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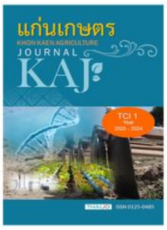

Modified fish-based index to assess biological integrity for evaluation of running water in Northern Thailand

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ABSTRACT: The fish-based index of biotic integrity (F-IBI) is widely used to assess river ecosystems. We have adapted modification and used Karr's index of biotic integrity (IBI) and also literature for the running water, including 18 metrics in seven categories. With survey data from the Maetang River fishery resources in 2003 and 2019, fish diversity, fish status, habitat composition, tolerant, trophic composition, fish health and altitude distribution in the river's Maetang River were examined. The fish data of this study consisting of 13 family and 32 species. These metrics were used in the final IBI, which ranged from 18 (worst) to 90 (best). The total Fish-IBI score of 53 was calculated, which ranked as fair level. This study will become a great reference for water resources management and ecosystem restoration in the running river.
Keywords: ecological indicators; metrics; fish assemblages; species richness indicator; habitat quality

Introduction

Freshwater ecosystems are important components for all creatures living in the rivers which provide important ecosystem services. However, these important ecological features are being altered, degraded, and even destroyed and threatened due to anthropogenic pressures and experiencing declines in biodiversity (Riecki et al., 2020). Biological assessments are crucial tools for measuring the ecological integrity of freshwater ecosystems and for protecting aquatic life (Aparicio et al., 2011). Fish are considered sensitive indicators of stream habitat since they were well studied and easy to identify. Even small and fish communities also represented several trophic levels and they have long been used as indicators of stream ecosystem health, collectively grouped under the term "index of biotic integrity" (IBI) (Capmourteres et al., 2018). Most fish-based indices are derived from the original IBI and are popular in the world, but not appear in Thailand.

Maetang River in Chiangmai Province, which is a rapidly developing tourist region located in the upper Ping River basin have become degraded in recent decades. All of the above changes have led to a marked deterioration in the ecosystem function. The investigation of fish assemblages in the Maetang river was conducted in 2000 (Suvarnaraksha, 2003) and the study focused on the diversity of fish. There were no studies that have evaluated the ecosystem health based on fish assemblages. The main objective of the study is to develop and apply the fish index of biotic integrity for used assess running ecosystem health and provide a baseline for future water quality assessment in the running water.

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Materials and methods

2.1 Study area

The Maetang River is a tributary of the Ping River in Chiang Mai Province, covered by mountains and forests, agricultural areas, and urban; 72.1 %, 25.4 %, and 0.3% respectively. The location of the Maetang river is bounded by coordinates 19° 10' to 19° 45' N and 98° 27' to 98° 55' E and the river mainstream is 135 km. long and drains an area of approximately 223.51 km^2 (Suvarnaraksha, 2011). The elevation range of the Maetang River is 338-1342 m. above sea level. The Maetang River is fast-flowing and clear water with rocks, gravels and pebbles as its sandy bottom are covered by forest canopy (Suvarnaraksha, 2011). Fish data are collected from 31 stations along the Maetang River (**Figure 1**).

2.2 Data sources and sampling protocols

1. Previous data: the data was conducted from August 2000 to June 2001 with electric-fishing with an AC shocker (Honda EM 650, DC 220 V. 550BA 450VA, 1.5-2 A, 50 Hz.) together with block nets and scoop nets (100 m^2 per sampling site) (preserved). Fish were identified to species and preserved followed (Suvarnaraksha, 2018). The specimens were identified followed (Vidthayanon et al., 1997; Suvarnaraksha, 2003; Suvarnaraksha, 2017; Suvarnaraksha, 2018; So et al., 2018). Physicochemical water quality samples were collected from 31 stations was then measured by YSI 556 in the field. Meanwhile, the substrate types were recorded i.e. rocky, sandy and gravel (Suvarnaraksha, 2003).

2. Present data: fish specimens were collected from tributaries of Meatang River from May 2019 to April 2020by using push-net and gill net. Fishes were identified and classified followed (Suvarnaraksha, 2003; Suvarnaraksha, 2011; Vidthayanon, 2017; Froese and Pauly, 2019).

