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The diversity and density of Plecoptera in the headwaters of Cisadane River, West Java, Indonesia

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Abstract

The headwaters of Cisadane River originally flow from Salak and Gede-Pangrango Mountains of West Java, part of Mount Halimun-Salak National Park. As a conservation area, the presence of the park would protect the ecological health of headwaters. It is therefore interesting to compare the ecological status of the headwaters located inside and outside the park. Plecoptera is one of the pollution-sensitive orders and is commonly used in river health biomonitoring. Therefore, the presence of this order is often used as river health indicator. The aim of this study was to compare the diversity and density of Plecoptera in Cisadane River's headwaters inside and outside of national park. The present study was conducted in the headwaters of Cisadane River. One of the headwaters is located in protected area of the national park. Plecoptera nymphs were collected from four sites inside the park (station 1, 2, 3, and 4) and from two sites outside the park (station 5 and 6). Collections were made fortnightly, starting from April to June 2015 using surber (30x30 cm). The results showed that 5 genera of 4 families were found in the river, i.e. family Capniidae (*Nemocapnia* sp.), family Chloroperlidae (*Haploperla* sp.), family Nemouridae (*Amphinemura* sp.), and family Perlidae (*Acroneuria* sp. and *Neoperla* sp.). The density decreased following the gradient from the upper sites of the park to the lower sites. In addition, no Plecoptera was found at the outside of the park. The presence of the national park was proved to provide better habitat for Plecoptera.

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Introduction

Headwaters are the most sensitive aquatic ecosystems, serve as focal point of mountain landscapes and support unique plant and animal communities, as well as the determinant for the quality and quantity of lowland rivers. Water quality, biodiversity, and ecological health of a freshwater ecosystem depend on natural functions of the headwaters (Silveri, 2008). Mountain streams, as a part of high altitude habitats with different environmental characteristics, have high variability in terms of environmental parameters (Crisci-Bispo *et al.*, 2007).

In Province West Java, Indonesia the headwaters of Cisadane River are originally from Salak and Gedepangrango Mountains and flow into Teluk Naga coastal waters in Province Banten. The river provides economic values to people living in the cities where the river goes through (Rahayu *et al.*, 2015). The river has multiple uses to fulfill agricultural, domestic, and industrial needs (Siahaan *et al.*, 2012).

As an aquatic ecosystem, headwaters of stream is favorable habitat for several benthic animals and is mostly dominated by aquatic insects such as Plecoptera (Anzani *et al.*, 2013; Sudarso *et al.*, 2013; Yoga *et al.*, 2014).

Plecoptera (stonefly) is a macrozoobenthos organism living on river bottom with low temperature and strong current (Bhagat, 2012). Therefore, this organism can only be found at a river’s headwater where the temperature, organic materials, climate, and hydrological conditions are favorable for it.

The presence of Plecoptera is crucial since it is one of the critical taxa in aquatic ecosystems and is an important food source for fish, birds, and other vertebrates (Myers *et al.*, 2011). The composition and distribution of Plecoptera are determined by its physiological tolerance against various environmental variables (Stoyanova *et al.*, 2014). In addition, the organism is one of the pollution-sensitive orders and used in river’s health biomonitoring (Abhijna *et al.*, 2013). This study was conducted in the headwaters of Cisadane River in protected area of Mount Halimun-Salak National Park. The aim of this study was to compare the diversity and density of Plecoptera in Cisadane River’s headwaters inside and outside of the national park.

Material and methods

The study were carried out inside the area of Mount Halimun-Salak National Park-Bogor (station 1, 2, 3, and 4), and outside the park (station 5 and 6) (Fig. 1).

