

Comparison of Fish Species Diversity and Abundance Between Protected and Unprotected Areas in the Ing River (Mekong Basin), Thailand: Implications for Collaborative Community-Based Conservation

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Abstract

This research aims to compare the fish species diversity and abundance between established community-based conservation areas (protected zones) and non-protected areas within the Ing River Basin, Thailand. Furthermore, the study seeks to identify appropriate approaches for the collaborative and sustainable management of fish conservation zones by local communities. The study area was divided into four sampling sites along the river: Upper Ing River, Middle Ing River, Lower Ing River, and Confluence with the Mekong River. Fish samples were collected using a multi-mesh gill net array to ensure a comprehensive representation of the fish community.

Fish samples were collected six times between September 2023 to July 2024 including effect of seasonal and lunar phases. 58 fish species belonging to 22 species were found, with the Cyprinidae as the majority group, comprising 25 species, or 43.10%. The effect of protected and unprotected areas was significantly different in riverine sampling sites (Middle Ing River- Confluence with Mekong) and reservoir sampling site (Upper Ing River). The dominant species for each sampling sites were *Parambassis siamensis* for upper Ing river, *Barbonymus schwanefeldii* for middle Ing river, *Thynnichthys thynnoides* for lower Ing River and *Mystacoleucus obtusirostris* for confluence of Mekong river.

The findings will provide essential baseline data of regional ecology and propose practical strategies for enhancing the effectiveness of community-managed fish sanctuaries

Keywords

Diversity and Abundant, Community-based fish sanctuaries, Ing River

Introduction

Wang Sa-nguan, a fish conservation zone, represents an ingenious indigenous wisdom for managing water resources within local communities. This wisdom is a blend of several fields of knowledge, including ecology, sociology, cultural anthropology, and economics which combine to create a management practice that aligns with the specific conditions of the Ing River's cultural ecosystem.

The clear success of one village, which saw a significant increase in its fish population, led to the establishment of these conservation zones spreading to other communities. Recently, there are no less than 62 Wang Sa-nguan across various villages along the entire Ing River Basin.

The Ing River is a tributary of the Mekong River. It originates in the Phi Pan Nam Mountain Range, or Doi Luang, in Phayao Province. It flows through several districts of Phayao, including Mae Chai, Mueang, Dok Khamtai, Phu Kam Yao, Chun, and Chiang Kham, before continuing into Chiang Rai Province through Pa Daet, Thoeng, Phaya Mengrai, and Khun Tan. The river finally merges with the Mekong River at Ban Pak Ing in Chiang Khong District, Chiang Rai. The total length of the river is 260 kilometers, and its entire basin covers an area of 7,388 square kilometers, spanning both Phayao and Chiang Rai provinces.

The establishment of the fish conservation zones in the Ing River Basin was a direct result of recognizing the decline in the river's fish population. This decline was caused by overfishing which exceeded the recovery ability of resources, environmental changes and infrastructure development that negatively impacted the ecosystem, and water quality issues.

The primary objective of zoning creation is to restore and maintain the biodiversity of the fish population in the area. These zones act as a sanctuary for local, ecologically important fish species. They also serve to reconnect the ecosystems of the Ing River and the Mekong River. Other benefits include promoting food security and creating sustainable income from local fishing.

In addition, the Ing River conservation zones are regarded as a model for community-based resource management leading to the formation of a network of cooperation between communities and the joint development of regulatory rules. The network operations include the conservation of fish species at risk of extinction, the protection of spawning and nursery grounds, and the restoration of degraded ecosystems. These actions are very important for ensuring sustainable resource use.

Materials and Methods

Study Area

Eight sampling stations were established in the Ing River basin including as following: **Station SI1**, inside the fish conservation area, 47Q, x: 593926 y: 2120092; **Station SO1**, outside the fish conservation area, 47Q, x: 593126 y: 2119493 (located approximately 1 km from the survey point inside the conservation area); **Station SI2**, inside the fish conservation area, 47Q, x:609599 y:2150303;**Station SO2**, outside the fish conservation area, 47Q, x:610121 y:2149900 (located approximately 1 km from the survey point inside the conservation area); **Station SI3**, inside fish conservation area, 47Q, x: 629516 y: 2199157; **Station SO3**, outside the fish conservation area, 47Q, x: 630309 y: 2199536 (located approximately 1 km from the survey point inside the conservation area); **Station SI4**, inside conservation area, 47Q, x: 651519 y: 2234884; and **Station SO4**, outside the fish conservation area, 47Q, x: 650656 y: 2234581 (located approximately 1 km from the survey point inside the conservation area).

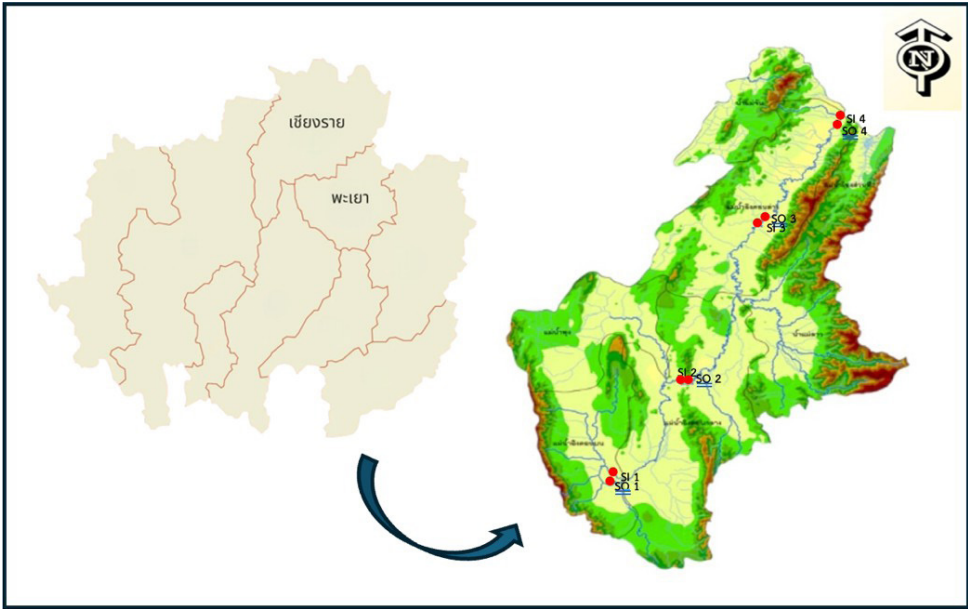


Figure 1 Map showing fish sampling stations in the Ing River.

