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Effect of selected water quality parameters on the prevalence of *Poecilia reticulata* (Guppy) population in Sri Jayewardenepura canal system

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ABSTRACT

Present study was carried out to determine the effect of some selected water quality parameters on the prevalence of P. reticulata(Guppy) population in Sri Jayewardenepura canal system. Fish and water samples were collected in six locations from January 2016 to December 2017. Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Electrical Conductivity (EC), Hardness, Alkalinity, Nitrate-Nitrogen (N-NO_3^-), Orthophosphate (PO_4^{3-}) ,Temperature, pH ,Water velocity and depths in each sites were measured. Total lengths and weights of specimens (n-520) were measured and relative densities (RD) were calculated. Guppy was the most abundant species in all sites and high densities were recorded at slow moving and stagnated shallow waters. Results revealed that all the sites were subjected to moderate or high pollution and most conspicuous were the low DO (0.83±0.12-4.84±0.76 mg/l) and high BOD (1.78±0.4-9.10±0.6 mg/l) levels. Polluted water quality of studied locations were further confirmed by high values for (N-NO3-) (3.9±0.8-11.5±1.2 mg/l), PO43- (1.9±0.4-3.9±0.3mg/l) and EC (257.6±12.8-801.6±42.0µS/cm). Other recorded water quality parameters pH (6.6±0.2–8.3±0.4), Temperature (29.9±1.1-8.3±0.4), Hardness (80.0±10.4- 113.3±13.1 mg/l) and Alkalinity (70.7±11.5-179.6±20.4 mg/l) are in suitable range of fish and aquatic life. Despite the fact that the locations were polluted, RD of guppy (32.7±27.7-85.7±22.9) were considerable in all locations. The study showed that the RD of guppy significantly varied with some of the water quality parameters; decreasing with increasing DO, N-NO_3^- ,PO_4^{3-} levels ($P \leq 0.05$) as well as with water depths and velocity of water and increasing with increasing pH, BOD and alkalinity of water. The study recorded that the average adult sizes of fish were smaller (♀-35 mm, ♂-25 mm) than the previous records (♀-60 mm, ♂-40 mm) in the present study area. Thus, study concludes that, although the water quality parameters are affecting their growth rates and relative densities.

KEYWORDS: *Guppy, Water quality parameters, Polluted water, Fish density*

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1 INTRODUCTION

P. reticulata is a small freshwater fish belonging to the family Poeciliidae, which was first introduced to Sri Lanka in 1928 and used for the control of malaria mosquito vector during1940-1950 (Silva & Kurukulasuriya 2010). In Sri Lanka, they are distributed and well established across North Western (Weerasinghe 2008), Western (Bambaradeniya 2008) and Southern (Gunawardena 2008) provinces. They are found in a variety of aquatic habitats such as streams, marshes, paddy fields as well as in polluted waterways (Pethiyagoda 1991; Edirisinghe & De Alwis 2012).

The role of *P. reticulata* in mosquito control has debatable views as their success in getting established in new environments makes them potentially invasive, which has been experienced by several countries (CABI 2008; CABI 2010). When they become invasive, they can change the ecosystem by interfering with native or endangered/threatened species through competition by monopolizing resources, predation, hybridization and rapid growth. In the Sri Lankan context, use of this species to control different mosquito species in polluted waters where no native or endangered/threatened fish species are found and in water containers such as drinking water stocking tanks is an economically viable option (Amarasinghe *et al*,2008; Bambaradeniya 1999; Wijesinghea *et al*,2009). Particularly, in many urban areas, polluted ditches infested with vector mosquito species such as *Culex sp* are on the rise which calls for controlling measures, and the use of *P. reticulata* stands as a pragmatic solution. In order to do this, it is important to know the ecological factors that affect the successful survival of this fish species in polluted waters.

In addition, their tolerance to a wide range of environmental conditions has made its survival and establishment worldwide. For example, *P. reticulata* can tolerate a wide range of temperatures (18-28°C), can live and breed in pH of 5-9 and salinities ranging from 0 to 45 ppt, including normal seawater, but are generally found in freshwater streams near the coast (Chervinski 1984; Shikano & Fujio 1998;Pethiyagoda *et al*., 2019). However, it is reported that they cannot tolerate water temperatures below 15°C and above 39-41°C, total mortalities have been reported for Venezuelan guppies (Chong 2004). In non-native areas, guppies are commonly found as the only species in heavily polluted water bodies (Barua *et al.,* 2001).

Colombo, the commercial capital of Sri Lanka has many freshwater wetlands (mainly marshes) in its vicinity. They have provided water and environmental services for the city and suburbs for centuries. Reports indicate that rapid urbanization accompanied by weak urban planning has caused a steady degradation of these wetlands in the past 15-25 years (CEA 1994; MoFE 2001), threatening the sustainability of the services provided. Although few past research projects highlighted a general degradation of surface water quality in the study area (CEA 1995; CEA 1994), they failed to identify the dominant pollutants, or establish any spatial or temporal trends.

