

Water Quality and Freshwater Fish Diversity at Khao Luang National Park, Thailand

S. Sutin, M. Jaroensutasinee, and K. Jaroensutasinee

Abstract—Water quality and freshwater fish diversity from nine waterfalls at Khao Luang National Park, Thailand was examined. Streams were shallow, fast flowing with clear water and rocky and sandy substrate. The mean water quality of waterfalls at Khao Luang National Park were as following pH 7.50, air temperature 24.27 °C, water temperature 26.37 °C, dissolved oxygen 7.88 mg/l, hardness 4.44-21.33 mg/l, alkalinity 3.55-11.88 mg/(as CaCO₃). Twenty fish species were found at Khao Luang National Park belonging to nine families. A cluster analysis of water quality at Khao Luang National Park revealed that waterfalls at Khao Luang National Park were divided into two groups: A and B. Group A composed of two waterfalls (i.e. Aie Kaew and Wangmaipak) that flew to the Gulf of Thailand side. Group B composed of seven waterfalls (i.e. Promlok, Kalom, Nuafa, Suankun, Soidaw, Suanhai, and Thapae) that flew to the Andaman Sea side (Fig. 2). The Cyprinids represented the major species in all the waterfalls comprising of 45%.

Keywords—Water quality, Freshwater fishes, National Park, Khao Luang, Thailand.

I. INTRODUCTION

THAILAND is located in the tropics with many different ecosystems and a great diversity of fish species. [1]. A previous fish survey in Nakhon Si Thammarat Province (Tapee watershed, Trang watershed, and other watersheds) was undertaken using native and electro-fishing techniques. A total of 112 freshwater fish species was recorded. The dominant family was Cyprinidae. Based on the survey report on fundamental natural resources in 2005, fishes found at Khao Luang National Park showed the vast diversity of freshwater fish only in the running water sites and there were found only seven fish species from 3 orders, 5 genera, 7

Manuscript received November 30, 2006. This work was supported in part by PPT Public Company Limited, TRF/Biotec special program for Biodiversity Research Training grant BRT T_148017 and CXKURUE, the Institute of Research and Development, Walailak University.

Sutin S. is with School of Science, Walailak University, 222 Thaiburi, Thasala District, Nakhonsithammarat 80161, Thailand and Faculty of Science, Rajabhat Nakhon Si Thammarat University, Muang, Nakhon Si Thammarat 80280 (phone: +66 75 318 355; Fax: +66 75 318 356; e-mail: asuparporn@yahoo.com).

Jaroensutasinee M. is with School of Science, Walailak University, 222 Thaiburi, Thasala District, Nakhonsithammarat 80161, Thailand (phone: +66 75 672 005; Fax: +66 75 672 004; e-mail: jmullica@wu.ac.th).

Jaroensutasinee K. is with School of Science, Walailak University, 222 Thaiburi, Thasala District, Nakhonsithammarat 80161, Thailand (phone: +66 75 672 005; Fax: +66 75 672 004; e-mail: krisanadej@gmail.com).

families. Among these seven species, two species were reported to be found only in the Southern Thailand. These two species were *Clarias* sp. found in Kiriwong streams and *Trichopsis vittatus* found in the streams of lowland. The study on the habitat of *Clarias* sp. in Ban Plai Uan, Promlok district, Nakhon Si Thammarat province revealed that freshwater fishes living in the running water ecosystem always hide in the roots of the trees, holes under leaves and under stones. *Clarias* sp. is a nocturnal fish. Fishes that are always found in the habitat of *Clarias* sp. are pigmy gourami (*Trichopsis vittatus*), *Channa limbata*, blue danio (*Brachydanio albolineata*), brook carp (*Neolissocheilus soroides*), T-barb, spanner barb (*Puntius lateristriga*), and stone-lapping fish (*Garra taeniata*) [2].

Khao Luang National Park is dominated by a rugged mountain range running north to south. The area contains a large tropical rainforest, wildlife habitats, and many waterfalls. Protected areas such as national parks could play an important role in the conservation of freshwater fish in Thailand, but there is a need to better identify and assess the conservation value of these areas in relation to biogeographical diversity of fish population and the habitat characteristics of fish communities. However, only few studies of freshwater fish fauna in the Khao Luang National Park have been carried out to date.

This study aimed at examining water quality and freshwater fish diversity in the streams of the waterfalls at Khao Luang National Park. The findings from the study will also benefit the planning and management of sustainable fisheries and conservation of natural resources at national level.

II. MATERIALS AND METHODS

A. Study Area

Khao Luang National Park was declared as the 9th National Park of Thailand on 18th December 1974. The landscape is rugged mountain range which lays down from north to south, about 40 km long. The study was undertaken at nine waterfalls: Aie-kaew, Wangmaipak, Promlok, Kralom, Tapae, Suankun, Nuafa, Suanhai and Soidaw Waterfalls (Fig. 1), from July-September 2004.



