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EFFECT OF SIEVE MESH SIZE ON THE ESTIMATION OF BENTHIC INVERTEBRATE ABUNDANCE AND COMPOSITION IN THE HONI RIVER, KENYA

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ABSTRACT

Characterisation of benthic invertebrate communities, taxonomic abundance and composition provides information that is used during river bioassessment. However, the mesh size of the sieves used during processing of invertebrate samples may affect the estimation of taxonomic abundance and composition. In the current study, the effect of sieve mesh size (>0.5 and <0.5 mm) on the estimation of invertebrate taxonomic abundance and composition was tested in the Honi River (Kenya) in 2011. The abundance of invertebrates retained by the >0.5 mm mesh sieve was significantly ($p < 0.05$) lower than that found in the total sample. At the Honi River midstream site, most invertebrates (85%) belonged to the <0.5 mm fraction and were dominated by chironomids. Hydracarina and ostracods were only found in the <0.5 mm fraction of invertebrates. This study shows that sieve mesh size should be taken into consideration when characterising benthic invertebrates in rivers where invertebrate taxa are unknown and with high abundances of small sized invertebrates.

Keywords: benthic invertebrates; sieve mesh size; river; Kenya

INTRODUCTION

Benthic invertebrates refer to aquatic organisms without a backbone, such as insects, leeches and crayfish. They inhabit the bottom substrates (*e.g.* wood, macrophytes, and sediments) of aquatic ecosystems. Benthic macroinvertebrates (size: 0.2−0.5 mm) are the main group of organisms used in the assessment of freshwater ecosystems (Bae *et al.*, 2005). Separation of benthic invertebrates from extraneous organic and inorganic materials, identification and enumeration is expensive in terms of time and effort (Vlek *et al.*, 2006). Although thorough separation of benthic invertebrate samples from extraneous materials is the only way to ensure a comprehensive characterisation of the structure of invertebrates, alternative methods that enhance analysis of samples have been developed (Santos *et al.*, 1996; Alonso and Camargo, 2010).

The methods used during sampling and analysis of invertebrate samples have an effect on the characterisation of the invertebrate community being studied and the size of sieves used during sieving of samples is a main influencing factor (Morin *et al.*, 2004; Barba *et al.*, 2010; Pinna *et al.*, 2014). Despite the fact that a fine mesh sieve (*e.g.* <0.2 mm) provides a more accurate evaluation of benthic invertebrate community structure, the time and effort required during analysis of samples increases, when taking smaller organisms into account (Buss & Borges, 2008). Therefore, to enhance processing of invertebrate samples, mainly sieves with large mesh size (*e.g.* 0.5 mm) are used in aquatic ecosystems bioassessments (*e.g.* Mophin-Kani & Murugesan, 2014). However, this may lead to loss of small-sized (<0.2 mm) invertebrates. This may result in underestimation of the abundance and taxonomic composition of invertebrates in less studied aquatic ecosystems, where the existing invertebrate taxa are unknown.

Kenyan rivers support a rich but incompletely known benthic invertebrate community, being an important, yet underestimated part of the aquatic biodiversity. These rivers serve as a major source of water for the local people and natural habitat for organisms. Characterisation of invertebrate communities in such rivers may help in the assessment of water and habitat conditions. In the current study, the objectives were: (i) to characterise the invertebrate community in terms of abundance and taxonomic composition, and (ii) to assess the effect of sieve mesh size on the estimation of benthic invertebrate abundance and composition in the Honi River, Kenya.

METHODS

Study river and sites description

The Honi River (length: 80 km) is a third-order stream originating from the Aberdare National Park in Kenya (00°05'−00°45' S 36°30'−36°55' E). The Park (area: 774 km^2) is located approximately 100 km north from Nairobi City and covers an altitude ranging from 1850 to 4000 metres above sea level. Three study sites designated as the upstream (Honi US), midstream (Honi MS) and downstream (Honi DS) sites were chosen for study (figure 1). The sites were selected based on the level of anthropogenic perturbations: Honi US was less affected by anthropogenic activities (*e.g.* water abstraction), when compared with Honi MS (5 km from Honi US) and DS (15 km from Honi MS). Honi US was located near a maize plantation and there was riparian vegetation on the right river bank. Water abstraction by a few people and watering of domestic animals were observed. Honi MS was heavily frequented by livestock and a water pumping station was located on the left river bank. Water abstraction for domestic use and construction was common. At Honi DS, abstraction of water for domestic use, irrigation, construction and watering of livestock was observed. Details of geographical positions and habitat characteristics of the study sites are presented in table 1.