Preliminary studies have shown that *P. reticulata* (Guppy) and *G. affinis* (Mosquito fish) are abundant in the Sri Jayewardenepura canal system, one of the oldest canal systems in Sri Lanka located in a highly urbanized, highly polluted area (Edirisinghe & De Alwis 2012) and urban areas provide preferred breeding sites for anthropophilic mosquitoes (Manawadu *et al.,* 2006). Thus, the present study was carried out in Sri Jayewardenepura canal system to study the ecological factors affecting the successful prevalence of *P. reticulata* population.

2 MATERIALS AND METHODS

2.1 Study Area

Present study was carried out in six selected locations (covering three sampling points in each location) in the Colombo -Sri Jayewardenepura canal system which is a part of the Diyawanna Oya canal network. It is a man-made canal system located on the left bank of the lower valley of Kelani Ganga. It is situated in the Western province, Colombo district of Sri Lanka, latitudes 6^{0} 52’ 55” - 6^{0}55’ 45” N and longitudes 79^{0} 52’ 35” – 79^{0} 55’ 15” E (Fig. 1). The average depth of the canal system is about 1.5m (CEA 1995). It may vary seasonally due to heavy sedimentation of silt and bank erosion in the rainy season and it gets frequently clogged with floating weeds & dumps (polythene, plastics & domestic wastes (CEA 1995). Present study was carried out covering approximately 15km of the canal network. Six locations (Table 1) and the sampling points at each location were selected considering environmental factors such as abundance of aquatic vegetation, surface velocity of water, water depth etc. and where significant populations of *P. reticulata* occurred.

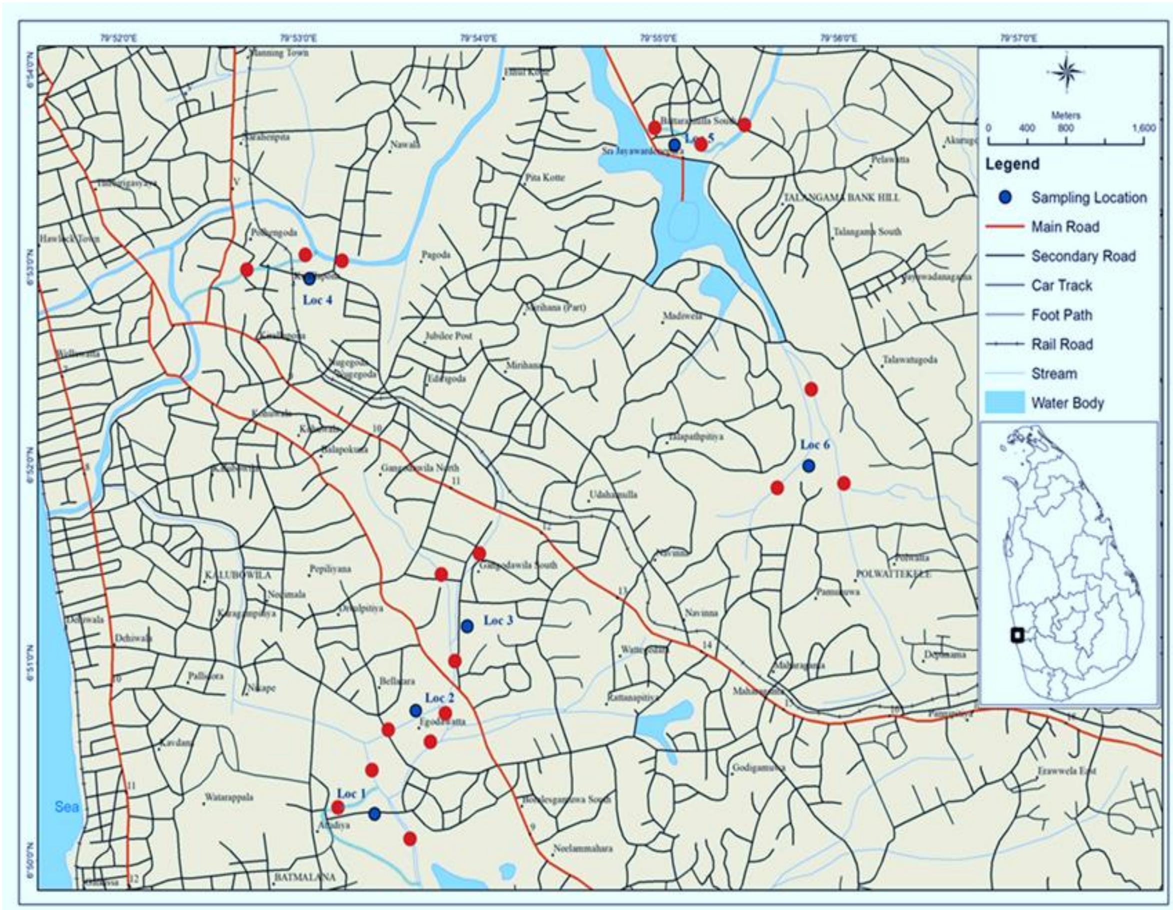


Figure 01: Study locations (in blue) and sampling points (in red) in the Colombo-Sri Jayewardenepura canal system.

Table 01: Study locations and GPS coordinates.

