Diversity of Aquatic Macroinvertebrates in Streams in the Belgrade Region (Does Different Stream Types Matter?)

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Abstract

The paper presents the study of macroinvertebrate diversity in the Belgrade region. The study is based on material collected in September of 2012. A total of 21 localities, belonging to 5 different stream types are analyzed. A total of 65 taxa were identified. Oligochaeta were found to be the most diverse group overall, as well as in each analyzed watercourse type. Besides Nematoda and Chironomidae, tubificid worms *Limnodrilus hoffmeisteri* Claparede, 1862 and *Potamothrix hammoniensis* (Michaelsen, 1901), as well as snail *Physella acuta* Draparnaud, 1805 were common for all analyzed stream types. Although a low number of commom taxa in analyzed types could suggest faunistical differences, the performed multivariate analysis (DCA) could not separate watercourses in the Belgrade region in respect to their macroinvertebrate fauna. Such faunistical structures with no difference in respect to water types could be due to deteriorated habitats in this urban area. For more reliable analysis, prolonged and more detailed sampling is needed.

Keywords: macroinvertebrates, streams, tipology, urban area, Belgrade.

Introduction

Urbanization is a process which alters the physical and chemical characteristics of streams as well as causing significant biological and ecological degradation (Cuffney et al., 2010). Such deterioration of stream habitats and consequently its biota, caused by urbanization nowadays is recognized as „urban stream syndrome“(Walsh et al. 2005). Accordingly, an urbanized and densely populated area such as the Belgrade region, inevitably contributes to a wide range of anthropogenic impacts to its aquatic habitats. As the most important, hydromorphological pressures (regulation and channelization, bank reinforcement and embankments, sediment/sand extraction), organic and nutrient pollution (communal and urban wastewaters, agricultural drainages) and industrial and toxic pollution (industrial wastewaters, medical waste), should be noted. Besides, sometimes overlooked sources of toxicants are heavily trafficked roads, which some authors consider as one of principal pollution sources in many urban areas (Beasley and Kneale, 2002). Despite expansion in the field of urban ecology and hydroecology (Vermonden, 2010; Pickett et al., 2011), in Serbia there is a general lack of data even for its largest urban area – the Belgrade region.

Belgrade is located at the confluence of two large European rivers – the Danube and the Sava. In addition, there is also a number of various smaller watercourses. While large rivers – the Danube and the Sava - are well researched, as a result of research conducted in the urban region (for example Kalafatić et al., 1997; Martinović-Vitanović et al., 1999; Jakovčev-Todorović et al., 2005; Popović et al., 2013), or as a part of broader research (for example Paunović et al., 2007; Paunović et al. 2008), whereas the smaller streams have been neglected. With scarce data, although it is proved that it could be valuable habitats for aquatic macroinvertebrates (Vermonden, 2010). Marković et al (2013) provided an overview of freshwater snail fauna in Belgrade Region. The ecological status of smaller Belgrade watercourses was assessed by Kračun et al. (2013), while Dragićević et al. (2010) estimated the water and habitat quality of the Topčider River.

Our aim in this paper is to contribute to the knowledge of aquatic macroinvertebrate fauna of this urban region, and to test if the differences in its diversity could be due to its different water types.

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Material and Methods

In September 2012, during the low water period, as a part of regular surface water quality monitoring in the Belgrade region, conducted by the Belgrade Institute of Public Health and the Institute for Biological Research "Siniša Stanković", benthic macroinvertebrate samples were taken. Semi-quantitative sampling was done by using a hand net (25x25 cm, 500 µm mesh size) and a Van Veen grab (270 cm²). Where possible, a multi-habitat sampling procedure (AQEM, 2002; Hering et al., 2004) was applied. The samples were preserved by using 4% formaldehyde solution and further processed in the laboratory. Identification was done to species-level for the majority of taxa using appropriate taxonomic keys.

The Belgrade region, with 1.7 million residents living in a 3223 km² metropolitan area (530 inhabitants per km²), is the largest and the most populated urban area in Serbia. Besides the Danube and the Sava Rivers, many smaller rivers, streams and canals and the left and right tributaries of these large rivers contribute to a very unevenly developed hydrographic network. Furthermore, geomorphology with its two main regions – the southern hilly Šumadija/Balkan region and the northern flat Pannonian Plain region, contributes to the unique hydrographic network of this urban area.

