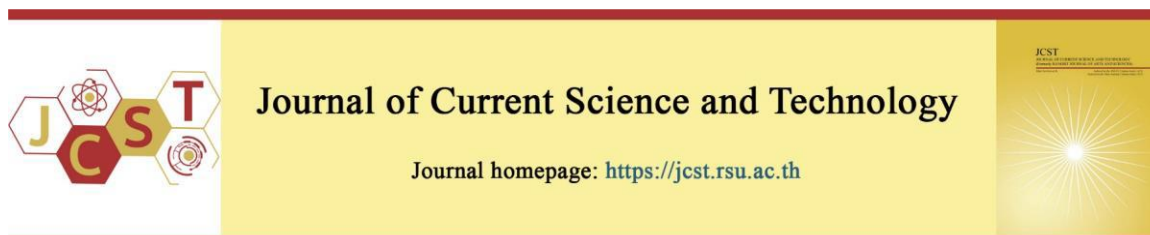


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Species Diversity of Fish and Consumption in Nan River in Bang Krathum District, Phitsanulok Province, Thailand

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Abstract

The fishery is an essential part of Thai culture and provides the rural population with a significant amount of animal protein. This research targeted the examination of fish species, the status of fish capture and consumption along the Nan River in the Bang Krathum district, Phitsanulok province, Thailand. Between November 2019 and April 2020, three sites were sampled along the river, and four sites were sampled in the local markets. A total of 35 individuals including fishermen, fish traders, and governmental officers involved in the region's fish resource management were subjected to purposive sampling. The data analysis was undertaken utilizing methods such as mean, frequency and percentage. The findings revealed 28 fish species across 11 families and six orders. The family Cyprinidae in the order Cypriniformes had the highest number of species (10 species). The number of fish species found in the local markets (19 species) was higher than those found in the river (17 species). In terms of consumption, the majority of fishermen and fish traders were female (65.71% and 84.62%, respectively). However, 95.00% of them lacked certification for fishing in public areas. The preferred method of fishing was floating netting, with predominant catch of carp species recorded at least twice a week. Compared to previous figures, productivity has decreased indicating a need for adequate training and knowledge about natural resource management and stocking enhancement.

Keywords: fish diversity; fish supplier; fisherman; Nan River; fish species; fish capture

1. Introduction

The Himalayas and the Tibetan Plateau, along with their southeastern extensions, are the source of several significant rivers. These include the Ayeyarwady or Irrawaddy, Chindwin, Salween, Sittaung, Mekong and Chao Phraya. These rivers are central to individuals' livelihoods and lifestyle, providing vital resources such as food (Tordoff et al., 2012; Barman et al., 2018). These rivers span a large geographical area, constituting an Asian hotspot that potentially boasts the highest diversity

of freshwater fish. Despite this, the regions remain largely under-researched, leaving room for further exploration and discovery (Lee & Zöckler, 2017; Zhang et al., 2021).

Over 1,178 species and more than 100 families of fish inhabit these rivers. Of these, 470 species are found in the Ayeyarwady, 151 species in the Salween, 328 species in the Mae Klong–Chao Phraya and over 500 species in the Mekong (Kottelat et al., 2012; Welcomme et al., 2016; Li et al., 2021). These regions form part of the Indo-

Burma hotspot, centered on the Indochinese Peninsula, and encompassing of Cambodia, Laos, Myanmar, Vietnam, Thailand, and parts of Southern China. Despite being one of the world's most biologically diverse and endemic hotspots, these areas also face immense threats (Tordoff et al., 2012; Hughes, 2017; Eriksen et al., 2021).

