Species Diversity and Distribution of Fish in Huai Kao Reservoir, Na Chauk District, Maha Sarakham Province, Thailand.

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Abstract

Fish diversity in reservoirs is one of the most important food resources for people in villages. Huai Kao reservoir, located in the Na Chauk district of Maha Sarakham province in northeastern Thailand, is a main food source, especially for fish, for villagers in that area. This research aims to study the species diversity and distribution of fish species in Huai Kao reservoir. Six stations were assigned to collect fish samples from January to November, 2022. The samples were collected using a gang of mesh size gillnets with sizes of 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, and 6.0 centimeters, and then their composition, frequency of occurrence, fish numbers and fish diversity were analyzed. A total of 3691 individuals belonging to 14 families containing 22 species were discovered, with the Cyprinidae family being the most diverse, accounting for 8 species (36 .36%), dominated by *Hampala dispar* (28.72%). The species with the highest frequency of occurrence (100%) were *Anabas testudineus*, *Oxyeleotris marmorata*, *Cyclocheilichthys armatus*, *Labiobarbus lineata*, *Hampala dispar*, *Notopterus notopterus*, and *Monotrete fangi*. The highest number of individuals was found in Winter, January, and Station 3, with 1881, 579, and 804 individuals, respectively. The average value of the Shannon diversity index (H), Species Richness index (S) and Evenness index (E) was 1.50, 1.74, 0.75 respectively.

Keywords: Fish, Species Diversity, Distribution, Huai Kao Reservoir

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Introduction

Thailand is a country with high biodiversity, and the catch of fish in natural water sources in 2022 was 112,604.48 tons, valued at 7,370.87 million baht. When compared to the previous year, 2021, there was a decrease in the volume of 4,245.73 tons (3.63%) and a decrease in value of 92.83 million baht (1.24%) (Department of Fisheries, 2023). Over the past four years, Thailand has discovered 7 new fish species: *Garra surinbinnani*, *Oreoglanis omkoiense Suvarnaraksha*, *Trigonostigma truncatat*, *Melamphaes brachysomus*, *Channa auroflammea*, *Nemacheilus zonatus*, and *Carcharhinus obsolerus* (ONEP, 2020). However, fish biodiversity is expected to decline due to the invasion of foreign species, an increasing population, land use changes, water pollution caused by agricultural run-off (pesticides and fertilizers) and industrial discharge, and habitat loss, which may affect the fish's feeding guild structure and lead to extinction in the future (Koushlesh *et al.*, 2022)

In Thailand, there are a total of 470 reservoirs with a capacity of 83,306.58 million cubic meters. These can be divided into two sizes: medium, with 435 reservoirs and a capacity of 5,409.88 million cubic meters, and large, with 35 reservoirs and a capacity of 77,896.7 million cubic meters. The main purposes of building reservoirs in Thailand include water storage for use in irrigation, electricity generation, flood prevention, and domestic and agricultural consumption during times of water scarcity, such as during the dry season. They are also used for tourism, recreation, and the production of tap water, as well as for the cultivation and conservation of aquatic life. (Royal Irrigation Department, 2023). Huai Kho reservoir is a medium-sized water storage pond located at 15°49'35.3"N 103°02'14.3"E in Tambon Khwai Rai, Amphoe Na Chueak, Maha Sarakham province (Figure 1). It is 150 meters above sea level and has an area of approximately 2,113 square kilometers or 6,340 acres. Its capacity is 31.338 million cubic meters and it can hold 208.00 square. kilometers of rainwater. It was constructed in 1968. The distinct feature of Huai Kho reservoir is its three sandy island in the middle of the water. The reservoir is used for irrigation, domestic water supply, and fish farming. It is also a popular place for recreational activities like swimming and boating. Fishing can be done throughout the year as a main source of livelihood for the local fishermen living around the Huai Kho reservoir. Fish caught in the reservoir are sold both as fresh fish and processed products such as orange roughy and pickled fish. (CMARE, 2020)

The surrounding area of Huai Kao reservoir has been studied for fish species diversity, such as in Sirinhron reservoir in Ubon Ratchathani province (Srincharoendham *et al.*, 2002), Tawatchai reservoir in Roi Et province (Chunchom and Taruwan, 2006), Bung Klua reservoir in Roi Et province (Jantharachit *et al.*, 2006), Ubolratana reservoir in Khonkaen province (Nachaipherm and Musikaew, 2006), Lam Pao reservoir in Kalasin province (Nachaipherm and Chunchom, 2008), Huai Jorakhe Mak Reservoir in Buriram province (Saowakoon, 2012), Huai Luang Reservoir (Thalerngkiet-leela *et al.*, 2017), Huay Huat reservoir in Sakon Nakhon province (Rayan *et al.*, 2017), and Nonghan Swamp in Sakon Nakhon province (Rayan *et al.* 2020). However, there has been a lack of research on fish in the Huai Kao reservoir and how it has caused changes in the water quality, flow, and habitat conditions. These changes can potentially reduce biodiversity and modify ecological and biological processes such as reproduction and the recruitment of species with different life history patterns. Fishermen still lack knowledge and understanding of the changes in fish populations in reservoirs. In addition, the number of fish in reservoirs has decreased every year. Therefore, the study of the diversity and distribution of fish species in the Khao Kho reservoir is necessary to assess the current state of fish resources and utilize these resources in the Khao Kho reservoir area. This information will also serve as a basis for developing management strategies and plans for water management, designated conservation areas for fish resources and the environment, and control of fishing tools used in the Khao Kho reservoir.

