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Some observations on altered morphology in *Amphipsyche meridiana* (Hydropsychidae: Trichoptera) larvae from the Pasak Jolasit Dam Outlet, central Thailand

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Abstract

Amphipsyche meridiana Ulmer, 1909. larvae from the River Pasak below the Pasak Jolasit Dam were examined for alteration of morphological structure such as the anal papillae, surface, and tracheal gills of the larvae. The tracheal gills were the most altered followed by surface and anal papillae. Factors such as conductivity, and inputs of orthophosphate, sulfate, turbidity, other contaminants, and/or stream profiles may have contributed to the abnormalities.

Key words: Trichoptera, Hydropsychidae, Amphipsyche, altered morphology, outlet, Thailand

Introduction

The gills of aquatic macroinvertebrates are one of the most affected structures on an organism when the surrounding environment is altered. They are particularly sensitive due to their large surface area, which increase the accumulation of compounds and gases (Skinner & Bennett 2007). Direct effluent discharges and agricultural runoff contains complex mixtures of contaminants which may produce new compounds due to break-down and transformation processes and hence contribute to the complexity of the total toxic burden. The use of only chemical and physical measurements may not fully assess the synergistic effect of pollution on the biotic community (Resh & Jackson 1993). In general, biological indicators provide the potential for direct observation of the overall effect of environmental contaminants by virtue of their role in aquatic ecosystems (Warwick 1988).

The larvae of Hydropsychidae can be ideal subjects for the study of the effect of water quality on morphological abnormality for several reasons. First, hydropsychids are widely distributed and abundant in many types of running waters. Second, they respond to variations in the water quality and their autecology is well enough known for the impact of pollutants to be distinguished (Vuori 1995). Third, due to their robust bodies, hydropsychid larvae are easily handled and observed for morphological abnormalities. Fourth, abnormalities in the hydropsychid tracheal gills and the ion-regulatory, anal papillae, can be attributed to a disruption of the respiratory and ion regulation functions of the individual (Camargo 1991; Vuori 1994). Fifth, the relatively large size facilitates sampling and analysis of the concentrations of chemicals in the larvae. Finally, the hydropsychid larvae, as facultative filter feeders, are exposed to pollutants in seston, flowing water and the organic matter accumulated in riffle microhabitat (Vuori & Kukkonen 1996).

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The purpose of this study was to investigate the individual morphological abnormalities of the *Amphipsyche meridiana* larvae living in the side channels below the Pasak Jolasit Dam and to consider possible impacts of physico-chemical factors (e.g., dissolved oxygen (DO), pH, water temperature, conductivity, total dissolved solids (TDS), sulfate and nutrients) on morphological structure.

Study area

Investigations were conducted at the outlet of the Pasak Jonlasit Dam which was constructed across the Pasak River. The origin of the Pasak River (N 14° 21' 44" ~ 17° 06' 02", E 100° 34' 40" ~ 101° 32' 56", area: 15 779 km^2, length of main stream**:** 1 039 km) is in the highlands of Phetchaboon Province and flows through hundreds of kilometers of the central plain of Lopburi and Saraburi, and joins the Chao Phraya River at Ayutthaya Province. This river flows from the mountainous north to the south. There are short tributaries from the east and the west joining the river as it flows to the Chao Phraya River (Fig. 1).

FIGURE 1. Sampling site at Pasak Jolasit dam outlet, Lopburi Province, Thailand; N 14º 51’28**,** E 101º 04’ 07.

Material and methods

Larvae of the hydropsychid *Amphipsyche meridiana* were sampled from the margins of the Pasak River below the Pasak Jolasit Dam. The specimens were collected during July to December 2008. In each month, larvae were hand-picked for 30 min and preserved in 95% ethanol, and checked for morphological abnormalities.