Thailand, in particular, enjoys abundant natural resources, including a rich aquatic fauna and flora that thrive due to its diverse climate, topography, and habitats. Freshwater sources, such as large and small rivers, streams, rivulets, lakes and wetlands, and floodplains, feature prominently in the country's terrain. Notably, wetlands constitute around 7.60% of Thailand's land area (Singh et al., 2021). The Chao Phraya, perhaps the most well-known Thai river, is formed by four rivers (the Ping, Wang, Yom, and Nan) that originate in northern Thailand. The Ping and Nan meet at Pak Nam Pho sub-district in Nakhonsawan province to form the Chao Phraya, which then traverses 10 provinces before reaching the Gulf of Thailand (Veesakul, 2016).

The Nan, considered as one of the four largest rivers in Thailand, originates from the Northern region of the Luang Phra Bang Range along the Laotian border. It traverses Uttaradit, Phichai, and Phitsanulok provinces before converging with the Ping in Nakhonsawan province. Serving as a critical water source for both agriculture and aquaculture, the Nan River also supports the livelihood of approximately one million residents in Phitsanulok province, including those in Bang Krathum district (Chuenchum et al., 2017; Nusit et al., 2019).

Historically, the Nan River housed a diverse range of aquatic plants and animals such as green algae (Ruen-Pham et al., 2021), aquatic insects (Buntha et al., 2020; Phutthanurak & Thapanya, 2020) and particularly fish (Lothongkham et al., 2014; Lothongkham & Ratmuangkhwang, 2018; Lothongkham & Jaisuk, 2020), on which many locals heavily relied. The inhabitants of the Nan River basin have developed various fishing techniques, such as angling, use of hooves, and bamboo traps. In this region, fish form a significant source of animal protein and also generate income for the community.

Nevertheless, a rapid decline in fish diversity in the Nan River has been observed (Noommeechai et al., 2015). These shifts have been attributed to changes in river flow, natural conditions, and a range of human activities in the basin, including fishing during the spawning season and dumping of wastewater, sewage, and trash into the river. These activities have altered the physical characteristics of the river, leading to a significant loss of animal diversity.

2. Objectives

The objective of this study is to investigate the variety of fish species, the condition of fish harvesting, and its consumption in the Nan River within Bang Krathum district, Phitsanulok province, Thailand. The findings from this research could provide useful insights for local authorities, aiding in the development of plans to effectively manage and enhance conservation of natural resources in the region.

3. Materials and methods

The study was conducted in Bang Krathum, which has an area of 447 km² and approximately 47,000 inhabitants. The location is divided into seven communes, with the Nan River flowing through Sanam Khli (1), Ban Rai (2), and Khok Salut subdistricts (3). The survey of fish suppliers was undertaken in the four main markets: Bang Krathum (a), Ta Yom temple (b), Noea Kum (c), and Train station (d) (Figure 1).

The study utilized purposive sampling to obtain input from 20 fishermen in the above-mentioned subdistricts, 13 fish traders from local markets, and two government officials involved in Nan River management. Between November 2019 and April 2020, fish samples were collected once a month from local fishermen and marketplaces. The classification of fish was determined by their morphological characteristics such as mouth, fins, and scales, following the methods of Vidthayanon (2017) and Jaiphong & Pepperboonchan (2018), and confirmed using descriptions from the FishBase site.

The collected data were analyzed using statistical measures such as mean, frequency and percentage.

