J. Viet. Env. **2014**, Vol. 6, No. 3, pp. 220-226
DOI: 10.13141/jve.vol6.no3.pp220-226

JOURNAL of VIETNAMESE ENVIRONMENT

Preliminary data on the aquatic invertebrate fauna of the Ma River, Thanh Hoa province

Dẫn liệu ban đầu về khu hệ động vật không xương sống sông Mã, tỉnh Thanh Hóa

Research article

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A field survey for the invertebrate fauna conducted in the Ma River, Thanh Hoa province in 2013. The research applied multivariable analysis performed by the Primer v.6 software, such as CLUSTER, one-way ANOSIM, BEST and DIVERSE. The results showed a list of 138 aquatic invertebrate species. Of these, most were freshwater wide-distributing species coupled with others characterized for brackish and marine waters. The biodiversity status was quite high compared to several other rivers in the North of Vietnam. The list contained many economic-valued species and 2 of these were listed in the Red Data Book of Vietnam. The aquatic invertebrates showed a significant relation to the two different combinations of physiochemical factors for zooplanktons and zoobenthos, respectively. The values of the species number, abundance and Shannon-Weiner index for both of zooplanktons and zoobenthos showed a curved trend from the upper river segments to lower river segments. These figures for zooplanktons peaked in the middle river segments, whereas the numbers for zoobenthos achieved the highest numbers in the estuaries. The species composition of the estuaries differentiated significantly from that of other freshwater habitats.

Năm 2013 đã tiến hành một đợt điều tra khu hệ động vật không xương sống sông Mã, tỉnh Thanh Hóa. Nghiên cứu sử các phân tích đa biến thông qua phần mền Primer v.6, bao gồm: CLUSTER, one-way ANOSIM, BEST và DIVERSE. Kết quả phân tích thu được 138 loài với thành phần loài chủ yếu là những loài nước ngọt thường gặp và phân bố rộng, ngoài ra còn có các loài đặc trưng cho nước lợ và mặn. Trong số các loài thu được, nhiều loài có giá trị kinh tế và 2 loài có tên trong Sách Đỏ Việt Nam. Khu hệ động vật không xương sống sông Mã có quan hệ chặt với hai nhóm chỉ số thủy lý hóa học khác nhau, tương ứng cho động vật nổi và động vật đáy. Giá trị các chỉ số sinh học gồm số lượng loài, mật độ và Shannon-Weiner hồi quy theo đường cong phi tuyến từ thượng lưu tới hạ lưu; đạt giá trị cao nhất tại cửa sông đối với động vật đáy và vùng trung lưu với động vật nổi. Thành phần loài cửa sông khác biệt rõ rệt với thành phần loài các sinh cảnh nước ngọt khác.

Keywords: Ma River, aquatic invertebrate fauna, biodiversity, habitat distribution

1. Introduction

The Ma River originated in north-western Vietnam with a total length of approximate 512 km runs about 100 km through Laos and then back more than 400 km through Vietnam, meeting the sea at the Gulf of Tonkin. In Thanh Hoa province, the length of the Ma River is about 240 km, creating the third largest delta, namely Thanh Hoa delta, in Vietnam (Tran et al., 1987; Vu, 1999) and contributes significantly to growth of many economic sectors, such as transportation, tourism, fisheries, agriculture and living water supply. It plays an essential role on providing

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http://dx.doi.org/10.13141/JVE
ISSN: 2193-6471

ecological services for the province as well, e.g. water regulation, toxic neutralisation, biodiversity maintenance etc. (Hoang, 2008). Recently, there have had several investigations on the Ma's biodiversity, e.g. one research on fish resource and two others focused on the biological resources in estuaries (Duong, 2007; Ho, 1998; Ho et al., 1998). Though the aquatic invertebrates contribute significantly to the total yield of aquatic resources exploitation from the river (DAREP, 2012), very few studies on these species have been conducted.