Five different water types according to current regulations/legislative (Official Gazette, 74/2011) were investigated. A list of sampling sites and watercourses with corresponding water types is provided in Table 1. Type 1 watercourses are large lowland rivers with a domination of fine substrate; Type 2 are large rivers with a medium-sized substrate, apart from the Pannonian rivers; Type 3 are small to medium watercourses with a domination of larger substrate fraction, in altitudes below 500 m.a.s.l.; Type 6 are either watercourses which are not covered by current legislative (Official Gazette, 96/2010), or small watercourses outside the Pannonian Plain, apart from Type 3 and Type 4; Type 8 includes artificial water bodies – canals.

Table 1: Sampling sites.

No	Locality/Sample	N lat	E long	Elevation (m.a.s.l.)	Watercourse	Type
1	Batajnica	44°55' 27"	20° 19' 14"	73	Danube	1
2	Vinča	44° 46' 09"	20° 37' 10"	69	Danube	1
3	Obrenovac	44° 40' 08"	20° 14' 19"	71	Sava	1
4	Makiš	44°46'1.65"	20°21' 7.16"	70	Sava	1
5	Obrenovac	44° 39' 12.23"	20° 13' 03.81"	71	Kolubara	2
6	Ćelije	44° 22' 01.89"	20° 11' 43.49"	104	Kolubara	2
7	Topčider Bridge	44° 45' 54.33"	20° 26' 40.92"	86	Topčiderska	3
8	Downstream Barajevo	44°23' 15.37"	20° 23' 41.86"	115	Barajevska	3
9	Stepojevac	44° 29' 39.03"	20° 17' 37.64"	89	Beljanica	3
10	Veliki Crljeni	44° 29' 23.09"	20° 17' 31.21"	90	Turija	3
11	Medoševac	44° 25' 19.18"	20° 15' 54.3"	95	Peštan	3
12	Đurinci	44° 31' 22.79"	20° 36' 38.70"	154	Sopotska	3
13	Barič	44° 39' 12.15"	20° 15' 28.45"	78	Barička	6
14	Železnik	44° 43' 37.92"	20° 21' 55.94"	80	Železnička	6
15	Obrenovac	44° 39' 28.10"	20° 13' 26.10"	70	Obrenovački canal	8
16	Pumping station	44° 46' 09.76"	20° 20' 40.94"	70	Galovica	8
17	Dobanovci – Hunting area	44° 48' 40.07"	20° 11' 01.24"	73	Galovica	8
18	Bridge on the old Pančevo Road	44° 53' 15.93"	20° 35' 43.45"	69	Sibnica	8
19	Kotež	44° 51' 13.70"	20° 26' 50.76"	70	Vizelj	8
20	Čenta	45° 05' 48.55"	20° 22' 36.17"	73	Karaš	8
21	Pumping station	44°55' 18.87"	20°21' 40.97"	70	PKB canal	8

Generally, all watercourses in this region are under intense anthropogenic pressures. The canals in the northern, Pannonian region are exposed to heavy organic\nutrient pollution, mainly from agricultural land drainage, but also from households and slaughterhouses in this part of the region. Streams in the southern, Šumadija region, particularly those in the metropolitan area are under more intense urban pressure, with a higher proportion of impervious surfaces (due to "urban wash-off" which commonly occurs; Duda et al., 1982), in addition to communal, industrial and toxic pollution. Large rivers such as the Sava and the Danube, into which all the other smaller streams in the region flow, act as the main overall collectors in addition to being exposed to all the above mentioned pollutants.

It should be noted that, excluding the Danube and the Sava, the majority of the investigated watercourses are situated in the southern, Šumadija region. In the northern, Pannonian region, except for the Obrenovac Canal, all the investigated watercourses belong to Type 8 (canals).

Detrended correspondence Analysis (DCA; Hill and Gauch, 1980) was performed on a 21-by-65 samples-by-taxa (presence/absence) data matrix. The obtained ordination biplot, consisting of points representing taxa and squares representing samples, has exhibited their multivariate relations. The calculation was done using FLORA software (Karadžić et al., 1998; Karadžić, 2013).