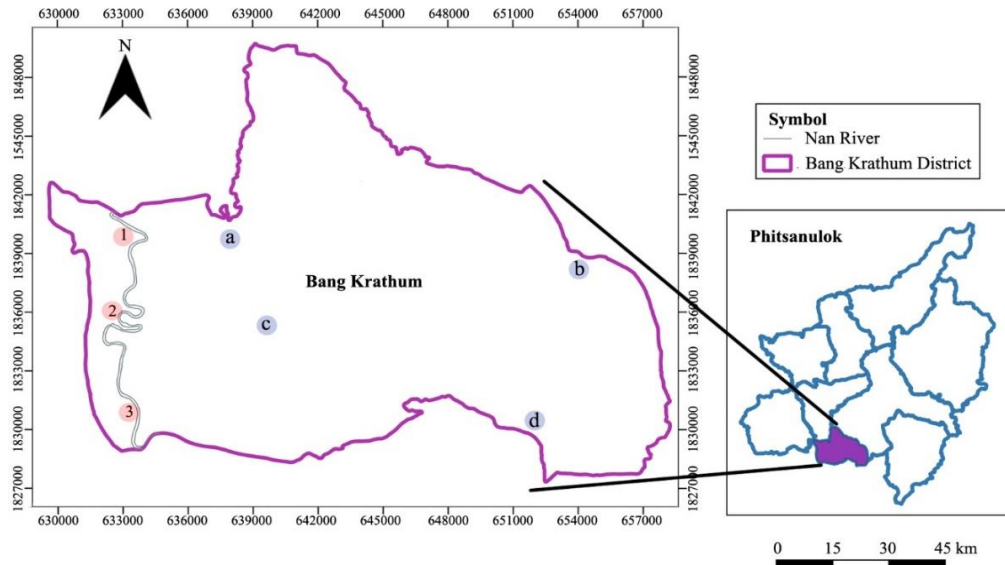


Figure 1 Locations of the study area (Bang Krathum district, Phitsanulok province, Thailand) were mapped using free and open-source software (QGIS).

Table 1 Species list of freshwater fish, presence (+)/absence (-) in the two study sites.

Order	Family	Scientific name	Common name	Local name	Natural fish	Local market
Anabantiformes	Anabantidae	<i>Anabas testudineus</i>	Climbing Perch	Pla Mor	+*	-
	Channidae	<i>Channa lucius</i>	Snakehead	Pla Ka Song	-	+
		<i>Channa striata</i>	Striped Snakehead	Pla Chon	+	+
		<i>Trichopodus pectoralis</i>	Snakeskin Gourami	Pla Sa Lid	-	+
	Osphronemidae	<i>Trichopodus microlepis</i>	Moonlight Gourami	Pla Kra Di	+*	-
Cichliformes	Cichlidae	<i>Oreochromis niloticus</i>	Nile Tilapia	Pla Nil	-	+
		<i>Oreochromis niloticus x O. mossambicus</i>	Red Tilapia	Pla Tub Tim	-	+
Cypriniformes	Cyprinidae	<i>Barbonymus schwanenfeldii</i>	Tinfoil Barb	Pla Ta Pien Tong	+*	-
		<i>Barbonymus gonionotus</i>	Silver Barb	Pla Ta Pien	+	+
		<i>Hampala macrolepidota</i>	Hampala Barb	Pla Soop	-	+
		<i>Henicorhynchus siamensis</i>	Siamese Mud Carp	Pla Soi	+	+
		<i>Labiobarbus siamensis</i>	Minnnow	Pla Luk Khuy	+	+
		<i>Osteochilus vittatus</i>	Bonylip Barb	Pla Nok Khao	+	+
		<i>Paralaubuca riveroi</i>	East Asian Minnows	Pla Paeb	+	+
		<i>Puntioplites proctozystron</i>	Minnnow	Pla Kra Mang	+*	-
		<i>Systemus rubripinnis</i>	Javaen Barb	Pla Kam Cham	-	+
		<i>Thynnichthys thynnoides</i>	Minnnow	Pla kled Tee	+*	-
Osteoglossiformes	Notopteridae	<i>Notopterus notopterus</i>	Bronze Featherback	Pla Cha Lad	-	+
Siluriformes	Bagridae	<i>Hemibagrus filamentus</i>	Asian Redtail Catfish	Pla Kod Kang	-	+
		<i>Hemibagrus nemurus</i>	Yellow Mystus	Pla Kod Lueng	+*	-
		<i>Hemibagrus wyckioides</i>	Asian Redtail Catfish	Pla Kod Kheiw	-	+
		<i>Mystus multiradiatus</i>	Bagrid Catfish	Pla Kha Yaeng	+	+
	Clariidae	<i>Clarias batrachus</i>	Philippine Catfish	Pla Duk	-	+
Pangasiidae	<i>Pangasianodon hypophthalmus</i>	Striped Catfish	Pla Sa Wai	+	+	
	<i>Pangasius larnaudii</i>	Spot Pangasius	Pla The Pho	+*	-	
Siluridae	<i>Ompok bimaculatus</i>	Butter Catfish	Pla Cha On	+*	-	
	<i>Phalacronotus bleekeri</i>	Sheatfish	Pla Deng	+*	-	
Synbranchiformes	Synbranchidae	<i>Monopterus albus</i>	Asian Swamp Eel	Pla Lai	-	+
Total: 6	11	28			17	19

