Songklanakarin J. Sci. Technol.
35 (4), 483-488, Jul. - Aug. 2013

SJST SONGKLANAKARIN JOURNAL OF SCIENCE AND TECHNOLOGY
http://www.sjst.psu.ac.th

Original Article

Distributions of the endemic and threatened freshwater fish depik, *Rasbora tawarensis* Weber & de Beaufort, 1916 in Lake Laut Tawar, Aceh Province, Indonesia

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Received 28 August 2012; Accepted 21 April 2013

Abstract

Depik fish, *Rasbora tawarensis* is an endemic and threatened species in Lake Laut Tawar (Central Aceh, Indonesia), and the population of depik has been decreased drastically over the last two decades. Information about distribution patterns is crucially needed in relation to plan better conservation strategies. Hence, the objective of present study was to evaluate the distribution patterns (spatial and seasonal distribution) based on catch per unit efforts and fish abundance data. Stratified random sampling was utilized in this study. Two fishing grounds were selected based on information from local fishermen, and a total of 14 fishing sites (seven sites per fishing ground) were determined randomly. Sampling was conducted in different seasons; dry and wet season. The *Rasbora tawarensis* is widespread in the lake but most abundant in shallow waters and the near shore, however, the size is small on average for this area. In contrast, bigger fish was found in deep waters offshore, but with lower abundance. In conclusion, the distribution of depik is not seasonally dependent, but more spatially.

Keywords: CPUE, abundance, conservation, depth, Takengon

1. Introduction

Rasbora tawarensis locally known as depik is an endemic freshwater fish and one of the important species in Lake Laut Tawar (Central Aceh, Indonesia); it is targeted by a large portion of fishermen. Presently, the fisheries activities in Lake Laut Tawar are not well regulated and managed, resulting in over exploitation and ecological perturbations. An indicator for this is the decrease of catch-per-unit effort (CPUE) over the years. According to Muchlisin *et al.* (2011a) the CPUE of depik declined from 1.17 kg/m^2 net in 1970s to only 0.02 kg/m^2 in 2009. Therefore, a sustainable management of fisheries in general and depik in particular is crucially needed to maintain fish production in the future and to ensure this endemic species is sustained. For these purposes, information on the distribution pattern of fish populations is needed to plan for better management strategies.

An understanding of fish population, its habitat characteristics including distribution pattern is required for the management and conservation of fish communities or species (Tripe and Guy (1999). In general, the distribution of fishes is directly or indirectly affected by various abiotic factors, such as lake morphology (Jarvalt *et al.,* 2005), water depth (Hyndes *et al.,* 1999), water temperature (Peterson and Ross, 1991), turbidity (Cyrus and Blaber, 1992), dissolved oxygen, salinity (Whitfield *et al.,* 1999; Jaureguizar *et al.,* 2004), and substrate type (Wantiez *et al.,* 1996; Cushman *et al.*, 2004), as well as biotic factors, for example, food availability, predation (Gaudreau and Boisclair, 1998), and fish density (Linlokken and Hougen, 2006).

Knowledge of fish distribution within a water body is one the key steps to understand complex biotic and abiotic interactions and processes in freshwater ecosystems and moreover, information on fish distribution patterns is also

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valuable for fisheries management (Vasek *et al.,* 2004) and conservation (Argent *et al.,* 2003). In general, the spatial distribution of a stock refers to the position of the population or parts of it in its area of distribution. This is clear in the case of sedentary species, but in the case of non-sedentary populations, the spatial distribution should also include a description of regular patterns of movement, i.e. migration (Hernandez and Seijo, 2003).

Currently, distribution of fish has received great attention in fisheries management due to the aforementioned reasons. Muchlisin *et al.* (2010a, 2011b) have reported on the reproductive biology and length-weigh relationship (Muchlisin *et al.,* 2010b) of the depik and taxonomy of *Rasbora* group in Lake Laut Tawar (Muchlisin *et al*., 2012). However, no information on the distribution pattern of the depik *R. tawarensis* was available. Therefore, this study is an important contribution for basic information on the distribution of depik *R. tawarensis* in relation to management and conservation of this endemic species. The objective of the present study was to evaluate the distribution patterns of depik in the Lake Laut Tawar based on catch per unit effort data, abundance, and fish sizes

2. Materials and Methods

2.1 Study area

Lake Laut Tawar is situated in Central Aceh, Aceh Province, at 04°362 433N 096°552253E. It is located approximately 1,200 m above sea level. The lake is an old volcanic caldera of circa 16 km in length, 5 km in width with an estimated depth of 80 m and surrounded by mountains reaching over 2,000 meters. Detail description of the lake was reported in Muchlisin *et al.* (2010a; 2010b).