Under the pressure of economic growth, biodiversity of the Ma River has been increasingly threatened. Evidently, a field trip of environmental survey in 4 collecting sites along the river showed values of some main water parameters (BOD_5, SS, NO_2^-, NH_4^+) were 1.1 – 5.8 times higher than those in the National water quality criteria of A2 and B1 - QCVN (2008); particularly, figures for oil concentration was 5 – 24.3 times higher (DoNRE, 2010). On the other hand, although the yield of aquatic resources in the Ma River tended to increase due to the increasing number of boats, the productivity showed a considerable decrease (DAREP, 2012); recently, some molluscs and crustaceans were rarely recorded even common in the past. A projection predicted that biodiversity in Thanh Hoa province were likely to be more seriously declined due to increasing pollution, habitat deterioration and unsustainable exploitation (DoNRE, 2010). This research aims to investigate the biodiversity status of the invertebrates of the Ma River with a focus on the length in Thanh Hoa province, and its changes according to differences of environment characteristics and topography. The results could be used as rationale for policy makers in biological conservation and environmental protection of the river.

2. Materials and methods

2.1 Research area and methods

A field trip was conducted in the Ma River in Thanh Hoa province, from March to April 2014. The invertebrate samples were collected in 18 collecting transections by the standard methods (Dang, 1974; Dang et al., 1980) (Table 1 and Figure 1), i.e. zooplanktons specimens were collected by zooplankton Nets, No. 50 and 52, for qualitative and quantitative purposes, respectively; zoobenthos were collected by Hand Net and Peterson Grab. Samples were fixed by 5% formalin solution, then stored in 200 ml or 500 ml plastic containers and deposited in Institute for Ecology and Works protection (WIP), Hanoi city, Vietnam.

Table 1. Information of the collecting transections in the Ma River, Thanh Hoa province

Transection No.	Location	Coordinate information
1.	Confluence of the Ma River and the Sim stream, Vietnam-Laos boundary zone	20°33'33.30"N; 104°27'44.22"E
2.	Chieng Nua bridge	20°31'48.69"N; 104°41'0.45"E
3.	Confluence of the Luong and Ma Rivers	20°24'9.95"N; 105° 4'44.11"E
4.	Confluence of the Lo and Ma Rivers	20°22'43.84"N; 105° 06'7.16"E
5.	Con Thac Voi	20°21'54.83"N; 105° 8'49.20"E
6.	Hon Tra stream	20°17'41.27"N; 105°10'35.11"E
7.	Ba Thuoc 2 (Hydroelectricity dam)	20°12'46.63"N; 105°27'53.86"E
8.	Go Cho	20°13'28.66"N; 105°26'52.26"E
9.	Go Song	20°14'38.74"N; 105°26'9.84"E
10.	Go Phen	20°13'41.50"N; 105°26'56.80"E
11.	Nui Mo	20°12'25.40"N; 105°27'51.10"E
12.	Cam Thuy bridge	20°13'21.89"N; 105°28'16.77"E
13.	Ba Bong	19°57'20.16"N; 105°45'49.47"E
14.	Con Sanh	19°53'4.80"N; 105°45'44.00"E
15.	Thanh Hoa city	19°50'25.25"N; 105°47'38.98"E
16.	Lach Sung (estuary)	19°57'10.09"N; 106° 0'10.58"E
17.	Lach Truong (estuary)	19°53'15.01"N; 105°56'49.70"E
18.	Cua Hoi (estuary)	19°46'48.49"N; 105°55'1.57"E

Species identification was based on the main key documents (Boxshall and Halsey, 2004; Dang and Ho, 2001; Dang et al., 1980; Quang Hung Nguyen, 2010; V. C. Nguyen, 2000; V. K. Nguyen, 2001; X. Q. Nguyen et al., 2001; Voigt and Bestimmungswerk, 1956). In addition to species samples, 15 physiochemical parameters were measured for each site, including Temperature (T^oC), pH, Dissolved oxygen (DO-mg/l), Turbidity (NTU), Total suspended solid (TSS-mg/l), Chemical oxygen demand (COD-mg/l), Biological oxygen demand (BOD_5-mg/l), NO_3^- (mg/l), NH_4^+ (mg/l), Cl^- (mg/l), PO_4^+ (mg/l), As (mg/l), Hg (mg/l), Pb (mg/l) and Cd (mg/l).