Note: * nine species were used for consumption in the household.

4. Results

4.1 Fish Species Identification

During the study, it was observed that the fish were abundant and widely spread across the area. From the study sites selected, 28 species of fish from 11 families across six orders (Anabantiformes, Cichliformes, Cypriniformes, Osteoglossiformes, Siluriformes, and Synbranchiformes) were collected (Table 1). The order Cypriniformes had the greatest variety, with 10 species recorded. All captured species were sorted based on their economic importance.

Of the total species identified, nine were consumed domestically, leaving 19 species with significant economic value. Interestingly, while the Cichlidae, Notopte-ridae, and Synbranchidae families were not among the caught fish, they were available in local markets. Conversely, the family Siluridae, presented in the list of caught fish, did not feature in the markets.

4.2 Fish Capture Practices

The study revealed that there was an estimated total of 23 (65.71%) women fishers and 12 (34.29 %) men fishers in the regions sampled. A total of 78 fish traders, most of them were 66 (84.62%) women and 12 (15.38%) were men. Many fishermen, 95.00%, fished from public waters whereas a meager 5.00% reported fishing from private bodies of water.

The most popular tool for capturing fish was the floating net, used by 80.00% of the fishermen. The next popular tool was the casting nets, used by 5.00% of the fishermen. The choice of netting was largely due to its ease of use, particularly by women who constituted 65.71% of the participants in the survey.

Other tools (15.00%) used were angling rods, and traps. Importantly, no participant reported using blast fishing. Nets used had a mesh size that varied between 2-7 cm, with the preferred size being 4 cm. The next popular sizes were 3 and 6 cm, respectively.

In this scene, fishermen heavily relied on this profession to make ends meet, with half of them fishing 2-4 times weekly and a quarter indulging in the activity more than 5 times a week. They all reported that they could fish anytime except during fish breeding seasons. They, however, lacked clear indicators or specific timings for these breeding seasons.

Fish captures were reported to have reduced compared to past years. Most (80.00%) only managed to capture less than 10 kg per day. Only 10.00% admitted to catching 10-20 kg each day while an undisclosed number reported larger catches (Table 2). Most participants (95.00%) lacked formal authorization to fish in public waters; they attributed this to their proximity to the rivers. Only one participant held a permit, he admitted to relying heavily on fishing as a primary source of income for his family. Interestingly, however, a majority (60.00%) of the fish caught was for home use.

Survey results indicated that the fish caught by fishermen comprised 17 species from seven families and three orders (as per Table 3). The order Cypriniformes, primarily consisting of carp, was found to be the largest group, accounting for over half of all species (51.82%, or eight species within a single family). Within this order, *Henicorhynchus siamensis* (Figure 2a) and *Barbonymus gonionotus* (Figure 2b) stood out as the species most frequently caught by fishermen, contributing 28.14% and 12.54%, respectively.

The order Siluriformes was the second most abundant, comprising 24.77% of caught fish and showcasing six species from three families. Out of these, *Mystus multiradiatus* (9.43%) and *Hemibagrus nemurus* (6.25%) were the most caught. The least caught species among surveyed fishermen was the *Anabas testudineus* (1.48%), which is a part of the family Anabantidea within the order Anabantiformes.