2.2 Consensus

Herein, fish distribution is defined as the seasonal and spatial distributing of fish abundance and size. Seasonal distribution was evaluated based on sampling data from two seasons, dry and wet season, while spatial distribution was evaluated based on different sampling locations regarding the ecological conditions of the lake, i.e. water depth and distance from shoreline.

2.3 Sampling

Stratified random sampling was utilized in this study. Two sampling periods were conducted in different season; the first sampling was in dry season (23-26 July 2009) and the second sampling was in wet season (21-24 November 2009). The sampling was done at the same sites for both periods.

Two fishing grounds were selected based on information from local fishermen, and a total of 14 fishing sites (seven sites per fishing ground) were determined randomly. The coordinates, depths, distances from shore and main water quality parameters (surface water temperature, pH and dissolved oxygen) of each sampling site were recorded. Based on the depth data, the selected sites were further divided into four categories, i.e. depth <20 m, depth <40 m, depth <60 m, and depth <80 m. Based on the distance o the shoreline, the selected sites were divided into five categories, <200 m, <400 m, <600 m, <800 m, and a distance of <1,000 m from the shoreline.

Two sets of selective gill nets (each net was 20 m in length, 1.5 m in height, and 1.4 cm mess size) were set up at 0.50 m below the water surface (two nets with the same mesh size in chains). The nets were set over the night (18:00-07:00 hrs), and the captured fishes were collected and recorded for number and volume.

2.4 Evaluation of catch-per-unit-effort

The catch-per-unit effort is often used as a measure of fish abundance and species composition (Olin *et al.,* 2004), and CPUE is a function of both fish abundance and catchability at the time of fishing (Linlokken and Haugen, 2006). The CPUE was examined for stratified random sampling data, interview data, and fishermen catch data. Because of differences in net size and in the values used by fishermen, the CPUE was converted to a similar standard unit in meter square (m^2). Therefore, herein, the CPUE is expressing the total fish catches (g) per meter square (m^2) of net per night of fishing activities (12 hours).

2.5 Statistical analysis

The multivariate general linear model (GLM) was performed to analysis the main effects and interactions between the variables depth, distance, CPUE, and fish abundance. The Duncan's multi range test was utilized to evaluate the significant differences among the CPUE and fish abundance data according to depth and distance.

3. Results

Five variables (distance from the shore, water depth, dissolved oxygen, water turbidity and surface water temperature) were recorded at every sampling site. The values for dissolved oxygen, water turbidity and surface water temperature ranged from 6.62 ppm to 6.35 ppm, 2.1 m to 2.23 m and 22.92°C to 23.41°C, respectively. This data indicate no significant differences in the values among the different locations, and therefore these variables were not used in the analysis, while the variables distance from the shore and water depth were retained for further evaluation.

The effects of two variables, depth and distance, on the fish distribution indicated by the variation of fish abundance and fish size were evaluated. The results from the multivariate of general linear model test show that depth and distance have a significant effect on the response variables ($P<0.05$). In addition, the interaction effects between the