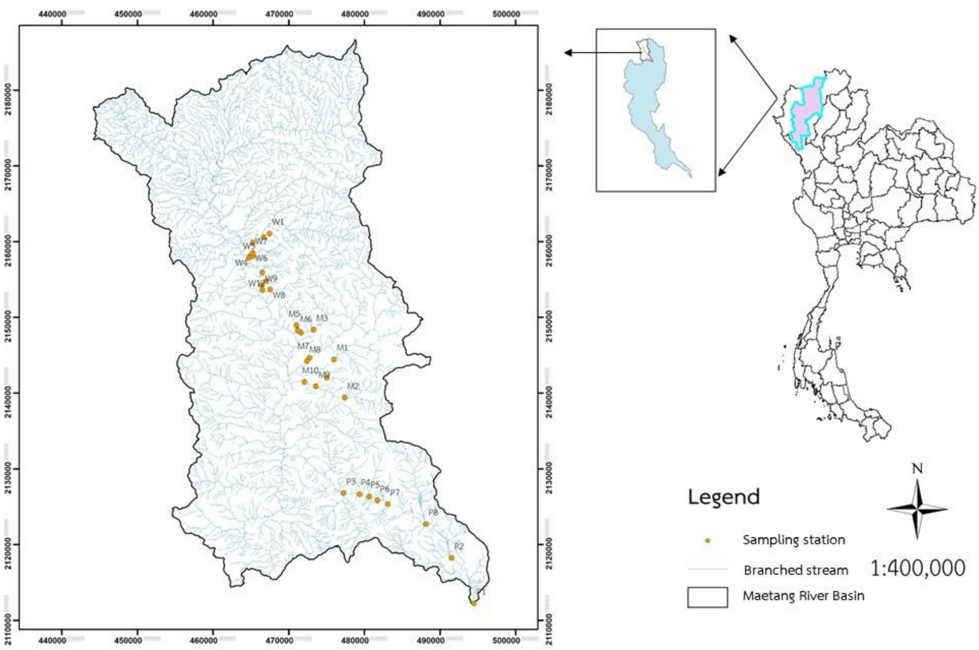

Figure 1 Map of Maetang River, Chiang Mai province

2.3 Development the fish index

We applied metrics of running water by based on literature (Karr et al., 1986; Lyons, 2006; Zhu and Chang, 2008; Suvarnaraksha et al., 2012; Wu et al., 2014; Li et al., 2018; Vile and Henning, 2018; Zogaris et al., 2018)

In the studies of Karr (Karr, 1981; Karr et al., 1986; Li et al., 2018) the scores were classified into 6 grades indicating ‘‘Excellent’’ to ‘‘No fish’’ from high score to low score when the score values range from 0 to 60. In this case, the underlying ideas of the hypothetical reference score method (Wu et al., 2014; Van Oosterhout and Van Der Velde, 2015; Sapounidis et al., 2019; Zogaris et al., 2018; HaRa et al., 2019; Chen et al., 2020) are used.

Results and Discussion

Fish assemblages

About 20 years ago, a total of 51 fish species under 16 families were recorded from 31 stations of Maetang River (Suvarnaraksha, 2003). As of writing and data collected in 2019, the Maetang River fish diversity was decreased and it includes 32 species with 13 families. The characteristics of assemblages of Maetang River had been described with its fish status, habitats, trophic guilds, and altitude distribution appearance based on the data recorded. (Suvarnaraksha, 2003). The classified fish for evaluation are given in **Table 1**; family Cyprinidae dominated the river, and most of them are native species while there are only four alien species (**Table 1**). The trophic composition was dominated by insectivores (34 species), omnivores (9 species), and carnivores (8 species). The altitude distribution was dominated by 31 piedmont, 9 lowland, 6 mountain, and 5 transitory species. The habitat composition was dominated by the bottom, water column and pelagic species with 29, 14 and 8 species, respectively. The last group in fish health status includes 33 intolerant and 18 tolerant species, and no number of disease health (area-dependent) was found.

Developing the running water IBI’s

The fish index developed in this study consists of 18 metrics, which are the new metrics for Thailand. It delineates the differences in biotic integrity among different sites. Although the Fish IBI was developed to assess lakes (Rayan and Ngamsnae, 2020), no information for assessing rivers was reported. Thus, the metrics for assessing a river case study of the Maetang River was a new model for river assessment in Thailand.