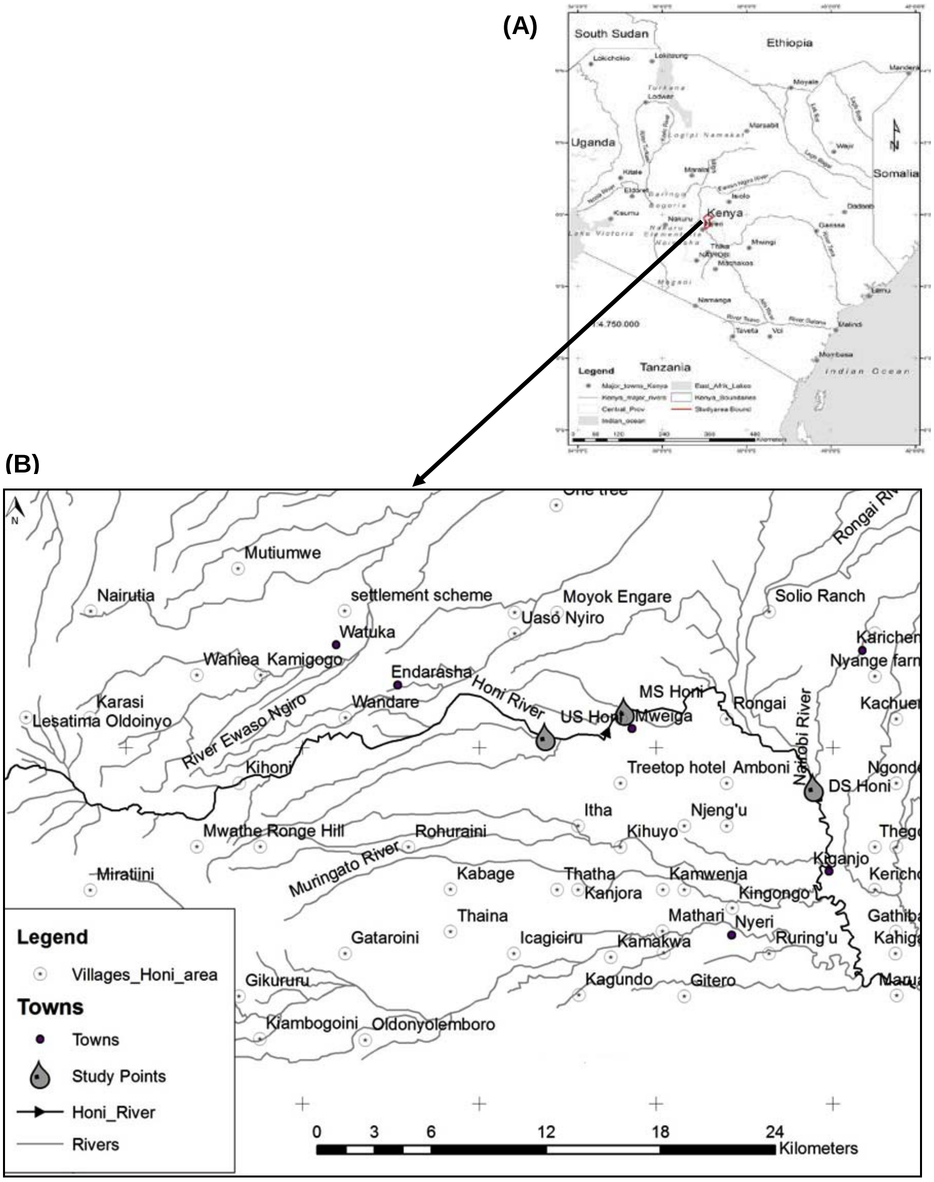

Figure 1. The Honi River and the study sites. (A) Location of the Honi River in Kenya, (B) the Honi River study sites: US Honi (Honi upstream), MS Honi (Honi midstream) and DS Honi (Honi downstream).