2. Materials and Methods

2.1 Ethical statement: This research project has been approved by Ethical Principles and Guidelines for the Use of Animals No. IACUC-MSU-17/2023 of Mahasarakham University, Thailand. The project leader holds a license number for Ethical Principles and Guidelines for the Use of Animals No. U1-08403-2562 from the Institute of Animals for Scientific Purposes Development (IAD), National Research Council of Thailand (NRCT), Thailand.

2.2 Sample collection and laboratory analysis: Fish specimens were collected through monthly samples taken from January 2022 to December 2022 at six sampling stations (ST1-ST6) in the Huai Kao reservoir **(Figure 1).** Samples were collected using 1.0-1.5 m deep gill nets with mesh sizes of 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, and 6.0 cm. Six sets of gill nets were tied together in a linear configuration. Six replicates were randomized and performed

at each survey point between 4:00 p.m. and 4:00 a.m. (12 hours). The fish were taxonomically identified to species. Unidentified species were stored in 10% formalin for later identification using the modified method of comparison with the FishBase online database (http://www.fishbase.org/home.htm) in 2023, as well as the methods of Rainboth (1996) and Vidthayanon (2008).

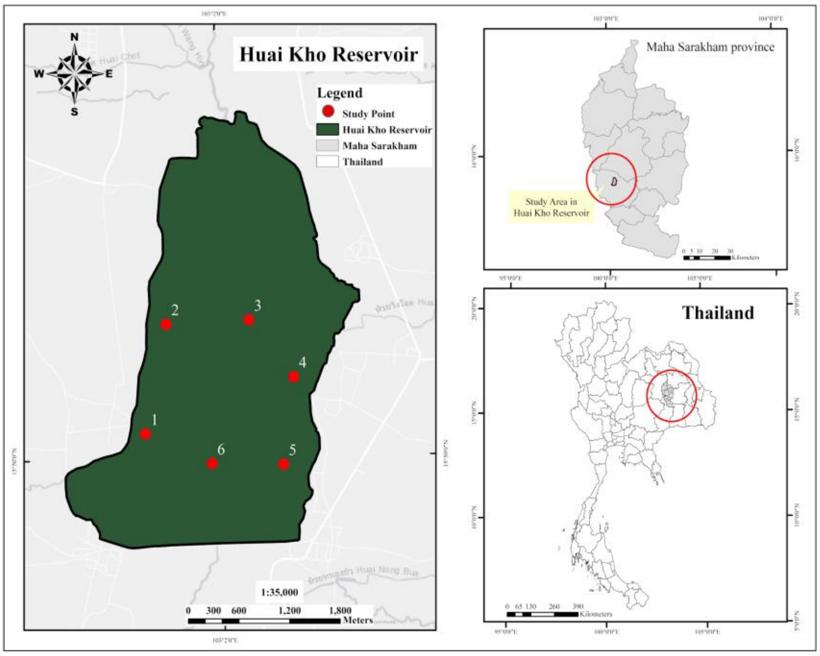


Figure 1. Map and location of the 6 sampling stations in the Huai Kao reservoir, Na Chauk of District, Maha Sarakham Province, Thailand.

2.3 Frequency of occurrence (%F): The frequency of occurrence is defined as the frequency or probability of finding a fish species during a specified time period in the study. This value represents the spatial and temporal distribution of a fish species expressed as a percentage. The formula for calculating the frequency of occurrence is: %F = (Number of times each fish species was found x 100) / Total number of samplings.

2.4 Fish of evaluation status. The local and global conservation status of fishes were determined following the list published by IUCN Thailand (ONEP, 2 0 1 7), and IUCN online database(https://www.iucnredlist.org/) in 2023,Global Invasive Species Database online database (http://www.iucngisd.org/gisd/search.php) in 2023.

2.5 Regarding data analysis; fish numbers, fish species, Shannon diversity index (H), Species richness (S), and Evenness index (E) were collected from each sampling station and month during the survey period in the Huai Kao Reservoir were analyzed using one-way ANOVA (Tukey honestly significant difference test, P = 0.05) conducted using SPSS©. (Simpson, 1949; Magurran, 1988; Krebs, 1985; Shannon and Wiener, 1963).

Table 1. Sampling Stations in the Huai Kao reservoir, Na Chauk of District, Maha Sarakham Province, Thailand.

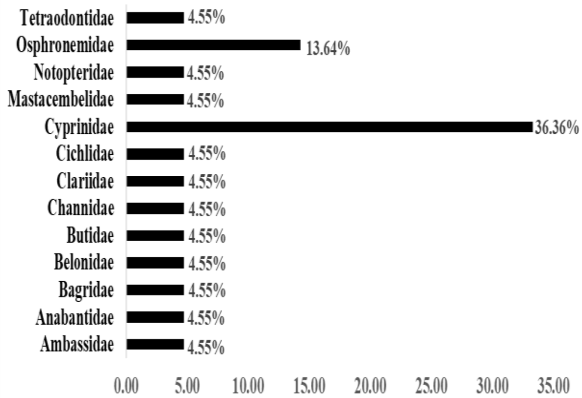
Sampling stations	**Site Code**	**Latitude**	**Longitude**
Ban Kao Kwang	ST1	15°83'59.38"N,	103°02'47.81"E.
Ban Sumsang	ST2	15°84'72.21"N	103°02'72.71"E
Koh Nonkha	ST3	15°84'75.05"N	103°03'64.11"E
Pattaya Na Chauk 2	ST4	15°84'15.43"N	103°04'12. 46"E
Pattaya Na Chauk 1	ST5	15°83'25.43"N	103°03'99.59"E
Huai Kho reservoir	ST6	15°83'26.98"N	103°03'26.62"E