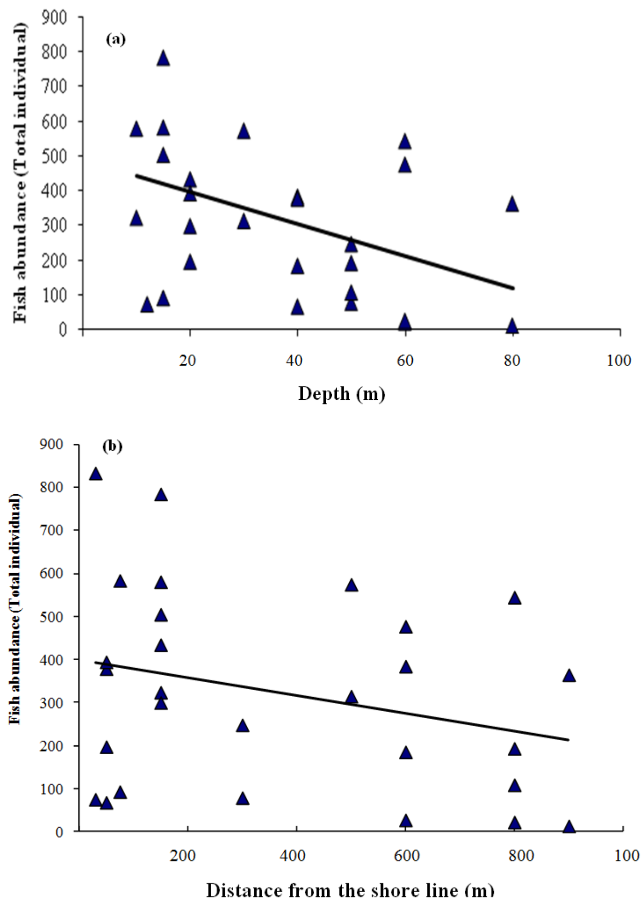

Figure 1 (a) The relationships between the depth with fish abundance and fish size. (Fish abundance, y = -4.59x + 486.6, r^2 = 0.2. Fish size, y = 0.01x + 1.8, r^2 = 0.20. (b) The relationship between the distance with fish abundance and fish size. (Fish abundance, y= -0.21x + 398.9, r^2 = 0.10. Fish size, y= 0.00x + 2.0, r^2 = 0.04).

main variables were also significant. Test results show that the depth has a significant effect on fish abundance and CPUE (P<0.05). In general, the fish abundances hav e a negative relationship with depth and distance. (Figure 1a and 1b). On the depth basis, the fish abundance was higher at 20 meters depth in the dry season, but it was not significant different with other depth levels (P>0.05); while in the wet season the highest fish abundance was at 10 depth, but not significantly different in comparison to 20 and 40 meters depth (P>0.05) (Table 1). Overall, higher fish abundance was found between 10 to 40 meters depth for both seasons.

For the distance from the shoreline, the fish abundance was higher at a distance of 200 meters for both dry and wet season. However, in the wet season the fish abundance was not significant different for different distances (P>0.05) (Table 2). Overall, for both seasons, the highest fish abundance was found at 200 meters from the shore. For the fishing ground basis, the fish showed the highest abundance in the dry season in first fishing ground, while in the wet season, there were not significant differences in abundance for both fishing grounds (Figure 2). Overall, the fish abundance was higher in the wet season compared to dry season.

4. Discussion

The present study revealed that depik fish are widespread from lakeside to the middle of the lake. However, the fish was most abundant in the depth range of 10 to 20 meters and 100 to 200 meters distance from the shore in both dry and wet season. In general, the fish is most abundant in shallow water near the shore. The finding is in agreement with Gray and Kennelly (2003) and Rueda and Defeo (2003) who stated that the littoral or coastal lakes contain abundant and diverse fish fauna. In addition, Prchalova *et al.* (2009) reported that CPUE and biomass per unit effort of Cyprinidae, Percidae, Esocidae, Coregonidae, Salmonidae, and Siluridae in canyon shaped Rimov Reservoir, Czech Republic, decreased with depth and distance. A similar trend was also reported in bullhead (*Cottus gobio* L.) and salmon parr (*Salmo salar* L.), where the total catch of fish felt significantly with increasing distance and depth, for example a total of 260 salmon parr and 55 bullheads were caught in the shallow zone (0±3 m), while 16 salmon and 12 bullheads were caught in deeper parts (>3 m) (Jorgensen *et al.,* 1999). Moreover, Gray *et al.* (2009) have done a series survey in the Lake Macquarie and St. Georges Basin, NSW Australia and they found that most species were caught in greater numbers in shallow parts, which had greater proportions of small fish.

Table 1. Average (±SE) value of fish abundance and fish size according to water depth and season. Mean values in the same column followed by the different superscripts were significantly different (P<0.05).

Depth (m)	Average of fish abundance (total of individual fish catches)		
	Dry season	Wet season	Mean
10	196.0±176.8^{a}	706.0±179.6^{b}	451.0±1.41^{c}
20	270.8±79.2^{a}	547.5±79.6^{ab}	409.1±0.7^{bc}
40	186.0±71.7^{a}	443.7±68.8^{ab}	314.3±0.7^{abc}
60	55.3±21.0^{a}	363.3±86.0^{a}	209.3±32.8^{ab}
80	9.0±0.0^{a}	362.0±0.0^{a}	185.5±0.0^{a}

Table 2. Average (±SE) value of fish abundance and fish size according to water distance and season. Mean values in the same column followed by the different superscripts were significantly different (P<0.05).

