

Research Paper

Fish Diversity and Fishery Status in the Ba Che and Tien Yen Rivers, northern Vietnam, with Consideration on Factors Causing Recent Decline of Fishery Products

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Abstract

The present study investigated the fish biodiversity and status of supply and exploitation of fishery resources in the Ba Che and Tien Yen Rivers, northern Vietnam. During a period of four years, from 2008 to 2011, a total of 245 species belonging to 169 genera, 76 families and 20 orders were identified. Of the above species, two were unidentified species and twelve were listed as rare species in the Red Data Book. Interview surveys with a questionnaire about their life and fishery status were carried out with local people, including fishers, twice at each study site. For local communities along the rivers, fish are an important food source consumed on a daily basis. However, the incomes these communities have obtained from aquatic products have declined by 37–46% in the last five years and by 50–64% in the last 10 years; the rates of decline were higher in river areas at higher elevation. The frequency of exploitation and the fish caught per trip were highest in the lowlands, where the income of fishers depends almost entirely on local fishery resources. Looking at the condition of fisheries in the study area, the possible reasons for the rapid decline of fishery products over recent years can be seen as overfishing, the use of destructive fishing methods such as electro-fishing and small-meshed nets, water pollution, and poor management. Proposals are given for sustainable development of the fishery resources in the two rivers.

Key words: fish diversity, fishery status, conservation, Ba Che and Tien Yen Rivers, northern Vietnam

1. Introduction

The Ba Che and Tien Yen Rivers are the two largest rivers in Quang Ninh Province, having separate basins within Vietnam and flowing into the Gulf of Tonkin via Cua Mo. The Ba Che and Tien Yen estuaries have large tidal flats with an average tidal range of approximately 3–4 m, and accordingly the systems contain a diverse range of marine and brackish-water fish species. Moreover, these estuaries are the funnel-shaped type, being different from those of southern Vietnam (Vu 2009). These environmental conditions contribute to the unique regional ichthyofauna that is a subject of this research.

As in various other waters of Vietnam, a continued downward trend in fish catches in these areas has most probably been due to anthropogenic pressures including the use of destructive methods (i.e., small mesh-size nets, electro-fishing, poison, mine or fishing during spawning

periods), habitat degradation, impediments to water flow, pollution, introduced species, and over-fishing (Vu, 2009). Nevertheless, little is known about fish biodiversity and fishery resources in the area, in particular with regard to the status of freshwater fish species in Quang Ninh Province and adjacent waters. In addition, a number of recently discovered species new to science or to Vietnam show a high potential for fish diversity in this region (Kottelat 2004, Chen & Kottelat 2005, Conway & Kottelat 2008, Tran *et al.* 2012; Ta & Tran 2013). Therefore, it is necessary to investigate ichthyofauna in the two estuaries in order to provide the basic information about fishery resources for sustainable exploitation and protection of these resources. To gain better knowledge of the unique ichthyofauna and basic information on fishery resources, we explored the ichthyofauna in the Ba Che and Tien Yen Rivers and conducted research based on interviews with fishers there.

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2. Materials and Methods

1) The study area

The Ba Che River (ca. 79 km in length) is located in Quang Ninh Province (Hoanh Bo and Ba Che District), and the Tien Yen River (ca. 82 km in length) flows through Lang Son (Dinh Lap District) and Quang Ninh (Binh Lieu and Tien Yen District) provinces. The highlands of the two rivers are in the Dong Trieu–Binh Lieu mountain zones, although those of the latter river are partly located in China (Fig. 1). Both rivers flow into the Gulf of Tonkin via Cua Mo, and the two bodies of water resemble each other geographically and topographically, and are similar in their climate, hydrography, and estuaries. The Ba Che and the Tien Yen are substantial but are small compared to the larger rivers of Vietnam. Because of the similar situations of the two rivers, the information collected on both was combined in the present study.

2) Method of survey

Eleven surveys were conducted at 27 stations of the Ba Che and Tien Yen rivers in August and October of 2008, in April, July, August and September of 2009, in January, March, April, June and July of 2010, and in February of 2011. Sampling at each station was done from two to six times during the study period. According to environmental characteristics of the two rivers, the 27 stations were categorized into lowlands (stations 1–4 and 15–17), middle lands (stations 5–8 and 18–21), and highlands (stations 9–14 and 22–27) (Fig. 1).

Sampling stations were set to represent the entire basin (i.e., highlands, middle lands and lowlands), and

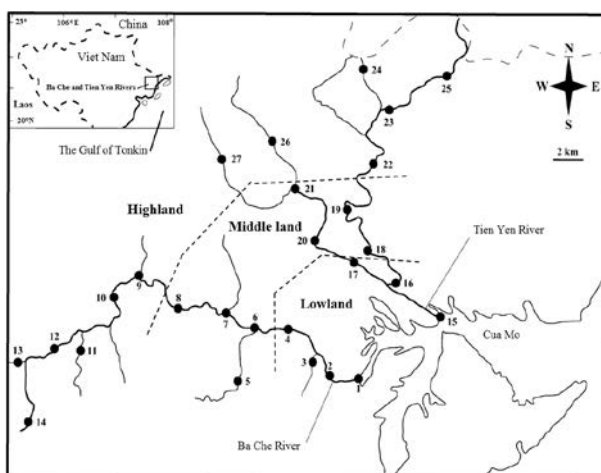


Fig. 1. Map of the Ba Che and Tien Yen Rivers, northern Vietnam, with the sampling stations. Broken lines indicate the boundaries among the lowland, middle land, and highland stations.

