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Species composition and abundance of fishes with seasonal fluctuations of rainfall and water level in Vavuniya reservoir, Sri Lanka

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Abstract

Dramatic loss of freshwater fish bio-diversity and survival of un-described local inland fish species in Sri Lanka justifies the requirement of systemic surveys. Extreme hydro-climatic events and its consequent shifts in seasonality lead to water scarcity in dry zone aquatic resources such as Vavuniya reservoir, threatening fish species richness and abundance. Weekly filed surveys were made to collect biological, ecological and hydro-climatic data from January, 2013 to July, 2014. Fish species composition and abundance in the catch were estimated by using random sampling at the landing site. Clarias brachysoma, Esomus thermoicos and Labeo lankae were the endemic freshwater fish species identified along with 16 indigenous and 8 exotic species. A significantly higher abundance of indigenous species was found in July and August 2013. During these periods, higher rainfall was observed but water level receded to medium level. Peak abundance of Channa striata (July & August 2013 and March & July 2014), Puntius dorsalis (August 2013 and July 2014) and P. sarana (August, 2013) were observed during these periods. Higher catches of Labeo dussumieri was observed in October - December 2013 and June 2014. Mystus keletius and Heteropneustes fossilis showed higher abundance during July - November 2013. However, M. keletius catch was higher in March and June and H. fossilis, in January, 2014. Glossogobius giuris showed a higher abundance during August 2013 and January 2014. Higher abundance was observed with the onset of rainfall and with lower water level. Fish species composition and abundance were significantly different (p=.02) for each month of the year 2013 and 2014 with respect to monthly total rainfall and monthly mean water level. Hence, the seasonal changes in the hydro-climatic factors play a significant role in fish species composition and abundance in tropical reservoirs.

Keywords: Species composition, Rainfall, Water level.

Introduction

Sri Lanka has a rich freshwater fish species composition that consists of 91 local species including 50 endemics[1-3]. Among the local fish species, endemics are threatened severely, indicating the present poor management[4]. However, there are evidences of undiscovered species still surviving in both wet and dry zones of Sri Lanka. Thus, there is an urgent need for systematic surveys to get baseline data regarding distribution and ecological status of freshwater fishes of this country[1]. Therefore, fish species composition and abundance in the catch were studied in the Vavuniya reservoir, Northern Province of Sri Lanka. As Vavuniya reservoir is located in the dry zone and used primarily for agricultural purposes, water level fluctuations mainly depended on the seasonal rainfall patterns and irrigation practices.

Rainfall and water level play a major role in the freshwater fish species composition and abundance in low land dry zone reservoirs. Climatic consequences such as extreme events in rainfall patterns and drought may lead to unexpected impacts on fish present in this reservoir. Therefore, severe water scarcity that leads to habitat degradation, intensive fishing, reduced recruitment *etc* are the threats for the persistence of a rich fish species diversity in this region.

Materials and methods

Initially, a preliminary survey was conducted from November, 2012 to January, 2013 to gather information regarding the fish species diversity, population dynamics and hydro-climatic regimes in Vaunia reservoir through a Participatory Appraisal Method[5]. Weekly field visits were made from January, 2013 to July, 2014 to landing sites in order to collect biological, ecological and hydro-climatic data. Fish species composition and abundance were estimated by random sampling (in the catch, outside the sluice, spills and shoreline) and from daily fish catch data obtained from the logbook of the fishers.

Randomly collected local fish specimens (indigenous and endemic) were brought to the laboratory and species identification was done by referring to Goonatilake (2012), Pethiyagoda (1991) and Munro (1955). Total body length (nearest 0.1 mm) and gut analyses (for pisivorous species) were

done on these fresh specimens. Daily rainfall data were obtained from the Meteorology Department and calculated monthly total rainfall of the Vavuniya District, Sri Lanka. Weekly water level data were recorded to get monthly average water level. Occasional surveys were made to adjacent reservoirs (during rainy seasons) to trace fish migrations and recruitments. Most of the ecological and biological data were imaged using a digital camera (Sony DSC-W350 14.1 Mega Pixel, 72dpi).