Habitat assessment, sample collection and data processing

River habitat assessment and invertebrate sampling were undertaken on two sampling sessions in June and September, 2011, a period characterised by cool weather conditions. Sampling was conducted between 9.00 a.m. and 5.00 p.m. Water electrical conductivity was measured with a WTW-LF 90 conductivity meter. Dissolved oxygen content was measured with a WTW-OX192 oxygen meter and pH and water temperature were measured with a WTW-pH 91 meter

Table 1. Geographical positions and habitat characteristics of the Honi River study sites.

	Sites		
	Honi upstream	Honi midstream	Honi downstream
Code	Honi US	Honi MS	Honi DS
Latitude	S 00°19´04.8˝	S 00°18´58.9˝	S 00°21´06.1˝
Longitude	E 36°54´03.5˝	E 36°54´06.4˝	E 36°59´29.5˝
Elevation (m.)	1881	1880	1758
Canopy cover	30	1	20
Mean width (m)	5.5	6.5	4
Mean depth (m)	0.34	0.25	0.47
Mean conductivity	58.9	71.8	73.9
Mean temperature (°C)	13.3	19.7	18.8
Mean dissolved oxygen (mg/l)	8.0	7.6	7.3
Mean pH	7.7	7.6	7.5
Velocity (m/s)	0.1	0.4	0.6
Discharge (m^3/s)	0.4	0.9	1.0
Substrates	Boulders: 10 %; cobbles:75 %; sand and mud:15 %	Boulders: 10 %; cobbles: 30 %; sand and mud: 60%	Boulders: 5 %; sand and mud: 95 %

(Wissenschaftlich-Technische Werkstätten, Weilheim, Germany). Canopy cover and river substrates were assessed visually (Bain & Stevenson, 1999; Jennings *et al.*, 1999). Water velocity was measured with a flow meter (Model 2030 R, General Oceanics, Florida, USA) and discharge was calculated from velocity, width and depth values (Gordon *et al.*, 2004). During every sampling session, five benthic invertebrate samples were taken from riffle biotopes with a Hess sampler (area: 0.029 m^2; mesh size: 100 µm) from each site. Samples were placed in polythene bags, preserved with 4% formalin and transported to the laboratory. The samples were sieved through a 0.5 mm mesh sieve, which created two invertebrate fractions: one retained by the 0.5 mm mesh sieve (here after referred to as '>0.5 mm fraction') and one filtered through it ('<0.5 mm fraction'). The sum of the < and >0.5 mm fractions is termed as 'total sample'. Invertebrates were sorted under a dissecting microscope, identified (Gerber & Gabriel, 2002) to order and family levels and counted. Invertebrate abundance was expressed per unit area (ind. m^{-2}). Comparison of invertebrate abundances in June and September, and in >0.5 mm mesh sieve and in total sample was performed using paired sample t-test. Comparison of invertebrate abundances among the sites was performed using analysis of variance (ANOVA) (R Development Core Team, 2013).

RESULTS

A summary of the invertebrate taxa encountered in the Honi River study sites is presented in table 2. The most abundant invertebrate taxa included Chironomidae, Baetidae and Oligochaeta (figure 2). Chironomidae were found in large numbers at the Honi MS and DS sites, and were mainly retained in the <0.5 mm fraction (figure 2). At Honi MS, 85% of all invertebrates belonged to the <0.5 mm fraction and oligochaetes, water mites (Hydracarina) and ostracods represented 100 % of the <0.5 mm fraction (table 3). Mean invertebrate abundances ranged from 563.2±142.2 (Honi DS) to 1330.5±654.3 ind.m^{-2} (Honi MS) (figure 3) and differed

Table 2. Abundances (ind. m^{-2}) of invertebrates collected from the Honi River study sites. Values are means (± SD).