3. Results

3.1 Species composition

Fish samples were randomized and evaluated from 6 sampling stations around the Huai Kao Reservoir between from January 2022 to December 2022. Details are as follows: A total of 14 families with 22 fish species were found (Figure 2). The most

Figure 2. Composition of fish families caught by gillnets in the Huai Kao reservoir, from January 2022 to December 2022.



abundant family was Cyprinidae (8 species (36.36%)). The second dominant family was Osphronemidae (3 species (13.64%)). Families of Ambassidae, Anabantidae, Bagridae, Butidae, Belonidae, Channidae, Clariidae, Cichlidae, Mastacembelidae, Notopteridae, Osphronemidae and Tetraodontidae were recorded with 1 species each (4.55%). (Figure 2)

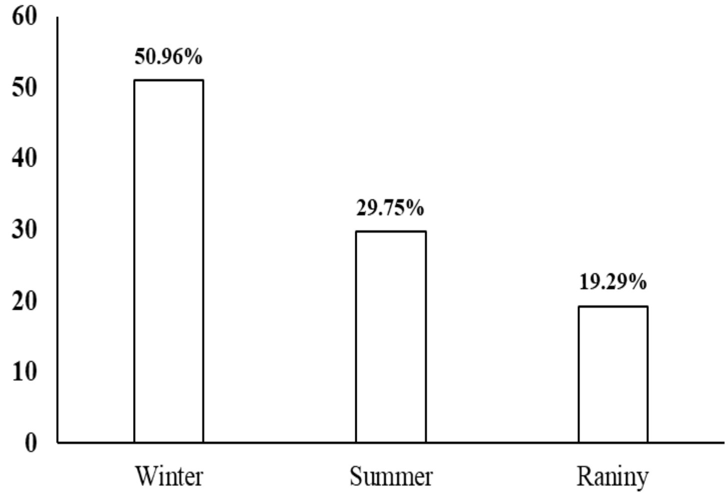
3.2 The comparison of the number and species of fish

A total of 22 fish species were found. The number of fish species in the Huai Kao reservoir area was observed in Station 1, having the highest number at 21 species (95.45%), followed by Station 2 and Station 3 with 20 species (90.91%), Station 5 with 19 species (86.36%), Station 4 with 18 species (81.82%), and Station 6 with 17 species (77.27%) respectively. The species *Anabas testudineus*, *Oxyeleotris marmorata*, *Clarias batrachus*, *Oreochromis niloticus*, *Cyclocheilichthysarmatus*, *Cyclocheilichthys lagleri*, *Labiobarbus lineata*, *Hampala dispar*, *Henicorhynchus caudimaculatus*, *Henicorhynchus siamensis*, *Puntius brevis*, *Notopterus notopterus*, *Monotrete fangi*, and *Trichopodus trichopterus* were collected in all research stations (100%) (Table 1).

The number of fish species was December and November having the highest number at 17 species (77.27%), followed by January with 16 species (72.73%), February with 14 species (63.64%), March with 14 species (63.64%), May with 14 species (63.64%), June with 14 species (63.64%), August with 14 species (63.64%), September with 14 species (63.64%), October with 14 species (63.64%), April with 13 species (59.09%), and July with 12 species (54.55%) respectively. The species *Anabas testudineus*, *Oxyeleotris marmorata*, *Cyclocheilichthys armatus*, *Labiobarbus lineata*, *Hampala dispar*, *Notopterus notopterus*, and *Monotrete fangi* were collected in all research months (100%) (Table 2).

A total of 3691 individuals were found. The number of individuals was *Hampala dispar* having the highest number at 1060 individuals (28.72%), followed by *Cyclocheilichthys armatus* with 520 individuals (14.09%), *Henicorhynchus caudimaculatus* with 383 individuals (10.38%), *Oxyeleotris marmorata* with 284 individuals (7.69%), *Notopterus notopterus* with 263 individuals (7.13%), *Anabas testudineus* with 263 individuals (7.13%), *Puntius brevis* with 225 individuals (6.10%), *Cyclocheilichthys lagleri* with 181 individuals (4.90%), *Henicorhynchus siamensis* with 118 individuals (3.20%), *Labiobarbus lineata* with 104 individuals (2.82%), *Monotrete angi* with 55 individuals (1.49%), *Trichopodus trichopterus* with 49 individuals (1.33%), *Oreochromis niloticus* with 47 individuals (1.27%), *Channa striata* with 45 individuals (1.22%), *Parambassis*