Survey Period

The survey and data collection were conducted every month from September 2023 to July 2024. Fish samples were collected during both the waxing moon and waning moon phases, specifically on the 14th day of the waning moon (new moon) and the 15th day of the waxing moon (full moon) (Table 1). Fishing nets were set for one night from 06.00 PM to 06:00 AM in both protected and unprotected areas, approximately 1 kilometer in length. Fish samples were collected in the following morning. For net fishing, local fishers set the nets along the watercourse, and during data collection, the catch was retrieved and sorted according to mesh size. The aquatic animals were then identified by species, recorded, and photographed. For measurement of length, each specimen was placed on a white board with the head positioned to the left, with the body arranged horizontally. A label indicating the type of net and mesh size was included, along with a ruler with 0.1-cm precision. Photographs were taken, and fish weights were measured using a scale with 0.1-gram precision. (Table 1)

Table 1 Details of sampling dates during the study period

Date	Month	Lunar phase	Quarter	FCZ
14	Sep-23	Waning moon	New Moon	Inside, Outside
29	Sep-23	Waxing moon	Full Moon	Inside, Outside
12	Nov-23	Waning moon	New Moon	Inside, Outside
27	Nov-23	Waxing moon	Full Moon	Inside, Outside
10	Jan-24	Waning moon	New Moon	Inside, Outside
25	Jan-24	Waxing moon	Full Moon	Inside, Outside
9	Mar-24	Waning moon	New Moon	Inside, Outside
24	Mar-24	Waxing moon	Full Moon	Inside, Outside
7	May-24	Waning moon	New Moon	Inside, Outside
22	May-24	Waxing moon	Full Moon	Inside, Outside
5	Jul-24	Waning moon	New Moon	Inside, Outside
20	Jul-24	Waxing moon	Full Moon	Inside, Outside

Data analysis

The collected data included the number, weight, and length of fish sampled across the survey areas and seasons in the Ing River Basin. Catch data obtained from gill net sampling were standardized to enable comparison by expressing catch per unit effort (CPUE) based on net area and soaking time. Weight was standardized as grams per 100 square meters of net area per night, and abundance as individuals per 100 square meters of net area per night. The standardized data were then analyzed using the following indicators and indices. The collected data included the number, weight, and length of fish sampled across the survey areas and seasons in the Ing River Basin. Catch data obtained from gill net sampling were standardized to enable comparison by expressing catch per unit effort (CPUE) based on net area and soaking time. Weight was standardized as grams per 100 square meters of net area per night, and abundance as individuals per 100 square meters of net area per night. The standardized data were then analyzed using the following indicators and indices

1) Relative abundance of fishing nets This index aims to determine the abundance of aquatic animals in terms of catch per unit of effort (CUE), measured in grams per 100 square meters of net area per night. The calculation is based on Swingle's (1950) formula as follows

$$\begin{aligned} \text{Catch per unit effort (CPUE) of} &= \frac{\text{Total weight of sampled fish (grams) Net}}{\text{the gill-net gear set}} \times \text{Fishing duration (nights)} \\ & \text{(grams/100 m}^2 \text{ of net area/night)} \quad \text{area (100 square meter)} \end{aligned}$$

The mean catch-up effort (CPUE) of the network equipment was analyzed for spatial and time- based variance. The differences in means were then compared using Tukey's method at a 95 percent confidence level.

Preliminary statistical analysis

The samples collected from aquatic animal specimens were subjected to taxonomy up to the species and family level. The number of each species was counted, and the species were classified according to aquatic animal identification manuals. The data was recorded in Microsoft Excel.

percentage species composition This value represents the survival efficiency of various fish populations in a body of water. It is usually calculated in two ways: by fish species composition based on abundance (number; %N) and by fish species composition based on biomass (weight; %W), expressed as a percentage. (Kolding, 1989) The calculation uses the formula

$$\text{Components of abundance (\%N)} = \frac{\text{Number of individuals of fish species observed}}{\text{Total number of fish individuals observed}} \times 100$$

$$\text{Biomass composition (\%W)} = \frac{\text{Weight of each fish species observed}}{\text{Total weight of all fish species observed}} \times 100$$

2) Frequency of sightings of fish species The value indicates the frequency or probability of encountering each fish species during the study period, showing the spatial and temporal distribution of fish species, expressed as a percentage (Kolding, 1989) and calculated by using the formula.

$$\text{Probability of encountering fish species (\%F)} = \frac{\text{Number of occurrences of aquatic}}{\text{Total number of sampling events}} \times 100$$

3) Index of relative importance, IRI The value indicates the relative importance level of aquatic animal species based on the total number of individuals found, the total weight found, and the frequency of each species found in each randomly selected sample. It is calculated using the formula of Caddy and Sharp (1986), which is as follows:

$$\begin{aligned} \text{IRI} &= (\%N + \%W) \times \%F \\ \text{by IRI} &= \text{Relative Importance Index} \\ \%N &= \text{Percentage of each fish species} \\ \%W &= \text{Percentage by weight of each fish species} \\ \%F &= \text{Percentage frequency of each fish species} \end{aligned}$$

Results and discussion

Geography and ecology of the survey stations

The Ing River Basin is a tributary of the Mekong River. The main river has headwaters which originates from Doi Luang or the Phi Pan Nam Range, fed by 12 branched streams. It flows through both small and large lowland plains that are home to communities and agricultural areas. In Phayao Province, the basin covers Mae Chai, Mueang Phayao, Dok Khamtai, Phu Kamyao, Chun, and Chiang Kham Districts. whereas in Chiang Rai Province, it covers Pa Daet, Phan, Phaya Mengrai, Thoeng, and Khun Tan Districts. The river ultimately flows into the Mekong River at Ban Pak Ing, Si Don Chai Subdistrict, Chiang Khong District, Chiang Rai Province. The total length of the river is approximately 260 kilometers. The Ing River Basin covers an area of 7,388 square kilometers and spans two provinces in Upper northern Thailand: Phayao and Chiang Rai (**Figure 1**)



Figure 2. Ecology of four sampling sites in the Ing River.