Location	GPS coordinates
Location 1. Attidiya	6^0 83’ 72” N, 79^0 89’ 03” E
Location 2. Bellanwilla	6^0 84’ 59” N, 79^0 89’ 41” E
Location 3. Rattanapitiya	6^0 85’ 30” N, 79^0 89’ 89” E
Location 4. Nawala	6^0 88’ 23” N, 79^0 88’ 43” E
Location 5. Near Parliament ground	6^0 89’ 36”, N 79^0 91’ 81” E
Location 6. Near Jayewardenepura hospital road	6^0 86’ 65” N, 79^0 93’ 05” E

2.2 Sampling

Sampling was carried out once a month from January 2016 to December 2017 between 8.00 am to 2.00 pm. Care was taken to reach the same location at approximately the same time of the day during the sampling period.

Three sampling points covering different habitats in each location were sampled for all selected water quality parameters.

Three replicates were taken from each sampling point and average values were considered (Wetzel & Likens 2000). Selected water quality parameters were measured using standard procedures (APHA 1999), either on site or using preserved samples at the laboratory of the Department of Zoology, University of Sri Jayewardenepura. For preservation, samples were immediately transferred to properly labelled plastic bottles and were fixed with recommended chemicals. Following physico–chemical and biological parameters were measured.

At the site, Water Temperature(T) was measured using a mercury thermometer (Model: Immersion, Philip Harris, England) at site by dipping it in the water column. The reading was read while the thermometer was dipped in water. The pH value of water was measured using a standard meter (Model: pH 3110.WTW Co,Weilheim, Germany) and Electrical conductivity(EC) of water was measured using a standard conductivity meter (Model: Cond 3110, WTW Co., Weilheim, Germany). Water depth of each location was measured using a standard meter ruler to the nearest 1 cm. A surface velocity of water on each sampling location was measured using floating method. (Time was recorded at each location; same float object was allowed to float along a known distance).

$$\text{Surface Velocity of Water} = \frac{\text{Distance}}{\text{Time}}$$

Water Quality Analysis

Dissolved Oxygen (DO) was measured by using the Winkler method (Silva 1996)

Filtered water samples were analyzed for concentration of orthophosphate and Nitrogen-Nitrate ($N\text{-}NO_3^-$) at the laboratory following the standard spectrophotometric method (APHA 1999)

Biological Oxygen Demand (BOD) samples were incubated for 5 days at 20 ^{0}C and then fixed and measured using Winkler method (Silva 1996) Water.

Alkalinity was measured by using phenolphthalein and titrated with 0.1M HCl and hardness was measured with Eriochrome black T indicator and titrated with 0.02M sodium EDTA solution (APHA, 1999).

In the field, all sampling points were observed for the occurrence of *P. reticulata* and samples were collected using a hand net (35 cm × 26 cm rim and 1 mm^2 mesh) and a push net (30cmx 20cm and 1 mm^2 mesh). A total of 520 specimens of *P. reticulata* were collected from the study locations during the study period, of which 148 were males, and 372 females and immediately preserved in properly labeled plastic bottles using 5% formaldehyde. All preserved fish samples were brought to the laboratory of the Department of Zoology, University of Sri Jayewardenepura for further analyses. Total lengths (mm) and total weights (g) of all specimens were measured. Fish were then grouped into 3 mm length groups and percentages of each length group were calculated. The relative densities of *P. reticulata* were calculated using the following formula (Ghosh & Biswas 2017)

Relative Density = Catch by sampling gear / Sampling effort

3 RESULTS & DISCUSSION

3.1 Water quality and relative densities of *P. reticulata* in study locations

Table 2 depicts the mean values recorded for selected Water quality parameters and relative density of *P. reticulata* wild population at six sampling locations in Sri Jayewardenepura canal system during the study period. Fig. 2 shows the relationships of selected water quality parameters that were examined with the relative density of *P. reticulata* wild population in the study locations over a period of two years (2016-2017).

The water quality parameters studied, mean DO was ranged between 0.83±0.12 - 4.84±0.76 (mg/l) (minimum values –L_2; maximum values- L_6).These values in the locations were less than the recommended values for fish and aquatic life (minimum 5 mg/l) (CEA 2017). Mean BOD ranged between 1.78±0.4 - 9.10±0.6 (mg/l) (minimum values –L_6; maximum values- L_4) and except two locations (L_3 and L_6), BOD values in other locations were higher than the recommended values for fish and aquatic life (maximum 4 mg/l) (CEA 2017). The high average annual range in biochemical oxygen demand (BOD), total coliform (TC) and low dissolved oxygen (DO) levels reported in the rivers of some South Asian countries are mainly due to the huge discharge of municipal wastewater and urban drainage into river basins (Karn & Harada 2001). The research conducted on the Jinshui River Basin of the South Qinling Mountains, China, predicted the most correlated water quality parameters, which have strong correlation with population (Bu *et al.*, 2016).

Mean N-NO_3^- ranged between 3.9±0.8 - 11.5±1.2 (mg/l) (minimum values –L_3; maximum values- L_6). Location L_6 always recorded higher values than the recommended value for fish and aquatic life (maximum 10mg/l) (CEA 2017). However, in other locations these values were within the limits or close to the maximum limit. Mean Ortho-PO_4^{3-} ranged between 1.9±0.4 - 3.9±0.3 (mg/l) (minimum values –L_3; maximum values- L_6) and these values in the locations were much higher than the recommended values for fish and aquatic life (maximum 0.4 mg/l) (CEA 2017). The research was conducted on the Characterization and Description of Surface Water Quality in the Threatened Urban Wetlands around the City of Colombo (Hettiarchchi *et al.*, 2011). It can be observed that parameters indicative of domestic wastewater pollution (Burton & Stensel 2001) such as BOD_5, ammonia and PO_4-P deviate significantly from the standards indicated. DO is also critically lower than the indicated threshold value, which is typical of any highly polluted water source (Burton & Stensel 2001). NO_3-N, EC, T and pH are all below or nearly at the stipulated threshold limits.