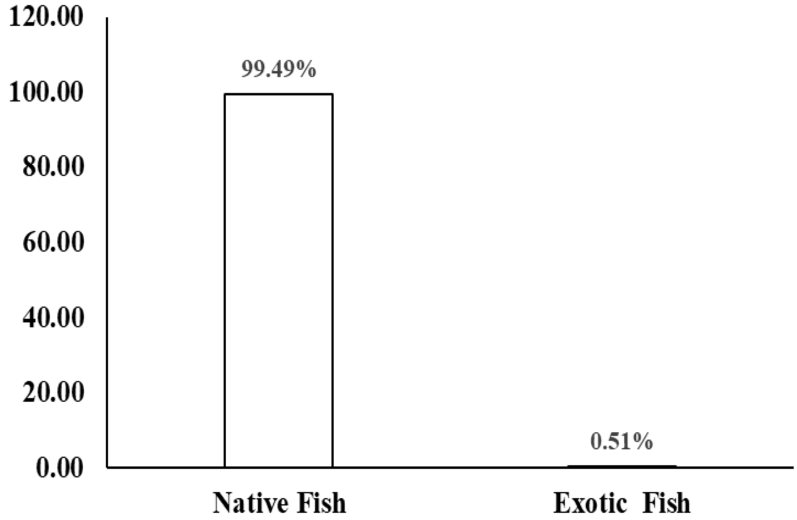
Figure 2. Percentage of fish number caught by gillnets in the Huai Kao reservoir, from season



apogonoides and *Clarias batrachus* with 19 individuals (0.51%), *Macrognathus siamensis* with 7 individuals (0.19%), *Xenentodon cancila* and *Trichogaster microlepis* with 5 individuals (0.14%), *Hemibagrus nemurus* with 2 individuals (0.05%), and *Trichogaster pectoralis* with 1 individual (0.03%) respectively. (Table 2). Threatened Status of Fish, Most fish species were in the "Not Evaluated" and "Least Concern" groups (Table 1). Whereas, the exotic species, especially Nile tilapia (Oreochromis niloticus) with 47 individuals (0.51%), comprised of all fish caught (Figure 3). The species *Anabas testudineus*, *Oxyeleotris marmorata*, *Cyclocheilichthys armatus*, *Labiobarbus lineata*, *Hampala dispar*, *Notopterus notopterus*, and *Monotrete fangi* were collected in all research stations and months (100%).

The results showed that the number of fish individuals in the Huai Kao reservoir area was 1881 (50.96%), 1098 (29.75%), and 712 (19.29%) individuals during the winter (Oct.-Jan.), summer (Feb.- May), and rainy seasons (Jun.-Sep.), respectively

Figure 3. Percentage of the threatened status of fish caught by gillnets in the Huai Kao reservoir from January 2022 to December 2022



(Figure 2). The results showed that the number of fish individuals in the Huai Kao Reservoir area was station 3 having the highest number at 804 individuals (21.78%), followed by station 4 with 684 individuals (18.53%), station 2 with 616 individuals (16.69%), station 1 with 590 individuals (15.98%), station 5 with 556 individuals (15.06%), and station 6 with 441 individuals (11.95%) respectively. A total of 361 individuals were found. The results showed that the number of fish individuals in the Huai Kao reservoir area was January having the highest number at 579 individuals (15.69%), followed by November with 488 individuals (13.22%), December with 453 individuals (12.27%), October with 361 individuals (9.78%), May with 306 individuals (8.29%), March with 275 individuals (7.45%), April with 264 individuals (7.15%), February with 25 3 individuals (6.85%), August with 217 individuals (5.88%), September with 186 individuals (5.04%), June with 163 individuals (4.42%), and July with 146 individuals (3.96%) respectively.

3.3 Diversity index

The average Shannon diversity index (H) was 1.50. The results showed that the Shannon diversity index (H) was not significantly different ($p>0.05$) between stations. Station 2 had the highest average Shannon diversity index (H) at 1.60, followed by Station 1 and Station 3 at 1.59, Station 4 at 1.50, Station 5 at 1.40, and Station 6 at 1.32 respectively. (Table 3). The results showed that the Shannon diversity index (H) significantly differed ($p<0.01$) between months. The month of January had the highest average Shannon diversity index (H) at 1.97, followed by December at 1.93, November at 1.68, October at 1.66, February and May at 1.51, June at 1.49, March at 1.41, July at 1.31, April at 1.26, September at 1.19, and August at 1.08 respectively. (Table 4)

The average Species richness (S)was 1.74. The results showed that the Species richness (S) was significantly different ($p<0.05$) between Stations. Station 2 had the highest average Species richness (S) at 2.02, followed by Station 1 at 1.92, Station 3 at 1.84, Station 4 at 1.71, Station 5 at 1.52, and Station 6 at 1.46 respectively. (Table 3). The results showed that the Species richness (S) was significantly different ($p<0.01$) between month. The month of had the January highest average Species richness (S) at 2.44, followed by December at 2.27, November at 1.97, October at 1.88, June at 1.82, May at 1.65, September at 1.63, March at 1.59, July at 1.51, February at 1.41, April at 1.40, and August at 1.37 respectively. (Table 4)