Physico-chemical parameters of water quality in the river were recorded directly at the sampling site and included pH, water temperature, dissolved oxygen (DO), conductivity, and total dissolved solids (TDS). Water samples from each collecting period were stored in polyethylene bottles (500 ml). The ammonia nitrogen (NH_4-N), sulfate (SO_4^{2-}), nitrate-nitrogen (NO_3-N), orthophosphate (PO_4-P) and turbidity were determined in accordance with standard procedures (APHA 1992).

Structural changes in the tracheal gills, surface and anal papillae of the larvae were observed and counted under a stereomicroscope. Minor darkening (often single, pigmented spots) was not catergorized as a morphological abnormality because this may be induced by natural causes.

Analyses

The physico-chemical water quality parameters and hydropsychid impairment were analyzed by Pearson's correlation in SPSS software programs (Version 13.0 for Windows).

Results and discussion

The physico-chemical parameters of water quality are shown in Table 1. A total of 1,227 individual larvae of *Amphipsyche meridiana* were collected during 6 months (Table 2).

TABLE 1. Values of physico-chemical variables.

Month	Temp.W (°C)	pH	Cond. (us/cm)	TDS (mg/L)	DO (mg/L)	NO_3-N (mg/L)	NH_4-N (mg/L)	PO_4-P (mg/L)	SO_4^{2-} (mg/L)	Turbidity (FTU)
Jul-08	31	8.1	244	135	5.7	1.4	0.55	0.27	35	74
Aug-08	27.5	7.55	276	137	6.55	1.45	0.27	0.055	18	8
Sep-08	26.2	7.9	294	146.5	6.35	2	0.27	0.03	22	7
Oct-08	29.1	7.7	311	156	5.85	1.5	0.26	0.03	21	4
Nov-08	27.3	7.8	316	156	4.19	1	0.01	0.11	21	6
Dec-08	26.2	7.3	308	152.7	3.56	0.8	0.05	0.1	21	1

TABLE 2. Percentage of larval impairment in each month.

Month	Number of larvae collected	Number of larvae impairment	% Impairment
Jul-08	453	71	15.7
Aug-08	426	46	10.8
Sep-08	298	28	9.4
Oct-08	102	11	10.8
Nov-08	182	17	9.3
Dec-08	219	25	11.4

Hydropsychid morphological abnormalities were easily distinguished as heavy darkening, malformation and/or reduction of single gill tufts. Darkening of the gills appeared to start either at the basal or distal ends. Three morphological categories were found: A) all structures considered normal with pale, clear gills and surface; B) tracheal gills malformed and surface of abdomen with small wounds; and C) tracheal gills reduced to single gill tufts and surface of abdomen with large wounds. A normal morphology compared to an impaired morphology is shown in Fig. 2.