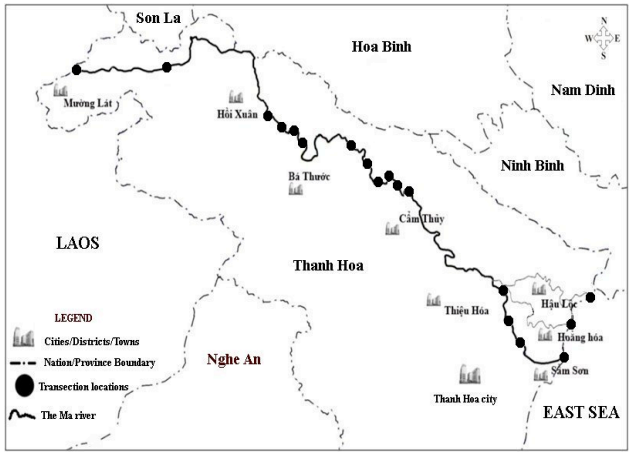

Figure 1. Map showing the transection locations in the Ma River, Thanh Hoa province

2.2 Data analysis

The data was stored and managed by Excel® program (MS Office™ v. 2007). Some ecological analyses were performed by using statistical software of PRIMER™ v.6 with a prior data transformation of Log(X+1). The analysis includes DIVERSE (Shannon-Weiner index, H'; number of species, S; number of individuals or abundance, N), CLUSTER analysis (using Bray-Curtis similarity and the cluster mode of group average), BEST (Biota and/or Environment matching) and one-way ANOSIM (Analysis of Similarity) (Clarke and Gorley, 2001; Clarke and Warwick, 1998).

3. Results

3.1 Environmental characteristics

Based on the National criteria for surface waters (MONRE, 2008), values of the 8 environmental parameters met the requirement for the criterion of A2. On the other hand, the three of DO, COD and BOD_5 showed higher values than those in B1 and the figure for TSS was even higher than that in B2.

The BEST analysis showed that a combination of Cl^- and PO_4^{3-} could "best explain" for the species pattern of zoobenthos (p = 0.013 and Rho = 0.66) and a combination of T, NO_3^-, Cl^- and As for zooplanktons (p = 0.001 and Rho = 0.727).

Table 2. The biodiversity characteristics of the invertebrate fauna in the Ma River, Thanh Hoa province in terms of the species number (S), abundance (N) and H' index

Transection	Zoobenthos			Zooplanktons		
No.	S	N	H'(loge)	S	N	H'(loge)
1.	17	93	2.781	5	1900	1.358
2.	17	72	2.744	12	10633	2.301
3.	19	99	2.907	8	5000	2.051
4.	18	79	2.827	7	11250	1.869
5.	15	70	2.585	19	18133	2.822
6.	18	72	2.821	9	4350	2.075
7.	13	72	2.537	10	9483	2.176
8.	15	72	2.578	19	25150	2.888
9.	11	50	2.319	13	6400	2.36
10.	19	96	2.894	14	13100	2.584
11.	18	105	2.833	24	26700	3.107
12.	17	82	2.738	19	16967	2.735
13.	19	89	2.835	10	10650	2.226
14.	17	105	2.664	23	41717	3.009
15.	19	115	2.837	24	25750	3.079
16.	41	153	3.58	8	7778	2.019
17.	41	160	3.599	8	7908	2.05
18.	43	204	3.681	8	10238	2.041

3.2 Species diversity

The analysis showed a list of 138 species of the aquatic invertebrates, covering 58 families and 13 orders of 3 phyla (Anthropoda, Mollusca and Rotatoria). Amongst these, zoobenthos had 39 families and 85 species, whereas the figures for zooplanktons were 19 and 53 respectively.
There were 2 species listed in the Red Data Book of Vietnam (2007) (VAST, 2007), all were crustaceans (*Ranguna kimboiensis* and *Potamon tannanti*) and categorized as VU. The biodiversity information (S, N and H') of the aquatic invertebrates amongst the transections was showed in Table 2.