Table 1. Fish of diversity and distribution by station in the Huai Kao Reservoir

Family	Scientific Name	Station						Number (Ind.)	Percent (%)	F (%)	Fish species[1]	IUCN Thailand[2]	IUCN[3]
		ST1	ST2	ST3	ST4	ST5	ST6						
Ambassidae	*Parambassis apogonoides*	6	5	5	0	2	1	19	0.51	83.33	Native	NE	LC
Anabantidae	*Anabas testudineus*	20	20	78	24	64	57	263	7.13	100	Native	DD	LC
Bagridae	*Hemibagrus nemurus*	0	1	0	0	0	1	2	0.05	33.33	Native	NE	LC
Butidae	*Oxyeleotris marmorata*	35	51	61	81	21	35	284	7.69	100	Native	NE	LC
Belonidae	*Xenentodon cancila*	3	0	1	1	0	0	5	0.14	50.00	Native	NE	LC
Channidae	*Channa striata*	11	13	12	1	8	0	45	1.22	83.33	Native	NE	LC
Clariidae	*Clarias batrachus*	4	3	3	5	2	2	19	0.51	100	Exotic	NT	LC
Cichlidae	*Oreochromis niloticus*	6	6	3	10	5	17	47	1.27	100	Native	NE	LC
Cyprinidae	*Cyclocheilichthys apogon*	5	1	19	4	6	0	35	0.95	83.33	Native	NE	LC
	Cyclocheilichthys armatus	49	108	136	110	79	38	520	14.09	100	Native	NE	LC
	Cyclocheilichthys lagleri	27	18	56	49	9	22	181	4.90	100	Native	NE	LC
	Labiobarbus lineata	19	18	25	4	21	17	104	2.82	100	Native	NE	NE
	Hampala dispar	192	205	229	189	147	98	1060	28.72	100	Native	NE	LC
	Henicorhynchus caudimaculatus	69	67	35	79	93	40	383	10.38	100	Native	NE	NE
	Henicorhynchus siamensis	15	22	22	30	17	12	118	3.20	100	Native	NE	NE
	Puntius brevis	29	19	49	45	41	42	225	6.10	100	Native	NE	LC
Mastacembelidae	*Macrognathus siamensis*	1	1	0	3	1	1	7	0.19	83.33	Native	NE	LC
Notopteridae	*Notopterus notopterus*	64	45	37	42	28	47	263	7.13	100	Native	NE	LC
Osphronemidae	*Trichogaster microlepis*	1	3	2	0	0	0	6	0.16	33.33	Native	NE	LC
	Trichopodus trichopterus	18	4	12	5	5	5	49	1.33	100	Native	NE	NE
	Trichogaster pectoralis	1	0	0	0	0	0	1	0.03	16.67	Native	NE	LC
Tetraodontidae	*Monotrete fangi*	15	6	19	2	7	6	55	1.49	100	Native	NE	NE
	Grand total	**590**	**616**	**804**	**684**	**556**	**441**	**3691**	**100**				
	Percentage population	**15.98**	**16.69**	**21.78**	**18.53**	**15.06**	**11.95**						
	Total species	**21**	**20**	**20**	**18**	**19**	**17**						
	Percentage diversity	**95.45**	**90.91**	**90.91**	**81.82**	**86.36**	**77.27**						

Remark: ST1–ST6 = Sampling stations for collecting fishable

[1] ONEP. (2017)

[2] IUCN (2023).

[3] Global Invasive Species Database. (2023)

NE = Not Evaluated

DD = Data Deficient

LC = Least Concern

NT = Near Threatened

Table 2. Fish of diversity and distribution by month in the Huai Kao Reservoir

Family	Scientific Name	Month												F (%)
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Ambassidae	*Parambassis apogonoides*	0	1	3	2	1	2	0	2	3	1	3	1	83.33
Anabantidae	*Anabas testudineus*	151	10	8	1	1	1	10	2	5	12	29	33	100
Bagridae	*Hemibagrus nemurus*	0	0	1	0	0	1	0	0	0	0	0	0	16.67
Butidae	*Oxyeleotris marmorata*	8	53	30	34	26	29	17	31	14	9	27	6	100.00
Belonidae	*Xenentodon cancila*	2	2	0	0	1	0	0	0	0	0	0	0	25.00
Channidae	*Channa striata*	11	0	2	3	0	0	1	3	0	6	10	9	66.67
Clariidae	*Clarias batrachus*	3	0	1	1	1	0	0	0	1	4	7	1	66.67
Cichlidae	*Oreochromis niloticus*	0	0	0	0	1	0	1	1	5	37	1	1	58.33
Cyprinidae	*Cyclocheilichthys apogon*	20	0	0	0	0	0	0	0	0	0	7	8	25.00
	Cyclocheilichthys armatus	20	65	63	62	127	20	34	31	18	16	31	33	100
	Cyclocheilichthys lagleri	55	0	0	0	0	0	0	0	0	3	24	99	33.33
	Labiobarbus lineata	14	10	3	3	20	11	6	1	2	1	12	21	100
	Hampala dispar	88	70	114	114	48	60	54	123	113	151	62	63	100
	Henicorhynchus caudimaculatus	130	0	1	0	1	3	4	4	6	25	131	78	83.33
	Henicorhynchus siamensis	18	7	0	0	26	10	9	1	3	7	6	31	83.33
	Puntius brevis	12	2	0	0	5	3	2	2	4	50	115	30	83.33
Mastacembelidae	*Macrognathus siamensis*	0	1	2	1	0	3	0	0	0	0	0	0	33.33
Notopteridae	*Notopterus notopterus*	21	26	34	19	39	13	3	14	6	37	21	30	100
Osphronemidae	*Trichogaster microlepis*	0	1	3	2	0	0	0	0	0	0	0	0	25.00
	Trichogaster pectoralis	0	0	0	0	0	0	0	0	1	0	0	0	8.33

	Trichopodus trichopterus	22	4	1	14	0	1	0	1	0	0	1	5	66.67
Tetraodontidae	*Monotrete fangi*	4	1	9	8	9	6	5	1	5	2	1	4	100
	Grand total	**579**	**253**	**275**	**264**	**306**	**163**	**146**	**217**	**186**	**361**	**488**	**453**	
	Percentage population	**15.69**	**6.85**	**7.45**	**7.15**	**8.29**	**4.42**	**3.96**	**5.88**	**5.04**	**9.78**	**13.22**	**12.27**	
	Total species	**16**	**14**	**14**	**13**	**14**	**14**	**12**	**14**	**14**	**14**	**17**	**17**	
	Percentage diversity	**72.73**	**63.64**	**63.64**	**59.09**	**63.64**	**63.64**	**54.55**	**63.64**	**63.64**	**63.64**	**77.27**	**77.27**	