To determine the distribution (non-uniformity/uniformity) of the species composition and abundance, Chi-square test was conducted for each species separately[9]. Graphical out puts and statistical analysis were performed in Minitab 16.0.

Results and discussion

Species composition and abundance of fish in the Vavuniya reservoir mainly depended on the seasonal hydro-climatic factors. Rainfall and water level were the major seasonal hydro-climatic factors, which influenced fishing, natural mortality (water scarcity and predation), emigration, stocking of fingerlings (exotic species) and natural recruitment (reproduction and immigration). Three endemic, 16 indigenous and 08 exotic fish species were identified hitherto (Table-1).

Among the endemic species, *Labeo lankae* is a critically endangered endemic fish of Sri Lanka. After 1980's it was considered as gone extinct due to the disappearance in its natural habitat. However, in 2008 its existence in Knuckles Mountain had been rediscovered[10]. In Vavuniya reservoir, particularly in 2013, availability of 3 individuals of *Labeo lankae* was observed. *Oreochromis niloticus, Cirrhinus mrigala, Labeo rohita* and *Catla catla* were the major stocked exotic species along with *Cyprinus carpio* and *Macrobranchium rosenbergii* (Giant freshwater prawn). Interestingly, a few individuals of *Oreochromis mossambicus* (hybrids) and *Tilapia randalli* (hybrids) were also observed during the study period. Natural recruitment and immigration from other reservoirs were shown by endemic (*Esomus thermoicos*) and indigenous species such as *Puntius sp., Anabas testudineus, Heteropneustes fossilis, Rasbora danicnius, Channa striata* and *Wallaga attu.* Natural immigration of those species from Thandikkulam reservoir was observed during spilling.

Vavuniya reservoir (higher elevation= 585 ft) is situated 2.48 km away and South-eastern to Thandikkulam reservoir (lower elevation= 552 ft), which acts as a nursery (Figure-1) for most of the local fish species and provide fish species to Vavuniya reservoir when interconnected *via* spilling waters.

Freshwater fish migration occurred from lower elevation to higher elevation reservoirs of the cascade system in the Vavuniya District during spilling (Figure-1). Exotic species like *Oreochromis sp.* and *Trichogaster pectoralis* also showed natural recruitment *via* immigration. Both of these species were categorized as invasive alien species in Sri Lanka.

Table-1: Identified freshwater fish species compossion in Vavuniya reservoir.

No	Endemic	Indigenous	Exotic
01	*Esomus thermoicos*	*Amblyphyrangodon melettinus*	*Catla catla*
02	*Labeo lankae*	*Anabas testudineus*	*Cirrhinus mrigala*
03	*Clarias brachysoma*	*Anguilla bicolor*	*Cyprinus carpio*
04		*Channa striata*	*Labeo rohita*
05		*Glossogobius giuris*	*Oreochromis mossambicus* *
06		*Heteropneustes fossilis*	*Oreochromis niloticus* *
07		*Lepidocephalichthys thermalis*	*Tilapia randalli* *
08		*Labeo dussumieri*	*Trichogaster pectoralis*
09		*Macrobrachium rosenbergii*	
10		*Mystus keletius*	
11		*Mystus vittatus*	
12		*Puntius dorsalis*	
13		*Puntius fillamentosus*	
14		*Puntius sarana*	
15		*Rasbora danicnius*	
16		*Wallaga attu*	

*Indicates the hybrids with enhanced species specific external features.

Among all the fish species, largest species was *Wallaga attu* (87.5 cm) while the smallest species was *Lepidocephalichthys thermalis* (07.6 cm), where both are indigenous species. Largest predatory pisivorous fish species in this reservoir was *Wallaga attu,* which fed primarily on *Puntius sarana* (Figure-3).

Second largest piscivorous species was *C. striata* that mainly consumed juvenile tilapia (Figure-4).

Glossogobius giuris and *Anabas testudineus* are also piscivorous species that preyed on *Puntius sarana* (Figure-5) and *Amblyphyrangodon melettinus* respectively (Figure-6).