The adapted metrics M1-M3 (Vile and Henning, 2018; Wu et al., 2014; Zogaris et al., 2018) were not used previously in developing fish indices in Thailand. The total number of fish species reflects the biodiversity of the river (Karr, 1981). Generally, the smaller number of fish species, the more destructed habitat it is. The habit composition in the water body reflects the ecological health degree of the habitat (Li et al., 2018). Additionally, we applied each of the 2 adapted metrics to support the part of diversity, which were M4 and M5(Lyons, 2006; Zhu and Chang, 2008). In this study, we modify the metrics used by Rayan and Ngamsnae (2020) and separated the native species and benthic species as individual. The native species are important as the increase in their number reflects natural abundance. As such, the *D. maetaengensis* is an endemic native species inhabiting to Maetang River while *O. Siamensis* is vulnerable benthic species inhabiting endemic to Inthanon Mountain. *O. Siamensis* must well adapt to the special habitats with flatten belly, adhesive maxillary barbel and pair fins, streamline body shape, and aerodynamic dorsal part. They are also feeding on the small invertebrates and aquatic insect larva on the rock (Suvarnaraksha, 2011). Alien species was intended to reflect the number of alien species established as well as the proportional abundance of alien individuals concerning native fish (Aparicio et al., 2011).

Trophic composition metrics evaluate integrity associated with functional (food chain) conditions, which are reflected in the structural changes in trophic composition (Karr et al., 1986). In the studies, three of the original metrics (M6-M8) were adapted (Pont et al., 2006; Hu and Chang, 2008; Raburu and Masese, 2012; Wu et al., 2014). Top carnivorous adults eat other predominant fishes or large invertebrates for assessing loss of trophic diversity and keystone species (Zhu and Chang, 2008). Carnivorous and insectivorous species will tend to decrease in response to an alteration of their habitat (HaRa et al., 2019). In contrast, a metric basis on omnivorous species will tend to increase in response to disturbance as omnivorous species can adapt their trophic regime in response to an alteration of river food webs (Pont et al., 2006).

Altitude distribution (M9-M12) is the new metric in Thailand. They are used to explain variation in fish community structure along a river gradient in the large-scale whole basin (Suvarnaraksha et al., 2012). Habitat compositions, two of the original metrics (M14-M15) were adapted (Zogaris et al., 2018). M14-M15 have been used to evaluate the effect of anthropogenic stress on fish assemblage integrity of Nong Han wetland (Rayan and Ngamsnae, 2020). In contrast, these metrics were used to evaluate only the percentage of the bottom species (Raburu and Masese, 2012; Jia et al., 2013). The new metric is the percentage of water pelagic species (M13) for this area and has been applied (Wu et al., 2014). It identifies some species living on the surface and feed on surface insect and an active swimmer.

Tolerance, abundance, and condition are divided into 3 metrics (M16-M18). We adapted M16-M18 (Van Oosterhout and Van Der Velde, 2015) which has been used in another country (Raburu and Masese, 2012; Jia et al., 2013). Some countries used only the percent of tolerant individuals (Zhu and Chang, 2008). These groups reflect species sensitivity (Pont et al., 2006), intolerant species are those that first decline with environmental degradation (Oberdorff et al., 2002) while the percentage of tolerant fish species would increase (Lyons, 2012; Schleiger, 2000). In Thailand, there is very little information on F-IBI of this metric, so we classified species as intolerant to evaluate species sensitivity to human influence on watersheds, determined by ichthyological books (Suvarnaraksha, 2003; Suvarnaraksha, 2011; Suvarnaraksha, 2017; Vidthayanon, 2017; IUCN, 2019; Rayan and Ngamsnae, 2020;). The number of metrics of disease health or anomalies (M18) depicts the health and condition of individual fish. The classification of four fish assemblages from the headwater to the lowland river reaches is important in explaining variation in fish community structure along the longitudinal gradient of a large, tropical river (Suvarnaraksha et al., 2012).