all types of habitats (i.e., river, stream and rice field). In particular, each site was designated as a research location being convenient for sampling (i.e., nearby fishery locality, favorable to fishing). Gill nets with various mesh-apertures and sizes (10 to 50 mm mesh size, 150–200 m in length, 0.6–1.7 m in height) were used for sampling fish. Electro-fishing provided by fishers was employed in case of necessity at some stations. Specimens caught by local people or collected from markets were also used for the study. Specimens were initially fixed in 10% formalin solution in the field, and subsequently preserved in 5% formalin in the laboratory.

Fish were identified according to some main references: Mai (1978), Zheng (1989), Nguyen & Ngo (2001), Nguyen (2005), Kottelat (2001a, b), and Nakabo (2002). Family and order names followed Nelson (2006), and genus and species names were in accordance with Nakabo (2002). All specimens were deposited in the Department of Zoology, Faculty of Biology, Hanoi National University of Education, Vietnam.

Interviews with questionnaires about role, status, exploitation and protection of fishery resources in the area were made with local people and fishers who have had good experiences in fishing in the site. This interview was conducted twice in each part of the two rivers. The questionnaire (Appendix 1) was designed partly according with previous literature (e.g. Toi *et al.* 1996, Hori *et al.* 2006).

We carried out the following activities for the above surveys: issuing questionnaires in combination with interviews with fishers or local residents in three research areas (i.e. lowlands, middle lands and highlands); organizing some gatherings of interviewees and chairing the discussion in each area. The total number of interviewees was 35, 34 and 50 in highlands, middle lands and lowlands, respectively.

3. Results and Discussion

1) Species diversity of fish

Based on a total of 2,370 specimens collected from the Ba Che and Tien Yen Rivers, 245 species of 169 genera, 76 families and 20 orders were identified (Appendix 2). This is the first intensive list of fish in the two rivers. Of the species collected, *Rhodeus* sp. and *Liniparhomaloptera* sp. were unidentified to species level, *Acheilognathus nguyenvanhaoi* was recently described as new to science (Nguyen *et al.* 2003), and twelve were listed in Vietnam's Red Data Book, (Ministry of Science and Technology of Vietnam 2007) (Table 1). This indicates that the ichthyofauna in the two

Table 1. Fish species listed in Vietnam's Red Data Book (Ministry of Science and Technology of Vietnam, 2007) collected from the Ba Che and Tien Yen Rivers, northern Vietnam.

Species	Level*	Sampling station**
<i>Megalops cyprinoides</i> (Broussonet, 1782)	VU	4
<i>Elops saurus</i> Linnaeus, 1766	VU	15
<i>Albula vulpes</i> (Linnaeus, 1758)	VU	15
<i>Clupanodon thrissa</i> (Linnaeus, 1758)	EN	1, 2, 15, 16, 18
<i>Konosirus punctatus</i> (Temminck & Schlegel, 1846)	VU	2, 15, 16-18
<i>Nematalosa nasus</i> (Bloch, 1795)	VU	1, 2, 4, 15, 16, 18
<i>Parazacco vuquangensis</i> Nguyen, 1995	VU	9, 10, 12-14, 19, 20, 22, 24, 26, 27
<i>Hemibagrus guttatus</i> (Lacépède, 1803)	VU	19
<i>Plectorhinchus gibbosus</i> (Lacépède, 1802)	CR	1, 16
<i>Parachaetodon ocellatus</i> (Cuvier, 1831)	VU	15, 16
<i>Bostrychus sinensis</i> Lacépède, 1801	CR	1, 2, 15
<i>Channa maculata</i> (Lacépède, 1801)	EN	3, 4, 18-20, 23, 25, 27

*. Level in the Vietnam Red Data Book (2007): *VU*. Vulnerable, *EN*. Endangered, *CR*. Critically Endangered. **. See the Fig. 1 for the locality of station.

rivers consist of a number of rare species which make up approximately 14 % of the total number of species of Vietnamese rare fish listed in Vietnam's Red Data Book. Of the twelve species, a number of specimens of two (*Parazacco vuquangensis* and *Channa maculata*) were found in various sites in the research area. Hence, we recommend these two species should not be listed in the Vietnam's Red Data Book at the current time.

Of the 245 fish species collected in the area, 237 were native (96.7% of the total species), and eight were introduced freshwater species (3.3%), of which seven were from other countries and one (*Trichogaster trichopterus*) was transported from southern Vietnam (Appendix 2). The 245 species were categorized into 85 species (34.45%) of freshwater inhabitants and 160 species (65.6%) of marine or brackish water inhabitants. Among the marine fish, some are species found in sub-tropical waters or coral reefs, such as the Japanese red fin wasp fish *Paracentropogon rubripinnis*, the sulphur goat fish *Upeneus sulphureus*, the dragonet *Callionymus curvicornis*, the dotted gizzard shad *Konosirus punctatus*, and the Japanese sea bass *Lateolabrax japonicus* (Nakabo 2002).

