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Gyanendra Gautam
A) Kathmandu Model College, Kathmandu, Nepal
B) Central Department of Zoology, Tribhuvan University, Kathmandu, Nepal

Ravi Jain
School of Aeronautical, Mechanical and Manufacturing Engineering, RMIT University, Melbourne, VIC 3083, Australia

Laxmi Poudel
A) Department of Food Technology and Quality Control, Ministry of Agriculture, Kathmandu, Nepal
B) Food Science and Technology, Department of Applied Sciences, RMIT University, Melbourne, VIC 3083, Australia

Mani Shrestha
A) Faculty of Info Tech, Monash University, Melbourne, VIC 3800, Australia
B) School of Media and Communication, RMIT University, Melbourne, VIC 3001, Australia

Correspondence
Gyanendra Gautam
A) Kathmandu Model College, Kathmandu, Nepal
B) Central Department of Zoology, Tribhuvan University, Kathmandu, Nepal

Fish faunal diversity and species richness of tectonic Lake Rupa in the mid-hill of central Nepal

Gyanendra Gautam, Ravi Jain, Laxmi Poudel and Mani Shrestha

Abstract
A study of fish diversity in stagnant, but running water body is very interesting for the conservation of wetlands and protection of native species. We studied the fish fauna of tectonic Lake Rupa located in the mid-hill region of Central Nepal. We explored the fish diversity, species richness and conservation status at one of the biggest water resources of Pokhara valley enriched with fish fauna. We sampled the species using local fishers based on some informal questionnaire survey with local people and fishers. We found that 23 different species of fish from 5 orders, 6 families, and 18 genera occupy this aquatic ecosystem wherein 19 species are indigenous whereas four of them are exotic. The order Cypriniformes was dominant in terms of both species composition (69.56%) as well as individuals captured (70.76%). Also, the popular indigenous game fish *Tor putitora* contributed only 0.12% of the catch in total number of individual species sampled. To the best of our knowledge the invasive catfishes namely *Clarias batrachus* and *Clarias gariepinus* are being reported for the first time from the lake.

Keywords: Conservation, Lake Rupa, biodiversity, natural resources

1. Introduction
Fish displays the greatest biodiversity of the vertebrates with over 27,500 species including 41 percent of freshwater species [1]. Fishes occupy all aquatic habitats that have liquid water including thermal and alkaline springs, hypersaline lakes, dark caves, swamps, temporary ponds, torrential rives, coasts, high altitude and high latitudes. An estimated 41% of fish lives in fresh water and 58 % in seawater and 1% between fresh water and seawater [2]. Our study is on the fresh water fish diversity and its richness in Lake Rupa in the mid-hill region of Nepal.
Nepal is one of the world's rich countries in fresh water resources. Fresh water resources in Nepal categorized in inland fresh water resources like lakes, reservoirs, river systems, ponds, wetlands and irrigated rice fields. Nepal contains only 0.61% of total surface area of Lakes amongst these water resources [3]. Studies on aquatic fauna especially fish diversity of Nepal are very low in comparison to other fauna [4]. There has been a long-standing interest by researchers in aquatic vertebrates of Nepal since the time of Hamilton [5-10]. "Fishes of Nepal" by [11] covers a detail of 120 fishes of Nepal and thereafter many other researchers continued to explore different water systems of Nepal. Edds [12] studied the fishes of Kali Gandaki / Narayani River and Chitwan National Park reporting 111 and 107 fish species respectively. Furthermore, Shrestha [13] reported 217 indigenous fish species from Nepal. Carps, catfishes, featherbacks, eels and hill stream fishes are the main types of fishes found in Nepal.
The major threats to fish biodiversity are intense i.e. overexploitation, flow modification, destruction of habitats, siltation, invasion by exotic species, pollution including the worldwide phenomena of eutrophication and sedimentation, all of which are interacting very pertinently [14]. On the basis of Chlorophyll A and Phosphorus concentration Lake Rupa is Oligoeutrophic [15]. Polyculture fish farming practice along with four exotic carp fishes is in regular practice in this lake since 1984/1985 [16]. But, in this study we aimed to find out the fish diversity and their richness at Tectonic Lake Rupa.

2. Materials and methods
2.1 Study Area
The research was conducted on the panoramic Lake Rupa (Figure 1), which covers an area of 135ha [17] at the elevation of 600m above sea level in the mid-hill region of Central Nepal [18].