Survey Station 1 San Klaep Dam Community (Upper Ing River Basin). The upper Ing River Basin is characterized as a headwater area and an important watershed forest for Kwan Phayao. The station is located approximately 30.55 kilometers from Nong Leng Sai, at an elevation of 390 meters above sea level. This site is where 12 tributaries of the Ing River converge at Kwan Phayao. The water level is relatively deep, and most of the river section consists of deep pools. The riverbed is composed of rocks and soil. There are riparian areas where support as aquatic vegetation such as duckweed, water hyacinth, and various plant species. The surrounding landscape consists of agricultural fields interspersed with residential areas along both banks of the Ing River (Figure 2).

Survey Station 2 Wang Sila Community (Middle Ing River Basin). The middle section of the Ing River has an average width of approximately 20–25 meters and is deeper than the upper section. The station is located about 84 kilometers downstream from Survey Station 1, at an elevation of 378 meters above sea level. This site is where the Phung River, a tributary of the Ing River, joins the main river. The water level is relatively deep, and the river channel is sinuous and wide, featuring alternating shallow riffles and deep pools. Aquatic plants and riparian vegetation are widely distributed along the riverbanks. The riverbed is mainly composed of gravel and sand, and the current is relatively strong. The surrounding landscape consists of agricultural fields interspersed with residential areas along both banks of the Ing River (Figure 2).

Survey Station 3 Pa Kha Community (Lower Ing River Basin). The lower Ing River Basin has a river width of approximately 150–200 meters. This station is located about 122.73 kilometers downstream from Survey Station 2, at an elevation of 353 meters above sea level. This section is deeper than the upper and middle reaches, resulting in a larger water volume. The river channel is relatively wide and sinuous, with a fairly deep water level and a relatively strong current. The riverbed is mainly composed of gravel and sand. The surrounding landscape consists of wetland forests (Som Saeng swamp forest), agricultural fields, and residential areas interspersed along both banks of the Ing River (Figure 2).

Survey Station 4 Pak Ing Community (Lower Ing River Basin). The lower Ing River Basin has a river width of approximately 150–200 meters. This station is located about 84.57 kilometers downstream from Survey Station 3, at an elevation of 345 meters above sea level. This section is deeper than the upper and middle reaches, resulting in a large water volume, particularly during the flood season when it is influenced by the Mekong River. During this period, fish from the Mekong River migrate upstream to spawn in the area. The physical characteristics of the downstream section include a meandering channel that forms numerous deep pools and oxbow-like wetlands, contributing to greater fish species diversity and abundance compared to the upper and middle reaches. In addition, several important tributaries—such as Nam Rong Chae, Nam Loi, Nam Lao, and Nam Mae Tak—serve as key areas for subsistence of local fisheries. The main livelihoods of local communities include agriculture, livestock raising, and fishing. The Ing River ultimately converges with the Mekong River at Ban Pak Ing (Figure 2).

Fish biodiversity

The results of the study revealed a total of 58 fish species belonging to 22 families, with 9,113 individuals recorded. The family Cyprinidae was mostly diverse, comprising 25 species, accounting for 43.10% of all recorded species. The family was followed by the family Xenocyprididae with 4 species (6.89%), and the family Danionidae with 3 species (5.17%). The families Notopteridae, Siluridae, Bagridae, Mastacembelidae, Osphronemidae, Channidae, and Cichlidae were each represented by 2 species, accounting for 3.44% per family of the total species recorded. The remaining 12 families (e.g., Clupeidae, Botiidae, Cobitidae, Sisoridae, Clariidae, Ailiidae, Loricariidae, Eleotridae, Anabantidae, Pristolepididae, Ambassidae, and Belonidae) were each represented by a single species, accounting for 1.72% of the total species recorded. When fish species diversity classified by survey station, Station 3 recorded the highest species richness with 41 species from 17 families, followed by Station 4 with 39 species from 18 families, Station 2 with 33 species from 14 families, and Station 1 with 27 species from 14 families (**Table 2**) (**Figure 3**)

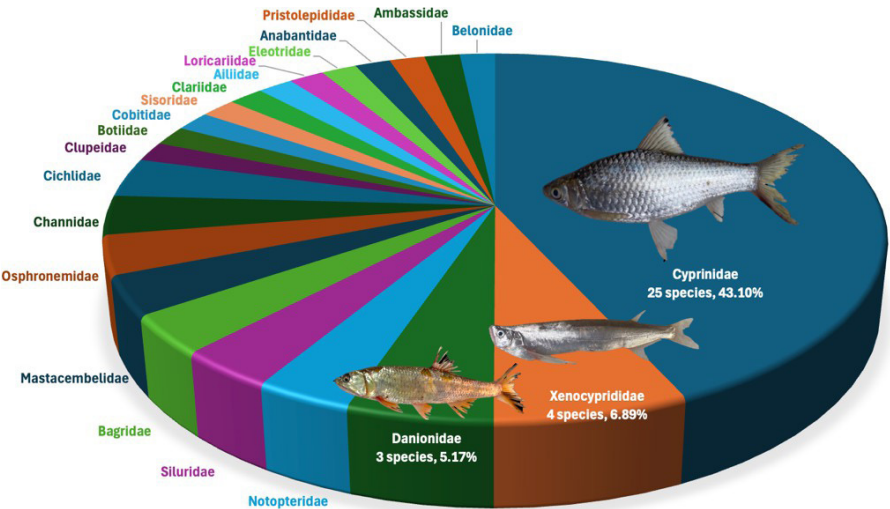


Figure 3. Composition of the fish families collected from 4 sampling sites in Ing River

Table 2. Fish species composition based on gill net sampling (Opportunity to encounter).