3.2 Species distribution

Zooplankton tended to increase considerably the values of S, N and H' from the upper river segments and peaked in

the middle river segments, then the figures gradually decreased in the lower river segments. The level of correlation of this trend to the actual data ranged from about 24% to 46% (Figure 2). Zoobenthos, on the other hand, illustrated with an opposite curved line. The values of correlation were quite higher than zooplanktons, varying from 74.3% to 87.6%. The values of S and N showed a slight decrease from the upper river segments and obtained the lowest figures in the middle river segments in spite of more diverse river beds and stability of environmental conditions. Running through the middle river segments, the numbers increased markedly and got peaks in the estuaries. The H' index changed in the same manner with S and N but a much lower sloop value (Figure 2).

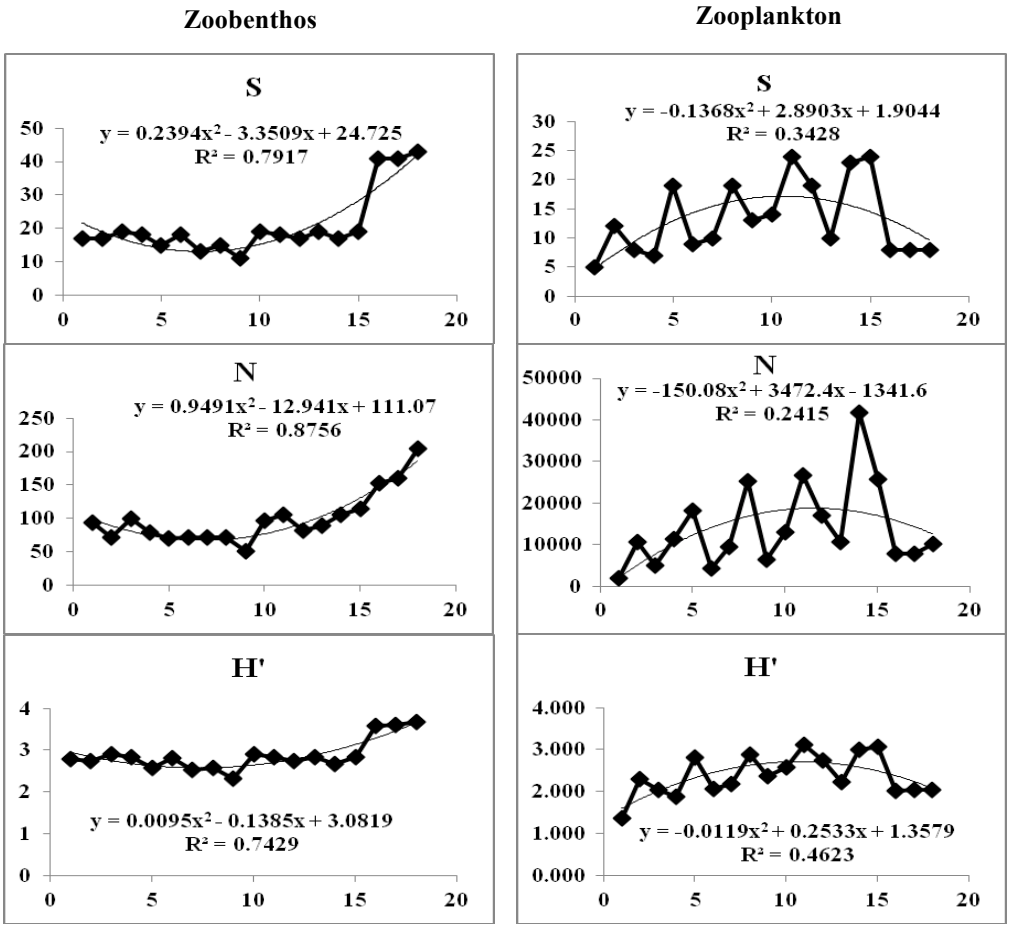

Figure 2. Trend lines of the zooplanktons (three small figures on the right) and zoobenthos (three small figures on the left) in terms of the species number (S), abundance (N) and H' index from the upper river segments, through lower river segments, to estuaries.

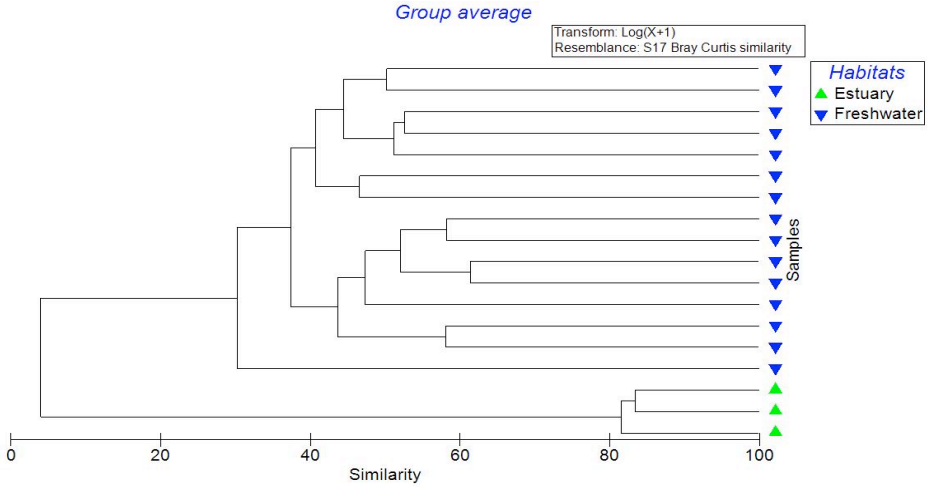

Figure 3. Similarity among the collecting transections with a clear-separated group of estuaries

The result of the cluster analysis was shown in Figure 3 and illustrated a separated group of estuary transections out of other freshwater ones. The ANOSIM analysis showed that this separation was significant (p value = 0.001).

