Faunal composition of meio- and macroinvertebrates associated with aquatic macrophytes in Central Kalimantan and West Java, Indonesia, with special reference to oligochaetes

Akifumi Ohtaka1*, Dede Irving Hartoto1, Yoyok Subarro2, Tariono Buchar1, Fifi Widian1, Toshio Iwakuma1 and Hidenobu Kunii1

1 Department of Natural Science, Faculty of Education, Hirosaki University, Hirosaki 036-8560, Japan
2 Research Center for Limnology, Indonesian Institute of Sciences, Cibinong 16911, Indonesia
3 Department of Fisheries, Faculty of Agriculture, University of Palangka Raya, Palangka Raya 73112, Central Kalimantan, Indonesia
4 Faculty of Fisheries and Marine Science, Bogor Agricultural University, Campus IPB, Darmaga, Bogor 16680, Indonesia
5 Graduate School of Environmental Science, Hokkaido University, Sapporo, 060-0810, Japan
6 Research Center for Coastal Lagoon Environments, Shimane University, Matsue 690-8504, Japan
* Corresponding author: Tel +81-172-39-3369, Fax +81-172-32-1478, e-mail: ohtaka@cc.hirosaki-u.ac.jp

ABSTRACT Composition of meio- and macroinvertebrates associated with aquatic macrophytes was compared between acid waters in a peat swamp area of Central Kalimantan (CK) and neutral waters in West Java (WJ). Among the invertebrate assemblages, cladocerans and/or copepods dominated in both regions. On the other hand, relative abundances of chironomids and ostracods were significantly higher in CK and WJ, respectively. Eighteen taxa of oligochaetes were recorded from the regions, of which 14 ones belonged to the subfamily Naidinae of the family Tubificidae. The oligochaete composition was quite different between CK and WJ, in that Pristina species dominated in CK, while Stylaria fossularis dominated in WJ. WJ harbored more diverse oligochaetes than CK. The difference in oligochaete composition is related to water acidity.

Keywords: aquatic invertebrates, aquatic macrophytes, Central Kalimantan, oligochaetes, West Java.

It is widely recognized that macrophytes in lakes and rivers play important roles in aquatic ecosystems. They offer many microhabitats for invertebrates, where various kinds of animals can live, feed, oviposit, thereby creating diverse communities. Invertebrates associated with aquatic macrophytes are an important natural food source for fishes and other higher consumers. In tropical zone, submerged root systems of the floating vegetation have been intensively studied for invertebrate diversity (e.g. Junk, 1977; Poi de Neiff & Carignan, 1997; Heckman, 1998).

In addition to neutral freshwaters, tropical regions often have acidic waters derived from tropical peat. These are often brownish colored and are called “blackwaters”. Similar acidic waters are also widely found in Sphagnum bog mires in cool climate regions. In general, the species diversity of larger animals is very low in Sphagnum bog waters, and major animal groups are poorly represented or often lacking there (Wetzel, 1983). On the other hand, the characteristics of invertebrate structures - including meiofauna - in the acid waters of tropical peat swamp areas have been poorly studied.

In the present study, to clarify the invertebrate faunal differences between acid and neutral waters in tropical Asia, the composition of meio- and macroinvertebrates (with special reference to oligochaetes) associated with aquatic macrophytes was compared between the acidic waters in a peat swamp area of Central Kalimantan and neutral waters in West Java.

STUDY SITES AND METHODS

The material was collected from six vegetated sites in a peat swamp area of Central Kalimantan (CK) during 11–14 December 1998, and from three sites in Bogor, West Java (WJ) during 2–4 March 2001 (Fig. 1). The CK sites included two canals (CK 1 and CK 2) and a fish farm pond (CK 3) in the Kapuas River Basin, the littoral Lake Tundai in the Kahayan River Basin (CK 4), the upper Sebangau River (CK 5), and a canal in a suburb of Palangka Raya (CK 6). The WJ sites included a pond in the Bogor Botanical Gardens (WJ 1), and the littoral zones of two small, eutrophic lakes, L. Bojongari (WJ 2) and L. Cikaret (WJ 3).

All survey’s were conducted during the day. Specimens were randomly collected by scooping in the water with a dip net (opening 190 µm) in and among
variable macrophytes. These included both primarily aquatic forms (the submerged parts of emergent plants, submerged plants, and the roots of free-floating plants), and sinking terrestrial weeds. Animals collected were immediately fixed in a 10% formalin solution. Water temperature and pH values were measured at each sampling site. Limnological data in CK sites were partly given in Iwakuma (1999).