Fish-IBI metric for the Maetang River

We designed from separate assemblage metrics in the main two categories based on biological parameters and environmental parameters. The biological parameters consist of 3 parts i.e. 1) species diversity (M1-M3); 2) fish status (M4-M5); and 3) trophic composition (M6-M8). The environmental parameters consist of 4 groups i.e. 1) altitude distribution (M9-M12); 2) habitat composition (M13-M15); 3) tolerance (M16-M17), and 4) fish health (M18). The new metrics were altitude distribution classified by Suvarnaraksha (2012). Altitude distribution (M9-M12) group consists of lowland, transitory, piedmont and mountainous species. The lowland species (M9) are inhibited in larger watershed closed to agricultural and urban areas, which have high phosphorus loadings such as *Trichopodus trichopterus* and *Trichopsis vittata*. The transitory species (M10) are fishes in assemblages i.e., *Mystacoleucus obtusirostris*, and *Systomus rubripinnis* that lives in the lower portion of the river course, where the river width and depth were more than the previous two assemblages. The piedmont species (M11) are inhabiting the lower attitude area mountainous species such as *Barilius pulchellus* and *Discherodontus schroederi*. The mountainous species (M12) are inhabiting the small stream in high attitude area with low temperature, high water current velocity, and non-polluted, which includes *Oreoglanis siamensis* and *Glyptothorax trilineatus*. The Siamese bat catfish (*O. siamensis*) was in a high level of dissolved oxygen and well adapted to special habitat (Suvarnaraksha et al., 2012).

The scoring criteria were developed for each of the 18 metrics and the sum of the metric scores restricted to the range of 18 (worst) to 90 (best), which was the overall IBI score. Scoring criteria were established for the remaining metrics. For each metric, threshold values between "good" and "fair" values and between "fair" and "poor" values were defined based on the 75th and 25th percentile values for the least and strongly impacted groups (Lyons, 2012). The Maetang River had 53 scores which is in a fair level. It is similar to Nong Han wetland with 38 scores (Rayan and Ngamsnae, 2020) which ranked as fair level. The F-IBI was done by applying it to assess targeted sites in each country such as Yellow River with 18 scores (Li et al., 2018) evaluated as ‘‘fair’’ while the Lake Victoria had a good F-IBI value of 51 (Raburu and Masese, 2012). The biological health based on the IBI model also suggested that the watershed health was in fair to very poor condition (HaRa et al., 2019). The results were different depending on the areas and human activities in the past to the present. Any human activity that disturbs the pool-rifle structure, such as changes to the flow regime, increases in sediment load, and making an anoxic condition would affect this assemblage (Suvarnaraksha et al., 2012). The classification of biological integrity and their attributes corresponding to F-IBI scores based on the sum ratings was obtained as shown in **Table 3**. F-IBI index systems were established for the Maetang River and the scoring method was introduced above. The IBI values were 53 scores (**Tables 2**) and can be evaluated as ‘‘fair’’

Table 1 Classification of fish assemblages encountered during the study in terms of origin (Na= Native species and Al = Alien species), trophic group (ON= omnivores, IN= insectivores, and CA= carnivores), tolerance (IT=intolerant species, TO=tolerant species), Ad; altitude distribution (MT= mountainous species, PM=piedmont species, TS= transitory species, LL= lowland species) and habitat (PG = pelagic species, WC= water column species, BT= bottom species)

No.	Family/ Species	Origin	Trophic group	Tolerance	Habitat	Ad.	IUCN
1	*Barilius pulchellus* (Yellow Baril, ปลาน้ำหมึก)	Na[7]	IN[1, 2, 3]	IT[6]	PG [3]	PM	LC
2	*Danio albolineatus* (Pearl Danio, ปลาซิวใบไผ่แถบเล็กขาว)	Na[7]	IN[1, 2, 3]	TO[7]	PG [3]	MT	LC
3	*Devario maetaengensis* (Maetang Danio, ปลาซิวใบไผ่แม่แตง)	Na[7]	IN[1, 2, 3]	TO[7]	PG [3]	MT	LC
4	*Esomus metallicus* (Flying Barb, ปลาซิวหนวดยาว)	Na[7]	IN[1, 2, 3]	IT[7]	PG [3]	LL	LC
5	*Rasbora myersi* (Myer's Minnow, ปลาซิวมายเออร์)	Na[7]	IN[1, 2, 3]	IT[7]	PG [3]	PM	LC
6	*Rasbora paviana* (Black Striped Minnow, ปลาซิวควายแถบดำ)	Na[7]	IN[1,2, 3]	IT[7]	PG [3]	TS	LC
7	*Bangana sinkleri* (Stone Lapping Barb, ปลาเพ้า)	Na[7]	IN [2]	IT[3]	BT[3]	PM	DD
8	*Discherodontus schroederi* (Stream Barb, ปลาแดงน้อย)	Na[7]	IN[1, 2]	IT[7]	WC[7]	PM	LC
9	*Ceratogarra cambodgiensis* (Stone Sucker, ปลาเลียหิน)	Na[7]	ON[1, 2, 3]	IT [6]	BT[3]	PM	LC
10	*Garra fuliginosa* (Rhino Stone Sucker, ปลามูด)	Na[7]	ON[1, 2, 3]	IT [6]	BT[3]	PM	LC
11	*Mystacoleucus obtusirostris* (Black Margin Spiny Barb, ปลาหนามหลัง)	Na[7]	IN[2, 3]	TO[3, 6]	WC[3]	TS	LC
12	*Neolissochilus stracheyi* (Blue Mahseer, ปลาพลวง)	Na[7]	ON[1, 2]	IT[6]	WC[3]	PM	LC
13	*Onychostoma gerlachi* (Shovel-jaw Barb, ปลาขิ้ง)	Na[7]	ON[6]	IT[6]	WC[6]	PM	NT
14	*Poropuntius bantamensis* (Stream Barb, ปลาจาด)	Na[7]	ON[3]	IT[6]	WC[3]	PM	LC