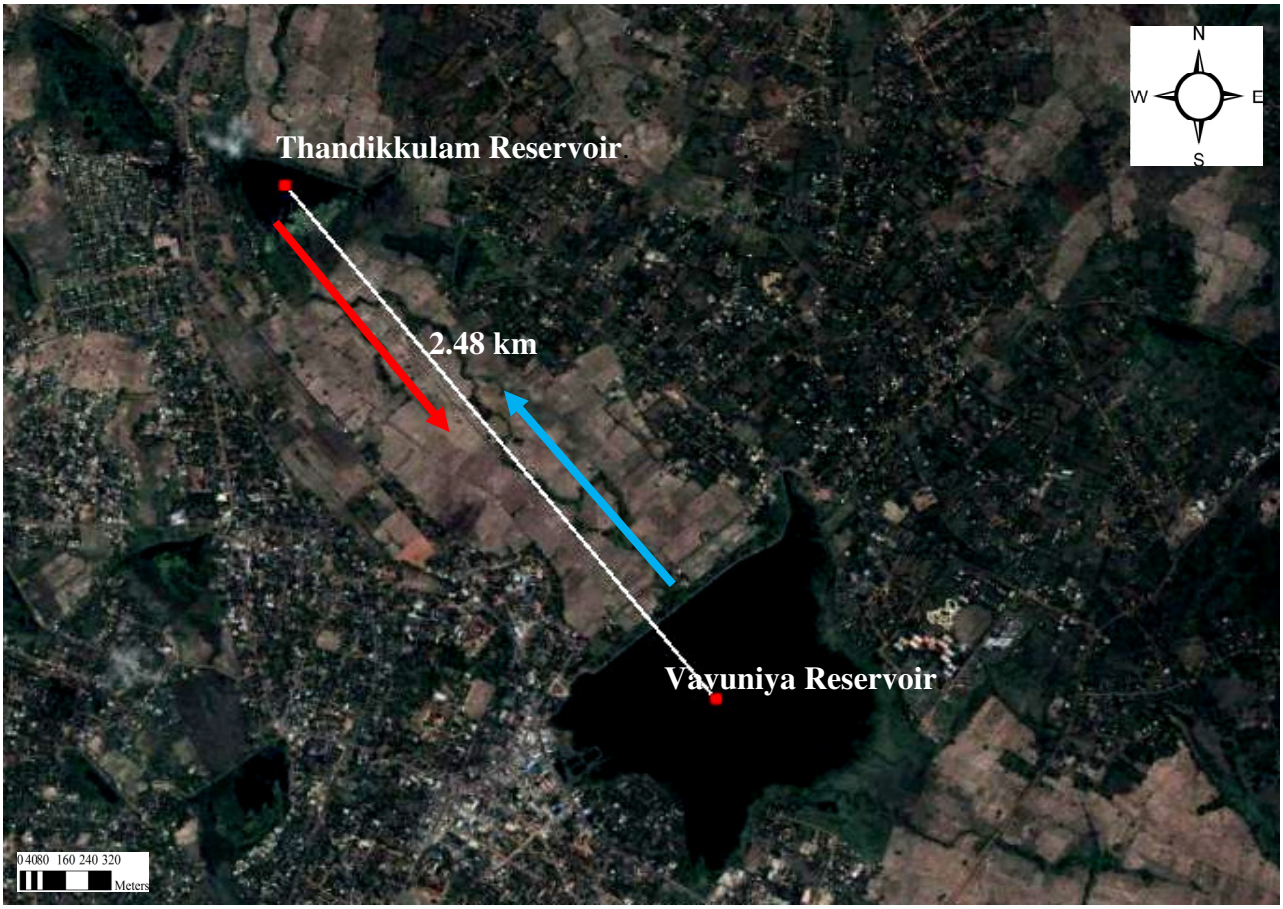

Figure-1: Location of Thandikkulam reservoir (8°46'37.71"N, 80°29'21.09"E) and Vavuniya reservoir (8°45'31.11"N, 80°30'24.05"E), red arrow: direction of fish immigration and blue arrow: direction of water movement during spilling.