To determine the faunal composition of each sample, 300–900 meio- and macroinvertebrate specimens were randomly identified into phylum, class, order, or family levels. Based on these compositions, the Simpson’s index of diversity (SID; Kimoto & Takeda, 1989) was calculated for each site, and a dendrogram using average-linkage cluster analysis was depicted for grouping the sites on the basis of similarity indices, Pianka’s $\bar{I}$ (Kimoto & Takeda, 1989). Invertebrates less than 100 µm long, protozoans and rotifers for example, were not examined in the present study because the dip net sieve used was too coarse to retain them.

The collected oligochaetes were examined specifically for intact specimens for mounting on slides either in CMCP-10 (Polysciences Inc.) or Canada Balsam after first being dehydrated in a graded series of ethanol and water solutions, and then being cleared in methyl salicylate. To determine the oligochaete composition, 10–90 randomly selected worms were identified. In this paper, species previously included in the family Naididae were placed in the subfamily Naidinae within the family Tubificidae (Erséus & Gustavsson, 2002), and the naidine genus Pristinella Brinkhurst was merged into the genus Pristina Ehrenberg (Collado & Schmeltz, 2000). The SID of each site was calculated and an oligochaete-depicting dendrogram was created by the above-mentioned methods. The significance of differences between CK and WJ in the faunal composition and SID were tested by ANOVA.

The specimens used in the present study are deposited in the Department of Natural Science, Faculty of Education, Hirosaki University, Hirosaki, Japan.

RESULTS

Faunal composition

Central Kalimantan: Waters of all the CK sites were brownish colored and acidic with pH values ranging from 2.9 to 4.5. Surface water temperatures ranged from 28.8 to 34.3°C.

Sixteen taxonomic groups of invertebrates were found in the CK sites studied, of which three groups, the Cladocera, Copepoda, and Chironomidae were common to all sites (Table 1). Among these, cladocerans were the most dominant in all sites except CK where copepods predominated; these two taxa combined to account for more than 63% of all invertebrates recorded in all CK sites. Chironomids were the next most dominant, accounting for 24.9% of all invertebrates. Hemipterans, in which notonectids were overwhelmingly dominant, comprised 14.1% of all invertebrates at CK. Nematodes, turbellarians, oligochaetes, acari, ostracods, odonates, ephemeropterans, trichopterans, lepidopterans, and dipteran ceratopoginids, culicids, chaoborids were found in one to three CK sites at a proportion of less than 1% of all animals. The SID ranged from 0.25 to 0.41 with a mean value of 0.36 (Table 2).

Oligochaetes were collected in all CK sites except for CK 5. Nine taxa were found in the samples (Table 3). All species except the enchytraeids belonged to the subfamily Naidinae of the family Tubificidae. They included five Pristina species (P. longiseta, P. aequiseta, P. biserrata, P. poboscidea, and P. sp.), of which Pristina poboscidea was the most dominant. The Pristina species combined occupied from 67% (CKI) to 100% (CK1 and CK6) of the entire oligochaete assemblages (Fig. 2). The oligochaete SID ranged from 1.0 to 2.0, with a mean value...
Aquatic Invertebrates in Central Kalimantan and West Java

Table 1. Relative abundance (%) of meio- and macroinvertebrates associated with aquatic macrophytes in Central Kalimantan (CK) and West Java (WJ). Vegetation; EM, emergent plant; SM, submerged plant; FF, free-floating plant

<table>
<thead>
<tr>
<th>Water temp. (°C)</th>
<th>CK1</th>
<th>CK2</th>
<th>CK3</th>
<th>CK4</th>
<th>CK5</th>
<th>CK6</th>
<th>WJ1</th>
<th>WJ2</th>
<th>WJ3</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>2.9</td>
<td>2.9</td>
<td>4.2</td>
<td>4.5</td>
<td>3.6</td>
<td>3.9</td>
<td>6.5</td>
<td>6.5</td>
<td>7.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vegetation</th>
<th>SM</th>
<th>SM</th>
<th>SM</th>
<th>FF</th>
<th>EM</th>
<th>SM</th>
<th>SM</th>
<th>FF</th>
<th>SM, FF</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. examined</td>
<td>756</td>
<td>806</td>
<td>481</td>
<td>659</td>
<td>305</td>
<td>612</td>
<td>825</td>
<td>663</td>
<td>832</td>
</tr>
</tbody>
</table>