Results and Discussion

A total of 65 taxa were identified in this investigation (Table 2). Oligochaeta were found to be the most diverse group with 17 taxa, followed by Crustacea and Gastropoda with 10 and 9 taxa, respectively. The diversity of other main macroinvertebrate groups was significantly lower (Table 3) These were found to be Oligochaeta and Crustacea, with 7 taxa each (Table 3). The Oligochaeta were the most diverse group in all analyzed watercourse types. In the large lowland rivers with a domination of fine substrate (Type 1) the most diverse group, besides worms, was Crustacea, while in all other types it was Gastropoda (Table 3). Regarding localities, the greatest diversity (and the only one with >15 taxa) was present at Stepojevac (Beljanica) with 21 taxa. On the other hand at the Dobanovci hunting area locality (Galovica) only one taxon was found. Low diversities (<5 taxa) were recorded in samples from Sopot Stream and the Obrenovac Canal (2 taxa, each), as well as the PKB Canal and the Barička Stream (3 taxa each).

Table 2: Recorded taxa regarding different stream types (presence/absence data) with appropriate frequencies of occurrence (F); Eufrequent taxa (according to given criterium) are marked; abbreviations used are given in DCA.

	type1	type2	type3	type6	type8	F	DCA code
Nematoda	**1**	**1**	**1**	**1**	**1**	1	Nem
Planaria							
Dugesia lugubris Schmidt, 1861	0	0	0	0	1	0.2	Dug
Hydrozoa							
Hydra sp.	0	0	1	0	0	0.2	Hyd
Oligochaeta							
Aulophorus furcatus (Oken, 1815)	0	0	1	0	0	0.2	Aul fur
Branchyura sowerby Beddard, 1892	0	1	0	0	0	0.2	Bra
Chaetogaster limnaei (von Baer 1827)	0	0	1	0	0	0.2	Cha lim
Dero dorsalis Ferroniere, 1899	0	0	0	0	1	0.2	Der dor
Eiseniella tetraedra (Savigny, 1826)	0	0	0	0	1	0.2	Eis tet
Isochaetides michaelseni Lastockin, 1936)	1	0	0	0	0	0.2	Iso mic
Limnodrilus claparedeanus Ratzel 1868	1	1	1	0	1	0.8	Lim cla
Limnodrilus hoffmeisteri Claparede, 1862	1	1	1	1	1	1	Lim hof
Limnodrilus udekemianus Claparede, 1862	1	1	1	0	1	0.8	Lim ude
Nais bretscheri Michaelsen, 1899	0	0	1	0	1	0.4	Nai
Nais sp.	0	1	0	0	0	0.2	Nai sp
Potamothrix hammoniensis (Michaelsen, 1901)	1	1	1	1	1	1	Pot ham
Psammoryctides barbatus (Grube, 1861)	1	0	0	0	0	0.2	Psa bar
Stylaria lacustris (Linnaeus, 1767)	0	0	0	0	1	0.2	Sty lac
Stylodrilus heringianus Claparède, 1862	0	0	1	0	0	0.2	Sty her
Tubifex tubifex, Muller 1774	0	1	0	0	1	0.4	Tub
Uncinais uncinata (Ørsted, 1842)	1	0	0	0	0	0.2	Unc unc
Polychaeta							
Hypania invalida (Grube, 1860)	1	0	0	0	1	0.4	Hyp inv
Hirudinea							
Erpobdella octoculata (Linnaeus, 1758)	0	0	1	0	0	0.2	Erp
Helobdella stagnalis (Linnaeus, 1758)	0	0	1	1	0	0.4	Hel
Alboglossiphonia heteroclita (Linnaeus, 1758)	0	0	0	0	1	0.2	Alb
Gastropoda							
Litoglyphus naticoides (C. Pfeiffer, 1828)	1	1	0	0	1	0.6	Lit