4.3 Fish Selling Status

For all the fish sellers surveyed, selling fish at markets constituted their primary line of work. The survey identified four local markets within the district where fish obtained from fishermen was sold (refer to Table 4). The largest of these was the market situated in front of the station, regularly hosting seven fish sellers (53.85%). The ensuing market in terms of size was the one at Ta Yom temple (23.08%). In the remaining market, there was only a single seller (7.69%). Most fish sellers (53.85%) sold fish sourced from aquaculture farms, namely their own or neighboring farms. Meanwhile, five instances were identified where fish was sold after being sourced from nature (38.46%). In one case, the seller traded fish sourced from both aquaculture farms and natural habitats (7.69%).

Table 2 Information about catching fish in this survey.

Information	Number	Percentage
Fishing places		
Private area	1	5.00
Public river	19	95.00
Total	20	100.00
Catching tools		
Casting net	1	5.00
Floating net	16	80.00
Other tools	3	15.00
Total	20	100.00
Frequency of catching fish (Time of catching per week)		
≤1	5	25.00
2-4	10	50.00
≥5	5	25.00
Total	20	100.00
Amount of caught fish (Kg per catching time)		
≤10	16	80.00
10-20	2	10.00
20-30	1	5.00
≥30	1	5.00
Total	20	100.00

Table 3 Species list, number and percentage of fish caught by fishermen in this study.

Order	Family	Scientific name	Number	Percentage	Total (%)
Anabantiformes	Anabantidae	<i>Anabas testudineus</i>	39	1.48	23.41
	Channidae	<i>Channa striata</i>	372	14.09	
	Osphronemidae	<i>Trichopodus microlepis</i>	207	7.84	
Cypriniformes	Cyprinidae	<i>Barbonymus schwanenfeldi</i>	84	3.18	51.82
		<i>Barbonymus gonionotus</i>	331	12.54	
		<i>Henicorhynchus siamensis</i>	743	28.14	
		<i>Labiobarbus siamensis</i>	43	1.63	
		<i>Osteochilus vittatus</i>	41	1.55	
		<i>Paralabuca riveroi</i>	42	1.60	
		<i>Puntioplites proctozysron</i>	41	1.55	
		<i>Thynnichthys thynnoides</i>	43	1.63	
Siluriformes	Bagridae	<i>Hemibagrus nemurus</i>	165	6.25	24.77
		<i>Mystus multiradiatus</i>	249	9.43	
	Pangasiidae	<i>Pangasianodon hypophthalmus</i>	48	1.82	
		<i>Pangasius larnaudii</i>	24	0.91	
	Siluridae	<i>Ompok bimaculatus</i>	123	4.66	
		<i>Phalacrotonotus bleekeri</i>	45	1.70	
Total: 3	7	17	2,640	100.00	100.00

Survey results revealed that 19 species of fish from nine families and six orders were identified in the local markets. The most frequently available order was Siluriformes, making up 40.40% of the market presence with five species from three families. Cichliformes was the second most popular order, representing 21.16% of the market fish and containing only one family: Cichlidae. It is

noteworthy that, although the Cichlidae (21.16%) and Clariidae (19.19%) families were the most common in the market, all fish from these families originated from aquaculture farms. Further, the Channidae and Cyprinidae orders were equally represented in the market, each comprising 15.44% and 13.43%, respectively (see Table 5).



Figure 2 Most frequently caught fish species in order Cypriniformes by fishermen.