Figure-2: A school of *C. striata* fingerlings in Thandikkulam reservoir, act as nursery ground.

Figure-3: *W. attu* at the top and the prey *P. sarana* at bottom observed in gut analysis.

Figure-4: *C. striata* at the left and the prey *Tilapia sp.* at the right obtained in gut analysis.

Figure-5: *G. giuris* at the top and the prey *P. sarana* observed in gut analysis.

Figure-6: *Anabas testudineus* preyed *Amblyphyrangodon melettinus* (right bottom corner).

During the dry season, when water level decreased resulting in loss of vegetation in littoral zone made prey species more vulnerable to attack from predatory fish species[11]. Hence, water level seemed to be the most influencing hydro-climatic factor for the fluctuations of prey and predatory fish species abundance.

Remarkable changes in rainfall patterns and its consequent irrational irrigation practices caused sudden drop in the water level of this reservoir. Although this is a perennial reservoir, it experienced complete loss of fish species from June to September, 2012 due to complete removal of water by pumping water for irrigation of paddy fields. Therefore, all the fish species in Vavuniya reservoir were vulnerable due to water scarcity[12].

This justified the lower fish species composition and abundance in 2013 than in 2014. However, recovery of fish species was by natural immigration during spilling period (Nov, Dec. 2012 and Jan, Feb and May 2013) to this reservoir. Even in July 2014, water level dropped due to drought and pumping for irrigation, which resulted in severe fish demises. Shrinkage of Lake Chad has been occurring due to prolonged drought and over exploitation of water for agriculture in northwest Africa[13].

According to fishers of Vavuniya reservoir, *A. testudineus*, *A. bicolor*, *L. dussumieri*, *L. porcellus*, *G. giuris*, *P. fillamentosus*, *H. fossilis* and *W. attu* were the abundant species in the last couple of decades compared to the years 2013 and 2014 (Figure-7).

Figure-7: Declining local fish populations (Indigenous and endemic) in Vavuniya reservoir.

Indigenous species like *Channa spp.* was one of the most abundant species in the past and was totally absent in some months in 2007 in Sorabora reservoir, Sri Lanka[14]. In Vavuniya reservoir a few fish species appeared in the catch continuously. However, most of the fish appeared only during some months in 2013 and 2014.

Table-2: Seasonal fluctuations in rainfall and water level from 2013-2014.

Month of year 2013-2014	Hydro-climatic factors	
	Monthly total Rainfall (mm)	Monthly mean Water level (cm)
Jan	100.9	390.7
Feb	264.4	398.1
Mar	179.6	384.5
Apr	157.5	354.9
May	100.8	392.3
Jun	1.7	358.1
Jul	24.5	263.5
Aug	95.3	173.9
Sep	8.3	150.6
Oct	194.9	144.9
Nov	160.3	209.4
Dec	78.3	231.1
Jan	39.0	312.8
Feb	2.0	300.5
Mar	20.0	232.9
Apr	162.0	181.9
May	18.0	312.8
Jun	105.0	294.7
Jul	24.0	193.7

Among the indigenous species, *C. striata* and *P. dorsalis* were the species available in the catch through out the year in Vavuniya reservoir (Figure-8).

Most of the indigenous species such as *G. giuris*, *L. dussumieri*, *M. keletius* and *P. sarana appeared* in the catch only during some months in both 2013 and 2014. There were only a fewer numbers of *A. testudineus*, *A. bicolor*, *H. fossilis*, *L. lankae* (Orange fin labeo), *M. vittatus*, *P. fillamentosus* and *W. attu* (Freshwater shark) in 2013 than in the previous years. However, an increase in indigenous species in the catch was observed in 2014 (Figure-7) due to subsequent immigration from Thandikkulam reservoir when the latter spilled.

Mainly due to smaller size, *Amblyphyrangodon melettinus*, *Esomus thermoicos*, *Lepidocephalichthys thermalis* and *Rasbora daniconius* were not found in the catch. However, these fish were available outside the sluice and littoral peripheries of this reservoir during latter part of July 2014, when water was drained from the dead storage for agriculture.