It is one of the biggest Tectonic Lake located at the mid-hill area just 10 km away from Pokhara valley, one of the crowded touristic destination in Nepal. It extends from *Dobhan Khola* the feeder stream in north to *Tal Khola* the outlet in south (28°15′ N / 84°11′ E). It falls between two big hills (Bhirchok hill Northeast and Sundari hill northwest) and extends like a shape of boat. It is one of the major water resources of this valley.

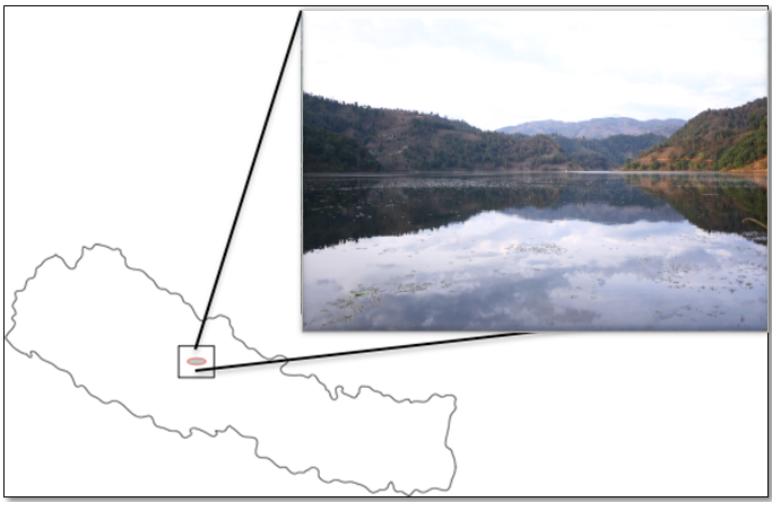

Fig 1: The geographical location of Lake Rupa in the mid-hill region of Central Nepal (28°15′ N / 84°11′ E). Color images show the shape of water body and area of the lake.

2.2 Sampling, data collections and identifications

Field visits were carried out during June to December 2002, five continuous days in each month. Three sites selected for sampling fish diversity: a. Site I: inlet area of the lake; b. Site II: Middle part of the lake; and c. Site III: South parts of the lake near the outlet area. We used traditional and locally available fishing gears like cast nets, gill nets, hook lines and fish traps for fish sampling (mesh size for gill nets 35-135mm and cast nets 25-35 mm). Sampling spot was maintained within each study site to ensure and maximize the collection of fish species. Cast nets, Hook lines, and Fish traps were placed during afternoon hours whereas the Gill nets were left installed overnight and observed next morning. The morphometric measurements of all fish species captured were taken in situ. The unidentified fish samples were preserved in 4-8% formaldehyde and brought to the laboratory of FRC, Pokhara for proper identification (Figure 2). The collected fish samples were identified using the standard references [19-22] and deposited at Central Department of Zoology, Tribhvuan University, Kathmandu, Nepal. Moreover, informal surveys around lake catchment areas were conducted during every field visit. Interviews with the local people and professional fishermen living around the Lake Rupa were also made.

2.3 Data Analysis and biodiversity parameters

The total species distribution based on the total catch of fish during seven months study period was calculated whereas diversity, richness and evenness indices were calculated based on each month total catch and each parameter estimation followed details in [23-24].

Shannon-Weaver diversity index

$H = -\Sigma pi \ln pi$

Margalef's richness index

$D = s-1/ \ln N$

Evenness index

$e = H / \ln S$

Where, H= diversity index
Pi = relative abundance (s/N)
s = the number of individual for each species
N = the total number of individuals
D = the richness index
S = the total number of species
E = the similarity or evenness index
Ln = natural logarithm