Table 4 Sources of fish and selling places in the region

Sampling area	Number of fish seller	Percentage
Selling places		
Bang Krathum market	2	15.38
Ta Yom temple market	3	23.08
Noen Kum market	1	7.69
Train station market	7	53.85
Total	13	100.00
Source of fish		
Aquaculture farms only	7	53.85
Capture from nature	5	38.46
Both of aquaculture farm and capture	1	7.69
Total	13	100.00

Table 5 List of fish species, number and percentage of their availability in the local markets

Order	Family	Scientific name	Number	Percentage	Total (%)
Anabantiformes	Channidae	<i>Channa lucius</i>	38	1.92	17.36
		<i>Channa striata</i>	267	13.52	
	Osphronemidae	<i>Trichopodus pectoralis</i>	38	1.92	
Cichliformes	Cichlidae	<i>Oreochromis niloticus</i>	228	11.54	21.16
		<i>Oreochromis niloticus x</i>	190	9.62	
		<i>O. mossambicus</i>			
Cypriniformes	Cyprinidae	<i>Barbonymus gonionotus</i>	40	2.03	13.43
		<i>Hampala macrolepidota</i>	37	1.88	
		<i>Henicorhynchus siamensis</i>	38	1.92	
		<i>Labio barbatus siamensis</i>	37	1.88	
		<i>Osteochilus vittatus</i>	38	1.92	
		<i>Paralabuca riveroi</i>	38	1.92	
		<i>Systomus rubripinnis</i>	37	1.88	
Osteoglossiformes	Notopteridae	<i>Notopterus notopterus</i>	114	5.77	5.77
Siluriformes	Bagridae	<i>Hemibagrus filamentus</i>	38	1.92	40.40
		<i>Hemibagrus wyckioides</i>	78	3.95	
		<i>Mystus multiradiatus</i>	77	3.90	
	Clariidae	<i>Clarias batrachus</i>	379	19.19	
	Pangasiidae	<i>Pangasianodon hypophthalmus</i>	226	11.44	
Synbranchiformes	Synbranchidae	<i>Monopterus albus</i>	37	1.88	1.88
Total: 6	9	19	1,975	100.00	100.00

5. Discussion

The present study found that fishermen in the region did not employ methods of mass fish extermination such as the use of electrical or explosive tools. Most of the fishermen, however, lacked formal training and authorization to fish in public areas. It became apparent that there is a need for training in fishing practices, appropriate equipment, and environmental management, including understanding fishing seasons and size limitations for species. Although fishermen in the region were able to use any net size which they deemed effective, the local government has yet to pay significant attention to the region's fishing habits and attitudes.

Bopuch et al. (2020) previously reported in this area that the fishermen hold certain educational levels, a factor that could facilitate training or introducing innovation in the region. Despite having a positive attitude towards animal conservation and making efforts to prevent over exploitation during the spawning season, the fishermen should be bestowed more knowledge in this regard. They need to understand net mesh regulations, fish spawning indicators, and catch limit periods. The local authorities also play a role in supplying information or establishing guidelines to the fishermen to effectively conserve aquatic animals in the region. For instance, Tuncharoen et al. (2018) suggested that fishermen must avoid catching fish during the reproductive season by using gillnets.

Even though 75.00% of the fishermen indicated that fishing is their primary occupation and often fish more than twice a week, the main labor in the interviewed households was less involved in this activity. This research found that the fish farmers in the region are women, a ratio considerably lower than in northeastern Thailand where Thalerngkietleela et al. (2007) reported it to be 97.20% (Nong Khai province) and 96.80% (Nakhon Phanom province). This is in line with Lebel et al. (2009) and Louis & Phimpakan (2017) who stated that women significantly contribute to fishing farms in northern Thailand. However, this also suggests that fishing is not a major income source for these individuals, as men - the main labor - participate less in the activity. In this case, women play a vital role in capturing fish and securing food for families in the region, implying that gender could influence fishing methods. It is observed that most fishermen prefer

using floating nets and dip-nets, which are easier for women to handle and set up.

In this study, the nets utilized by the fishermen varied in mesh sizes, ranging from 2 to 7 cm. This is in line with the survey at Sakon Nakhon province and Surin province reported by Rayan et al. (2020), and Maneechot et al. (2020), respectively. However, the fishermen here did not solely rely on floating nets or gillnets as seen in the previous study, they use casting nets as well. Furthermore, fishing during nighttime (from 7PM to 4AM) with a one-day gap after three days of fishing was observed, contributing to a sustainable approach to prevent overexploitation of aquatic resources.