The average Evenness index (E) was 0.75 The results showed that the Evenness index (E) was not significantly different ($p>0.05$) between Stations. Station 4 had the highest average Evenness index (E) at 0.77, followed by Stations 5 and Station 6 at 0.76, Station 2 at 0.75, Station 1 at 0.74, and Station 3 at 0.73 respectively. (Table 3). The results showed that the Evenness index (E) was significantly different ($p<0.05$) between months. The month of had the February highest average Evenness index (E) at 0.85, followed by December at 0.83, January at 0.79, April at 0.78, May and October at 0.77, March at 0.76, July and November at 0.75, June at 0.74, September and August at 0.62 respectively. (Table 4)

4. Discussion

4.1 Species composition

The variation and abundance of fish species in water resources development is influenced by environmental conditions such as location, reservoir size, tolerance to water quality, water volume, and water conditions (Negi and Mamgain 2013; Petsut *et al.*, 2017; Rayan *et al.*, 2020). Huai Kho Reservoir is a medium-sized water storage, and the water is clear. It is 150 meters above sea level and has an area of approximately 2,113 square kilometers, or 6,340 acres. Its capacity is 31.338 million cubic meters.

Table 3. Fish of diversity index by the station in the Huai Kao Reservoir

Station	H	S	E
ST1	1.59^{a}	1.92^{ab}	0.74^{a}
ST2	1.60^{a}	2.02^{a}	0.75^{a}
ST3	1.59^{a}	1.84^{abc}	0.73^{a}
ST4	1.50^{a}	1.71^{abc}	0.77^{a}
ST5	1.40^{a}	1.52^{abc}	0.76^{a}
ST6	1.32^{a}	1.46^{c}	0.76^{a}
Average	**1.50**	**1.74**	**0.75**

Remark: ST1–ST6 = Sampling stations for collecting fish

Table 4. Fish diversity index by month in the Huai Kao Reservoir

Month	H	S	E
Jan.	1.97^{a}	2.44^{a}	0.79^{ab}
Feb.	1.51^{cd}	1.41^{d}	0.85^{a}
Mar.	1.41^{cd}	1.59^{cd}	0.76^{ab}
Apr.	1.26^{de}	1.40^{d}	0.78^{ab}
May	1.51^{cd}	1.65^{cd}	0.77^{ab}
Jun.	1.49^{cd}	1.82^{acd}	0.74^{ab}
Jul.	1.33^{de}	1.51^{cd}	0.75^{ab}
Aug.	1.08^{e}	1.37^{d}	0.62^{b}
Sep.	1.19^{de}	1.63^{cd}	0.62^{b}
Oct.	1.66^{bc}	1.88^{bcd}	0.77^{ab}
Nov.	1.68^{abc}	1.97^{abc}	0.75^{ab}
Dec.	1.93^{ab}	2.27^{ab}	0.83^{a}
Average	**1.50**	**1.74**	**0.75**

These plants provide a habitat for various species of fish and other aquatic animals such as *Hydrilla verticillate*, *Utricularia aurea*, *Spirogyra* sp., and *Azolla pinnata*. This study found a total of 22 fish species belonging to 14 families in the Huai Kao Reservoir area. The most abundant family was Cyprinidae (8 species (36.36%)). After comparing the study of area reference with the reservoir, it was found that fish species and family of Cyprinidae as dominant and the most abundant by number, But the number of species of fish is less than the Sirinhron reservoir was 47 fish species and Cyprinidae (22 species (45.80%)) (Srincharoendham *et al.*, 2002), Tawatchai reservoir was 47 fish species and Cyprinidae (13 species (41.49%)) (Chunchom and Taruwan, 2006), Bung Klua reservoir was 53 fish species and Cyprinidae (26 species (49.06%)) (Jantharachit *et al.*, 2006), Ubolratana reservoir was 63 fish species and Cyprinidae (26 species (41.93%)) (Nachaipherm and Musikaew, 2006), Lam Pao reservoir was 57 fish species and Cyprinidae (26 species (44.82%)) (Nachaipherm and Chunchom, 2008), Huai Jorakhe Mak Reservoir was 32 fish species and Cyprinidae (13 species (40.62%)) (Saowakoon, 2012), Huai Luang Reservoir was 46 fish species and Cyprinidae (20 species (43.48%)) (Thalerngkiet-leela, et al., 2017), Huay Huat reservoir was 53 fish species Cyprinidae (13 species (56.60%)) (Rayan *et al.,* 2017), Nonghan Swamp was 45 fish species Cyprinidae (20 species (44.44%)) (Rayan *et al.,* 2020). Cyprinidae families had the highest number of species. Generally, dominance by the fishes in family Cyprinidae is common in the Asian freshwater bodies where they may contribute 40% or more of the species in a watershed (Alexandre *et al.,* 2010). Fish in the family of Cyprinidae are able to adjust well to the environment and tolerate changes in the ecosystem, which increases the fish species composition and the dominant fish species in a catch (Nelson, 1994). The fish diversity and abundance of the fish community in the lotic water ecosystem are influenced by natural factors such as feeding types, habitats, and hydrologic features, and also by water quality variables such as gradient, altitude, elevation, tidal velocity, and water temperature, as a result, if the conditions of the water source change, the fish diversity and abundance of sensitive species can decrease (Wongroj and Siriwattanarat, 2021)