Species name	Waxing moon				Waning moon				%F
	FCZ (INSIDE)		FCZ (OUTSIDE)		FCZ (INSIDE)		FCZ (OUTSIDE)		
	%N	%W	%N	%W	%N	%W	%N	%W	
<i>Chitala ornata</i>	0.04	0.15	-	-	-	-	0.06	0.73	12.50
<i>Notopterus notopterus</i>	0.12	0.46	0.28	1.77	0.17	1.44	0.19	1.89	58.33
<i>Tenuulosa thibaudeaui</i>	-	-	-	-	-	-	0.06	0.37	4.17
<i>Syncrossus helodes</i>	0.04	0.03	0.14	0.25	0.03	0.09	0.12	0.35	20.83
<i>Acantopsis dialuzona</i>	-	-	0.48	0.36	-	-	0.19	0.21	20.83
<i>Barbichthys laevis</i>	0.04	1.19	-	-	0.06	0.19	-	-	12.50
<i>Barbonymus gonionotus</i>	11.61	12.06	20.17	29.81	4.24	15.33	6.18	10.92	95.83
<i>Barbonymus schwanenfeldi</i>	2.27	13.10	2.07	9.25	0.35	2.58	1.19	1.49	79.17
<i>Cirrhinus cirrhosus</i>	0.46	1.83	-	-	-	-	-	-	4.17
<i>Cosmochilus harmandi</i>	0.08	0.27	-	-	-	-	-	-	4.17
<i>Cyclocheilichthys repasson</i>	4.69	1.54	2.28	1.58	4.09	2.01	6.49	4.41	95.83
<i>Cyprinus carpio</i>	0.04	0.95	-	-	0.17	-	0.06	2.67	8.33
<i>Hampala macrolepidota</i>	0.04	0.04	0.76	3.45	0.03	0.40	0.50	0.55	20.83
<i>Hampala dispar</i>	-	-	-	-	-	-	0.06	0.02	25
<i>Henicorhynchus siamensis</i>	1.81	3.77	2.07	2.28	1.85	7.11	4.87	16.75	95.83
<i>Labeo chrysophekadion</i>	0.23	4.46	-	-	0.03	0.60	0.06	0.04	25
<i>Labeo rohita</i>	0.12	3.66	0.21	0.03	-	-	-	-	8.33

Table 2. (continued).

Species name	Waxing moon				Waning moon				%F
	FCZ (INSIDE)		FCZ (OUTSIDE)		FCZ (INSIDE)		FCZ (OUTSIDE)		
	%N	%W	%N	%W	%N	%W	%N	%W	
<i>Labiobarbus leptocheilus</i>	2.42	3.17	3.18	4.05	5.82	11.37	4.49	8.77	87.50
<i>Mystacoleucus atridorsalis</i>	-	-	-	-	-	-	0.62	0.71	4.17
<i>Mystacoleucus marginatus</i>	3.42	1.47	17.20	4.24	7.96	5.68	13.55	7.65	91.67
<i>Osteochilus microcephalus</i>	-	-	-	-	-	-	0.12	0.23	4.17
<i>Osteochilus vittatus</i>	0.12	0.07	0.07	0.08	0.12	0.34	0.31	0.36	33.33
<i>Probarbus jullieni</i>	0.04	0.26	-	-	-	-	-	-	4.17
<i>Puntioplites proctozysron</i>	2.85	6.53	3.11	6.29	0.78	2.22	4.31	2.85	91.67
<i>Thynnichthys thynnoides</i>	3.65	0.80	0.55	0.13	5.31	1.73	1.25	0.33	37.50
<i>Systemus rubripinnis</i>	1.77	0.51	0.14	0.03	0.61	0.58	-	-	33.33
<i>Thynnichthys thynnoides</i>	6.92	22.47	1.80	2.51	5.62	29.12	2.50	10.67	91.67
<i>Barbonymus altus</i>	0.27	0.28	0.14	0.60	0.14	0.47	0.31	0.37	33.33
<i>Leptobarbus hoevenii</i>	-	-	-	-	0.06	0.39	-	-	8.33
<i>Crossocheilus reticulatus</i>	-	-	-	-	0.03	0.03	-	-	4.17
<i>Luciosoma bleekeri</i>	0.15	0.20	0.55	0.66	0.06	0.09	0.12	0.29	41.67
<i>Raiamas guttatus</i>	-	-	0.07	0.34	-	-	-	-	4.17
<i>Rasbora tornieri</i>	11.69	4.02	4.63	1.61	4.15	2.13	12.30	5.38	79.17
<i>Macrochirichthys macrochir</i>	0.12	0.33	-	-	-	-	0.06	0.04	12.50
<i>Parachela siamensis</i>	0.23	0.06	-	-	-	-	-	-	4.17
<i>Parachela williaminae</i>	1.35	0.21	2.97	0.71	0.55	0.20	8.68	3.27	58.33
<i>Paralabuca typus</i>	3.08	3.21	0.07	0.06	0.78	1.68	0.31	0.36	45.83
<i>Pimelodus bagarius</i>	-	-	-	-	0.06	0.02	-	-	4.17
<i>Kryptopterus geminus</i>	1.61	0.59	4.07	4.15	0.32	0.28	9.36	5.57	87.50
<i>Hemisilurus mekongensi</i>	0.04	0.23	-	-	-	-	-	-	4.17
<i>Clarias batrachus</i>	0.08	1.01	0.14	0.22	-	-	-	-	16.67
<i>Pseudolais pleurotaenia</i>	0.35	1.87	1.31	0.77	0.23	0.39	0.12	0.29	41.67
<i>Hemibagrus nemurus</i>	0.23	1.30	1.31	2.35	0.12	1.00	0.19	1.48	50
<i>Mystus singaringan</i>	-	-	0.48	0.51	0.03	0.09	0.12	0.08	25
<i>Hypostomus plecostomus</i>	0.04	0.25	0.14	2.21	0.06	0.81	0.06	0.50	20.83
<i>Oxyeleotris marmorata</i>	0.31	1.42	1.45	5.12	0.14	0.93	0.12	0.28	50
<i>Macrognathus siamensis</i>	-	-	0.07	0.03	-	-	-	-	4.17
<i>Mastacembelus armatus</i>	0.08	0.03	-	-	0.03	0.40	0.06	0.04	16.67
<i>Anabas testudineus</i>	0.04	0.07	0.07	0.10	-	-	0.06	0.07	12.50
<i>Trichopodus microlepis</i>	0.23	0.10	0.21	0.19	0.06	0.08	-	-	20.83
<i>Trichopodus trichopterus</i>	0.04	0.01	0.35	0.63	0.14	0.11	0.06	0.03	25