3. Results

3.1 Composition of fish fauna and Status

A total of 23 species of fishes belonging to 5 orders, 6 families and 18 genera were recorded during the period of present investigation (Table 1, see figure 2). Among them, 19 species were indigenous and other four species were exotic. The exotic species were *Cyprinus carpio*, *Ctenopharyngodon idella*, *Hypophthalmitrix molitrix* and *Aristichthys nobilis*. Cypriniformes was the dominant order comprising 69.56% of all the number of species recorded. Siluriformes and Perciformes were the second and third dominant orders contributing 13.04% and 8.69% respectively on the same basis (Figure 3). Similarly, order Cypriniformes was also dominant in terms of number of fish individuals caught by comprising 70.76% of the total catch (Figure 4). Furthermore, Cyprinidae was the most dominant family comprising 67.76% of total number of fishes caught. Channidae and Belonidae were contributing by nearly equal number of fishes by 12.67% and 12.18% of total catch respectively (Figure 5). The highest catch of 19 fish species was recorded in October whereas the lowest of catch was recorded in August by only13 species (Table 2). On the basis of number of individuals captured, the most dominant species was *Puntius sophore* that contributed by 25.47% of total no. of fish catch. Other two major fishes with high catch frequency were *Barilius barna* (15.79%) and *Xenentodon cancila* (6.18%) (Table1).
Among all fishes recorded, 17 species are found under Least Concerned (LC) category of IUCN red list. Similarly, *Tor putitora*, *Cyprinus carpio* and *Aristichthys nobilis* are reported as Endangered (E), Vulnerable (V), and Data Deficient (DD) fish species respectively. On the same basis, *Neolissocheilus hexagonolepis*, *Hypophthalmitrix molitrix* and *Ctenopharungodon idella* are reported as Not Threatened (NT) species (Table 1). However the local record is little different than IUCN status (see detail in table 1).

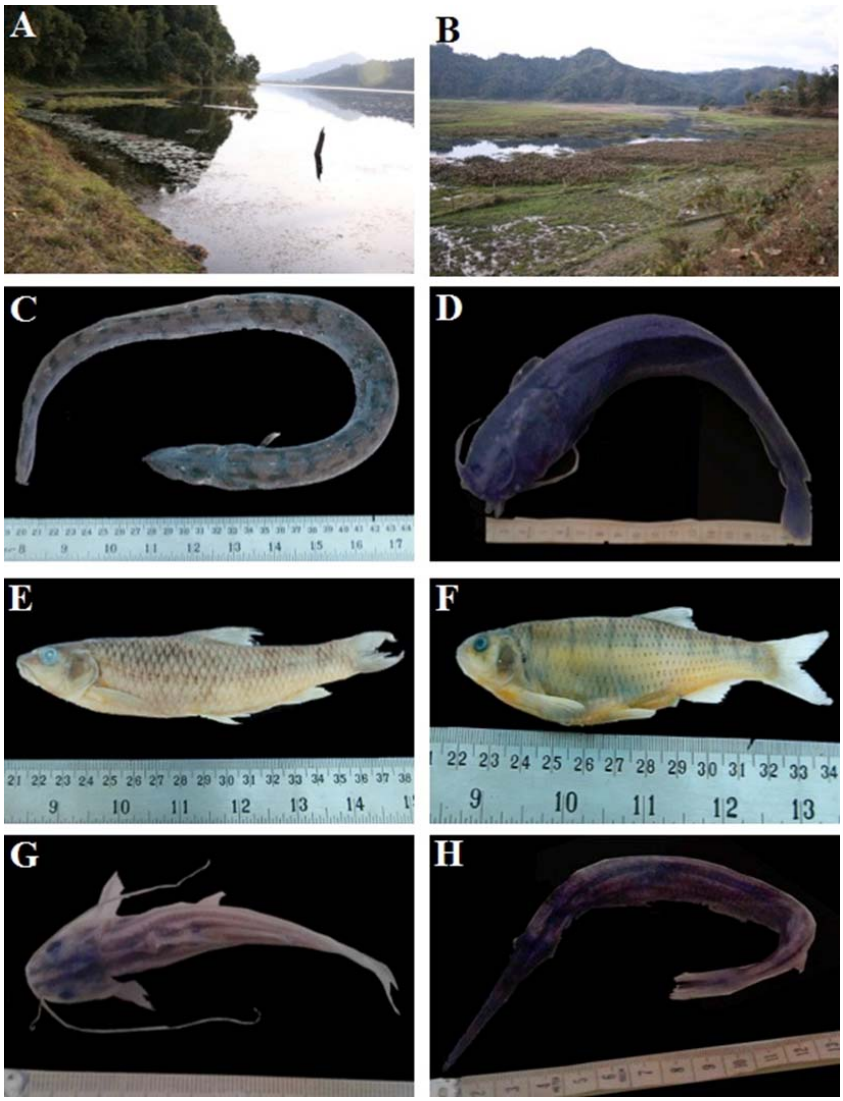

Fig 2: Fish habitat and different fish species found in Lake Rupa: A: Lake Rupa, B: Outlet of the Lake and encroachment area, C: *Mastacembelus armatus,* D: *Clarias batrachus,* E: *Neolissochilus hexagonolepis*, F: *Barilius barna*, G: *Mystus bleekeri,* H: *Xenentodon cancila.*

Table 1: Fish diversity of Lake Rupa with catch percentage (by number) and status in Nepal. Local Status are based on catch percentage of fish species and informal questionnaire survey; VC: Very Common, C: Common, R: Rare whereas IUCN status are based on the data available at fish database (#www.fishbase.org), LC= least common, DD= data deficit, NT= Not threatened, VU: Vulnerable, EN=Endangered. * = Exotic game fish, ** = Exotic invasive species.