The ayu *Plecoglossus altivelis* and the gobiid

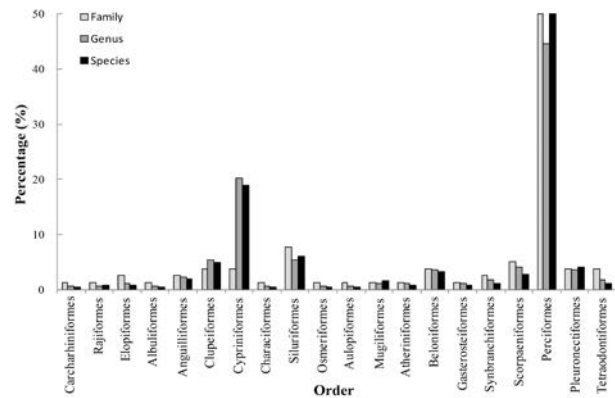


Fig. 2. Percentages of the family, genus and species number in the twenty orders in the Ba Che and Tien Yen Rivers, northern Vietnam.

Sineleotris saccharae were recorded for the first time in the Vietnamese ichthyofauna. Only one specimen of *Plecoglossus altivelis* was found, in station 26 on the Tien Yen River, and brief descriptions of it with some biological characteristics were given in Tran *et al.* (2012). The gobiid noted above was found in many stations along both rivers. This species was described in 1940 by Herre (1940), based on a specimen collected from Hokong. Tran & Ta (2013) made a redescription based on 56 specimens collected in the present study. This finding together with occurrences of some sub-tropical fishes and a number of rare fishes implies that the ichthyofauna in this area is unique and highly diverse.

Among the 20 orders found, Perciformes, Cypriniformes and Siluriformes were the dominant ones. In particular, Perciformes was the most diverse order in the present study; the family, genus and species numbers of this order comprised 50, 44.6 and 50%, respectively, of the total taxa (Fig. 2). At the family level, Cyprinidae, Gobiidae, Balitoridae, Carangidae and Leiognathidae were the dominant families. Among them, Cyprinidae was the most diverse family; the genus and species numbers comprised 14.3 and 13.5%, respectively, of the total taxa (Appendix 2). The dominance of the order Perciformes and of the family Cyprinidae in the number of species was similar to Nelson's (2006) work.

2) Current status and exploitation fishery resources The importance of fish for local residents

The results of the survey taken with interviewees are summarized in Table 2. Various information on the importance of fish for local residents was collected in interviews and market surveys in the present study as well as from the Ministry of Fisheries, Vietnam (1996). This information indicated that 70 of the 245 species

were commercial species. The results of the interview surveys indicate that fish are an important source of protein for the local community and are consumed on a daily basis. The consumption of fish as a source of protein is higher in the lowlands compared with the middle land or highlands. The income of fishers in the lowlands depends almost entirely on local fishery resources (Table 2).

The interviewees in the present study, especially those in the middle and highlands, told us that their sources of fish consumption were mainly marine and cultured species because these fish were cheaper than freshwater fish collected from the rivers. In the lowlands, many households utilized fish from the river, especially fish found in brackish waters. Considering their potential pressure on the fish fauna, more detailed information on

Table 2. Information on fisher and fishing based on the interviews with fishers in the three regions of the Ba Che and Tien Yen Rivers.

Region		Content	Low Land	Middle land	High Land	
Fisher		Number of interviewees	50	34	35	
		Ratio of fisher/total local people (%)	80.0	8.8	1.4	
		Residence in the region (year)	39	40	28	
		Education level (in 12 grade)	7.0	6.0	4.5	
		Fishing experience (year)	26.0	8.2	11.0	
		Fish consumed per week (day)	6.2	2.2	3.8	
		Percentages of income from fishing (%)	89.0	15.0	19.5	
Fishing		Workers/trip	2.3	1.0	1.1	
		Distance (km/trip)	6.5	2.8	2.5	
	Season (%)	Dry	5.6	61.5	33.3	
		Rain	5.6	7.7	22.2	
		Both dry and rain	88.8	30.8	44.5	
	Frequency	Day per week	5.7	3.1	3.7	
		Time of fishing (hour/trip)	4.2	3.7	3.4	
		Boat (<20 Horse-power) used in fishing (%)	73.5	0.0	0.0	
	Ratio of gear used in fishing (%)	Net	Electro-fishing	2.6	90.3	90.0
			Net (total)	95.6	9.5	9.8
			10–20 mm mesh aperture in total of net	65.5	87.8	94.9
			>20 mm mesh aperture in total of net	34.5	12.2	5.1
		Others	1.8	0.2	0.2	
	Product (kg/trip; kg/hour)	8.2; 1.95	2.0; 0.54	1.7; 0.5		
Decline of fisheries product		During past 5 years (%)	46.0	43.0	37.0	
		During 10 years (%)	64.0	60.0	50.0	

their fishery and fish ecology is necessary for conservation of the fauna and sustainable fisheries products.