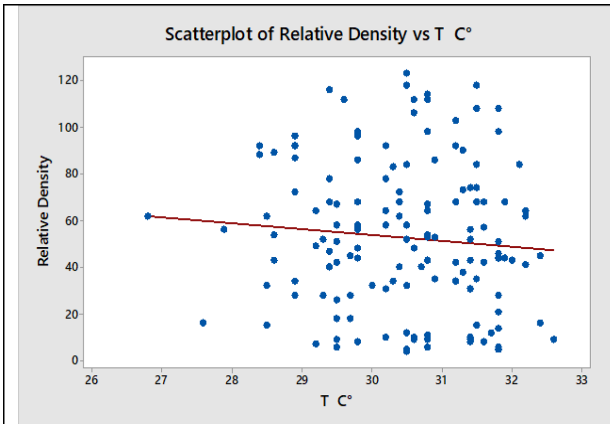
Mean EC of water ranged between 257.6±12.8 - 801.6±42.0 (µS/cm) (minimum values $-L_6$; maximum values- $L_{1)}$. These values in some locations were higher than the recommended values for fish and aquatic life (500 µS/cm) (Awoyemi *et al.*, 2014). Mean Alkalinity ranged between 70.7±11.5 - 179.6±20.4 (mg/l) (minimum values $-L_1$; maximum values- $L_{2)}$ and these values in the locations were within the recommended values for fish and aquatic life (5-500 l/mg) (Lawson 1995). Mean Hardness ranged between 80.0±10.4- 113.3±13.1 (mg/l) (minimum values $-L_1$; maximum values- $L_{4)}$ and these values in the locations were within the recommended values for fish and aquatic life (20-300mg/l) (Lawson 1995). Mean surface velocity of water of the study locations over the 24-month period varied between 0.011±0.009 - 0.056±0.064 (m/s) while the mean depths were between 1.02±0.48 - 0.34±0.10 (m). Location L_6 recorded a low relative density 6.9±1.9- 9.0±2.3 compared to other locations where higher relative densities ranging between 32.7±27.7 - 85.7±22.9 were recorded. The highest relative density was recorded at location L_2 (84.9±25.6 - 85.7±22.9) during the study period. The analyses of the Kolonnawa Marsh ecosystem mainly by organic pollutants, the values of BOD_5, ammonia and PO_4^-P either exceed or equal the values of similar highly degraded urban waterways/lakes polluted by urban domestic discharges in Sri Lanka and South Asia (CEA 1994; Nippon, 1991; Bhat *et al.*, 2009). Input of domestic waste, high in organic content in a wetland system can potentially lead to nutrient enrichment. Nutrient enrichment is the retention of nutrients in the inflows such as surface water flows, groundwater flows and precipitation and accumulation within the wetland ecosystem (Brenner *et al.*, 2001; Craft & Casey 2000). The spatial variation of water quality parameters among peripheral canals and internal waterways confirms a degree of retention of pollutants in the wetland. This may lead to negative environmental impacts such as reduced bio-diversity, proliferation of invasive vegetation and alteration of soil physical properties in the wetland (Keddy *et al.*, 1994). More recent studies indicate that a specific fungal pathogen, *A. invadans*, is the necessary cause of the disease (Lilley *et al.*, 1998). Seasonal occurrence of epizootic ulcerative syndrome seems to be related to environmental factors, some of which may act as risk factors that would stress the fish, thereby lowering their resistance to the disease (Pathiratne & Jayasinghe 2001).

For comparisons, the reading of each water quality parameters at which the median relative density (60) of fish were observed was taken as the optimal value and the range was determined from this point onwards. Accordingly, relative density higher than 60 was observed in waters with following ranges of water quality parameters; T- 28.5-32.5C° (Fig.2.a), pH 6.3-8.8 (Fig.2.b), EC 280-890µS/cm (Fig.2.c), Hardness 70-150 mg/l (Fig.2.d), DO 0.8- 2.8 mg/l (Fig.2.e), BOD 1.9-10 mg/l (Fig.2.f), $N\text{-}NO_3^-$ 3.2-11.4mg/l (Fig.2.g), Ortho-PO_4^{-3} 1.1-4.5 mg/l (Fig.2.h), Alkalinity 50-210 mg/l (Fig.2.i), Depth 0.2-0.8 m (Fig.2.j) and surface velocity of water 0 - 0.16 m/s (Fig.2.k). Of these water quality parameters, statistically significant ($p \leq 0.05$) positive relationships with relative fish densities were shown by pH ($p=0.022$), BOD ($p = 0.000$) and Alkalinity ($p = 0.000$), while statistically significant ($p \leq 0.05$) negative relationships with relative fish densities were shown by DO ($p=0.000$), N-NO_3^-) ($p = 0.000$), Ortho-PO_4^{-3} ($p = 0.000$), Water Depth ($p = 0.000$) and Surface Velocity of Water ($p = 0.000$).