Order	Family	Name of species	Local Name	Total no. of Catch (%)	Local Status	IUCN Status#
Beloniformes	Belonidae	*Xenentodon canaila*	Dhunge Bam	6.18	VC	LC
Cypriniformes	Cyprinidae	*Aristichthys nobilis**	Big Head Carp	1.69	C	DD
		Catla catla	Bhakur	2.65	C	LC
		Chagunius chagunio	Rewa	0.42	R	LC
		Cirrhinus mrigala	Naini	0.79	R	LC
		*Ctenopharyngodon idella**	Grass Carp	1.78	C	NT
		*Cyprinus carpio**	Common Carp	2.39	C	VU
		Labeo boga	Rahu	1.23	C	LC
		Labeo rohita	Rahu	4.69	VC	LC
		Neolissocheilus hexagonolepis	Katle	2.09	VC	NT
		Puntius sophore	Bhitte	25.47	C	LC
		Puntius conchonius	Bhitte	4.28	C	LC
		Tor putitora	Sahar	0.12	R	**EN**
		*Hypothalamichthys molitrix**	Silver Carp	2.39	C	NT

		Barilius barna	Bagh Faketa	15.79	VC	LC
		Barilius bendelisis	Chiple Faketa	3.09	C	LC
		Danio devario	Sera	1.80	R	LC
Perciformes	Channidae	*Channa punctats*	Bhoti	2.19	C	LC
		Channa gachua	Bhoti	10.48	VC	LC
Siluriformes	Bagridae	*Mystus bleekeri*	Junge	6.00	VC	LC
	Claridae	*Clarias batrachus***	Magur	1.69	R	LC
		*Clarias gariepinus***	Magur	0.21	R	LC
Synbranchiformes	Mastacembelidae	*Mastacembelus armatus*	Bam	2.49	C	LC

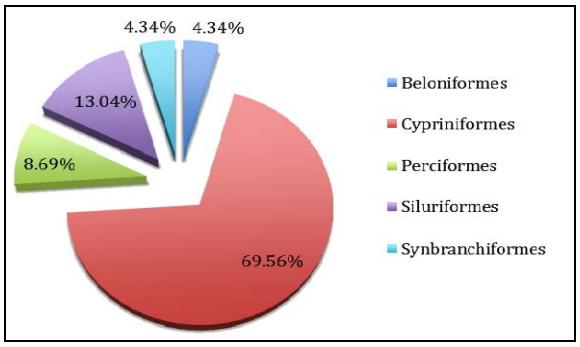

Fig 3: Total Fish species diversity based on total catch % at order level. [The highest is the order Cypriniformes and lowest are Beloniformes and Synbranchiformes.

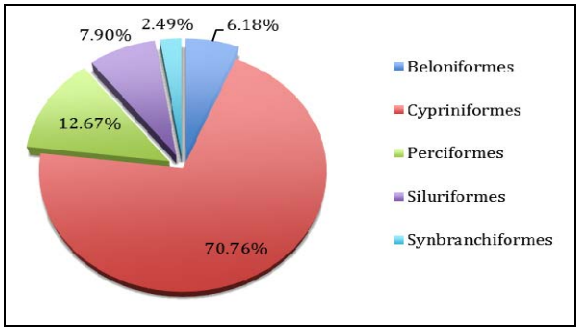

Fig 4: Total number of Fish species caught based on total catch % at order level. [The highest caught was in the order Cypriniformes and lowest was on Synbranchiformes.