Table 2. (continued).

Species name	Waxing moon				Waning moon				%F
	FCZ (INSIDE)		FCZ (OUTSIDE)		FCZ (INSIDE)		FCZ (OUTSIDE)		
	%N	%W	%N	%W	%N	%W	%N	%W	
<i>Pristolepis fasciatus</i>	0.23	0.30	0.55	0.95	0.26	1.37	0.81	1.02	54.17
<i>Channa striata</i>	0.08	0.19	0.07	0.29	-	-	0.06	0.09	16.67
<i>Channa micropeltes</i>	-	-	-	-	-	-	0.56	0.24	4.17
<i>Parambassis siamensis</i>	35.49	3.96	24.03	4.92	55.16	8.29	18.23	6.72	91.67
<i>Coptodon rendalli</i>	-	-	-	-	0.03	0.11	-	-	4.17
<i>Oreochromis niloticus</i>	1.54	1.52	2.56	7.21	0.20	0.16	0.37	0.89	45.83
<i>Xenentodon canceloides</i>	-	-	0.28	0.27	0.17	0.17	0.81	1.01	37.50

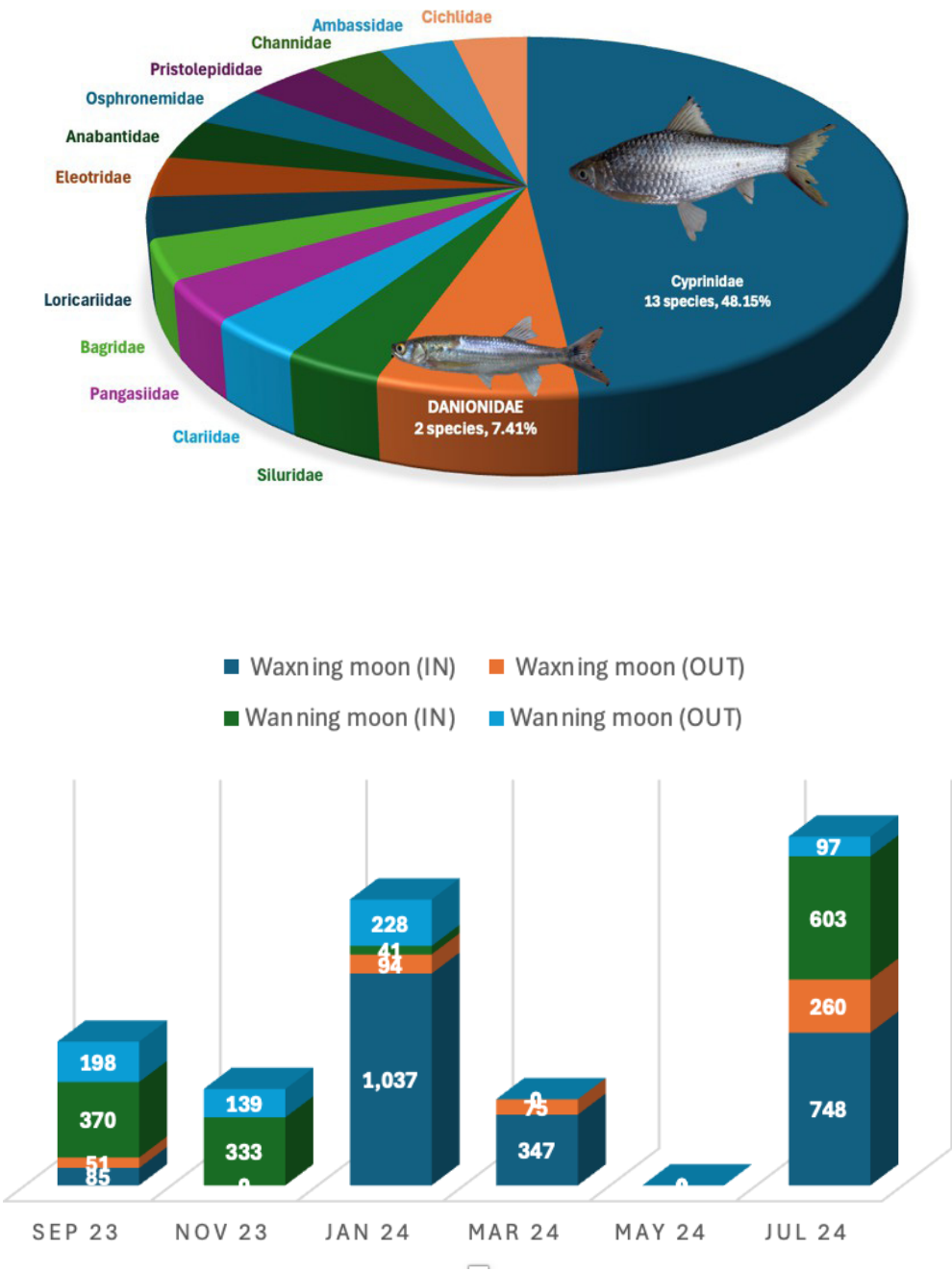


Figure 4. Biodiversity of fish Station 1: San Klaep Dam Community.