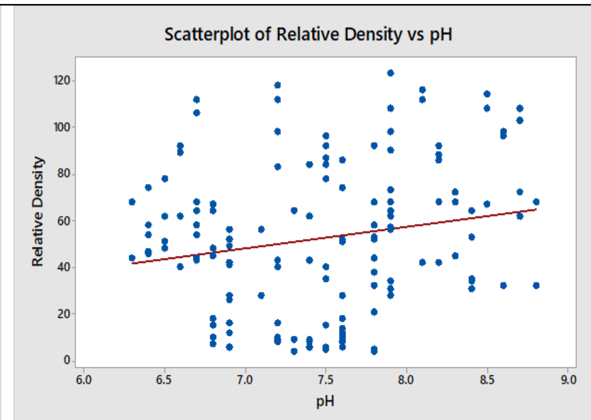
Table 02: Mean values recorded for selected water quality parameters and relative abundance of *P. reticulata* wild population in Sri Jayewardenepura canal system during 2016 and 2017.

Year	SL	Water quality parameters											Relative density of *P.reticulata* wild population
		Mean Water Temperature(C^0)	Mean pH	Mean Electrical Conductivity (µs/cm)	Mean Dissolved Oxygen (DO) (mg/l)	Mean Biological Oxygen Demand (BOD)(mg/l)	Mean Nitrogen-nitrate- ($N\text{-}NO_3^-$) (mg/l)	Mean Ortha-phosphate (PO_4^{-3}) (mg/l)	Mean Alkalinity (mg/l)	Mean Hardness (mg/l)	Surface Velocity (m/s)	Mean Depth(m)	
2016	L_1	30.2±1.6	7.6±0.2	800.3±43.5	0.88±0.07	5.99±0.7	9.3±0.9	2.8±0.4	70.7±11.5	80.0±10.4	0.015±0.023	0.45±0.10	55.5±25.3
	L_2	30.4±1.2	8.0±0.4	579.3±75.3	0.83±0.12	8.32±0.5	9.5±0.9	3.5±0.4	179.2±17.3	96.0±13.5	0.013±0.013	0.48±0.14	85.7±22.9
	L_3	30.6±0.9	7.6±0.7	270.7±11.2	2.33±0.39	2.52±0.3	3.9±0.8	1.9±0.4	148.9±20.6	92.4±20.7	0.026±0.024	0.34±0.10	80.5±21.7
	L_4	29.9±1.1	8.3±0.4	509.5±29.4	0.99±0.11	8.67±0.7	9.0±1.2	3.2±0.3	171.2±15.2	105.3±31.3	0.018±0.011	0.34±0.08	45.6±14.8
	L_5	30.5±0.9	6.6±0.2	281.0±16.1	1.51±0.23	4.92±0.5	4.6±0.6	3.0±0.3	160.4±15.2	127.9±8.1	0.011±0.009	0.46±0.09	51.6±8.8
	L_6	30.8±0.9	7.3±0.3	257.6±12.8	4.70±0.76	1.78±0.4	11.1±1.1	3.5±0.4	126.3±7.1	105.8±14.4	0.017±0.015	0.61±0.11	6.9±1.9
2017	L_1	30.6±1.5	7.3±0.3	801.6±42.0	0.87±0.07	6.09±0.6	9.7±0.7	2.9±0.3	77.2±12.2	80.0±9.5	0.056±0.064	1.02±0.48	32.7±27.7
	L_2	30.5±1.2	7.8±0.7	570.6±74.5	0.85±0.10	8.34±0.5	10.2±0.6	3.8±0.5	179.6±20.4	95.5±13.3	0.016±0.015	0.49±0.16	84.9±25.6
	L_3	30.3±1.1	7.4±0.7	271.6±11.6	2.40±0.40	2.77±0.4	4.2±0.7	1.9±0.4	151.5±20.0	92.4±19.7	0.023±0.015	0.38±0.10	78.0±24.9
	L_4	30.1±1.1	7.8±0.7	519.6±38.4	1.02±0.12	9.10±0.6	9.8±0.9	2.9±0.3	168.8±12.6	113.3±13.1	0.018±0.011	0.35±0.09	46.6±18.9
	L_5	30.8±1.1	6.7±0.3	297.9±45.6	1.58±0.19	5.35±0.5	4.9±0.6	3.0±0.4	162.6±12.7	129.0±9.6	0.013±0.009	0.49±0.10	55.6±12.2
	L_6	30.9±0.9	7.3±0.3	262.1±12.1	4.84±0.76	1.83±0.4	11.5±1.2	3.9±0.3	125.0±9.1	106.6±13.5	0.019±0.018	0.62±0.13	9.0±2.3