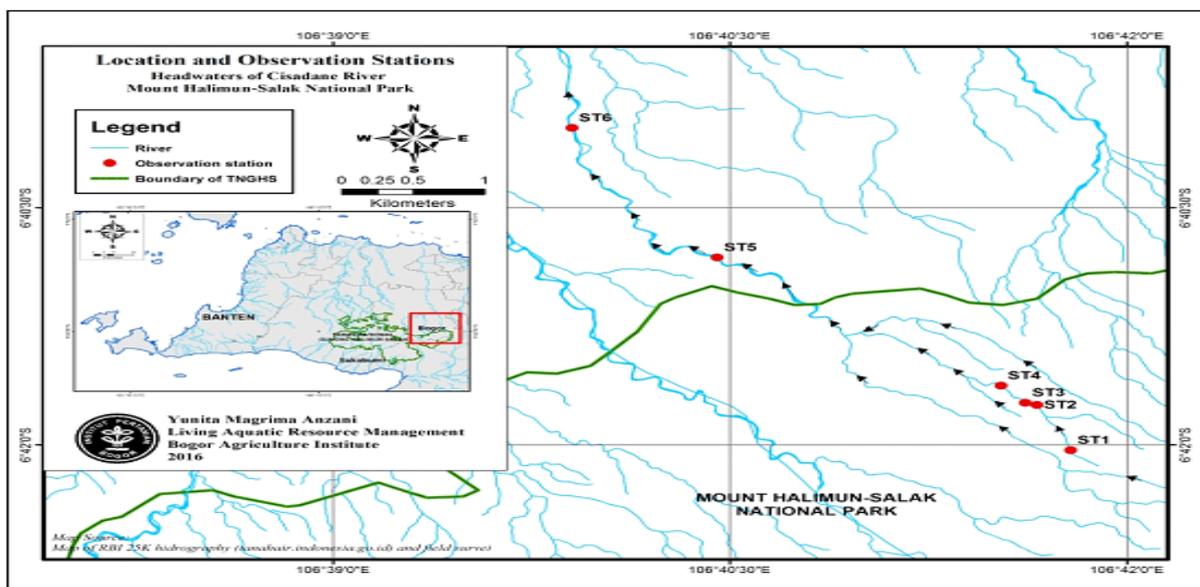


Fig. 1. Map of location and observation stations in the headwaters of Cisadane River, West Java - Indonesia.

Ten replicates of samples were collected in each station. Plecoptera nymphs were collected fortnightly, starting from April to June 2015 using Surber (30x30cm) and preserved using 70% alcohol. Nymphs were identified up to genus level following Mc Cafferty (1983) and Pescador *et al.*, (2000). Some environmental characteristics were recorded, *i.e.*, hydrological characteristics, current speed, temperature, dissolved oxygen (DO), and pH. To detect a significant difference of Plecoptera density

between stations inside and stations outside the national park t-test was performed at $p = 0.05$ using Microsoft Excel 2010.

Results and discussion

A total of 5 Plecoptera genera from 4 families were found in the headwaters of Cisadane River, *i.e.* family Capniidae (*Nemocapnia* sp.), family Chloroperlidae (*Haploperla* sp.), family Nemouridae (*Amphinemura* sp.), and family Perlidae (*Acroneuria* sp. and *Neoperla* sp.). Fig. 2 shows all genus found in the study sites.

Table 1. The density (ind/m²) of each Plecoptera genus found at the headwaters of Cisadane River, West Java – Indonesia.

Order	Family	Genus	St 1	St 2	St 3	St 4	St 5	St 6
Plecoptera	Capniidae	<i>Nemocapnia</i> sp.	0-65	0-5	4-67	0-12	0-4	0
	Chloroperlidae	<i>Haploperla</i> sp.	0-27	4-14	0-19	0-5	0-4	0
	Nemouridae	<i>Amphinemura</i> sp.	0-6	0-6	0-4	0-5	0-2	0
	Perlidae	<i>Acroneuria</i> sp.	0-3	0-2	0	0	0	0
<i>Neoperla</i> sp.		0-3	4-13	2-10	0-12	0-3	0	

Family Capniidae (slender winter stonefly) has a small, slender, and cylindrical body, often dark forms. When mature they measure only 3-6 mm, sometimes larger (not including tails). Hind wing pads are nearly parallel, generally lacking gills (Figure 3), paraglossae

and glossae are subequal in length (Pescador *et al.*, 2000). Lateral margins of abdomen as viewed from above appear zigzagged. Nymphs occur in habitats ranging from tiny springs to moderately sized streams, often among detritus or mixed substrate.

Table 2. Environmental characteristics of the headwaters of Cisadane River, West Java – Indonesia.

Parameter	Unit	St 1	St 2	St 3	St 4	St 5	St 6
River width	m	1.7	3.1	2.9	2.5	11.4	7.0
River body width	m	2.7	4.3	3.7	3.0	14.0	13.2
Canopy coverage	%	100	60-80	40-60	0-40	0	0
Altitude	m	1168	1090	1020	1168	717	584
Depth	cm	20.7	19.4	20.3	19.2	18.1	18.5
Current speed	m/s	0.45	0.43	0.37	0.38	0.22	0.28
Temperature	°C	20.08	20.33	20.48	22.57	24.15	27.78
Dissolved oxygen	mg/L	7.08	6.53	6.70	5.67	5.18	4.80
pH	-	5.87	6.53	5.97	6.13	6.13	6.24

Family Chloroperlidae (green stonefly) generally has a green body color and without pattern, 5-12 mm length when matured, deeply divided labium with each half appears somewhat projecting to outer margin, generally lacking gills, and nearly paralleled hind wing pads.