Note: The number in exponent corresponds to the following reference; 1. Suvarnaraksha (2003); 2. Suvarnaraksha (2011); 3. Suvarnaraksha (2017); 4. Vidthayanon (2017); 5. Rayan and Ngamsnae (2020); 6. IUCN red list (2019) and 7. Information from expert

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No.	Family/ Species	Origin	Trophic group	Tolerance	Habitat	Ad.	IUCN
15	*Pethia stoliczkana* (Stoliczkae's Barb, ปลามะไฟ)	Na[7]	IN[2]	IT[7]	WC[3]	PM	LC
16	*Puntius brevis* (Golden Little Barb, ปลาตะเพียนทราย)	Na[7]	IN[1,2,5]	IT[7]	WC[3, 5]	TS	LC
17	*Scaphiodonichthys acanthopterus* (Transverse Mouth Barb, ปลามอน)	Na[7]	IN[3]	IT[2]	BT	PM	LC
18	*Systomus rubripinnis* (Red-cheek Barb, ปลาแก้มช้ำ)	Na[7]	IN[1, 2, 5]	IT[5]	WC[3, 5]	TS	DD
19	*Tor tambroides* (Brook Trout, ปลาเวียน)	Na[7]	ON[1, 2]	IT[6]	WC[3]	PM	DD
20	*Gyrinocheilus aymonieri* (Siamese Algae Eater, ปลาลูกผึ้ง)	Na[7]	IN[3]	TO[7]	BT[3]	PM	LC
21	*Aperioptus gracilentus* (Dwarf Horse Face Loach, ปลารากกล้วยแคระ)	Na[7]	IN[3]	IT[7]	BT[3]	PM	LC
22	*Lepidocephalichthys berdmorei* (Burmese Mud Loach, ปลาอีดพม่า)	Na[7]	IN[2, 3]	TO[2]	BT[3]	PM	LC
23	*Lepidocephalichthys hasselti* (Hasselt's Mud Loach, ปลาอีดอัสเซลท์)	Na[7]	IN[2, 3]	TO[2]	BT[3]	PM	LC
24	*Balitora brucei* (Blue Mahseer, ปลาจิ้งจก)	Na[7]	IN[3]	IT[3]	BT[3]	PM	NT
25	*Homalopteroides smithi* (Smith's Stone Loach,ปลาผีเสื้อติดหินสมิท)	Na[7]	IN[1, 2, 3]	IT[6]	BT[3]	PM	LC
26	*Pseudohomaloptera Leonardi* (Leonard Stone Loach, ปลาจิ้งจกเลียวนาร์ด)	Na[7]	IN[3]	IT[6]	BT[3]	PM	LC
27	*Schistura breviceps* (Short Head Stone Loach, ปลาค้อหัวสั้น)	Na[7]	IN[1,2, 3]	IT[6]	BT[3,6]	PM	DD
28	*Schistura bucculenta* (Stone Loach, ปลาค้อ)	Na[7]	IN[1,2, 3]	IT[6]	BT[3]	PM	LC
29	*Schistura geisleri* (Small Spotted Stream Loach, ปลาค้อทรายแต้มเล็ก)	Na[7]	IN[3]	IT[6]	BT[3]	PM	LC

Note: The number in exponent corresponds to the following reference; 1. Suvarnaraksha (2003); 2. Suvarnaraksha (2011); 3. Suvarnaraksha (2017); 4. Vidthayanon (2017); 5. Rayan and Ngamsnae (2020); 6. IUCN red list (2019) and 7. Information from expert