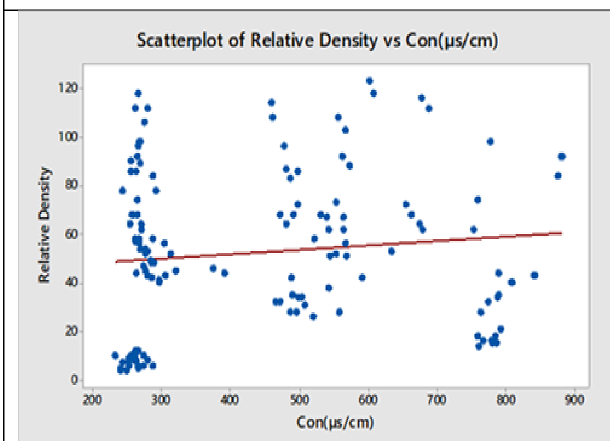
L_1- Attidiya , L_2 – Bellanwilla , L_3 – Rattanapitiya , L_4- Nawala , L_5–Near Parliament grounds , L_6- Jayewardenepura hospital road



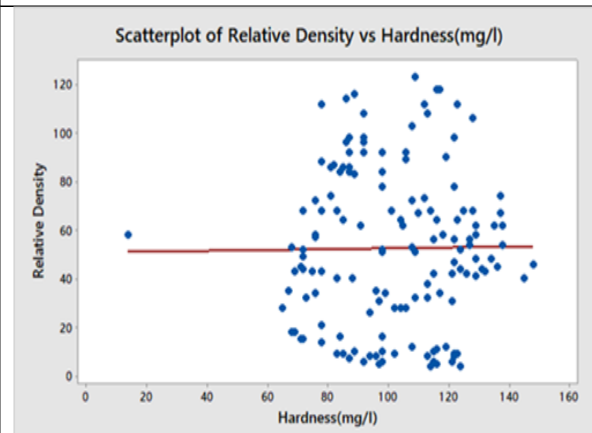
(a) Pearson correlation coefficient = -0.088, p = 0.295, n=144



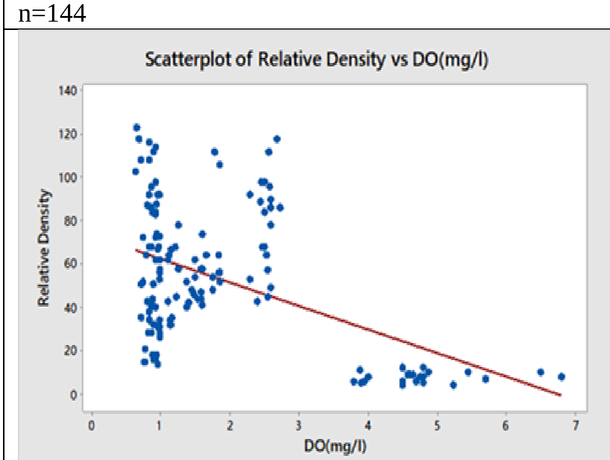
(b) Pearson correlation coefficient = 0.191, p = 0.022, n=144



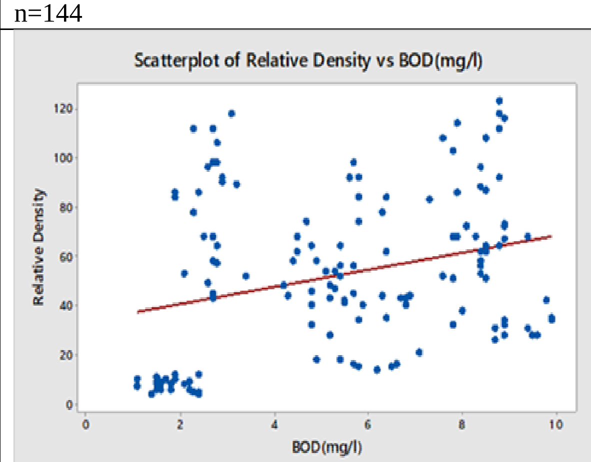
(c) Pearson correlation coefficient = 0.116, p= 0.164, n=144



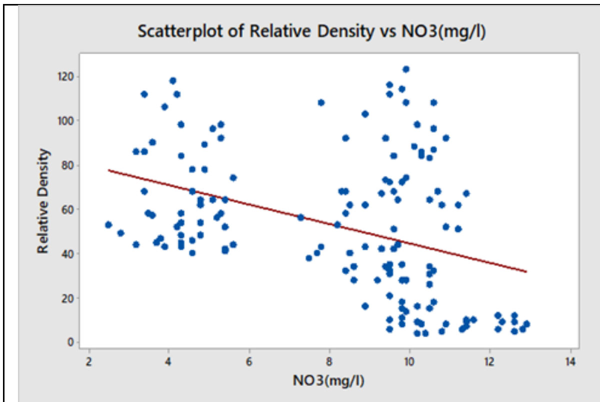
(d) Pearson correlation coefficient = 0.012, p = 0.884, n=144



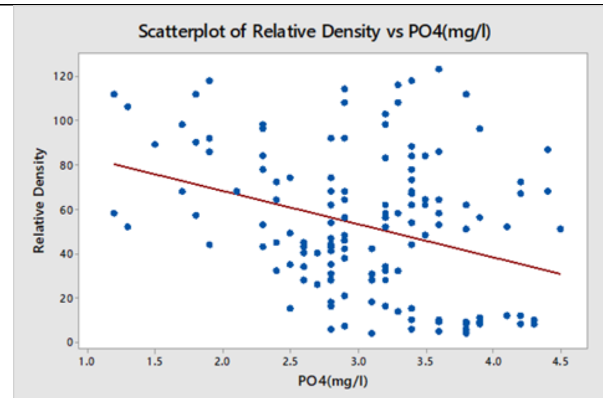
(e) Pearson correlation coefficient = -0.491, p = 0.000, n=144