Taxa	Honi US		Honi MS		Honi DS	
	June	September	June	September	June	September
Baetidae	827.5 ± 50.4	372.4 ± 27.1	1096.5 ± 150.9	648.3 ± 84.9	268.9 ± 53.6	634.5 ± 80.4
Heptageniidae	6.9 ± 1.4	6.9 ± 1.4	6.9 ± 1.4	6.9 ± 1.4	6.9 ± 1.4	13.8 ± 3.8
Caenidae	0 ± 0	34.5 ± 9.7	13.8 ± 3.8	0 ± 0	103.4 ± 9.0	0 ± 0
Chironomidae	324.1 ± 19.9	337.9 ± 19.2	1482.8 ± 107.0	2075.9 ± 80.2	572.4 ± 31.4	820.7 ± 81.4
Ceratopogonidae	13.8 ± 3.8	6.9 ± 1.4	0 ± 0	0 ± 0	0 ± 0	0 ± 0
Simuliidae	0 ± 0	13.8 ± 3.8	0 ± 0	0 ± 0	0 ± 0	0 ± 0
Perlidae	13.8 ± 3.8	972.4 ± 67.0	27.6 ± 4.9	55.2 ± 7.2	0 ± 0	0 ± 0
Zygoptera	0 ± 0	0 ± 0	0 ± 0	0 ± 0	6.9 ± 1.4	13.8 ± 3.8
Hydropsychidae	62.1 ± 6.3	0 ± 0	0 ± 0	0 ± 0	0 ± 0	6.9 ± 1.4
Elmidae	27.6 ± 7.8	82.8 ± 10.9	0 ± 0	15.8 ± 1.9	0 ± 0	0 ± 0
Ostracoda	6.9 ± 1.4	0 ± 0	75.8 ± 7.8	165.5 ± 21.8	0 ± 0	0 ± 0
Sphaeridae	20.7 ± 6.2	13.8 ± 3.8	41.4 ± 4.9	96.6 ±15.9	6.9 ± 1.4	16.8 ± 9.7
Oligochaeta	6.9 ± 1.4	0 ± 0	331.0 ± 30.6	96.6 ± 15.9	82.8 ± 15.1	151.7 ± 10.2
Hydracarina	19.2 ± 3.8	0 ± 0	55.2 ± 7.3	96.6 ± 15.9	0 ± 0	0 ± 0

significantly among the study sites (One-way ANOVA, $F (2, 29) = 6.2$, $p < 0.05$), but did not differ significantly (t-value = −0.6, $p > 0.05$) between September and June.

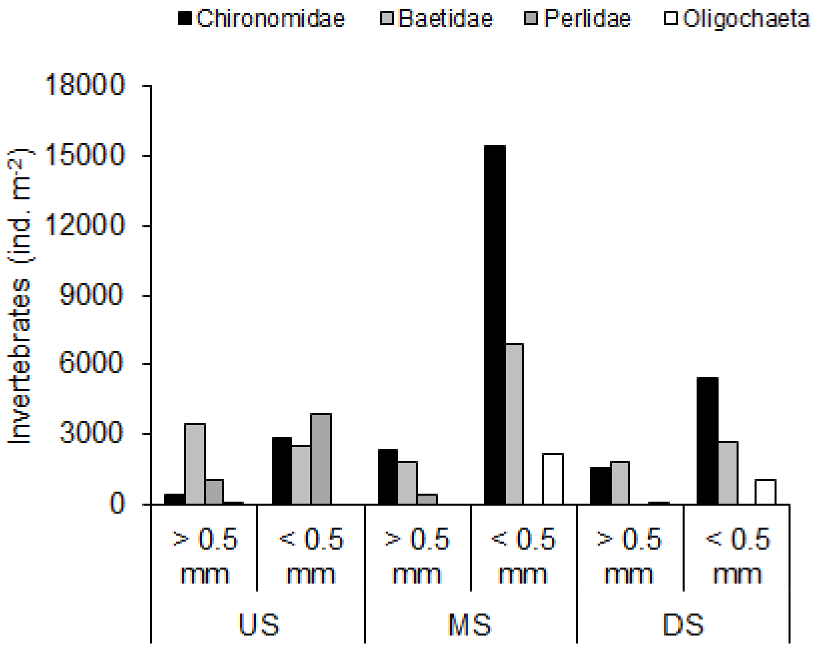

Figure 2. Mean abundances (ind.m^{-2}) of the major invertebrate taxa retained in the >0.5 and <0.5 mm fractions in the Honi River upstream (US), midstream (MS) and downstream (DS) sites.