4.2 The comparison of the number and species of fish

Freshwater fish are considered important for the species diversity and distribution of fish in reservoirs. There can be differences in the types, quantities, and distribution of fish according to the geography or location, water level in the reservoir, and the characteristics of the water sources in the area, from the upstream, which is connected to the main river or tributary streams, to the downstream and the use of water resources around the reservoir (Miranda, 2017; Aryani *et al.,* 2021; Pfauserova *et al.,* 2021). A total of 22 fish species were found. Huai Kho reservoir had 21 native species, and the exotic species of fish was Nile tilapia (*Oreochromis niloticus*) because the location of the Huai Kho reservoir has a main river or tributary streams that flow into the reservoir only during the rainy season. This results in a lower number of native species being found. The maintenance of more preserved tributaries and rivers ensures that fish have refuges, alternative migration routes, searching for food, predator avoidance, breeding sites, and places for growth, ensuring the right conditions to complete the life cycle of many species (Lian et al., 2017; Santos *et al.,* 2022). Station 1 had the highest species diversity with 21 species (95.45%) of fish compared to other stations due to its shallow depth of approximately 1 meter and its proximity to agricultural areas. These factors likely contribute to an increased availability of nutrients in the water, leading to a higher diversity of fish species at Station 1. Rainwater can wash nutrients, such as nitrogen and phosphorus, from agricultural areas into the water, which can encourage the growth of aquatic plants such as *Hydrilla verticillate*, *Utricularia aurea*, *Spirogyra* sp., *Typha angustifolia*, and *Nelumbo nucifera*. The presence of these plants can lead to a higher density of aquatic vegetation. The presence of aquatic plants can provide habitat and cover for aquatic animals, protecting them from predators. However, Station 6 had the lowest species with 17 species (77.27%) This may be due to its proximity to floodgates and the presence of a large number of tree roots and a small amount of aquatic vegetation in the water at this location. In December and November, there was a higher species diversity with 17 species (77.27%), compared to other months. This may be due to the higher water levels in the reservoir during these months, which can cause flooding and create small, shallow areas of water where aquatic plants can grow. These areas can provide shelter for fish. The diversity of fish species is correlated with increased water surface area (Lim *et al.,* 1999; Specziar *et al.,* 2013). Therefore, during the rainy season, there is a flow of new water from the river into Huai Kao Reservoir, allowing various fish species to migrate along the water currents. However, July had the lowest species with 12 specie (54.55%) There will be heavy rainfall and the water will be necessary for farmers to irrigate their fields and for the community to plant crops in the surrounding area. Thus, the water level in the Huai Kho reservoir remains at a stable, not too low or middle level from Jun to October. But this water level is suitable for predatory fish to hunt and feed on other fish as food, such as *Cyclocheilichthys armatus*, *Hampala dispar*, and *Oxyeleotris marmorata*, in early June. It is the time when the fish in the reservoir at Huai Kho begin to breed and lay eggs (Bruno *et al.*, 2019). The juvenile fish will become the food of the predatory fish, resulting in a decrease in the number of fish over time.

A total of 3691 individuals were found. *Hampala dispar* was the most dominant species of fish in the Huai Kao Reservoir area, with 1060 individuals (28.72%) observed. *Hampala dispar* is adaptable and can be found in both upland and lowland, standing or flowing waters. It typically feeds in groups, searching for food on the water surface and is capable of quickly chasing and catching prey. Its diet primarily consists of prawns, crabs, and shrimps, but it also feeds on some insect larvae and fish. Each species of fish in the area has its own behavior and feeding habits, as well as differing requirements and quantities of food. The feeding habits of each species of fish also differ (Heng *et al.*, 2018). A study of the stomach contents of *Hampala macrolepidota* found that approximately 64% consisted of *Parambassis siamensis*, *Henicorhynchus siamensis*, and *Labiobarbus lineata* (Keereelang, 2008). These species are also common prey for *Hampala dispar* in the Huai Kho Reservoir, and were found in high numbers and at all times of year. After comparing the species composition of fish in several nearby reservoirs with the reference area, it was found that Sirinhron reservoir had the highest abundance of *Ambassis notatus* (30.94%) (Srincharoendham *et al.*, 2002), Tawatchai reservoir had the highest abundance of *Clupeichthys aesarnesis* (41.49%) (Chunchom and Taruwan, 2006), Bung Klua reservoir had the highest abundance of *Labiobarbus lineata* (Jantharachit *et al.*, 2006), Ubolratana reservoir had the highest abundance of *Mystacoleucus marginatus* (28.59%) (Nachaipherm and Musikaew, 2006), Huai Luang Reservoir had the highest abundance of *Ambassis notatus* (30.27%) (Thalerngkiet-leela *et al.*, 2017), Huay Huat reservoir had the highest abundance of *Ambassis notatus* (72.15%) (Rayan *et al.*, 2017), Nonghan Swamp had the highest abundance of *Ambassis notatus* (48.30%) (Rayan *et al.*, 2020), Huai Jorakhe Mak reservoir had the highest abundance of *Hampala macrolepidota* (17.03%) (Saowakoon, 2012), and Lam Pao reservoir had the highest abundance of *Ambassis notatus* (30.94%) (Nachaipherm and Chunchom, 2008). It results in relative changes in the number of dominant species, differing mainly by the topography, habitat complexity, water environment, food, human activities, and community composition (Mishra *et al.*, 2014; Yang *et al.*, 2021).