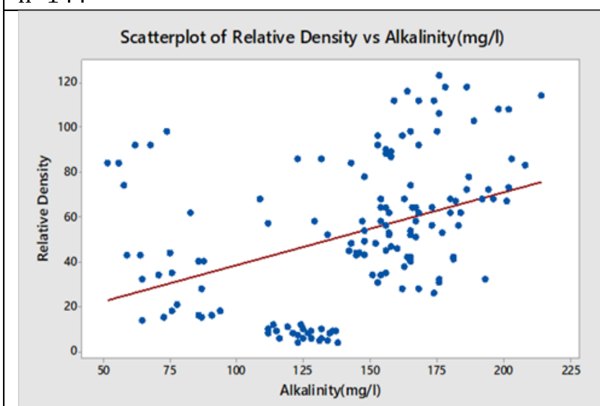
(f) Pearson correlation coefficient = 0.295 , p = 0.000, n=144



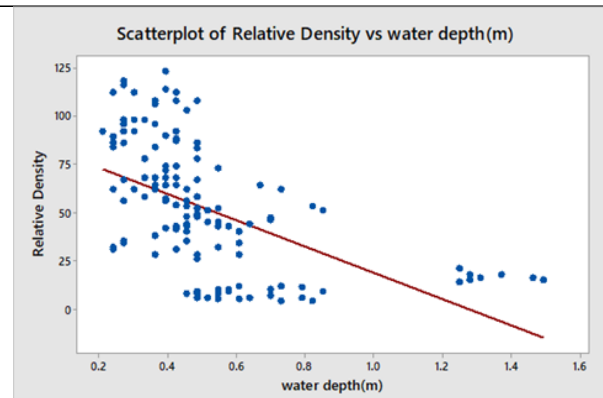
(g)Pearson correlation coefficient = -0.390, p = 0.000, n=144



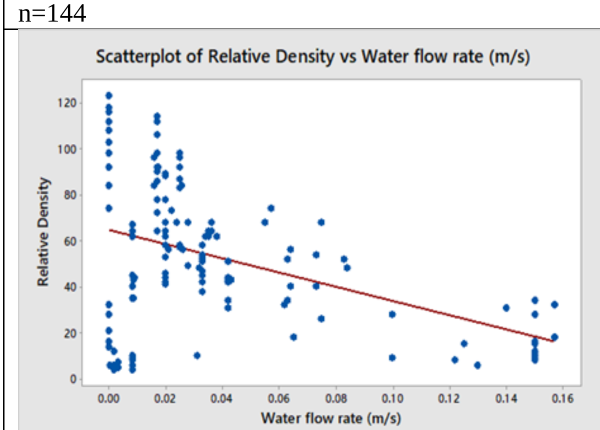
(h) Pearson correlation coefficient (r =-0.330, p= 0.000, n=144



(i) Pearson correlation coefficient = 0.392, p = 0.000, n=144



(j) Pearson correlation coefficient = -0.529, p = 0.000, n=144)



(k) Pearson correlation coefficient = -0.428,p = 0.000, n=144)

Figure 02: Relationships of selected monthly mean water quality parameters with the relative density of *P. reticulata* wild population in study locations over a period of two years (2016-2017).

3.2 Length class distribution in each locations of *P. reticulata*

Length class distributions of the 520 specimens of *P. reticulata* were examined during the study period. Fig.3 shows the relative density of male and female *P. reticulata* at 6 sampling locations. Relative density of females was always higher than that of the males. There was significant sexual dimorphism in terms of both body weight and length (p = 0.000 in both cases), with females being larger than males. Mean body length was 24.56 ± 5.46 mm (range: 15-35 mm) in females and 20.19 ± 2.75 mm (range: 15.0-24.5 mm) in males. Mean body weight in females was 0.174 ± 0.105 g (range: 0.026- 0.382 g) in comparison with 0.075 ± 0.021g (0.024-0.11 g) in males. Fig.4 illustrates the length class distribution of male and female *P. reticulata* in the wild population. The highest representation by males was in the 18-20mm length group while lowest was shown in 24-26mm length group. In contrast the highest representation by females was in 24-26mm length group while lowest was in 33-35mm length group.

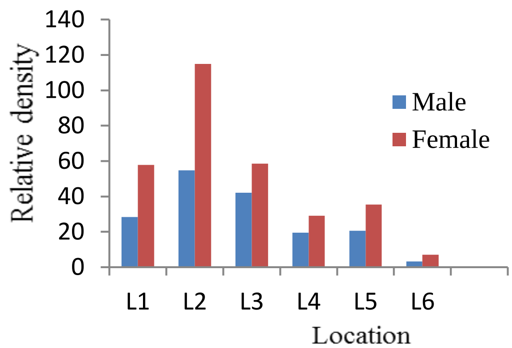


Figure 03: Relative density of male and female *P. reticulata* at 6 sampling locations.