	type1	type2	type3	type6	type8	F	DCA code
Theodoxus fluviatilis (Linnaeus, 1758)	1	1	0	0	0	0.4	The flu
Bythinia tentaculata (Linnaeus, 1758)	0	0	0	0	1	0.2	Byt
Valvata piscinalis (Müller, 1774)	0	0	1	0	1	0.4	Val
Gyraulus laevis (Alder 1838)	0	0	1	0	0	0.2	Gyr
Gyraulus sp.	0	0	0	0	1	0.2	Gyr sp
Physella acuta Draparnaud, 1805	1	1	1	1	1	1	Phy
Holandriana holandrii (Pfeiffer, 1828)	0	1	0	0	0	0.2	Hol
Radix auricularia (Linnaeus, 1758)	0	0	1	0	1	0.4	Rad aur
Bivalvia							
Unio crassus Retzius, 1788	0	1	1	0	0	0.4	Uni
Corbicula fluminea O. F. Müller, 1774	1	0	0	0	0	0.2	Cor
Dreissena polymorpha (Pallas,1771)	1	0	0	0	1	0.4	Dre
Pisidium sp.	1	0	1	0	0	0.4	Pis sp
Crustacea							
Astacus astacus Linnaeus, 1758	0	1	0	0	0	0.2	Ast
Dikerogammarus villosus (Sowinsky 1894)	1	0	0	0	0	0.2	Dik vil
Dikerogammarus haemobaphes (Eichwald, 1841)	1	0	0	0	0	0.2	Dik hae
Dikerogammarus sp.	1	0	0	0	0	0.2	Dik sp
Corophium curvispinum (Sars,1895)	1	0	0	0	0	0.2	Cor cur
Corophium sp.	1	0	0	0	1	0.4	Cor sp
Mysidae Gen. sp.	1	0	0	0	0	0.2	Mys
Limnomysis benedeni Czerniavsky, 1882	1	0	0	0	1	0.4	Lim ben
Asellus sp.	0	0	1	0	1	0.4	Ase
Jaera istri (Valkanov, 1938)	0	0	0	1	0	0.2	Jae
Odonata							
Calopterix splendens (Harris, 1789)	0	0	1	0	0	0.2	Cal
Gomphus vulgatissimus (Linaeus, 1758)	0	1	0	0	0	0.2	Gom
Platycnemis pennipes (Pallas, 1771)	0	1	1	0	1	0.6	Pla pen
Ischnura elegans (Vander Linden 1820)	1	0	1	0	1	0.6	Isc
Sympetrum sp.	0	0	0	0	1	0.2	Sym
Ephemeroptera							
Caenis sp.	0	0	1	0	0	0.2	Cae sp
Caenis robusta Eaton 1884	0	0	0	0	1	0.2	Cae rob
Caenis horaria (Linnaeus, 1758)	0	0	1	0	1	0.4	Cae hor
Baetis sp.	0	0	0	0	1	0.2	Bae
Diptera	0	1	1	1	1		
Ceratopogonidae	0	1	1	1	1	0.8	Cer
Chironomidae	1	1	1	1	1	1	Chi
Ephydridae Gen. sp.	0	0	1	0	0	0.2	Eph
Pericoma sp.	0	0	1	1	0	0.4	Per
Hemiptera							
Micronecta sp.	0	0	0	0	1	0.2	Mic
Nepa sp.	0	0	1	0	0	0.2	Nep
Trichoptera							
Hydropsyche contubernalis Malicky, 1977	0	0	1	0	0	0.2	Hyd
Lype sp.	0	0	0	0	1	0.2	Lyp
Coleoptera							
Haliplus sp.	0	0	1	0	1	0.4	Hal sp

Table 3: Diversity of taxonomic groups in different stream types.

Taxon/Type	Total number of taxa	type1	type 2	type 3	type 6	type 8
Nematoda	**1**	1	1	1	1	1
Planaria	**1**	0	0	0	0	1
Hydrozoa	**1**	0	0	1	0	0
Oligochaeta	**17**	7	7	8	2	9
Polychaeta	**1**	1	0	0	0	1
Hirudinea	**3**	0	0	2	1	1
Gastropoda	**9**	3	4	4	1	6
Bivalvia	**4**	3	1	2	0	1
Crustacea	**10**	7	1	1	1	3
Odonata	**5**	1	2	3	0	3
Ephemeroptera	**4**	0	0	2	0	3
Diptera	**4**	0	1	1	1	1
Hemiptera	**2**	0	0	1	0	1
Trichoptera	**2**	0	0	1	0	1
Coleoptera	**1**	0	0	1	0	1

Regarding the different stream types, overall diversity ranged from 9 taxa (Type 6) to 34 taxa (Type 8) (Figure 1).