Current status of fishery resources

Wild fishery resources. According to fishers and local residents, there were no established programs or guidelines for local people regarding use and protection of fish species. Almost all interviewees recognized that income from aquatic products from the two rivers had been declining rapidly. The rates of decline during the past five and ten years ranged from 37–46% to 50–64%, respectively, and these were highest in the highlands and lowest in the lowlands (Table 2). Although the total products have greatly declined, the following species still have high product values: *Pseudohemiculter dispar*, *Hemibarbus labeo*, *Mastacembelus armatus*, *Channa* spp., etc. in freshwater fish; *Konosirus punctatus*, *Acanthobagrus latus*, *Gerres filamentosus*, *Tephrinectes sinensis*, species of *Epinephelus*, *Leiognathus*, *Mugil*, *Liza*, etc. in marine fish.

Cultured fishery resources. There were some cultured species in the research area, such as *Ctenopharyngodon idellus*, *Hypophthalmichthys molitrix*, *Oreochromis* spp., but they were limited due to a shortage of freshwater, especially in Ba Che (stations 1 to 13) and Binh Lieu (stations 22–25).

Status of exploitation fishery resources

Information on fishers. All interviewees were working as fishers in the lowlands, but there were very few fishers in the middle land and highland areas. Household incomes were dependent on fishery resources in the lowlands (occupied ca. 89%), but were almost completely independent of such resources in the middle land and highlands (Table 2). The educational attainment of interviewees in the lowlands was higher than those subjects from the middle lands and highlands (Table 2).

Fishing. Fish were caught mainly in the dry season in the midlands, and were caught more evenly throughout the year in the lowlands and highlands. The frequencies of exploitation were highest in the lowlands. Fishers frequently caught fish by gill net in the lowlands, and by electro-fishing in the middle land and highlands (Table 2). The efficiency of fishing was about four times higher in the lowlands than in the other sites (Table 2).

3) Some possible impacts on fishery resources

Overfishing

In the lowlands many fishers used small boats (e.g., percentage of fisher using boat < 20 horse-power is 73.5% total of fishers) in fishing, but none in the middle

land and highland areas (Table 2), implying that fishing usually occurred in the nearshore or estuarine waters. This probably leads to higher pressures on fishery resources in the lowlands, and may have critical impacts on rare species listed in the Red Data Book (Table 1). Although the frequency of fishing in the midland and highland areas was lower than in the lowland areas, electro-fishing was used daily in the shallow waters and narrow streams (Table 2). This may have resulted in a rapid decrease in fishery resources.

The use of destructive means of catching fish

Many fishers used destructive gear, such as gill nets and casting nets with a small mesh size (10–20 mm) (Table 2). For this reason, we must consider the possibility that a lot of small fish may have been caught prior to reproduction, resulting in overfishing, thus leading to a decline in fisheries production. In the middle land and highland areas, many fishers used electro-fishing, which is a potential cause of overfishing as it kills all developmental stages of fish.

Management and local residents' awareness

To date, fishery resource status in the Ba Che and Tien Yen Rivers is unclear. There are powerless management regulations on record in the area. For instance, although electro-fishing is not allowed, many fishers have used this method in the middle land and highland areas without being subject to punishment. Moreover, their educational attainment was relatively low. Therefore, some difficulties might exist in connection in the control and management of fishery resources. Because of the weak management and regulation, fishery resources in the research may have declined from possible over exploitation.

Water pollution

Wastes from the Ba Che and Tien Yen paper factories near station 2 and station 16 (Fig. 3), sewage from human communities, and agricultural pesticide, weed killer and chemical fertilizer from farms are considered as possible sources that have influenced fish resources by degrading the aquatic environment. According to fishers and local residents around the two factories, the quality of water and the number of fish in the brackish water has gradually declined since the factories started working in the 1990s.

Other factors

Forest coverage is still high in the present area, but a greater area is covered by artificial forest as in other



Fig. 3. Waste water releasing directly to the Ba Che River at station 2 (see Fig. 1) from Ba Che Paper Factory (smaller picture). Photos by Tran, at 9 pm, 19 February 2011.

regions of Vietnam. Consequently, the hydrological function and regulation accomplished by forests in the highlands are considered as less effective than those in areas covered in natural forest. Moreover, mangrove forests in the lowlands have been significantly reduced since the 1990s or earlier (<http://mabvietnam.net/Vn/MERD1-vn.htm>). It is likely that these changes have had a significant negative impact on fish resources.

Introduced fish species can have a negative impact on native species through predation and competition for food and space (Ross 1991). Of the eight introduced species in the current study (Appendix 2), *Ctenopharyngodon idellus*, *Hypophthalmichthys molitrix*, *Aristichthys nobilis* and *Clarias gariepinus* have been considered as having a negative impact on native species (Le & Nguyen 2005).