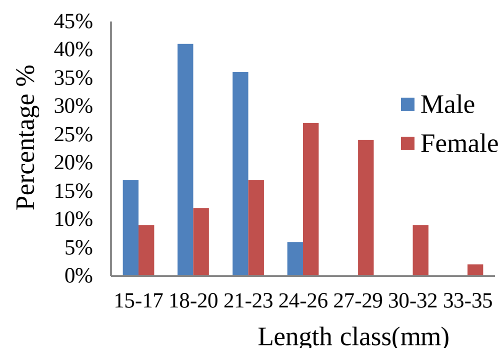


Figure 04: Percentage distribution of length classes of female and male *P. reticulata* in wild population.

Present study recorded a female-biased sexual dimorphism for *P. reticulata* wild population. In the wild population, mean weight in females was 0.174 ± 0.105 g (range: 0.026 - 0.382 g) and mean body length was 24.56 ± 5.46 mm (range: 15-35 mm) while mean weight in males was 0.075 ± 0.021g (0.024 - 0.11 g) and mean body length was 20.19 ± 2.75 mm (range: 15.0 - 24.5 mm). Observed mean lengths and weights of females were always higher than that of males for wild populations. Females of both species were more evenly distributed over the size classes, while males were restricted to narrower size classes, although signals of decreasing abundances in adults' classes were shown for *P. reticulata*. (Aranha & Caramaschi 1999). However, Pethiyagoda (1991) has recorded males of this species to reach up to 40 mm in length while females to grow up to 60 mm in Sri Lanka. Hernandez *et al*. (2004) have got different results for the same species and the degree of dimorphism was similar in studies. Hernández *et al*. (2004) recorded a maximum body length of 51.1 mm for females, and 30 mm for males. The maximum length values recorded in the present study for females and males were below these earlier reports, Pethiyagoda (1991).

The locations inhabited by *P. reticulata* in the study area recorded some water quality parameters that are not suitable for fish and aquatic life (CEA 2017). The presence of *P. reticulata* in high densities in this polluted water body shows their ability to withstand extreme water conditions, and similar observations have been made in previous studies (Chervinski 1984, Widianarko *et al*., 2000, Barua *et al*., 2001, Araujo *et al*., 2009, Rolshausen *et al*., 2015).

Results of the study revealed that the relative density of *P. reticulata* significantly varied with several water quality parameters ($p \leq 0.05$), namely, water pH, DO, BOD, N- NO_3^-, PO_4^{-3}, Alkalinity, water depth and flow rate. Among the above factors, relative densities of *P. reticulata* have decreased with increasing DO, N-NO_3^- , Ortho-PO_4^{-3} levels as well as with water depths and flow rates, while relative densities have increased with increasing pH, BOD and Alkalinity of water. Decrease in relative densities with increasing DO levels and increase with increasing BOD, pH and alkalinity levels further confirms their ability to live in polluted waters and also suggest that they can sustain in such waters very successfully without any inhibitions to their reproductive ability. Pandey *et al*., 2018, who studied impacts of industrial wastewaters on *P. reticulata* also have observed that, these waters that had low DO (2.8- 4.2 ppm), high BOD (12.5 - 13.1ppm), heavy metals, High EC, phosphates showed high pollutant levels, but when fish were exposed to these waters, they showed 90% survival. They identified changes such as increased space between gills and operculum, excessive excretion as well as increased surface activity and behavioral changes such as fin movement in relation to their high survival rate.

The decreased relative density observed with increasing N-NO_3^- and Ortho-PO_4^{-3} levels shows an adverse effect of N-NO_3^- and Ortho-PO_4^{-3} levels on their sustenance and that may be due to adverse effects on the reproduction of the species. De Silva & Samayawardhene (2005) reported the effects of chlorpyrifos (an organophosphate pesticide) on reproductive performances of *P. reticulata* found that low soluble concentrations of chlorpyrifos adversely affect mating behavior, number of offspring and offspring survival of guppy.

Results of the present study also show that fishes prefer shallow and slow moving/stagnated water. This may be related to their ability to get the oxygen from water- air interface thus moving to shallow places where surface access is easier. In a study (Weber & Kramer 2011) in which the effects of hypoxia and surface access on growth, mortality, and behavior of juvenile *P. reticulata* were investigated, it had been observed that when the fish were allowed to access the surface, they achieved high growth rates and low mortalities at very low oxygen concentrations (0.5 -8 ppm at 25-26 °C), but when the surface access was denied, reduction in growth rate was shown below oxygen concentrations between 2-3 ppm and they did not survive below 1ppm. They suggest that aquatic surface respiration under hypoxic conditions increases the energy available for growth by supplementing oxygen supply, which permits greater ingestion rate, and possibly by decreasing the cost of ventilation.

4 CONCLUSIONS

The presence of *P. reticulata* in high densities (32.7±27.7 - 85.7±22.9) in the polluted water body under investigation shows their ability to withstand poor water quality conditions. Despite the relatively poor quality of the water inhabited by the fish population, this species appears to have adapted its reproductive strategies to the prevailing conditions to sustain high population densities. Relative density of females was always higher than that of the males and there was significant sexual dimorphism in terms of both body weight (Female 0.026 - 0.382g & Male 0.024 - 0.11g) and length (Female 15 - 35 mm & Male15 – 24.5 mm) with females being larger than males.

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