In general, Hydracarina and Ostracoda could have been lost (100 %) from all sites if only the >0.5 mm fraction was analysed (table 3). Other invertebrate taxa that could be lost in great numbers when analysing just the >0.5 mm fraction included Sphaeridae and Baetidae (table 3). Zygoptera, Ceratopogonidae and Heptageniidae experienced 0% losses. The mean abundance of invertebrates in the total sample (1977.7±441.5 ind.m^{-2}) was significantly (t-value = – 4.1, $p < 0.05$) higher than in the >0.5 mm fraction (483.8±98.7 ind.m^{-2}). The mean abundance of invertebrates in the <0.5 mm fraction was 1493.9±367.6 ind.m^{-2}.

DISCUSSION

The high abundance of taxa such as oligochaetes and chironomids at the midstream site may be attributed to factors such as the high fine-sediment content recorded at this site. Fine sediment is an important habitat for oligochaetes and chironomids (Gregg & Rose, 1985; Diaz & Erséus, 1994), and the two taxa are more tolerant to silting and water pollution than other benthic invertebrate groups, such as Perlidae and some Hydropsychidae, which indicate better water quality (Van Dijk *et al.*, 2013). Jabłońska (2014) assessed oligochaete communities in streams and found high abundances in fine grained sediments. Moreover, fine sedimentary organic materials serve as a source of food for invertebrates and have an influence on their abundance and diversity (Rodriguez *et al.*, 2001; Mbaka *et al.*, 2014). Anthropogenic activities, such as clearance of riparian vegetation, increase the input of fine sediment into streams from riparian

Table 3. Total number (ind. m^{-2}) of invertebrates retained in the > 0.5 and < 0.5 mm fractions and percentage of invertebrates lost when examining only the invertebrates retained in the > 0.5 mm fraction.

Taxa	Honi US			Honi MS			Honi DS		
	>0.5 mm	<0.5 mm	Invertebrates lost (%)	>0.5 mm	<0.5 mm	Invertebrates lost (%)	>0.5 mm	<0.5 mm	Invertebrates lost (%)
Baetidae	3448.3	2551.7	42.5	1793.1	6931.0	79.5	1827.6	2689.7	59.5
Heptageniidae	69.0	0.0	0.0	69.0	0.0	0.0	103.4	0.0	0.0
Caenidae	69.0	103.4	60.0	69.0	0.0	0.0	517.2	0.0	0.0
Chironomidae	448.3	2862.1	86.5	2344.8	15448.3	86.8	1551.7	5413.8	77.7
Ceratopogonidae	103.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Simuliidae	34.5	34.5	50.0	0.0	0.0	0.0	0.0	0.0	0.0
Perlidae	1069.0	3862.1	78.3	413.8	0.0	0.0	0.0	0.0	0.0
Zygoptera	0.0	0.0	0.0	0.0	0.0	0.0	103.4	0.0	0.0
Hydropsychidae	137.9	172.4	55.6	0.0	0.0	0.0	34.5	0.0	0.0
Elmidae	206.9	344.8	62.5	69.0	0.0	0.0	0.0	0.0	0.0
Ostracoda	0.0	34.5	100.0	0.0	1206.9	100.0	0.0	0.0	0.0
Sphaeridae	172.4	0.0	0.0	103.4	586.2	85.0	103.4	0.0	0.0
Oligochaeta	34.5	0.0	0.0	0.0	2137.9	100.0	103.4	1069.0	91.2
Hydracarina	0.0	103.4	100.0	0.0	758.6	100.0	0.0	0.0	0.0

lands. Consequently, fine sediment may cover interstitial spaces and reduce habitat for sensitive invertebrates in the impacted sites (Larsen *et al.*, 2009; Betrab, 2013).