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No.	Family/ Species	Origin	Trophic group	Tolerance	Habitat	Ad.	IUCN
30	*Schistura menanensis* (Nan River's Stream Loach, ปลาค้อแม่น่าน)	Na[7]	IN [1, 2, 3]	IT[6]	BT[3]	PM	DD
31	*Schistura mahnerti* (Burmese border loach, ปลาค้อมาเนิร์ท)	Na[7]	IN[1,2, 3]	IT[6]	BT[3]	PM	LC
32	*Schistura obeini* (Giant Stone Loach, ปลาค้อยักษ์)	Na[7]	IN[1,2, 3]	IT[6]	BT[3]	PM	LC
33	*Schistura poculi* (Stream Loach, ปลาค้อแถบหน้าถี่)	Na[7]	IN[1,2, 3]	IT[6]	BT[3]	PM	LC
34	*Schistura spilota* (Large Spot Stream Loach, ปลาค้อจุดใหญ่)	Na[7]	IN[1,2, 3]	IT[6]	BT[3]	PM	DD
35	*Schistura waltoni* (Walton's Stream Loach, ปลาค้อวาลตัน)	Na[7]	IN [2, 3]	IT[6]	BT[3]	PM	DD
36	*Pterygoplichthys disjunctivus* (Vermiculated Saifin Armoured Catfish, ปลาเทศบาล)	Al[2,3]	ON[3]	TO[7]	BT [3]	LL	-
37	*Amblyceps foratum* (Torrent Catfish, ปลาดัก)	Na[7]	CA [3, 3]	IT[7]	BT[3]	MT	LC
38	*Oreoglanis siamensis* (Siamese Freshwater Batfish, ปลาค้างคาวสยาม)	Na[7]	IN[3]	IT[6]	BT[3]	MT	EN
39	*Glyptothorax trilineatus* (Three Stripes Stream Sisorid, ปลาแค้ติดหินสามแถบ)	Na[7]	CA[1, 2,3]	IT[2]	BT[3]	MT	LC
40	*Glyptothorax lampris* (Stream Sisorid, ปลาแค้ติดหิน)	Na[7]	CA[1, 2,3]	IT[2]	BT[3]	MT	LC
41	*Clarias batrachus* (Batrachian Walking Catfish, ปลาดุกด้าน)	Na[7]	CA[1, 2, 3, 5]	TO[5]	BT[3]	PM	LC
42	*Clarias* hybrid (Hybrid Walking Catfish, ปลาดุกลูกผสม)	Al[2,5]	CA[1, 2]	TO[7]	BT	LL	-
43	*Oreochromis niloticus* (Nile's Tilapia, ปลานิล)	Al [1,2,3,5]	ON [1, 2]	TO [5]	WC [5]	LL	LC

Note: The number in exponent corresponds to the following reference; 1. Suvarnaraksha (2003); 2. Suvarnaraksha (2011); 3. Suvarnaraksha (2017); 4. Vidthayanon (2017); 5. Rayan and Ngamsnae (2020); 6. IUCN red list (2019) and7.Information from expert

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No.	Family/ Species	Origin	Trophic group	Tolerance	Habitat	Ad.	IUCN
44	*Gambusia affinis* (Mosquito's Eater, ปลากินยุง)	Al[3]	ON[3]	TO[7]	PG[3]	PM	LC
45	*Monopterus albus* (Swamp Eel, ปลาไหลนา)	Na[7]	IN[2, 3]	TO[2, 3]	BT[3]	LL	LC
46	*Mastacembelus tinwini* (Tinwin Spiny Eel, ปลากระทิงภูเขา)	Na[7]	IN[1,2, 5]	TO[5]	BT[3]	TS	LC
47	*Anabas testudineus* (Climbing Perch, ปลาหมอ)	Na[7]	CA[1, 2, 3]	TO[5]	WC[5]	LL	DD
48	*Trichopsis vittata* (Croaking Gouramy, ปลากริมควาย)	Na[7]	IN[1, 2]	TO[7]	PG[7]	LL	LC
49	*Trichopodus trichopterus* (Three Spotted Gouramy, ปลากระดี่หม้อ)	Na[7]	IN[1, 2, 3, 5]	TO[5]	WC[3, 5]	LL	LC
50	*Channa gachua* (Stream Snakehead Fish, ปลาก้าง)	Na[7]	CA[1,2, 3]	TO[2]	WC[3]	PM	LC
51	*Channa striata* (Striped Snakehead Fish, ปลาช่อน)	Na[7]	CA[1, 2, 3]	TO[5]	WC[3]	LL	LC