The Khe Soong Dam constructed in 1996 in the main channel of the Tien Yen River (between station 18 and 19) could be one of the possible reasons for changes in fishery resources. Although it is difficult to assess the impact of the dam on fish supply in our data, local people have told us that the number of fish have declined since the dam was built. Dams have been known to affect an entire ecosystem and to negatively influence migration behaviour of some fish species (Schouten 1998).

4) Proposal for utilization and protection of fishery resources

The present study indicated that the fishery resources of the Ba Che and Tien Yen Rivers are the major daily living resources and the main source of the income for the local people. Since the fish products in the two rivers have been rapidly decreasing during last

decade (Table 2), protection and recovery of fishery resources are urgent issues to be solved. Considering the factors degrading fishery resources described above, we would like to make the following proposals which fishers, governors, politicians, or scientists can act on to solve these issues.

Reasonable exploitation

Fishing should be banned for the following species: *Megalops cyprinoides*, *Elops saurus*, *Albula vulpes* and *Hemibagrus guttatus*, as these species were only rarely collected in this area (Table 1).

Fishing should be limited for the following species: *Clupanodon thrissa*, *Konosirus punctatus*, *Nematalosa nasus*, *Plectorhinchus gibbosus*, *Parachaetodon ocellatus*, and *Bostrychus sinensis*, because these fish species were listed in the Red Data Book. *Eleutheronema tetradactylum* should also be included in this group. This species is a marine fish, but it often inhabits coastal or estuarine waters, and even a freshwater environment. In Vietnam, this species migrates to estuaries for spawning from February to May (Nguyen 2005). *Eleutheronema tetradactylum* is a high-quality commercial species so it is frequently targeted and caught (Ministry of Fisheries, Vietnam 1996). For this reason, we suggest that fisheries should not catch this species during its spawning season from February to May.

Some suggestions to help protect and develop fishery resources

Complete scientific data. This is needed to investigate, the ecological and biological characteristics of commercial species and in order to continuously monitor their abundance. This information is indispensable for an improved understanding of fish community structure and to propose conservation and development programs for fishery resources.

Establishing fisheries management. Regulation of exploitation, protection and recovery of fishery resources should be achieved by doing the following activities: 1) In order to reduce overfishing, fishing has to be under the management of the local government. The catch areas should be divided into various smaller sections, and the local people should be responsible for their management and exploitation. The local council should control fishing frequency, such as limiting the number of fishing trips per week, the fishing areas, the time of fishing and the distance covered in fishing trips. 2) In estuaries, which are important reproductive and nursery areas for some commercial fish, fishing should be prohibited or limited during the period of their reproduction. 3) To protect

larval and juvenile fish, destructive fishing methods, i.e. explosives, electro-fishing, toxic chemicals, nets with small mesh size should either be used appropriately under the control of the local governments or banned.

Resource development. Together with protection of the fishery resources, resource development, i.e. mariculture, will ensure the local residents' livelihood for a long-term phase especially in the lowlands, where their income largely depends on the fishery resources (Table 2). Marine fish cultivation by float-cage is suitable to the two estuaries because these areas are surrounded by small islands and the salinity is relatively high and substantial within the estuaries (Vu 2009). First, field and market research should be carried out to determine which species have a high market value and are suitable for culture under local conditions. However, establishing a local mariculture is challenging for residents because of difficulties associated with fund raising, permission for occupation of the area, collaboration of residents, and so on. Support and initiation by the local government will be necessary to solve the difficulties.

Training and education. In connection with fishery resource management and exploitation, the education and training of local people, including fishers, is vital because these activities must be carried out by the local population.

Environmental protection. Forests in the basins, especially natural forest in the highlands and mangrove forest in the lowlands, should be protected and developed. The wastes from Ba Che and Tien Yen factories and urban sewage must be treated prior to release into the environment.

4. Conclusion

The present study found a total of 245 fish species distributed in both the Ba Che and Tien Yen rivers in northern Vietnam, and it indicated that the ichthyofauna was unique and highly diverse, with many species listed in the Red Data Book. The percentages of species from the order Perciformes and the family Cyprinidae were higher than any others in this area, confirming the results of previous studies. The role of fishing and the status of fisheries differed at the three sites on the two rivers. A number of factors that had a possible impact on fishery resources were noted, and the results of our study led to documentation on the utilization, protection and development of fishery resources in the research area.