Hydrozoa: 0% Hydrozoa, 0% Nematoda, 0% Turbellaria, 0% Mollusca, 0% Oligochotae, 0% Conchostraca, 0% Cladocera, 0% Copepoda, 0% Ostracoda, 0% Decapoda, 0% Odonata, 0% Ephemeroptera, 0% Hemiptera, 0% Trichoptera, 0% Lepidoptera, 0% Chironomidae, 0% Ceratopogonidae, 0% Culicidae, 0% Chaoboridae

Table 2. SID (Simpson's index of diversity) values for whole invertebrate and oligochaete communities associated with aquatic macrophytes in Central Kalimantan (CK) and West Java (WJ). No oligochaete was collected from CK 5.

<table>
<thead>
<tr>
<th>Invertebrates</th>
<th>CK1</th>
<th>CK2</th>
<th>CK3</th>
<th>CK4</th>
<th>CK5</th>
<th>CK6</th>
<th>WJ1</th>
<th>WJ2</th>
<th>WJ3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oligochaetes</td>
<td>1.0</td>
<td>1.7</td>
<td>1.8</td>
<td>2.0</td>
<td>—</td>
<td>1.0</td>
<td>4.3</td>
<td>5.7</td>
<td>2.6</td>
</tr>
</tbody>
</table>

of 1.5 (Table 2).

West Java: In the three WJ sites studied, the waters were nearly neutral with pH ranging from 6.5 to 7.2. Surface water temperatures ranged from 28.6°C to 31.1°C.

Sixteen taxonomic groups of invertebrates were found in the WJ sites (Table 1). Cladocerans were the most dominant, occupying more than 43.9% of all animals in all sites. Copepods and ostracods were the next most dominant groups, ranging from 19.8% to 33.8% and from 1.9% to 24.6%, respectively. In addition, oligochaetes, decapods, odonates ephemeropterans, and chironomids commonly occurred in the WJ sites. Hydrozoans, mollusks, conchostracans, and decapods were also collected from several WJ sites. The SID for all invertebrates ranged from 2.8 to 3.4, with the mean value of 3.1 (Table 2).

Fifteen oligochaete taxa were found (Table 3). They were comprised of 11 species belonging to 7 genera of naidines, two tubificine and one rhyacodriline species, and one enchytraeid. A naidine species, *Sylaria fossularis*,...
Table 3. Comparison of oligochaete fauna associated with aquatic macrophytes between Central Kalimantan (CK) and West Java (WJ).

<table>
<thead>
<tr>
<th>Family Tubificidae</th>
<th>CK 1</th>
<th>CK 2</th>
<th>CK 3</th>
<th>CK 4</th>
<th>CK 5</th>
<th>CK 6</th>
<th>WJ 1</th>
<th>WJ 2</th>
<th>WJ 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subfamily Naidinae</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chaetogaster diaphanus (Gruithuisen, 1828)</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nais pardalis Piguet, 1906</td>
<td></td>
<td></td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allonais pectinata (Stephenson, 1910)</td>
<td></td>
<td></td>
<td></td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. paraguayensis (Michaelson, 1905)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dero digitata (Müller, 1773)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aulophorus furcatus (Müller, 1773)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Branchiodrilus hortensis (Stephenson, 1910)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Pristina longiseta Ehrenberg, 1828</td>
<td></td>
<td></td>
<td></td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P. aequiseta Bourne, 1891</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>P. biserrata Chen, 1940</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P. proboscidea Beddard, 1896</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P. sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stylaria fossularis Leidy, 1852</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naidinae spp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subfamily Tubificinae</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limnodrilus hoffmeisteri Claparède, 1862</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Tubificinae sp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subfamily Rhyacodrilinae</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Branchiura sowerbyi Beddard, 1892</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family Enchytraeidae</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enchytraeidae undet.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 2. Relative abundances of oligochaetes associated with aquatic macrophytes in 9 localities studied.
Aquatic Invertebrates in Central Kalimantan and West Java

Comparison of faunal composition and diversity between CK and WJ

Diversity indices (SID) for entire invertebrate communities did not significantly differ between the CK and WJ areas. The relative abundances of cladocerans and/or copepods were the highest among the invertebrate assemblages in both regions, and the combined proportions of these two animal groups among the whole invertebrates did not significantly differ between the two regions.