Note: The number in exponent corresponds to the following reference; 1. Suvarnaraksha (2003); 2. Suvarnaraksha (2011); 3. Suvarnaraksha (2017); 4. Vidthayanon (2017); 5. Rayan and Ngamsnae (2020); 6. IUCN red list (2019) and 7. Information from expert

Table 2 Metric Score for Maetang River

Code	Metric	Scoring					Results	Score
		5	4	3	2	1		
M1	No. of. Species richness	>22	12-22	9-11	5-8	<5	20.00	5
M2	Diversity index	>2.35	2.00-2.35	1.61-1.99	1.26-1.60	<1.26	2.54	5
M3	Dominant index	>0.56	0.26-0.56	0.19-0.25	0.08-0.18	<0.08	0.15	2
M4	%Native species	>42.31	23.08-42.31	16.98-23.07	9.62-16.97	<9.62	20.00	3
M5	Alien species	<1	1-2	3	4	>4	0	5
M6	% Omnivores	<10.38	10.38-16.59	16.60-22.21	22.22-44.44	>44.44	83.33	1
M7	% Insectivores	>42.86	25.71-42.86	18.55-25.70	11.43-18.54	<11.43	56	5
M8	% Carnivores	>37.50	12.50-37.50	11.11-12.49	8.32-11.10	<8.32	16.67	4
M9	% Lowland species	<16.24	16.24-21.67	21.66-33.32	33.33-88.89	>88.89	57.58	1
M10	% Transitory species	<23.88	23.88-31.84	31.85-59.99	60.00-80.00	>80.00	36.36	1
M11	% Piedmont species	>50.00	28.13-49.99	19.06-28.13	9.38-19.05	<9.38	32.56	4
M12	% Mountainous species	>33.33	16.67-33.33	12.14-16.66	9.10-12.01	<9.10	15.25	3
M13	% Pelagic	>75.00	37.50-75.00	27.47-37.49	12.50-27.46	<12.50	38.56	4
M14	% Water column	<7.14	7.14-20.01	20.02-28.56	28.57-64.29	>64.29	65	1
M15	% Bottom	>40.00	20.00-40.00	13.25-19.99	6.67-13.24	<6.67	32.26	4
M16	% of intolerant species	>55.88	29.41-55.88	13.39-29.40	11.76-19.38	<11.76	28.50	3
M17	% Tolerant species	<4.17	4.17-8.18	8.19-11.11	11.12-27.78	>27.78	55.56	1
M18	No. of disease health	<1	1-2	3	4	>4	5	1
					IBI score			53

Table 3 The F-IBI class boundaries and description adjusted according to the Maetang river fish characteristics

F-IBI value	Characteristics	Integrity classes
73-90	Comparable to the best situations without influence or no human activity.	Excellent
55-72	Largely natural with few modifications. A change in community characteristics may have taken place but species richness and presence of intolerant species indicate little modification.	Good
37-54	Moderately modified. A lower than expected species richness and presence of most intolerant species.	Fair
19-36	Largely modified. Dominated by omnivores and lowered presence of intolerant and moderately intolerant species also habitat generalists and condition factors commonly depressed	Poor
≤18	Seriously modified. A strikingly lower than expected species richness and the general absence of intolerant, mostly introduced, or very tolerant forms. Impairment of health may become very evident.	Very poor

Conclusion

The fish index of biotic integrity (F-IBI) has been widely applied and an effective tool in collecting fish assemblage data to assess the environmental quality of aquatic habitats. The present study utilized the preliminary application and development of F-IBI to evaluate of the health of the running river or the Maetang River as reference site. The fish data of this study reported 32 species under 13 families examined by 18 metrics. The total F-IBI score of 53 was calculated, which ranked as fair level. This evaluation can make a step for management aspects to some extent of conservation. With increasing human degradation, the number of fish species, and the abundance of fish in intermittent streams decline. An IBI with 18 metrics portrays the pattern of fish assemblage change in response to human degradation and an accurate and reasonably precise measure of intermittent stream environmental quality. As a bioassessment tool, the fish index was useful in the assignment as the basis for long-term monitoring of running water in northern Thailand. This study highlights the first to employ fish index of biotic integrity with 18 metrics to evaluate running river.

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