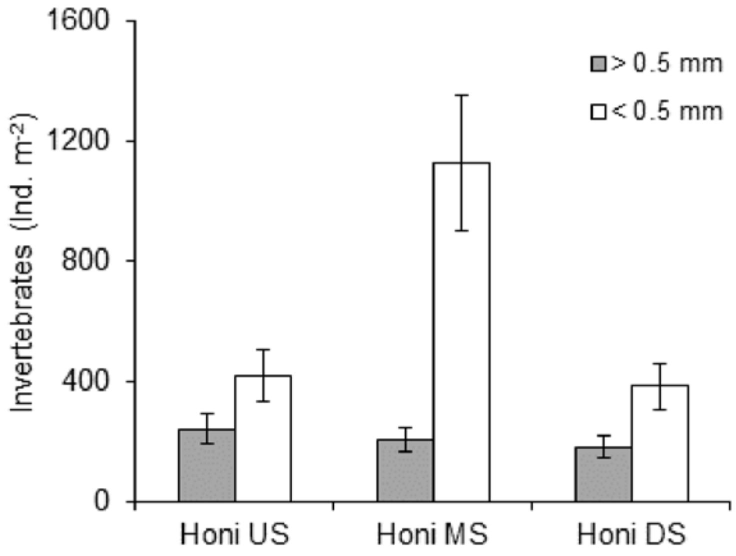

Figure 3. Mean abundances (ind.m^{-2}) of invertebrates retained in the >0.5 and <0.5 mm fractions in the upstream (US), midstream (MS) and downstream (DS) sites of the Honi River. Vertical bars are ± SD.

The retention of water mites and ostracods exclusively in the <0.5 mm fraction may be due to the fact that water mites and ostracods are generally small in body size (width: 0.3–0.5 mm; Wiles, 1999) and could easily pass through the 0.5 mm mesh sieve. Chironomids are also generally small in body size and passed through the 0.5 mm mesh sieve than taxa such as Heptageniidae (*e.g.* Mason *et al.*, 1975; Battle *et al.*, 2007). Heptageniidae and Zygoptera larvae are bigger than 0.5 mm in body size (Usseglio-Polatera *et al.*, 2000). The body morphology of invertebrates may also influence their ability to pass through mesh sieves (Bachelet, 1990). For example, oligochaetes do not have lateral appendages (*e.g.* legs), thus making it easier for them to pass through the 0.5 mm mesh sieve.

The estimation of invertebrate abundance and taxonomic composition was influenced by the size of mesh sieves used during processing of samples. In particular, the midstream site had most (85%) invertebrates retained in the <0.5 mm fraction. Our results from the Honi River are in line with several previous studies that found the estimation of invertebrate abundance and composition to be influenced by the size of mesh sieves used during processing of samples (*e.g.* Schlacher & Wooldridge, 1996; Morin *et al.*, 2004; Battle *et al.*, 2007; Barba *et al.*, 2010). Barba *et al.* (2010) processed invertebrate samples using mesh sieves differing in mesh size (0.5 and 1.0 mm) and found that the estimation of invertebrate abundance and composition was affected, if only the >1.0 mm fraction was examined. Battle *et al.* (2010) evaluated the effect of mesh sieves (0.5 and 1.8 mm) in the estimation of invertebrates abundance and composition and found the 0.5 mm mesh sieve to retain between 75 and 80% of total invertebrates in two rivers, affecting the abundance of major taxonomic groups. In the current study, we observed a significant difference in the abundance of invertebrates, in the >0.5 mm fraction and total sample, and loss of some taxonomic groups when examining the >0.5 mm fraction only. This finding is important when computing invertebrate assemblages based on descriptors of habitat conditions, such as abundance and composition. The retention of some invertebrates exclusively in the <0.5 mm fraction may affect the results of rapid bioassessments, which rely on identification of large (*e.g.* 1 mm) invertebrates in the field with naked eye, or computation of biotic indices (Bachelet, 1990; Dickens & Graham, 2002; Barba *et al.*, 2010). In particular, this may be a problem if sampling of invertebrates coincides with a period when invertebrates are at the beginning of larval development. In conclusion, mesh sieves used during processing of invertebrate samples had an effect on the estimation of abundance and composition. Future studies assessing river sites dominated by small sized invertebrates, especially where taxa are unknown, should consider using small sized mesh sieves to avoid underestimation of invertebrates taxonomic abundance and composition.

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