4. Discussions

4.1 Biodiversity and environment status

According to zoogeography views, most species had wide distributions and were commonly found in inland waters of the Northern Vietnam (Dang, 1980; Ho et al., 2002). Besides, some were characterized for brackish and marine waters, such as *Mongolodiaptomus birulai, Shcmackeria gordioides, Schmackeria bulbosa* and *Diaphanosoma sarsi* (Zooplanktons); *Alpheus euphrosyne, Metapenaeus brevicornis* and *Metapenaeus joyneri* (Zoobenthos). Most of the crustaceans (zoobenthos) and molluscs were economic-valued species and some of these are under threatened (two crustaceans listed in the Red Data Book of Viet Nam).

The number of zoobenthos species of the Ma River was equal to that of Nhue-Day rivers (85 species) but higher than Cau river by 28 species (Do, 2009; Quang Huy Nguyen et al., 2008; X. Q. Nguyen et al., 2005). However, noticeably, Insecta species were one of the majorities in species components of the Nhue-Day and Cau rivers. It is most certain that when adding the species number of insects, that was not covered in this research, the zoobenthos of the Ma River would be much higher. On the other hand, the species number of zooplanktons of the Ma River was lower than that of the Nhue-Day rivers by 12 species (X. Q. Nguyen et al., 2005) but the value of H' was slightly higher, 2.38 vs. 2.21, respectively.