Fig. 1 Nine waterfalls at Khao Luang National Park. (A1-A9) represent waterfalls. A1: Ai-kaew; A2: Wangmaipak, A3: Promlok; A4:Kralom; A5: Thapae; A6: Suankun; A7: Huafa; A8: Suanhai; A9: Soidaw

B. Data Collection

Fish species were collected from nine waterfalls at three stations/waterfalls with three replicates/station. The study also examined the physical and chemical makeup of the water and stream width and depth in the waterfalls were measured as described in APHA, AWWA and WWF (1992)[3] Water quality measurements were composed of water temperature, air temperature, pH, acidity, alkalinity, hardness, ammonia, nitrite, nitrate. Conductivity and dissolved oxygen levels were measured in the field using the X-mate Mettler Toledo Inlab 681. Acidity, alkalinity, hardness, ammonia, nitrite and nitrate were measured in the laboratory by using titration methods. The fish were caught by trawling with scoop-nets (mesh 5×5 mm; 1.35 m² = 1.5×0.9 m), gill nets (mesh 5×5 mm; 1.35 m² = 1.5×0.9 m), and cast nets (mesh 7×7 mm). Fish length, width, density, and sex ratio were recorded and categorized in one of the following groups: herbivore, omnivore, insectivore, piscivores and specialized insectivores [5]. The fish were identified [6]-[11].

C. Statistical Analysis

The classification of water quality with similar were examined by principal component analysis and cluster analysis [14].

III. RESULTS AND DISCUSSION

The characteristics and morphology of nine waterfalls were described in Table I. Generally, the waterfalls in the study areas were swift flowing. The water at all station was clear with sandy, rocky bottom and the banks were lined by boulders and rocks. The shore vegetation consisted of primary forest. This appearance was a typical of undisturbed forest stream at higher altitudes. However, local inhabitants reported that many of the fish habitats such as pools and deep areas were covered with sediments and rocks.

The physiochemical water parameters for the waterfall surveyed were summarized in Table II. The mean pH of the waterfall ranging from 7.23-7.50 and the air temperature was generally cool, ranging from 20.66-29.00 °C with a mean of 24.27°C. The water temperature ranging from 22.33-30°C with a mean of 26.37 °C. Dissolved oxygen was high with a mean of 7.88 mg/l, indicating a good aeration, which attributed to lower temperature and rapid flow rate. Acidity, ammonia, nitrite and nitrate values were rather uniform. All site showed very low hardness and alkalinity with the mean of 4.44-21.33mg/l, and 3.55-11.88 mg/as CaCO₃, respectively. This reflects their soft water nature. These hardness and alkalinity values were similar to most unpolluted waterfall found in Ban Parihual, Promlok Sub-district, Promkiri District, Nakhonsithammarat Province [2].

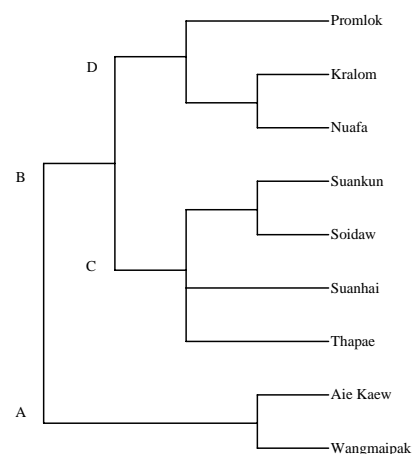


Fig. 2 Cluster analysis of water quality at nine waterfalls of Khao Luang National Park

A cluster analysis of water quality at Khao Luang National Park revealed that waterfalls at Khao Luang National Park were divided into two groups: A and B (Fig. 2). Group A composed of two waterfalls (i.e. Aie Kaew and Wangmaipak) that flew to the Gulf of Thailand side (Fig. 2). Group B composed of seven waterfalls (i.e. Promlok, Kralom, Nuafa, Suankun, Soidaw, Suanhai, and Thapae) that flew to the Andaman Sea side (Fig. 2). Group B were divided into two subgroups: C (i.e. Suankun, Soidaw, Suanhai, and Thapae) and D (i.e. Promlok, Kralom, and Nuafa). These results indicate that there were different in water quality and divided by mountain ridge. This implies that fish species live in group A waterfalls (i.e. Aie Kiew and Wangmaipak waterfalls) should be differed genetically from the other seven waterfalls. Our results from Table III showed that there was only Cyprinidae family found at Aie Kaew and Wangmaipak waterfalls. On the other hands, we found nine fish families from group B waterfalls. This suggests that there were higher fish diversities in the waterfalls at Khao Luang National Park that flew to the Andaman Sea side. It could be due to the fact that fish could migrate between these seven waterfalls and these fish could not get over the mountain ridge and migrate to the Gulf of Thailand side.