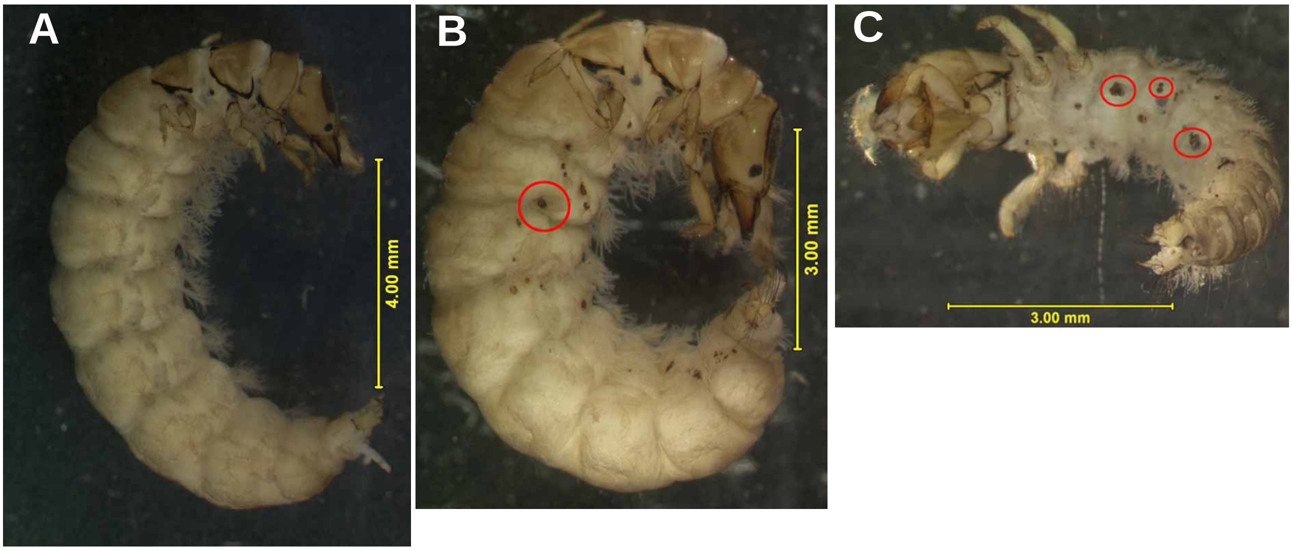

FIGURE 2. A. Morphology structure normal, B. tracheal gill malformation and surface of abdomen with small wounds, C. tracheal gill reduced to single gill tufts and surface of abdomen with large wounds.

The highest number of individuals collected occurred in July, and the lowest number was in October when the flood period occurred. In November, 182 hydropsychid larvae were examined for morphological abnormalities, and in September where 298 hydropsychid larvae were screened and exhibited the lowest levels of morphological impairment at the outlet, 9.3 and 9.4 respectively (Table 2).

The correlation between physico-chemical water quality parameters and hydropsychid impairment was also analyzed. Conductivity was negatively correlated with hydropsychid impairment ($p < 0.05$), while orthophosphate, sulfate, and turbidity were positively correlated with hydropsychid impairment ($p<0.05$) (Table 3).

TABLE 3. Pearson's correlations coefficient between physico-chemical parameters and hydropsychid impairment.

	Temp. W.	Conductivity	DO	NH_4-N	PO_4-P	SO_4^{2-}	Impairment
Turbidity	0.820*	-0.875*		0.821*	0.910*	0.963**	0.911*
TDS		-0.946**					
NH_4-N		-0.885*					
NO_3-N			0.884*				
SO_4^{2-}					0.901*		
Impairment		-0.821*			0.867*	0.877*	

**: Correlation is significant at the 0.01 level, positive (+)
*: Correlation is significant at the 0.05 level, negative (-).

Our results and observations are quite preliminary because data were collected only in the outlet of the dam and without data collected simultaneously in the natural unpolluted water. I plan to gather and analyze more physico-chemical data in the future. Moreover, experimental data are needed before one can surely determine factors causing the development of morphological abnormalities of this hydropsychid species in the outlet of the dam. It is fair to assume that the pollutants being discharged into the system are creating a stressful environment for benthic organisms, but the most stressful parameters have not been determined.

Various studies (Skinner & Bennett 2007; Vuori 1994; Vuori & Kukkonen 1996, 2002) pointed out that gill abnormalities present in aquatic macroinvertebrates collected from both polluted and unpolluted rivers may have minor darkening or broken branches with darkened wounds which may obscure interpretation. Wounded individuals may grow gills more slowly, fail to pupate and eventually die before completing their life cycles (Vuori 1994, 1995). However, additional data (e.g., experimental evidence and biochemical and physiological measures) are needed to confirm the ecological relevance of these morphological abnormalities.

Field studies indicate that hydropsychid anal papillae damage is possibly related to changes in ion exchange processes of streams, typical for acidified and metal-contaminated waters. These papillae function as ion regulatory (osmoregulatory) organs in hydropsychids. The anal papillae of freshwater caddisfly larvae possess specialized cells (chloride epithelia) which are able to absorb electrolytes and thus compensate for the loss of ions due to the hypotonic environment. On the other hand, gill abnormalities are more related to exposure to organic pollution, which typically results in decreased oxygen concentrations (Vuori 1995; Vuori & Kukkonen 1996).

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