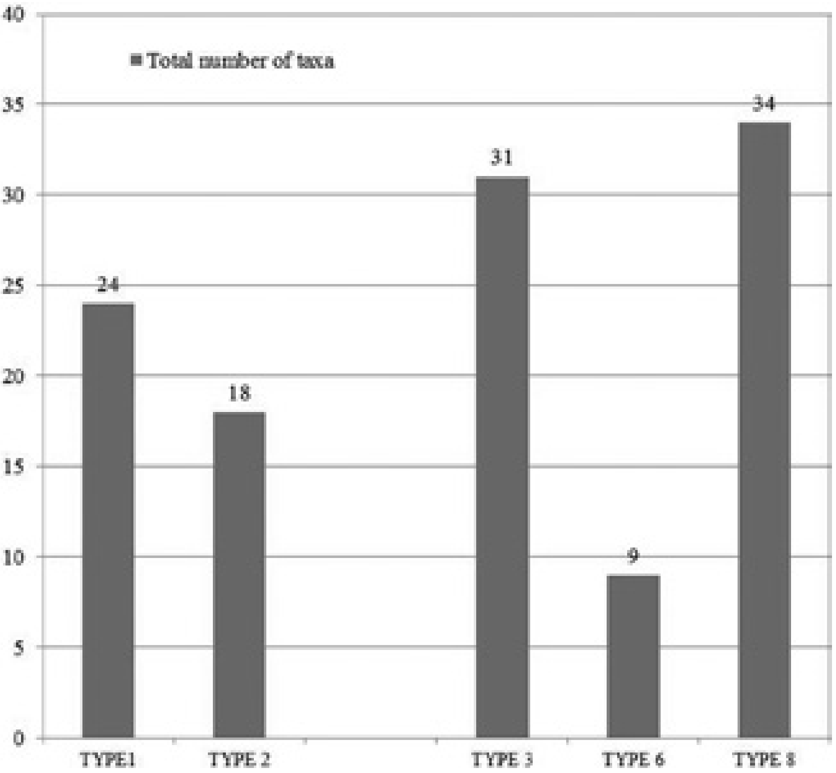

Figure 1: Total number of taxa found in different stream types.

In total, only five taxa were present in all the stream types. Besides Nematoda and Chironomidae, tubificid worms *Limnodrilus hoffmeisteri* and *Potamothrix hammoniensis*, and snail *Physella acuta* were common for analyzed stream types (Table 2). Tubificids *L. claparedeanus* Ratzel 1868 and *L. udekemianus Claparede, 1862* as well as biting midges (Ceratopogonidae), were present in all stream types, except in Type 6, i.e. the type with the lowest overall diversity (Table 2).

A relatively low number of common taxa among the analyzed types could suggest noticeable faunistical differences. However, the performed multivariate analysis (DCA) does not provide support for the above mentioned, as the obtained biplot reveals overlapping of samples belonging to different stream types (Figure 2). However, some differences, regarding localities could be noted along the first DCA axys, particularly between the Danube Batajnica locality (1) on the left side, and the Kotež -Vizelj locality (19) on the right.

The separation arises primarily due to the presence of taxa *Psammoryctides barbatus* (Grube, 1861) (code Psa bar), *Isochaetides michaelseni* Lastockin, 1936) (Iso mic) and *Corophium curvispinum* (Sars,1895) (Cor cur) in the first locality, i.e. due to the presence of *Eiseniella tetraedra* (Savigny, 1826) (Eis tet), *Dugesia lugubris* Schmidt, 1861 (Dug), *Alboglossiphonia heteroclita* (Linnaeus, 1758) (Alb), *Bythinia tentaculata* (Linnaeus, 1758) (Byt), *Sympetrum* sp. (Sym) and *Caenis horaria* (Linnaeus, 1758) (Cae hor) in the second (Vizelj-Kotež).

The performed multivariate analysis could not separate watercourses in the Belgrade Region, in regards to the corresponding types. As the main reason behind the revealed uniformity could be urbanization and other anthropogenic activities, resulting in a reduction in the number of less tolerant taxa, together with an increase in the diversity and significance of pollution-tolerant taxa (Walsh et al., 2005; Smith and Lamp, 2008). A faunistic shift is noticeable in the overall diversity of the main taxonomic groups, with Oligochaeta (ie tubificids) as the most diverse members of the macroinvertebrate community in all the analyzed types of watercourses. The performed ecological assessment analysis (Kračun et al., 2013) showed poor overall ecological status/potential of these urban watercourses, indicating deteriorated habitats and communities.