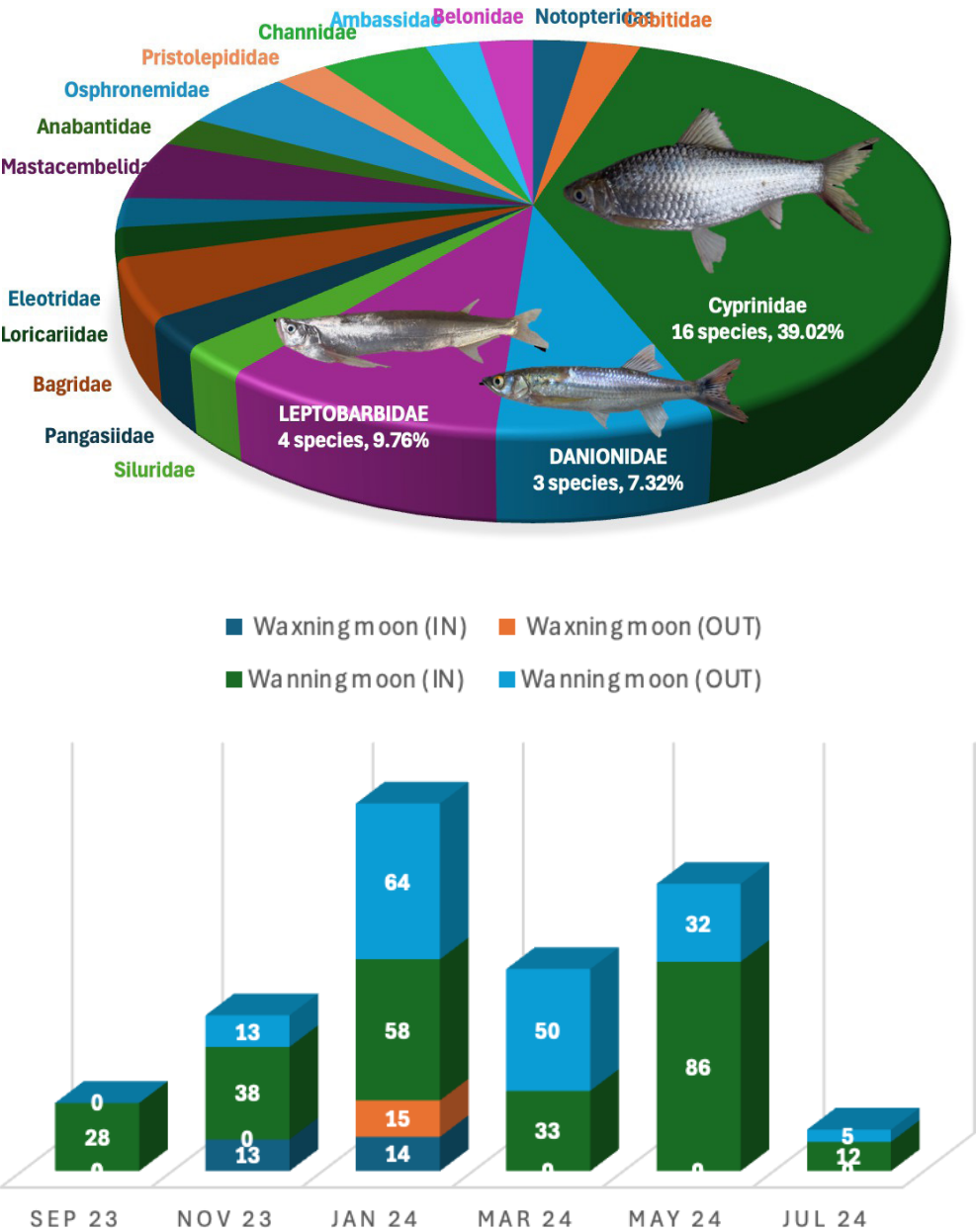


Figure 5. Biodiversity of fish Station 2: Wang Sila Community.