TABLE I
HABITAT CHARACTERISTICS AT THE NINE WATERFALLS OF KHAO LUANG NATIONAL PARK

Waterfall	Depth (m)	Current Velocity (m/s)	Habitat Description
Aie-Kaew	0.68-2.10	17.0-21.0	Big waterfall, almost 100 different levels, clear water, rocky and sandy bottom.
Wangmaipak	0.50-2.00	0.9-22.0	Medium waterfall, fast flowing and clear water, rocky and sandy bottom
Promlok	0.50-1.10	9.0-20.4	Big waterfall, 50-levels, fast flowing and clear water, rocky and sandy bottom.
Kralom	0.45-1.20	11.5-14.2	Big waterfall, 19-levels, fast flowing and clear water, rocky and sandy bottom, deep pools.
Thapae	0.70-0.90	12.7-17.7	Nature trail to the waterfall, 10-levels, deep pools
Suankun	0.50-1.50	11.2-13.9	Nature trail to the waterfall, 3-levels.
Huafa	0.45-1.00	15.0-20.0	Nature trail to the waterfall, 10-levels.
Suanhai	0.35-0.50	7.0-15.0	Nature trail to the waterfall, 5-levels.
Soidawn	0.50-1.00	12.0-15.0	Nature trail to the waterfall, Deep pools.

TABLE II
MEAN OF PHYSICO-CHEMICAL PARAMETERS AT NINE WATERFALLS OF KHAO LUANG NATIONAL PARK

Waterwall	pH	Air Temp (°C)	Water Temp.(°C)	DO (mg/l)	Acidity (mg/l)	Handless (mg/l)	Alkalinity (mg/l)	Ammonia (mg/l)	Nitrite (mg/l)	Nitrate (mg/l)
Aie-kaew	7.27	26.00	27.00	8.80	2.00	19.00	5.00	0.078	0.013	0.002
Wangmaipak	7.47	27.11	30.00	8.00	3.00	21.33	11.88	0.096	0.013	0.004
Promlok	7.23	29.00	26.00	7.24	3.00	5.33	3.55	0.070	0.014	0.011
Kralom	7.50	25.00	30.00	7.90	3.00	6.33	9.66	0.066	0.015	0.003
Thapae	7.41	20.66	26.33	7.73	3.00	4.77	5.22	0.071	0.029	0.007
Suankun	7.44	21.66	22.33	8.06	3.00	5.44	6.33	0.066	0.017	0.005
Huafa	7.43	26.00	28.00	7.83	3.00	4.44	8.00	0.070	0.015	0.000
Suanhai	7.41	21.00	23.00	7.68	3.00	5.00	9.33	0.071	0.013	0.015
Soidawn	7.30	22.00	24.00	7.66	3.00	5.00	6.55	0.067	0.016	0.016

TABLE III
FRESHWATER FISH DIVERSITY AT KHAO LUANG NATIONAL PARK, THAILAND. (+) INDICATES PRESENCE, (-) INDICATES ABSENCE

Family/Species	Waterfall Station								
	Aie-Keaw	Wangmaipak	Promlok	Kralom	Thapae	Suankun	Huafa	Suanhai	Soidaw
BELONIDAE									
<i>Xenentodon cancilla</i>	-	-	-	-	-	+	+	+	+
BALITORIDAE									
<i>Nemacheilus masyae</i>	-	-	+	+	+	-	-	-	-
COBITIDAE									
<i>Actinopterygii</i> sp.	-	-	-	-	-	-	+	-	-
CYPRINIDAE									
<i>Rasbora argyroteenia</i>	-	-	+	+	+	+	+	+	+
<i>Neolissocheilus soroides</i>	+	-	+	+	-	+	+	-	+
<i>Tor tambroides</i>	+	+	+	+	+	+	+	+	+
<i>Danio regina</i>	+	+	+	+	+	+	+	+	+
<i>D. aequipinnatus</i>	+	+	+	+	+	+	+	+	+
<i>Puntius lateristrica</i>	+	+	+	-	-	+	-	-	-
<i>Systemus binotatus</i>	+	-	-	-	-	-	-	-	-
<i>Garra taeniata</i>	+	-	-	+	-	-	-	+	-
<i>Esomus metallius</i>	-	-	-	-	+	-	-	-	-
<i>Puntius patipentazona</i>	-	-	-	+	-	-	+	-	-
GYINOCHEILIDAE									
<i>Gyrinocheilus aynonieri</i>	-	-	-	-	-	-	+	-	+
CHANNIDAE									
<i>Channa limbata</i>	-	-	+	-	-	-	-	-	-
<i>C. striata</i>	-	+	-	-	-	-	-	-	-
BAGRIDAE									
<i>Mystus wolffi</i>	-	-	+	-	-	+	-	-	-
CLARIIDAE									
<i>Clarias</i> sp.	-	-	+	-	+	-	-	-	-
MASTACEMBELIDAE									
<i>Macrognathus aculeatus</i>	-	-	+	-	-	-	-	-	-
<i>Mastacembelus amatus</i>	-	-	-	+	+	+	-	-	-

