorded for the same species in India (Kaushik et al. 2015).

However, the highest length (105.4 mm) and weight (10.4 g) recorded for *L. laubuca* in Pakistan (Hossain et al. 2009) were higher than the values recorded in the present study. *Laubuka laubuca* showed a positive allometric growth as observed for the same species in India (Kaushik et al. 2015) and Bangladesh (Hossain et al. 2011; Hossain et al. 2012). Therefore, stream habitat may provide a conducive environment for the growth of *L. laubuca*. As such, *L. laubuca* can be treated in the 'least concern' category of IUCN National Red Data list in Sri Lanka.

Conclusion

Laubuka laubuca in the stream habitats in Sri Lanka feed on plankton species which are abundant in the habitat. Being a euryphagous- planktivorous fish species, it is unlikely that there will be any potential threat to the existence of this species due to food limitations in the natural habitats. Although adults are relatively stenophagous, the food items that they feed on are abundant in the habitats. The body condition is high showing that the nutritive quality of ingested food items is sufficient to maintain viable populations where they occur. The results of the present study therefore imply that this species can be treated as 'least concern' in the IUCN National Red Data List of Sri Lanka.

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