Nymphs are commonly associated with waters with strong current and stones at river bed, making the order are more abundant in low temperature waters or waters in mountainous area (Mc Cafferty, 1983).

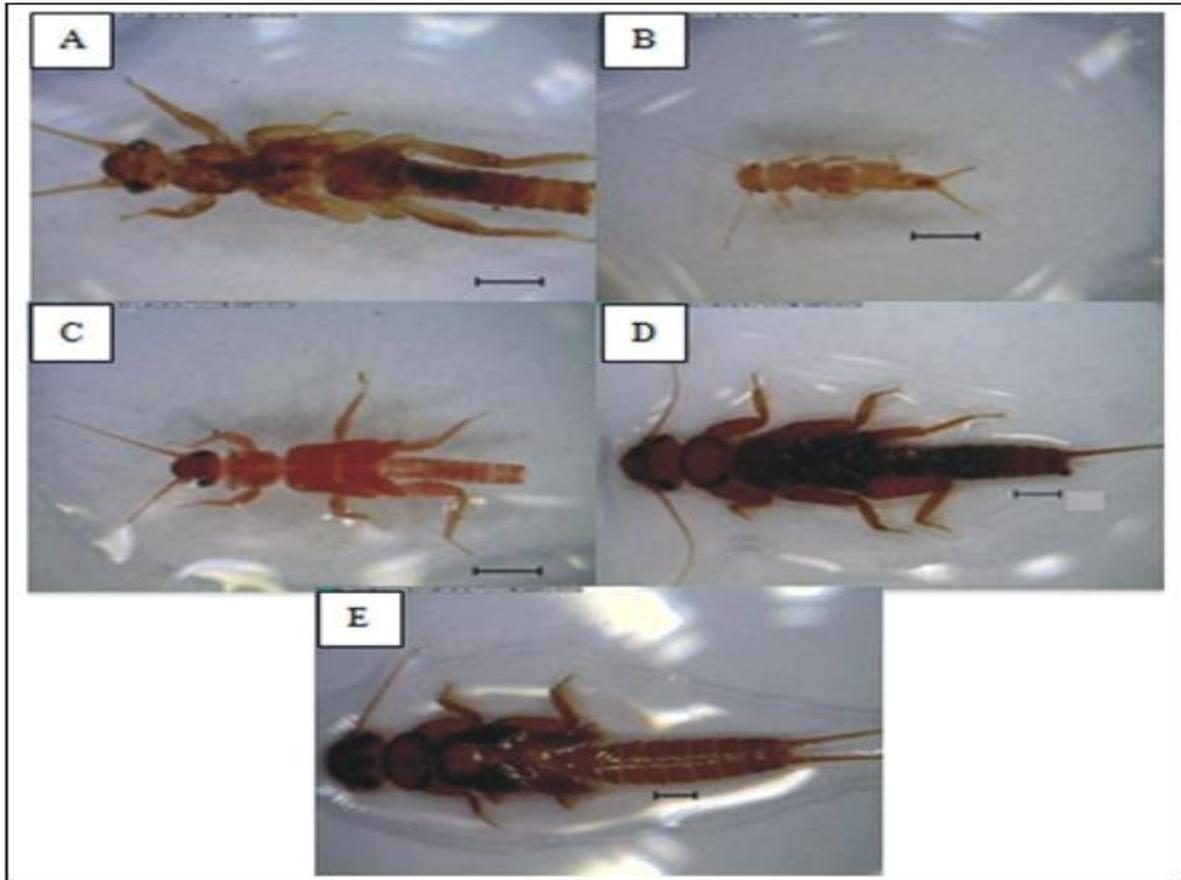


Fig. 2. Photos of Plecoptera organisms found in the headwaters of Cisadane River, West Java - Indonesia. A. *Nemocapnia* sp. B. *Haploperla* sp. C. *Amphinemura* sp. D. *Acroneuria* sp. E. *Neoperla* sp. (scale bar: 1 mm).