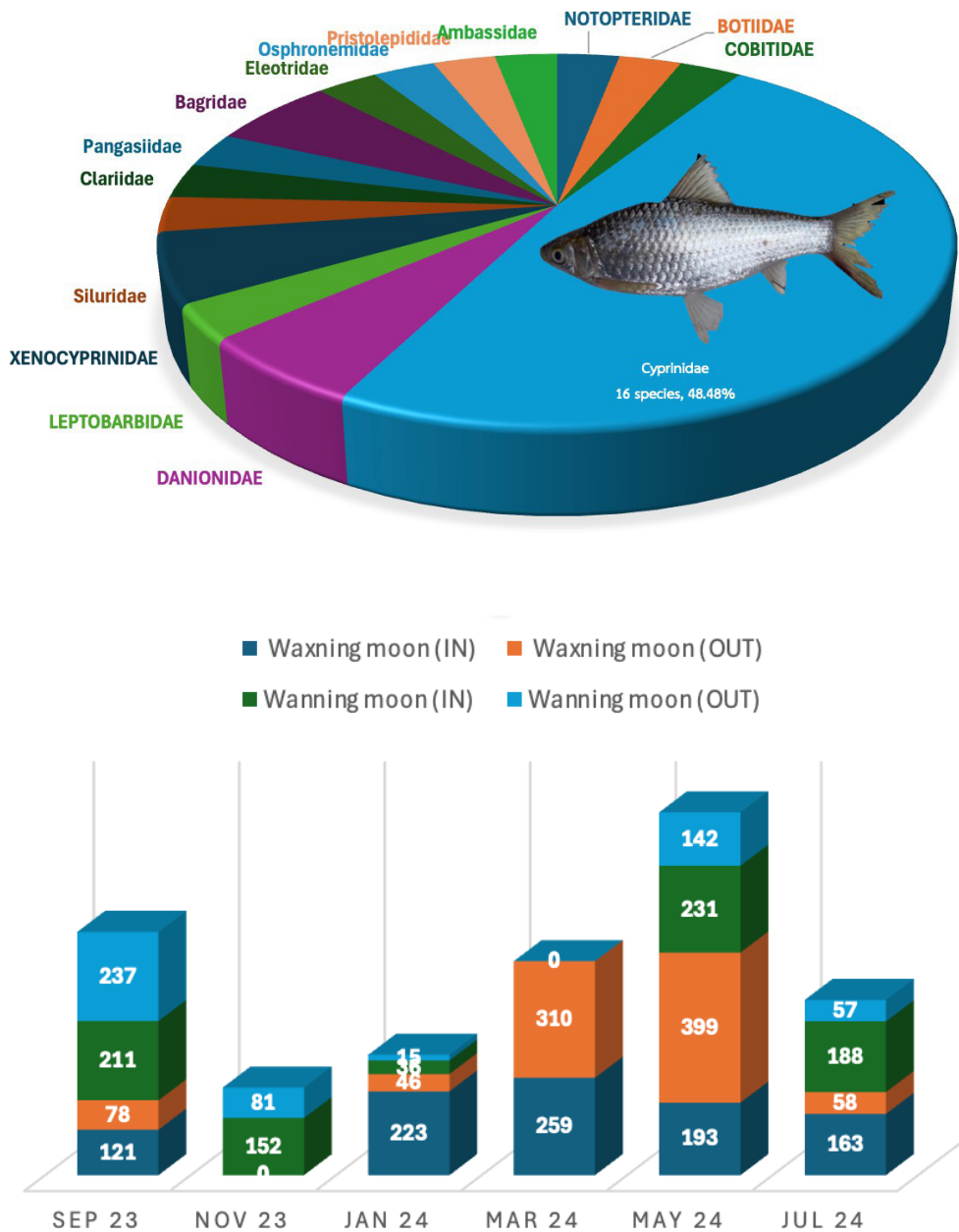


Figure 6. Biodiversity of fish Station 3: Pa Kha Community.

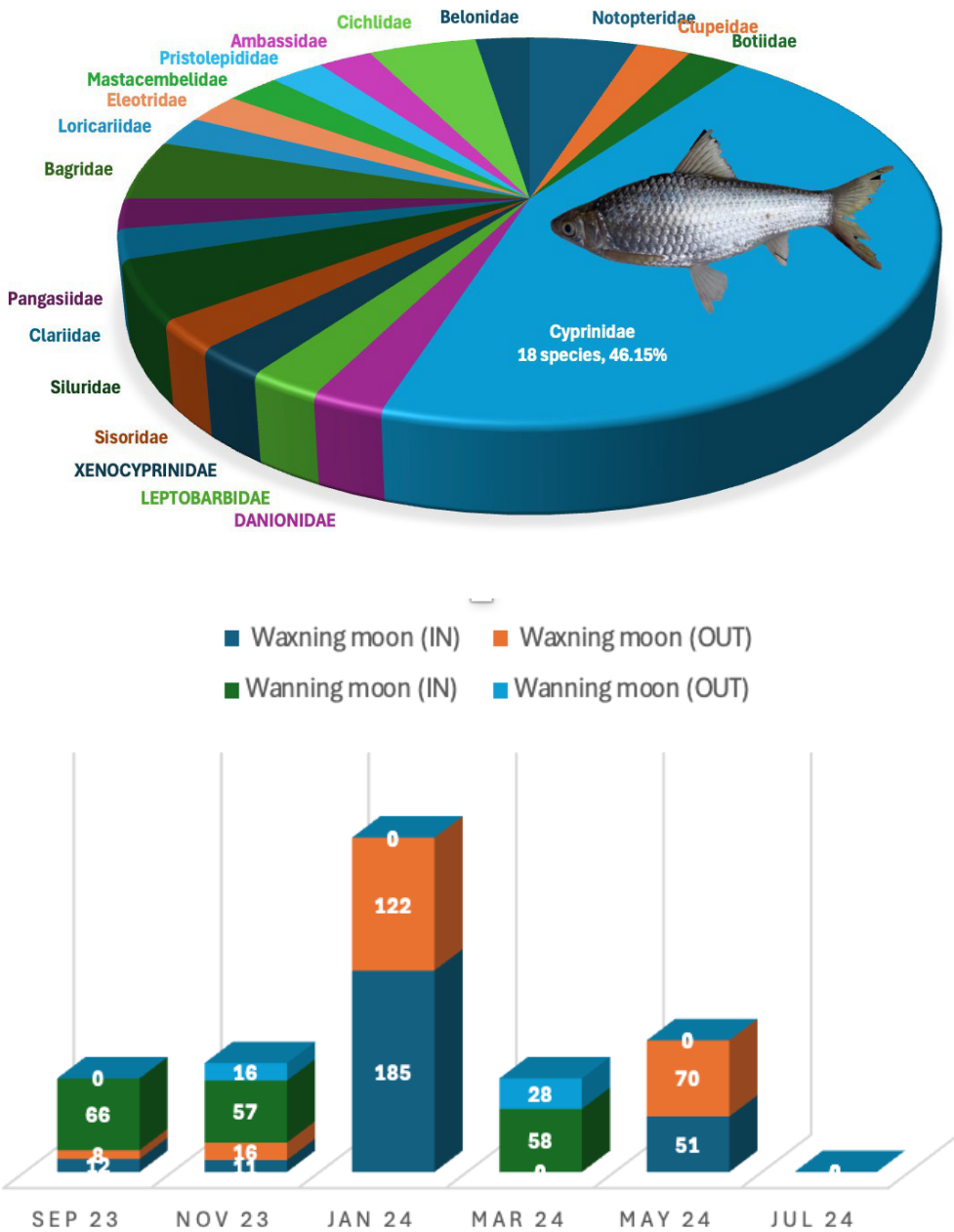


Figure 7. Biodiversity of fish Station 4: Pak Ing Community.

Table 3. (continued).