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References

- Chen, I.S. and Kottelat, M. 2005. Four new freshwater gobies of the genus *Rhinogobius* from Northern Vietnam. *J. Nat. Hist.*, 39: 1407–1429.
- Conway, K. and Kottelat, M. 2008. *Araiocypris batodes*, a new genus and species of cyprinid fish from northern Vietnam (Ostariophysi: Cyprinidae). *Raffles B. Zool.*, 56: 101–105.
- Herre, A.W.C.T. 1940. A new genus and two species of Chinese gobies with remarks on some other species. Notes on fishes in the Zoological Museum of Stanford University, *WIII* 73: 293–299.
- Hori, M., Ishikawa, S., Heng, P., Thay, S., Ly, V., Nao, T. and Kurokura, H. 2006. Role of small - scale fishing Kompong Thom Province, Cambodia. *Fisheries Sci.*, 72: 846–854.
- Kottelat, M. 2001a. “Fishes of Laos”, WHT Publications (Pte.) Ltd, Colombo, Sri Lanka. 198 pp.
- Kottelat, M. 2001b. “Freshwater fishes of northern Vietnam. A preliminary check-list of the fishes known or expected to occur in northern Vietnam with comments on systematic and nomenclature”, Environment and Social Development Sector Unit East Asia and Pacific Region. The World Bank, Washington, DC., 122 pp. + color pls.
- Kottelat, M. 2004. On the Bornean and Chinese Protomyzon (Teleostei: Balitoridae) with descriptions of two new genera and two new species from Borneo, Vietnam and China. *Ichthyol. Explor. Fres.*, 15: 301–310.
- Le, V.B. and Nguyen, V.C. 2005. Study on status of imported aquatic organisms in Vietnamese waters and management resolution. Marine Capture Fisheries, Directorate of Fisheries. 5 pp. (in Vietnamese)
- Mai, D.Y. 1978. “Identification of freshwater fish in the northern Vietnam”, Scientific and Technique Publishing House, Ha Noi. 339 pp. (in Vietnamese)
- Ministry of Fisheries, Vietnam 1996. “Fisheries Resources of Vietnam”, Aquaculture Publishing House, Ha Noi. 615 pp. (in Vietnamese)
- Ministry of Science and Technology of Vietnam 2007. “Vietnam’s Red Data Book, Part I. Animals”, Natural Science and Technology Publishing House. pp. 277–372. (in Vietnamese)
- Nakabo, T. 2002. “Fishes of Japan, with pictorial keys to species”, English edition I, II, Tokai University Press.
- Nelson, J.S. 2006. “Fishes of the World”, 4th edn, John Wiley and Sons, Hoboken.
- Nguyen, V.H. 2005. “Freshwater fish of Vietnam”, Vol. 2, 3. Aquaculture Publishing House, Ha Noi. (in Vietnamese)
- Nguyen, V.H. and Ngo, S.V. 2001. “Freshwater fish of Vietnam”, Vol. 1. Aquaculture Publishing House, Ha Noi. 622 pp. (in Vietnamese)
- Nguyen, H.D., Tran, D.H. and Ta, T.T. 2013. A new species of genus *Acheilognathus* Bleeker, 1859 from the Tien Yen River, Vietnam. *Journal of Biology* 35: 18–22. (in Vietnamese with English abstract)
- Ross, S.T. 1991. Mechanism structuring stream fish assemblages: are these lessons from introduced species? *Environ. Biol. Fish.*, 30: 359–368.
- Schouten, R. 1998. Effects of dams on downstream reservoir fisheries, case of Nam Ngum, Mekong Fisheries Network Newsletter, 4.
- Toi, K.A., Polissar, N.L., Liao, S. and Mittelstaedt, G.D. 1996. A fish consumption survey of the Tulalip and Squaxin Island tribes of the Puget Sound region, Tulalip Tribes, Department of Environment, 7615 Totem Beach Road, Marysville, WA 98271.
- Tran, D.H., Nguyen, H. D. and Ta, T.T. 2012. Preliminary data on the ayu (*Plecoglossus altivelis*) in Vietnam. Proceedings of the 1st national scientific conference on biological research and teaching in Vietnam, Agriculture Publishing House. pp. 94–99. (in Vietnamese with English abstract)
- Tran, D.H. and Ta, T.T. 2013. *Sineleotris saccharae* (Odontobutidae), a new record for ichthyofauna of Vietnam. *Journal of Science, Hanoi National University of Education* 58: 105–110. (in Vietnamese with English abstract)
- Vu, T.T. 2009. “Estuarine Ecosystems of Vietnam (Exploitation, Maintenance and Management Resources for Sustainable Development)”, Education Publishing House, Hanoi. 269 pp. (in Vietnamese)
- Zheng, C.Y. 1989. “Fishes of the Zhujiang River”, Science Press, Beijing. 438 pp. (in Chinese)

Appendix 1. Questionnaire about fisher and fishery resources in the Ba Che and Tien Yen Rivers, northern Vietnam

1. Interviewee's information

Name:.....; Address:.....;

Lowland ; Middle land ; Highland ;

Occupation:.....; Age:.....; Residence in the region (year):.....;

Education level (in 12 grade):.....; Fishing experience (year):.....

2. Current status and exploitation fishery resources

2.1 The importance of fish for local resident

Fish consumed per week (day):.....; Percentages of income from fishing:.....;

Fish species daily consumed:.....

Commercial species:

#	Fish name	Price/kg	#	Fish name	Price/kg
1			10		
2			11		
...			...		

2.2 Current status of fishery resources

Do you know any program in exploitation and protection of fish here?

Yes ; No

The rates of decline during the past 10 years:.....(%); 5 years:.....(%)

2.3 Status of exploitation fishery resources

Wokers/trip:.....; Distance (km/trip):.....;

Season fishing: Dry , Rain , Both ;

Frequency of fishing (day/week:.....hour/trip:.....);

Product (kg/trip:.....; kg/hour:.....).

Gears used in fishing: Electro-fishing ; Net (mesh apertures:.....);

Others (.....).