Freshwater fishes were collected and classified into 20 species and 10 families at Khao Luang National Parks (Table III). The dominant family was Cyprinidae, which was accounted for 45% (i.e. 9 species) of the total number of fish species found. The subdominant family was Belontiidae, which was accounted for 15%. *Tor* sp., *Danio regina* and *D. aequipinnatus* were the most abundant fishes species in the streams in all waterfalls. There were six endemic fish species including *Acanthopsis choirorhynchus*, *Esomus metallius*, *Channa limbata*, *C. gachua*, *C. striata* and *Clarias* sp.

IV. CONCLUSION

The surrounding undisturbed area of Khao Luang National Parks was vitally important in maintaining fish stock. The fishes of the Khao Luang National Parks in the upper rivers were dominated by the family Cyprinidae. These species have evolved a variety of mechanisms to adapt to living in swift flowing mountain rivers. The Cyprinid fish such as *Tor tambroides*, *Danio regina* and *D. Aequipinnatus*, known as one of the commercially important fishes, were found in all nine waterfalls. It was recommended that further studies should be done to develop techniques for culturing these fish. The use of illegal methods to catch fish should be banned in the area to prevent further depletion of freshwater fish resources in the waterfalls and streams of the Khao Luang National Park.

ACKNOWLEDGMENTS

We thank William Weheaton for comments on previous versions of this manuscript. This work was supported in part by PPT Public Company Limited, TRF/Biotec special program for Biodiversity Research Training grant BRT T_148017, CXKURUE, the Institute of Research and Development, Walailak University and Rajabhat Nakhon Si Thammarat University. We thank Khao Luang National Parks staff for their helpful assistance.

REFERENCES

- [1] J. R. Duncan, and J. L., Lockwood, "Extinction in a field of bullets: a search for the causes in the decline of the World's freshwater fishes," *Biol. Cons.* vol. 102, pp. 97-105, 2001.
- [2] S. Chankreaw, and P. Saad, "The effect of added alkalinity and hardness from Phromlok Waterfall, Nakhon Si Thammarat to the Growth of Pla Ngeah (*Neolissochielus* sp.)," Faculty of Science and Technology, Rajabhat Nakhon Si thammarat University, Nakhon Si Thammarat, 2004.
- [3] APHA, AWWA and WFF. Standard Methods for the Examination of Water and Wastewater. 18th ed. A. E. Greenberg, L. S. Clesceri and A. D. Eaton, Eds., American Public Health Association, Washington D.C., 1992.
- [4] G. V. Nikolsky, *The Ecology of Fishes*. London: Academic Press, 1963, 352 p.
- [5] C. Saylor, and E. M. Scott Jr., *Application of the Index of Biotic Integrity to Existing TVA Data*. Norris, Tennessee: Tennessee Valley Authority, Division of Air and Water Resources, TVA / ONRES /AWR 87/32, 1987, 25 p.
- [6] H. M. Smith, "Some Fresh – Water Fishes of Siam," *Trans. Amer. Fish. Soc.* vol. 56, pp. 213 – 226, 1927.
- [7] H. M. Smith, *The Fresh – Water Fishes of Siam, or Thailand*. Washington: United states Government Printing office, 1945, 622 p.
- [8] T. R. Robert, *The Freshwater Fishes of Western Borneo (Kalimantan Barat, Indonesia)*. California: California Academy of Science, 1989, 210 p.
- [9] M. Kottelat, A. J. Whitten, S. N. Kartikasari and S. Wirjoatmodjo, *Freshwater Fishes of Western Indonesia and Sulawesi*. Indonesia: Periplus Editions Ltd., 1993, 221 p.
- [10] J. S. Nelson, *Fishes of the world*. New York: John Wiley & Son Inc., 1994.
- [11] J. Shrestha, *Fishes, Fishing Implements & Methods of Nepal*. Thailand: Craftsman Press, 1994, 150 p.
- [12] W. J. Rainboth, *Fishes of the Cambodian Mekong*. Rome: Food and Agriculture Organization of the United Nations. 1996, 265 p.
- [13] J. A. Ludwig and J. F Reynolds, *Statistical Ecology: a Primer on Methods and Computing*. New York: Wiley-Interscience Publications, 1988, 337 p.