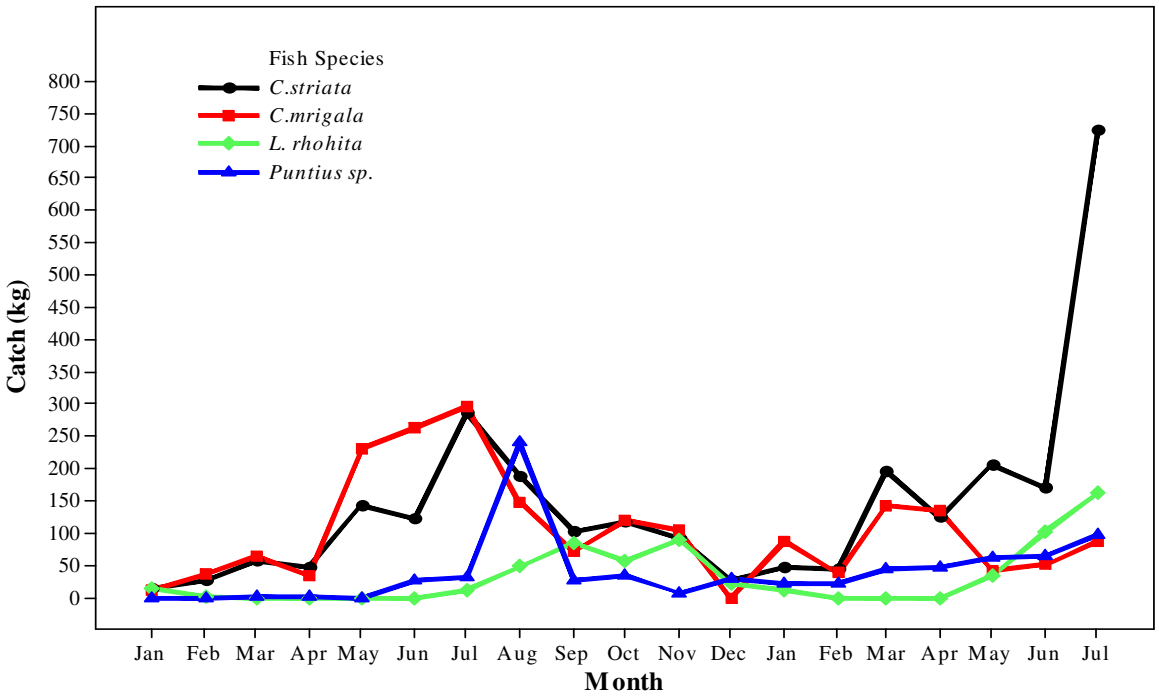

Figure-8: Seasonal fluctuations of major fish species abundance from 2013-2014.