Family Nemouridae (nemourid broadbacks) are relatively robust forms with many hairs on the body. Mature individuals usually measure 3-8 mm, sometimes longer, excluding tails. Gills are completely absent or restricted to the cervical (neck) area (Fig. 3). Hind wing pads are strongly divergent. Small rivers, streams, and springs are the most common habitats of nymphs. Some prefer soft substrates, and some commonly are associated with leaf packs and other detritus. Mountain species often occur in cold, rocky-bottomed streams. They are primarily detritivores, devouring leaves and the resident microorganisms of those leaves (McCafferty, 1983).

Family Perlidae (common stonefly) is generally brown with yellow spots, 8-35 mm in length when matured, somewhat horizontally oriented head, single incision that divides labium into two distally rounded lobes,

and branched thoracic gills (Fig. 3) (Doddall and Lehmkuhl, 1979). Numerous nymphs can be found in lotic habitats, often under stones in riffle areas and sometimes in sandy substrate areas. Mature nymphs are highly predaceous and make mayflies, midges, and small caddisflies as food sources, while young nymphs eat a living or decaying plant materials (McCafferty, 1983). Ventral view of thorax Plecoptera nymphs showing types of gills is presented in Figure 3.

Based on Table 1, the density of *Nemocapnia* sp., *Haploperla* sp., *Neoperla* sp. and *Amphinemura* sp. were of relatively higher at stations located inside the national park (Stations 1, 2, 3, and 4). The t-test analysis showed that the total density of Plecoptera in sampling stations inside the national park was significantly higher than that in sampling station outside the park ($p < 0.05$). Interestingly one species,

i.e. Acroneuria sp., was found only at two stations inside the national park, and none of them could be found outside the park.

Sharma and Chowdary (2011) and Thu Cao and Bae (2007) showed that the density of Plecoptera was affected by water physicochemical characteristics, including temperature and the altitude of the habitat.

Canopy coverage was also found to affect the existence of Plecoptera (Thu Cao and Bae, 2007). Some other studies showed that macrobenthic organisms belonging to Plecoptera are known tend to prefer cold waters and low ordered river with good water quality and generally located in mountainous areas (McCafferty, 1983; Sandberg and Szczytko, 1997).



Fig. 2. Photos of Plecoptera organisms found in the headwaters of Cisadane River, West Java - Indonesia. A. *Nemocapnia* sp. B. *Haploperla* sp. C. *Amphinemura* sp. D. *Acroneuria* sp. E. *Neoperla* sp. (scale bar: 1 mm).

The water temperature of the four stations were relatively low (Table 2), and the four stations are located in the orders 1 and 2 of the stream (see Figure 1). The altitude of Station 1 and 2, where *Acroneuria* sp. found is 1168 and 1090 m, respectively. In addition, canopy cover at the two stations was about 80-100%. Huckins and Burgess (2004) reported that the mean of Plecoptera density and diversity was higher following the canopy coverage. Canopy coverage was reported to affect the density and diversity of macroinvertebrate benthic in Eriora River, Niger Delta, Nigeria (Arimoro *et al.*, 2012).

Well-preserved riverside vegetation, as in the National Park Area, can prevent soil erosion and nutrient release into adjoining rivers because it stabilizes the river banks. Consequently, rivers with preserved watersheds have greater biodiversity (Osborne and Kovacic, 1993). In addition, Jun *et al.* (2011) reported severe decreases in the diversity and density of benthic communities and the elimination of the most sensitive Ephemeroptera, Plecoptera, and Tricoptera taxa in river area without a riparian forest. No Plecoptera was found outside the park at station 6,

presumably because of settlement area surrounding the station which brings about influence from anthropogenic wastes into the waters. As Plecoptera are very sensitive to water pollution (Marmita *et al.*, 2013), its presence and absence may indicate water quality. The absence of Plecoptera at station 6 indicated poor ecological condition of outside area of the national park. According to, Plecoptera prefers cool, natural, and clean rivers with high dissolved oxygen concentration (Myers *et al.*, 2011; Bottova *et al.*, 2013). Dissolved oxygen of the stations inside the national park ranged from 5.67 to 7.08 mg/l, while those outside the park were 4.80-5.18 mg/L. As seen in Table 2, the oxygen concentration was the lowest in Station 6.

Conclusion

The existence of Mount Halimun-Salak National Park supports the good condition of water quality in the headwaters of Cisadane River. As a consequence it plays also significant role to allow high diversity and density of Plecoptera in the river.

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