Distance from the shoreline (m)	Average of fish abundance (total of individual fish catches)		
	Dry season	Wet season	Mean
100	104.5±30.3^{a}	545.8±106.6^{a}	325.1±48.6^{ab}
200	373.7±65.1^{b}	598.3±102.2^{a}	486.0±82.6^{b}
400	75.0±0.1^{a}	245.0±0.1^{a}	160.0±0.0^{a}
600	172.3±83.6^{a}	476.7±55.2^{a}	324.5±59.8^{ab}
800	61.5±43.9^{a}	366.5±178.3^{a}	214.0±67.1^{a}
1000	9.0±0.1^{a}	362.0±0.0^{a}	185.5±0.0^{a}

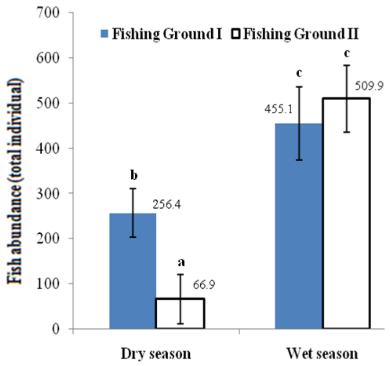

Figure 2. Average (±SE) value of fish abundance in relation to fishing ground and season. Bars with the same letter were not significantly different (P>0.05).

Schulze *et al.* (2004) reported that *Anguilla anguilla* in a mesotropic reservoir of Germany was observed to be most abundance at 1 meter depth with a decrease in abundance down to 10 meters.

The spatial distribution of fish within a water body is not random, but it was likely determined by various environmental factors, both biotic and abiotic (Prchalova *et al.,* 2009), such as physical and biochemical of the water. Fish utilize habitats within a water body that are physiologically convenient mainly in terms of oxygen concentration and water temperature (Gido and Matthews, 2000; Matthews *et al.,* 2004). Biotic factors such as food availability, predation risk and competition also play a role in the distribution patterns of fish (Mous *et al.,* 2004; Gliwicz *et al.,* 2006). Besides the distance from the shore and water depth, surface water temperature, dissolved oxygen and water turbidity at every sampling site were also recorded in this study and it was found that there were no significant differences among locations. Therefore it is assumed that there is no significant effect of water temperature, dissolved oxygen and water turbidity on depik distribution in Lake Laut Tawar.

The shallow water in the littoral zone is characterized by warm water. This condition was suitable for phytoplankton and other water plants to grow. Macro water plants such as hydra and eichornia were found predominant in shallow water the near shore. Water plants provide shelter and protection for younger and fish larvae from predators. Similarly, Indiarto and Nasution (2004) reported that the rainbow celebensis was most abundant in shallow water with the presence of water plants. Moreover, vegetated sites had higher densities of fish, especially smaller fish and greater species richness than unvegetated sites (Randall *et al.,* 1996; Jocobsen *et al.,* 2002).

In the present study, stratified random sampling was done in two different fishing grounds for wet and dry season, and the result shows that the fish abundance varied by fishing ground in the dry season, while no significant variations were detected during the wet season; it means that the fish was distributed evenly during this season.

It is assumed that the water depth is an important factor for determining the distribution pattern of depik in Lake Laut Tawar. The depth is also an important factor for distribution of marine fishes, for example the European hake, *Merluccius merluccius* (Kacher and Amara, 2005; Abella *et al.,* 2005), mummichog *Fundulus heteroclitus* and pinfish *Lagodon rhomboides* (Meyer and Posey, 2009). In addition, Garces *et al.* (2006) reported that the spatial distribution of marine demersal fish in South and Southeast Asia is influenced by depth. Besides that the depth is also an important factor for the distribution of mollusks, for example scallop, *Pecten jacobaeus* (Katsanevakis, 2005).

5. Conclusions

The depik, *R. tawarensis* is widespread in Lake Laut Tawar but most abundant in shallow waters and near the shore, however, the size is small on average for this area. In contrast, the bigger fish was found in deep waters offshore, but with lower abundance. Therefore, it can be concluded that the distribution of depik in Lake Laut Tawar is more spatially than seasonally dependent.

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