The results showed that Station 3 had the highest number of fish individuals with 804 individuals (21.78%) in the Huai Kao reservoir area, because Station 3 possibly had more aquatic plants and received effluent from a public canal, and it was adjacent to 3 islands. Fish use hiding places to avoid predators and serve as food sources. Station 3, which is supported by the flow of effluent from several public canals into the Huai Kao Reservoir, may harbor a variety of fish species including alien, endemic, and native fish. Fish may also migrate according to water currents. Sampling efforts were conducted during the night. According to Lian *et al.* (2017), there are generally three explanations for fish migration: searching for food, avoiding predators, and maintaining energy trade-offs through migration between different habitats. Fish migration tends to peak at transition periods, leading to maximum fish abundance in open water at midnight. Station 6 had the lowest number of fish individuals with 441 individuals (21.78%). It may be due to the proximity to floodgates. Wongroj and Siriwattanarat (2021) stated that floodgates have an impact on fish diversity and water quality. Floodgates can affect fish in two main ways: modifying water quality and limiting fish passage. Firstly, floodgates can alter water quality by limiting tidal exchange, which can lead to eutrophication and "dead zones" in lotic water. Secondly, when floodgates are closed, they restrict fish migration into or out of canals. There is a negative correlation between opening floodgates and noticing differences in fish communities above and below the floodgates (Gordon *et al.,* 2015; Doehring *et al.,* 2011; Wright *et al.,* 2014).

The number and type of fish in the reservoir will vary in abundance and diversity based on factors such as feeding habits, seasons, water flow, and water levels in the reservoir. The latter also has a relationship with the nutrient levels in the water (Nazeer *et al.,* 2016; Tongnunui *et al.,* 2016; Momi *et al.,* 2021; Santos *et al.,* 2021). January and winter (Oct.–Jan.) had the highest number of fish individuals, with 597 individuals (15.69%) and 1881 (50.96%), respectively, of fish compared to other months and seasons. From the study, it was found that Huai Kao Reservoir is a medium-sized, shallow, and moderate-capacity water storage facility. The water level and volume of the reservoir vary according to the seasonal changes in water flow and the release of water for agriculture. (Jaureguizar *et al.,* 2016). From October onwards, The Royal Irrigation Department (RID) will not release water due to the impact it would have on agriculture and rice harvesting. Additionally, water will be reserved for use during the summer season, causing water levels in reservoirs to increase. some areas may experience flooding at their highest levels, particularly in broad, suitable areas for egg laying, breeding grounds for juvenile fish, and areas where water is collected (Lim et al., 1999; Saowakhontha, 2005). The fish sample collection data showed that *Henicorhynchus caudimaculatus and Puntius brevis* was the most prominent species and quantity (Table 1). Follow with Saowakhontha, (2005) Almost all fish species reproduce by laying eggs to enhance the population of new generations. In particular, Puntius brevis is found in large numbers during this period at Krasieo Dam. July and the rainy season (Jun–Sep.) had the least number of fish individuals, with 597, 146 (3.96%), and 712 (19.29%), respectively. In July, the rainy season, causing an influx of sediment and algae in the water, spawning and juvenile grayling tended to decrease, leading to stress in fish, decreased appetite, and reduced food intake (Pisaturo *et al.,* 2021). As a result, fish populations are at their lowest individual levels.

3.4 Diversity index

The factors related to fish sampling and environmental conditions can impact the Shannon diversity index (H) Species richness (S) and Evenness index (E) of fish in a reservoir or station, causing differences in water catchment areas. These factors include the sampling tools used, the sampling duration, the number of sampling points, the differences in geographical characteristics, elevation, water quality, season, water flow, water volume, tributaries and catchment depth, and the availability of food sources such as plankton, aquatic plant, and terrestrial animals which serve as habitat and refuge from fish predators, such as woody debris and vegetation (Saowakoon, 2012; Mishra *et al.,* 2014; Lee *et al.,* 2014; Miranda, 2017; Sakset *et al.,* 2021). The average value of the Shannon diversity index (H), Species Richness (S) and Evenness index (E) was 1.50, 1.74 and 0.75 respectively. A value of 1-3 for the Shannon diversity index suggests that the water body is still suitable for the survival and growth of aquatic organisms (Tudorance *et al.,* 1975). In this study, the factors contributing to the diversity index area at Huai Kho reservoir were differences such as water quality, season, water flow, tributaries, water volume, catchment depth, and aquatic plants.

5. Conclusion

This study identified a total of 3691 individuals belonging to 14 families and 22 fish species. The most abundant family was Cyprinidae, comprising 8 species (36.36%). Threatened Status of Fish, Most fish species were in the "Not Evaluated" and "Least Concern" groups. Whereas, the exotic species, especially Nile tilapia (*Oreochromis niloticus*) with 47 individuals (0.51%), comprised all fish caught. Winter, January, and Station 3 had the highest number of individuals, with 1881, 804, and 579, respectively. The average values of the Shannon diversity index (H), Species richness index (S), and Evenness index (E) were 1.50, 1.74, and 0.75, respectively, indicating moderate diversity and sufficient productivity with fairly balanced ecosystem conditions and medium ecological pressure. This indicates a moderate level of fish abundance with a tendency towards decreasing productivity. To prevent further reduction of fish production in the reservoir, measures should be implemented to control the use of reservoir dredging, increase the capacity of the reservoir, use appropriate fishing equipment, prohibit fishing during spawning seasons, add habitat/cover for fish, establish rules and regulations for fishing in the community water supply, and increase the number of fish in the reservoir through the release of fish species and limiting the fishing in the reservoir.

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