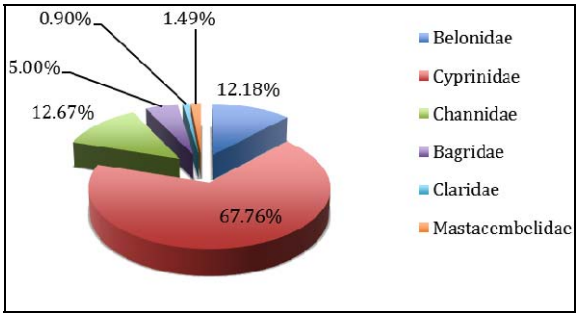

Fig 5: Total percentage (%) of Fish species representation at Family level. [The highest number caught belongs to family Cyprinidae (67.76%) and lowest for family Mastacembelidae (1.49%)]

3.2 Diversity, richness and evenness indices

Each month values of Shannon-Weaver diversity (H), Margalef's richness (D) and Pielou's evenness indices (e) collectively for all study sites of the lake were presented in Table 2. The values of H, D and e were recorded as 2.21, 2.88 and 0.79 respectively. Also, diversity index value ranged between 2.01 to 2.43, richness index ranked within 2.15 to 2.81. Similarly, the evenness index was calculated from 0.72 to 0.85.

Table 2: Fish diversity, richness and evenness indices of Lake Rupa.

Month	No. of Species	No. of individual	Diversity (H)	Richness (D)	Evenness (e)
June	16	224	2.01	2.77	0.72
July	14	241	2.22	2.37	0.84
August	13	261	2.05	2.15	0.79
September	16	76	2.43	3.69	0.85
October	19	143	2.27	3.62	0.77
November	17	205	2.17	2.81	0.78
December	18	466	2.36	2.76	0.81

4. Discussion

The present study revealed a total of 23 fish species including 19 indigenous and 4 exotic species from Lake Rupa. Some earlier researches had reported 22 and 20 species of fish from this lake [25-26]. However this study recorded two invasive species of catfish i.e. *C. batrachus* and *C. gariepinus*. According to local fishermen, this genus might have been introduced along with carp fingerlings during open water polyculture practices in 2000 at this lake. We found that Cypriniformes is the most dominant order holding maximum number of species and contributing maximum catch in percentage in comparison to other four orders. Pokharel [26] also reported similar findings. Our study reveals the richness of hardy species like *Puntius* sp. (29.75%), *Channa* sp. (2.67%) and *Xenentodon* sp. (6.18%) in terms of total number of catches. Such proliferation of hardy fishes, intervention of invasive and carnivorous species (*Clarias* sp.) might be the cause in reduction in catch of indigenous species like *Tor putitora* (0.12%), *Chagunius chagunio* (0.42%) and *Cirrhinus mrigala* (0.79%) in comparision with the findings of [26]. Moreover, *Tor tor* reported by Pokharel [26] was not observed during our study period.

Indices for both diversity and richness of fish species were calculated higher during September to December. Also, maximum number of fishes i.e. a total of 466 individuals were captured in December. Such higher capture of fish species as well as individuals during winter season may be due the less depth of water, minimal rainfall and long night period that allowed fishermen for efficient setting up of the gill-nets. Moreover, professional fishermen had suggested that the cast-net strokes also become more effective in clear water during winter in this lake. Similarly, there was active relationship between season (wet and dry) and depth of Opi Lake where collection of both fish hosts and their annelid parasites were higher when the rains had reduced and the aquatic habitat had contracted [28].

Fish samples are under high pressure of fishing in the areas with less or no covered of Water hyacinth. This is because the breeding seasons of the fish are very extensive as such regulations of the Water-hyacinth to protect breeding fish do not seem feasible. The convincing suggestions is to demarcate the protected area for the fishes and the water birds in some portions of the Lake while allowing the open portions for fishing, boating and other purposes. The Water-

hyacinth from these open use areas should be removed regularly and Water hyacinth in the protected areas of the lakes should be kept untouched in natural condition for the healthy and natural aquatic bio-diversity purpose [29].

5. Conclusion

The result shows that the introduced game fishes in the Lake affected native fish diversity. The major threats for native species like *Tor putitora, Chagunius chagunio* and *Cirrhinus mrigala* were identified. Cowx [27] indicated that anthropogenic disturbance and ignorance are the most important factor for decline and extinction of fish worldwide. Besides the sampling on fish diversity, our regular and informal survey with the local people and professional fishermen revealed that annual siltation into the lake from inlet stream, eutrophication due to rice-fields towards northern and southern boundaries of water body, human encroachment, seasonal macrophytic coverage and intervention of exotic as well as invasive species were observed as the major threats for local fish species. To overcome this situation, a long term fish habitat restoration program as well as indigenous species conservation practices should be implemented by the concerned authorities like Fisheries Research Center (FRC), Pokhara in co-ordination with local fishery communities in that watershed area.

6. Acknowledgment

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