On the other hand, the relative abundance of chironomids was significantly higher in CK (0.01<p<0.05), whereas that of ostracods was significantly higher in WJ (0.01<p<0.05). The structures of higher taxa of invertebrates were not so clearly distinguished as oligochaete structures (see below) between the study sites, although three WJ sites made up a single cluster (Fig. 3).

Fig. 3. Dendrogram resulting from an average-linkage cluster analysis of invertebrate communities associated with aquatic macrophytes in the 9 localities studied.

A total of eighteen oligochaete taxa were recorded from the two regions in the present study. Although the relative abundance of oligochaetes among invertebrate communities did not differ between the CK and WJ areas, the species composition was significantly different. That is, the number of taxa recorded was distinctly higher in WJ (15) than in CK (9), and Pristina species dominated in CK, while Stylaria fossularis dominated in WJ. The oligochaete SID was significantly higher in WJ (mean 4.2) than in CK (mean 1.5) (0.01<p<0.05). The oligochaete compositions in the CK and WJ sites were clearly distinguishable from each other as distinct clusters in which the similarity values a were higher than 0.9 and 0.6, respectively (Fig. 4).

Fig. 4. Dendrogram resulting from an average-linkage cluster analysis of oligochaete communities associated with aquatic macrophytes in 8 localities studied.

DISCUSSION

It is recognized that the chemistry of inland waters is highly variable in Southeast Asia. Johnson (1967a) once pointed out that southern Malayan blackwaters are characterized by low pH with a high concentration of sulphuric acid, low alkalinity and a lack of calcium. Chemically, they differ widely from the waters of Java and Bali as reported by Ruttner (1931). Quantitative and qualitative differences in freshwater biota between different areas in southeast Asia could, therefore, largely depend on water chemistry as well as zoogeographical differences, as suggested in prawn (Johnson, 1966), fish (Johnson, 1967b), odonate (Furtado, 1969) and bivalve (Junk, 1977) communities. However, information on freshwater invertebrate faunal differences within the freshwaters of Southeast Asia is still very limited.

From the viewpoint of oligochaete fauna, the Indo-Malayan subregion of the Sino-Indian zoogeographical region, which includes both Kalimantan and Java, is
characterized by numerous species of Naidinae (Timm, 1980). Thirty-five oligochaete species have so far been recorded from Sumatra, Kalimantan, Java and Bali (Michaelsen & Boldt, 1932; Ohtaka & Usman, 1997; Ohtaka et al., 2000), islands on which naidines are dominant. Naidine diversity increases in vegetated areas (Learner et al., 1978), and their predominant occurrence in epiphytic macrofauna has been found not only in tropical Asia but in temperate regions also (Ohtaka & Morino, 1986). The present study points out that oligochaete diversity is significantly lower in CK, and that the specific composition is differs widely between CK and WJ, although many of the species show potentially wide distributions (Brinkhurst & Jamison, 1971) and CK and WJ are close to each other in a common zoogeographical subregion. Therefore, the faunal differences between CK and WJ might be related to water quality.

Acid waters are generally characterized by low species diversity and low productivity (Welch, 1952), and major animal groups are poorly represented or often lacking (Wetzel, 1983; Ward, 1992). These tendencies have been demonstrated mainly in the Sphagnum bog waters of cool climate regions. Ohtaka (2000) recorded 17 oligochaetes from acidic Sphagnum bog waters in Ozegahara Mire, central Japan, where the pH ranged between 4.6–5.3. In his survey, Pristina aequiseta was the most frequently occurring naidine, and no Stylaria fuscularis were found, although the latter species is very common in the neutral waters of surrounding areas (Ohtaka, unpubl.). Such faunal characteristics resemble those in the CK sites of the present study in that Pristina species are predominant and Stylaria is rarely found. Therefore, faunal composition as well as low diversity in CK might be related to low water pH.

In the present study, the diversity index for whole invertebrates and the relative abundance of all higher taxonomic groups, except chironomids and ostracods, did not significantly differ between CK and WJ. However, it is highly probable that the species composition of many higher taxonomic groups is actually quite different in these two areas, as in the case in oligochaetes. Taxonomic studies on many groups of invertebrates are badly needed to clarify faunal characteristics in detail.

ACKNOWLEDGMENTS This study was a part of the Core University Program between Hokkaido University, Japan and the Research Center of Biology, LIPI, Indonesia, sponsored by Japan Society for the Promotion of Sciences.

REFERENCES


Michaelsen, W. & Boldt, W. 1932. Oligochaeta der


Received 7th Mar. 2006
Accepted 16th May 2006