FAMILY	Conserv ation status	Fish species	Sep-23			Nov-23			Jan-24			March-24			May-24			July-24		
			waxing moon			waxing moon			waxing moon			waxing moon			waxing moon			waxing moon		
			IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT
CLARIIDAE	LC	<i>Clarias batrachus</i>	-	-	+	-	+	-	-	-	-	-	-	-	-	+	-	-	-	-
ALIIDAE	DD	<i>Pseudolais pleurotaenia</i>	-	-	+	-	-	+	-	+	-	-	-	-	+	-	-	+	-	+
BAGRIDAE	LC	<i>Hemibagrus nemurus</i>	-	-	+	-	+	+	+	+	-	-	-	+	-	+	-	+	+	+
	DD	<i>Myxus singaringan</i>	-	-	+	-	-	-	+	+	-	-	+	-	-	+	-	-	-	-
LORICARIDAE	N	<i>Hypostomus plecostomus</i>	-	-	+	-	-	-	+	+	-	-	-	+	-	-	-	+	-	-
ELEOTRIDAE	LC	<i>Oxyeleotris marmorata</i>	-	+	+	-	+	+	+	+	-	+	+	-	-	+	-	-	-	-
MASTACEMBELIDAE	LC	<i>Macragnathus siamensis</i>	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	EN	<i>Mastacembelus armatus</i>	+	-	-	-	-	-	-	-	+	-	+	-	-	+	-	-	-	-
ANABANTIDAE	LC	<i>Anabas testudineus</i>	-	-	+	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+
OSPHRONOMIDAE	LC	<i>Trichopodus microlepis</i>	-	-	-	-	-	-	+	+	-	-	+	-	-	+	-	+	-	-
	LC	<i>Trichopodus trichopterus</i>	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+
PRISTOLEPIDAE	LC	<i>Pristolepis fasciatus</i>	-	+	-	-	+	+	+	+	-	+	+	-	-	+	+	-	-	-
CHANNIDAE	LC	<i>Channa striata</i>	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	LC	<i>Channa micropeltes</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AMBASSSIDAE	LC	<i>Parambassis siamensis</i>	+	+	+	-	+	+	+	+	+	+	+	-	+	+	+	+	+	+
CICHLIDAE	N	<i>Coptodon rendalli</i>	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
	N	<i>Oreochromis niloticus</i>	+	+	+	-	+	+	-	+	+	+	+	-	-	-	-	-	-	-
BELONIDAE	LC	<i>Xenentodon cancilloides</i>	-	+	-	-	-	+	+	+	-	+	+	-	+	-	+	-	-	-

Note: Conservation Status = Account status of IUCN, LC = Not near extinction, VU = Unstable, EN = Near extinction, CE = Critically endangered, DD = Insufficient information, N = Foreigners

Discussion

The results of fish species diversity and abundance revealed clear differences in fish community structure along the longitudinal gradient from upstream to downstream. These differences reflect the influence of varying physical and ecological factors across different river sections.

The upper Ing River exhibited lower fish biodiversity than the middle and lower reaches, which can be attributed to higher elevation, narrower river width, and lower habitat complexity, thereby limiting the number of fish species able to persist in this area.

Fish species diversity in the middle Ing River increased compared to the upper reach but remained lower than in the lower reach. This pattern may result from increased river width and depth, suitable substrate characteristics, and favorable flow conditions that support a greater variety of fish species.

The lower Ing River showed the highest fish diversity and abundance, characterized by greater water volume, diverse habitats, and the influence of the Mekong River during the flood season. These conditions contribute to a more complex fish community structure and higher species richness.

Furthermore, differences in dominant fish species among sampling stations reflect species-specific adaptations to local environmental conditions. The occurrence of non-native fish species in some areas may be associated with human activities and could potentially affect the structure of native fish communities in the long term.

In conclusion, the findings highlight the importance of river connectivity and habitat heterogeneity in maintaining fish biodiversity in the Ing River Basin. The results provide essential baseline information to support fisheries management and sustainable community-based conservation

Summary

At the upper Ing River survey station (Station 1), located at an elevation of 390 meters above sea level, fish biodiversity was lower than that observed in the middle and lower sections of the river. A total of 27 fish species belonging to 14 families were recorded, with 7 species belonging to the same family. Two non-native fish species were recorded in the Ing River such as the Nile tilapia (*Oreochromis niloticus*) and armored catfish (*Pterygoplichthys* spp.). The dominant species at this station were the Siamese glassfish (*Parambassis siamensis*) and the silver barb (*Barbonymus gonionotus*)

At the middle Ing River survey station (Station 2), located at an elevation of 378 meters above sea level, fish biodiversity was higher than in the upper section but lower than in the lower section of the river. A total of 33 fish species belonging to 14 families were recorded, with 16 species belonging to the family Cyprinidae. The dominant species at this station were the tinfoil barb (*Barbonymus schwanenfeldii*) and the Siamese glassfish (*Parambassis siamensis*)

At the lower Ing River survey station (Station 3), located at an elevation of 353 meters above sea level, fish biodiversity was higher than that observed in the upper and middle sections of the river. A total of 41 fish species belonging to 17 families were recorded, with 16 species belonging to the family Cyprinidae. One non-native fish species was recorded in the Ing River such as the armored catfish (*Pterygoplichthys* sp.). The dominant species at this station were the Tornier's rasbora (*Rasbora tornieri*) and the Thynnichthys barb (*Thynnichthys thynnoides*).

At the lower Ing River survey station (Station 4), located at an elevation of 345 meters above sea level, fish biodiversity was higher than that in the upper and middle sections of the river. A total of 39 fish species belonging to 18 families were recorded, with 18 species belonging to the family Cyprinidae. Four non-native fish species were recorded in the Ing River such as the Nile tilapia (*Oreochromis niloticus*), redbelly tilapia (*Coptodon zillii*), armored catfish (*Pterygoplichthys* sp.), and common carp (*Cyprinus carpio*). The dominant

species at this station were the margined carp (*Mystacoleucus marginatus*) and the Siamese mud carp (*Henicorhynchus siamensis*).

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