Boat used in fishing: Yes , No ; Horse-power:.....CV.

2.4 Some possible impacts on fishery resources

Overfishing ; Water pollution ; Destructive gears ; Deforestation ; Management ;

Others (.....).

2.5 Other information

Appendix 2. List of fish collected from the Ba Che and Tien Yen Rivers, northern Vietnam from 2008 to 2011. Species of each family are listed in alphabetical order. Introduced species are marked with *.

Carcharhiniformes

1. Carcharhinidae: *Rhizoprionodon acutus*

Rajiformes

2. Dasyatidae: *Dasyatis akajei*, *D. bennetti*

Elopiformes

3. Megalopidae: *Megalops cyprinoides*
4. Elopidae: *Elops saurus*

Albuliformes

5. Albulidae: *Albula vulpes*

Anguilliformes

6. Muraenesocidae: *Congresox talabon*, *Muraenesox cinereus*
7. Ophichthidae: *Muraenichthys gymnopterus*, *M. melabonensis*, *Pisodonophis boro*

Clupeiformes

8. Pristigasteridae: *Ilisha melastoma*
9. Engraulidae: *Coilia mystus*, *Encrasicholina zollingeri*, *Stolephorus commersonii*, *S. indicus*, *Thryssa dussumieri*, *T. hamiltonii*
10. Clupeidae: *Clupanodon thrissa*, *Konosirus punctatus*, *Nematalosa nasus*, *Sardinella fimbriata*, *S. gibbosa*

Cypriniformes

11. Cyprinidae: *Acheilognathus barbatulus*, *A. nguyenvanhaoi*, *A. tonkinensis*, *Acrossocheilus elongatus*, *A. iridescens*, *Aristichthys nobilis**, *Carassius auratus auratus*, *Ctenopharyngodon idellus**, *Cyprinus carpio*, *Hemibarbus labeo*, *Hypophthalmichthys harmandi*, *H. molitrix**, *Microphysogobio kachekensis*, *Mylopharyngodon piceus*, *Nicholsicypris dorsohorizontalis*, *N. normalis*, *Opsariichthys bidens*, *Parazacco vuquangensis*, *Pseudohemiculter dispar*, *Puntius semifasciolata*, *Rasbora steineri*, *Rhodeus ocellatus*, *Rhodeus* sp., *Sarcocheilichthys nigripinnis*, *Saurogobio dabryi*, *S. immaculatus*, *Sinibrama affinis*, *Spinibarbus hollandi*, *Squalidus argentatus*, *Varicorhinus (Onychostoma) gerlachi*, *V. (O.) laticeps*, *V. (Scaplesthes) erythrogenys*, *Zacco platypus*
12. Cobitidae: *Botia pulchra*, *Cobitis sinensis*, *Misgurnus anguillicaudatus*, *M. tonkinensis*, *Parabotia kimluani*
13. Balitoridae: *Beaufortia daon*, *Liniparhomaloptera* sp., *Oreonectes platycephalus*, *Protomyzon sinensis*, *Schistura chapaensis*, *S. fasciolata*, *S. incerta*, *Traccatichthys pulcher*

Characiformes

14. Curimatidae: *Prochilodus lineatus**

Siluriformes

15. Sisoridae: *Glyptothorax hainanensis*, *G. honghensis*
16. Siluridae: *Pterocryptis cochinchinensis*, *P. gilberti*, *P. wynaadensis*
17. Plotosidae: *Plotosus lineatus*
18. Clariidae: *Clarias fuscus*, *C. gariepinus**
19. Ariidae: *Arius arius*
20. Bagridae: *Hemibagrus chiemhoaensis*, *H. guttatus*, *H. pluriradiatus*, *Leiocassis virgatus*, *Pelteobagrus fulvdraco*, *Pseudobagrus kyphus*

Osmeriformes

21. Osmeridae: *Plecoglossus altivelis*, *Salanx cuvieri*

Aulopiformes

22. Synodontidae: *Saurida undosquamis*

Mugiliformes

23. Mugilidae: *Liza carinata*, *L. subviridis*, *Mugil cephalus*, *M. strongylocephalus*

Atheriniformes

24. Atherinidae: *Atherinomorus lacunosus*, *Hypoatherina valenciennei*

Beloniformes

25. Adrianichthyidae: *Oryzias curvinotus*, *O. pectoralis*
26. Hemiramphidae: *Hemiramphus marginatus*, *Hyporhamphus quoyi*, *Zenarchopterus buffonis*
27. Belonidae: *Strongylura leiura*, *S. strongylura*, *Tylosurus crocodilus*

Gasterosteiformes

28. Syngnathidae: *Hippichthys heptagonus*, *Syngnathus cyanospilos*

Synbranchiformes

29. Synbranchidae: *Monopterus albus*
30. Mastacembelidae: *Mastacembelus armatus*, *Sinobdella sinensis*

Scorpaeniformes

31. Scorpaenidae: *Inimicus didactylus*, *Paracentropogon rubripinnis*, *Sebastiscus marmoratus*, *Trachicephalus uranoscopus*, *Vespicula trachinoides*
32. Platycephalidae: *Inegocia japonica*, *Platycephalus indicus*