The current research found a total of 28 species from 11 families and six orders, the most dominant being the family Cyprinus. Nevertheless, this biodiversity is lower compared to the 38 species from 20 families found by Jaiphong & Pepperboonchan (2018) in the same area. In contrast to the 45 species and 19 families reported by Lothongkham et al. (2009) in Hang River (the tributary of upper Nan River), this study may not comprehensively reflect fish diversity considering no specific tool was used for sampling, but it does give insight into the fish caught and consumed by the local population. Previous studies including Naanan et al. (2011), Kulabong et al. (2013), Chapasri (2000), and Chankaew et al. (2022), reported varying findings indicating a decrease in both catch productivity and fish diversity in the region.

Captured fish remain important to the region, constituting approximately 40.00% of the market sales with the remainder being from aquaculture. This is in contrast to a recent report by the Southeast Asian Fisheries Development Center (2023) which stated a lower ratio of capture production to fishery production of freshwater fishery in Thailand in 2020 (8.60% and 5.15%, respectively). It is possible that these fisheries have long been a part of Thai culture and constitute a significant source of animal protein for the rural population, according to Chawpaknum (2013), and Pongsri & Sukumasavin (2023) in Food and Agriculture Organization's reports. Also, the fish is a critical component of food security in Thailand, including low-income countries (Teh et al., 2016; Piumsombun, 2003).

In this region, Tilapia (Cichliformes) and Catfish (Siluriformes) dominated the market, accounting for approximately 61.56% of all fish

species sold. These species were abundantly available, while other species, although rarer, attracted higher prices due to their scarcity. Interestingly, Tilapia held significant importance, to the extent that no fisherman reported being able to catch this species from the river. Similarly, the Climbing Perch (*Anabas testudineus*), a self-recruiting species, was seldom caught, possibly due to the size of the fish or the unsuitable tools utilized. The Carp family (Cyprinidae) emerged as the most accessible species for capture, but was not highly favored by the locals, except for the Silver Barb (*Barbonymus gonionotus*). These carp species were viewed as inexpensive fish, often reserved for home consumption rather than market sale. If sold, they were typically bundled and sold in groups.

Fish species from the Bagridae family have seen a significant decline in production, but they still represent 15.68% of the total catch and 9.77% of the market. Interestingly, local fishers reported a noticeable decrease in the size of these fish compared to the past. Most of the fish markets were sold fresh, with only 20.00% sold as processed products (mainly dried or fermented fish). The variety of fish species on sale slightly exceeded that reported by fishermen, with 19 species across nine families recorded in this region. This discrepancy was attributed to fish traders procuring fish from aquaculture farms, with 61.54% of them confirming this practice. This study, however, recorded a lesser diversity of fish in the market compared to the findings reported by Kunlapapuk & Kulabtong (2015) in the Noi River at the Ayutthaya province. It is possible that this study is relatively a small area. Therefore, it might be related to the lower number of recorded species.

6. Conclusion

This research contributed to updating data on fish species distribution in Thailand, discovering 28 distinct species from six orders and 11 families. Fish caught by fishermen were categorized into 17 species across seven families and three orders, while 19 species from nine families and six orders were found in local markets. Despite being among the captured species, the Siluridae family was absent from the markets. Conversely, Cichlidae, Notopteridae, and Synbranchidae - not listed as captured - appeared in local markets at frequencies of 21.16%, 5.77%, and 1.87%, respectively. The results underline the importance of aquatic resources for local inhabitants, predominantly managed by women. Nevertheless,

most of the region's fishermen lack formal training in natural resource management. Hence, local authorities need to establish suitable regulations to protect aquatic resources and enhance community knowledge about this aspect. Future studies should focus on evaluating fish distribution, threatened status, and economic value.

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