However, it should be pointed out that the number of analyzed samples/watercourses is limited, especially in the case of types 2 and 6 (only two each), which could be the reason for its lower general diversity, compared to the other types. For more reliable analysis, prolonged and more detailed sampling is needed.

Acknowledgments

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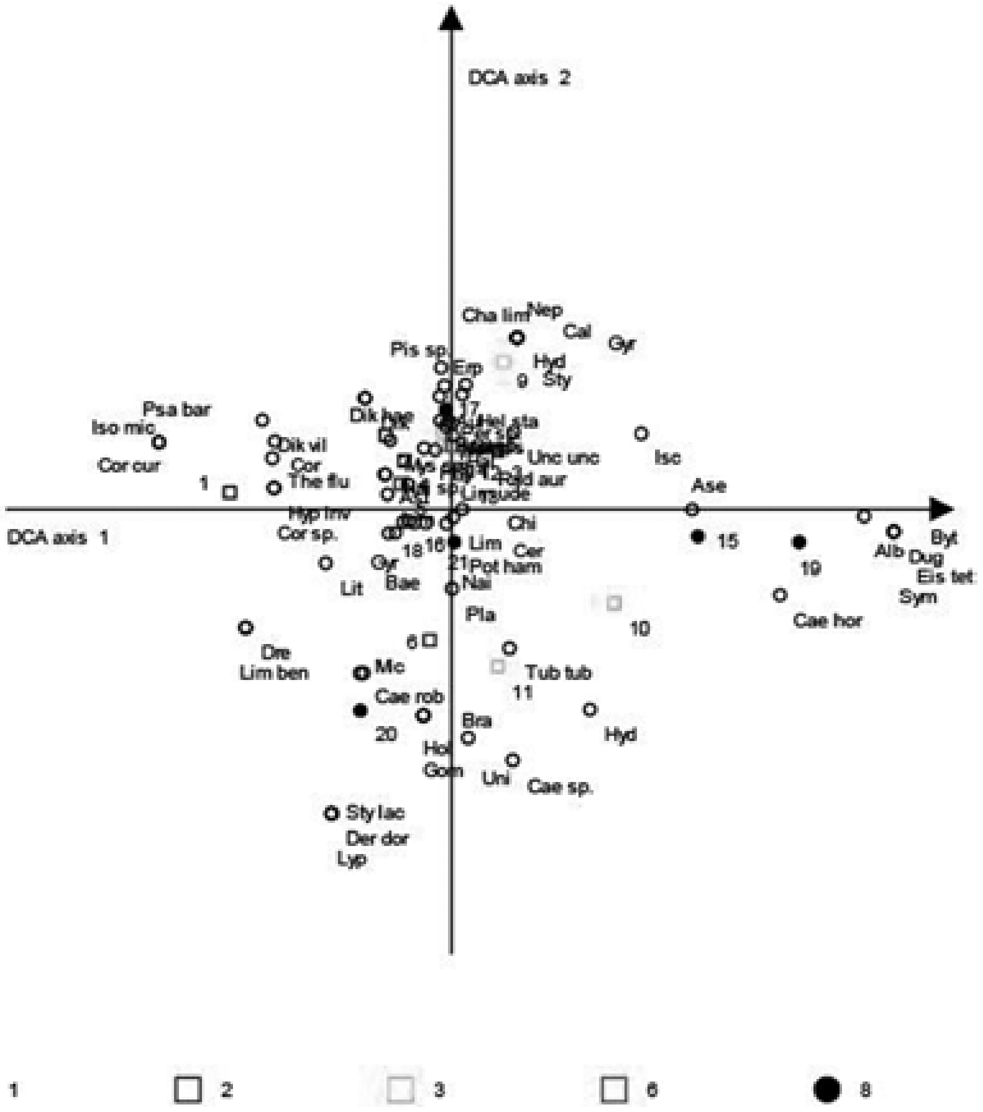

Figure 2: DCA performed on the 21 sample x 65 taxa data matrix (presence/absence); localities and taxa codes are provided in Tables 1 and 2, respectively.

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