Perciformes

33. Centropomidae: *Lates calcarifer*
34. Ambassidae: *Ambassis buruensis*, *A. gymnocephalus*, *A. kopsii*, *A. vachellii*

35. Percichthyidae: *Coreoperca whiteheadi*, *Siniperca vietnamensis*
 36. Moronidae: *Lateolabrax japonicus*
 37. Serranidae: *Diploprion bifasciatum*, *Epinephelus bruneus*, *E. coioides*, *E. maculatus*, *E. sexfasciatus*
 38. Apogonidae: *Apogon kiensis*
 39. Sillaginidae: *Sillago maculata*, *S. sihama*
 40. Echeneidae: *Echeneis naucrates*
 41. Carangidae: *Alepes djedaba*, *Carangoides malabaricus*, *C. praeustus*, *Caranx bucculentus*, *Gnathanodon speciosus*, *Scomberoides lysan*, *S. tala*, *Selaroides leptolepis*
 42. Leiognathidae: *Leiognathus bindus*, *L. daura*, *L. dussumieri*, *L. equulus*, *L. lineolatus*, *L. rivulatus*, *Secutor insidiator*, *S. ruconius*
 43. Lutjanidae: *Lutjanus argentimaculatus*, *L. fulviflamma*, *L. johnii*, *L. russellii*
 44. Caesionidae: *Caesio cuning*
 45. Gerreidae: *Gerres erythrourus*, *G. filamentosus*, *G. japonicus*, *G. limbatus*
 46. Haemulidae: *Diagramma picta*, *Plectorhinchus gibbosus*, *Pomadasyss hasta*
 47. Sparidae: *Acanthopagrus berda*, *A. latus*, *Parargyrops edita*, *Rhabdosargus sarba*
 48. Polynemidae: *Eleutheronema tetradactylum*
 49. Sciaenidae: *Argyrosomus macrophthalmus*, *Boesemania microlepis*, *Dendrophysa russelli*, *Nibea soldado*
 50. Mullidae: *Upeneus sulphureus*, *U. tragula*
 51. Drepanidae: *Drepane longimana*, *D. punctata*
 52. Monodactylidae: *Monodactylus argenteus*
 53. Chaetodontidae: *Chelmon rostratus*, *Parachaetodon ocellatus*
 54. Teraponidae: *Pelates quadrilineatus*, *P. sexlineatus*, *Rhyncopelates oxyrhynchus*, *Terapon jarbua*, *T. theraps*
 55. Cichlidae: *Oreochromis mossambicus**, *O. niloticus**
 56. Pomacentridae: *Abudefduf bengalensis*
 57. Blenniidae: *Omobranchus fasciolatoceps*
 58. Callionymidae: *Callionymus curvicornis*, *Dactylopus dactylopus*
 59. Odontobutidae: *Neodontobutis tonkinensis*, *Odontobutis potamophila*, *Sineleotris namxamensis*, *S. saccharae*
 60. Eleotridae: *Bostrychus sinensis*, *Butis butis*, *B. koilomatodon*, *Eleotris fusca*, *E. melanosoma*
 61. Gobiidae: *Acanthogobius flavimanus*, *A. stigmathonus*, *Acentrogobius caninus*, *A. chlorostigmatoides*, *A. viridipunctatus*, *Boleophthalmus pectinirostris*, *Ctenogobius brevirostris*, *Glossogobius fasciatopunctatus*, *G. giuris*, *G. sparsipapillus*, *Gnatholepis calliurus*, *Oxyurichthys microlepis*, *O. papuensis*, *O. tentacularis*, *Periophthalmus modestus*, *Rhinogobius brunneus*, *R. giurinus*, *R. variolatus*, *R. virgigena*, *Scartelaos histophorus*, *Tridentiger trigonocephalus*, *Trypauchen vagina*
 62. Ephippidae: *Platax teira*
 63. Scatophagidae: *Scatophagus argus*
 64. Siganidae: *Siganus canaliculatus*, *S. fuscescens*
 65. Sphyraenidae: *Sphyraena flavicauda*, *S. japonica*, *S. jello*
 66. Trichiuridae: *Lepturacanthus savala*
 67. Scombridae: *Scomberomorus commerson*
 68. Anabantidae: *Anabas testudineus*
 69. Belontiidae: *Macropodus opercularis*, *Trichogaster trichopterus**
 70. Channidae: *Channa asiatica*, *Ch. maculata*, *Ch. striata*
- Pleuronectiformes
71. Paralichthyidae: *Pseudorhombus arsius*, *Tephrinectes sinensis*
 72. Soleidae: *Brachirus orientalis*, *B. siamensis*, *Solea ovata*, *Zebrias zebra*
 73. Cynoglossidae: *Cynoglossus cynoglossus*, *C. microlepis*, *C. puncticeps*, *C. trigrammus*
- Tetraodontiformes
74. Triacanthidae: *Triacanthus biaculeatus*
 75. Monacanthidae: *Monacanthus chinensis*
 76. Tetraodontidae: *Chelonodon patoca*