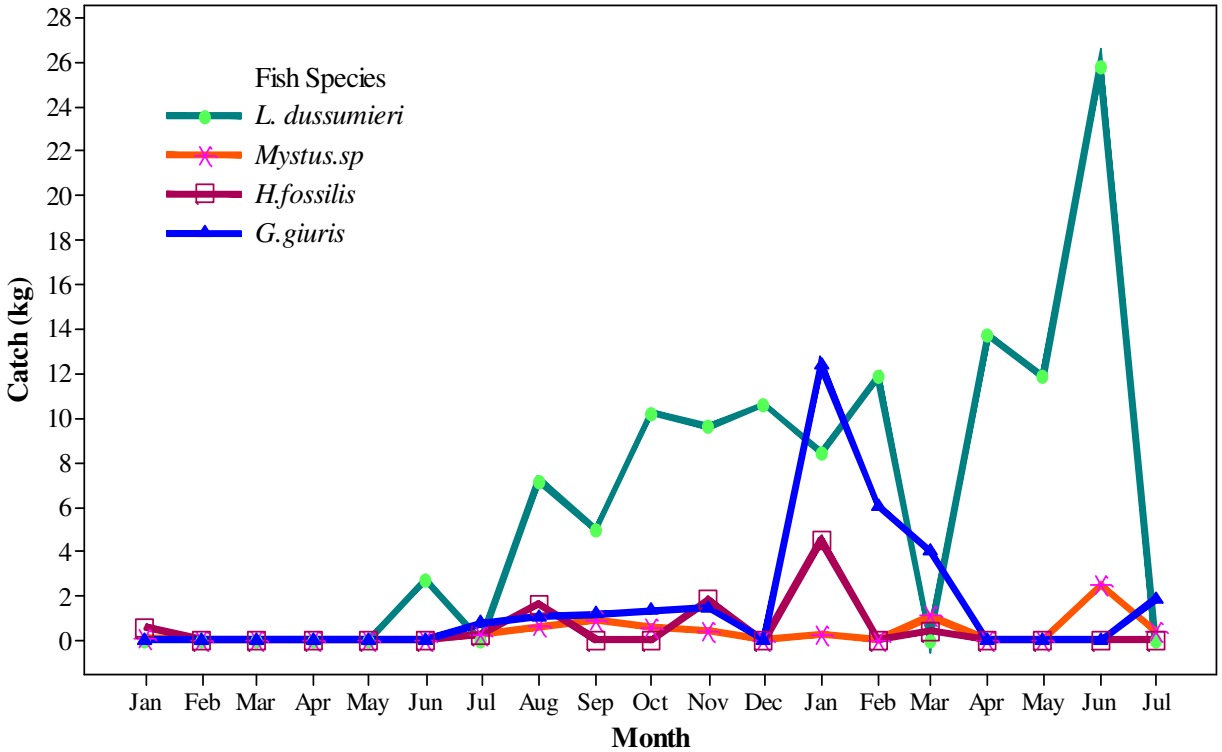

Figure-9: Seasonal fluctuations of minor fish species abundance in the catch during 2013-2014 periods.

A significantly higher abundance of indigenous species was found in July and August 2013. Peak abundance of *C. striata* was observed during July and August 2013 and March and July 2014. *P. dorsalis* showed peak abundance in August 2013 and July 2014. Similarly, highest abundance of *P. sarana* was observed in August 2013 (Figure-8). Higher catches of *L. dussumieri* was observed in October - December 2013 and June 2014 (Figure-9). During these periods higher rainfall was observed, though water level receded to medium level in Vavuniya reservoir (Table-2). *L. dussumieri* and *P. sarana*, tended to increase in catches with the rains due to migration to the rivers for reproducton, whereby they become more vulnerable to the gear[15]. Hence, seasonal rains had led to the grater abundance as reflected in the catch data of *Puntius sp.* and *L. dussumieri* (cyprinids) in Vavuniya reservoir.

Higher abundance of *M. keletius* and *H. fossilis* were observed during July - November 2013 compared to other months. However, *M. keletius in the catch was* higher in March and June and *H. fossilis* in January 2014. *G. giuris* showed higher abundance during August 2013 and January 2014. Generally, higher abundance was observed with the onset of rainfall and having a low water level.

Distribution of fish species composition and abundance were significantly different ($p<0.05$) for each month in 2013 and 2014. There were variations in the monthly catch distribution of fish species abundance due to the effect of hydro-climatic factors in Sorabora reservoir[14].

Hence, seasonal changes in the hydro-climatic factors play a significant role in fish species composition and abundance in reservoir fisheries. These findings showed that the abundance of local as well as exotic fish species mainly depended on the influences of seasonal hydro-climatic factors in different ways and specific to the reservoir.

Conclusion

Fish species composition and abundance in the lowland, dry-zone and tropical Vavuniya reservoir in Sri Lanka, fluctuated significantly with the rainfall and water level. Natural rainy season (October-January) and consequent spilling increased the fish species composition and abundance due to natural recruitment (immigration and reproduction). However, recent extreme events in seasonal rainfall patterns and drought are threatening the fish species diversity, population sizes and dynamics.

Undisturbed adjacent water bodies in the cascade system such as Thandikkkulam reservoir supplement most of the fish species to Vavuniya reservoir with spilling. Hence, there is an urgent need to study these adjacent water bodies in the cascade system, especially with respect to hydro-climatic consequences for sustainable management and conservation of the freshwater fish species diversity.

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