The high values of some environmental features might raise a question about the increasing wastewater in the river. In fact, there were some polluted incidences occurred recently in the Ma River related to injection of huge amount of untreated wastewater from manufactories, mineral exploitation sites and inhabitant areas (DoNRE, 2010; Ha, 2012; Hong, 2011). In addition, the measured values of Cl^- and PO_4^{3-} (the most effected on the zoobenthos pattern) and NO_3^-, Cl^- and As (coupled with T, most effected on zooplankton pattern) met the criterion of A2 but A1; if these parameters, all indicating for organic pollution, are on the increase, the biodiversity might be negatively affected.

These above results were preliminary but it is evidently to expect that more diverse invertebrates for the Ma River in further studies provided that the current environmental problems would be treated effectively. In contrast, the species components might process through a trend of increasing the tolerant species and disappearance of common ones, resulting in a significant decline of biodiversity as a consequence; the situation already occurred in Nhue-Day and Cau rivers.

4.2 Topography and habitat distribution

Both of zoobenthos and zooplanktons showed a non-linear trend, square equations, in all three features (S, N and H' index) but with opposite sloop values from upper segments to lower segments of the river (Figure 2). Noticeably, the trends summed up from this initial investigation and should be substantially strengthened by further studies. However, these provided a general view of the species distribution according to different topography and habitats varied along the river.

The trend of zooplanktons is likely to result from more stable conditions of water in the middle river segments, including low water velocity and more unchanged concentrations of physiochemical factors, collectively providing most favourable habitats to behaviours and growth of zooplanktons. In the upper river segments, in contrast, the water velocity is usually much higher which is a very unsuitable condition for inactive organisms like zooplanktons, causing the lowest values of S, N and H' index. The zooplankton composition in the estuary habitat is complemented by marine species. However, the highly volatile salinity and other features in estuaries, causing a decrease of freshwater zooplanktons and lower species number in total. It is considered as a common trend in many rivers in the North of Vietnam (Dang, 1980; Dang and Ho, 2007; Ho et al., 2002).

In the zoobenthos trend, the lowest values of S and N in the middle river segments could be explained by the intensive exploitation, rapid urbanization along the river banks and pollution. Some similar situations were recorded in other rivers in the North of Vietnam (Dang, 1980; Ho et al., 2002; X. Q. Nguyen et al., 2005). Besides, the highest values of S, N and H' index in the estuaries mostly result from the significant complement of brackish and marine species.

A clear differentiation of the aquatic invertebrates was observed between estuary habitats and other freshwater ones, leading to the two typical species groups for each ecosystem already shown in other rivers in the North (Dang, 1980; Ho et al., 2002). However, in both of zooplanktons and zoobenthos, some migrating marine/brackish species were recorded. The zooplankton, *Schmackeria bulbosa* for example, might migrate about 175 km into inland waters. The zoobenthos have nearer lengths of migration, e.g., *Eriocheir sinensis* could travel about 50 km far from the estuaries (Ho et al., 2002).

5. Conclusion

The biodiversity of the Ma River was quite high compared to several other rivers in the North of Vietnam (the Cau river and Nhue-Day rivers) and evidently expected more recorded species in further studies, especially the insect group. The invertebrate list contained many economic-valued species; two of these were listed in the Red Data Book of Vietnam. The aquatic invertebrates showed a significant relation to the two different combinations of physiochemical factors for zooplanktons and zoobenthos, respectively. The values of S, N and H' of both zooplanktons and zoobenthos showed a curved trend from the

upper river segments to lower river segments. These figures for zooplanktons peaked in the middle river segments, whereas the numbers for zoobenthos achieved the highest values in the estuaries. The species composition of the estuaries differentiated significantly from that of other freshwater habitats.

6. Acknowledgments

This study is a part of the project "*Planning for the Ma River as an inland-water reserve in Thanh Hoa province towards 2020"* managed by the Thanh Hoa Provincial People's committee and directly coordinated by the Thanh Hoa Department of Agriculture and Rural Development, the authors express their thanks.

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