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# Distributional Pattern of Macro Invertebrates across River Jhelum in Kashmir Valley

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**ABSTRACT**
In order to unravel the pattern in abundance and diversity of macro invertebrates across different segments of river Jhelum, a study was carried out during October, 2011 – September, 2012. Thirty one taxa were enumerated along the river. The highest density was recorded in the middle stretch, whereas the lowest was recorded in the upper reaches. Shannon-Wiener diversity showed a decreasing trend while moving downwards (Upper course 1.8≥ middle course1.0≥ lower course 0.9). The study revealed that the diversity and density of benthos were not only influenced by environmental factors, but also by altitudinal variation and the nature of substratum.

**Keywords:** River Jhelum, altitudinal variation, substratum, organic pollution.

## 1. Introduction

Benthic communities are integral part of an aquatic ecosystem as they form a major portion of the total biota in both lotic and lentic systems. They carry on many functions by acting as grazers, collectors, shredders or predators within a stream [1-3]. Benthic macro-invertebrates spend at least a part of their lifecycle at the bottom substrate in water bodies [4]. The assemblage includes a wide range of organisms like polychaeta and oligochaeta (Annelida), bivalves and gastropods (Mollusca), and crustaceans and insect (Arthropoda), which form different levels of the food web in aquatic ecosystem [5].

The distribution of macro zoobenthos is largely regulated by local habitat and regional variables in addition to the environmental factors [6-9]. The prevalence of macrozoobenthos was also influenced by the abundance of macrophytes, type of substrate and organic matter [10-15].

The River Jhelum, which flows through the almost entire valley of Kashmir, is facing tremendous pressure from natural as well as anthropogenic activities as a result of which deterioration of its water quality is a common feature. There have been attempts in the past in respect of the macro benthos of river Jhelum [16-23]. In the present paper an attempt has been made to analyze the distribution of the macrozoobenthos in the River Jhelum in response to changes in the ecological features.

## 2. Materials and Methods

The River Jhelum originates from Verinag spring situated at the foot of the Pir-Panjal in the south eastern part of the valley of Kashmir (Fig: 1) and traverses a distance of 203 km up to Khandanyar, the place where it leaves the main valley. The sampling sites along the river Jhelum were chosen with the objective to gather information about the water body, effluents and also altitudinal variation which would be correlated with the distribution and abundance of macrozoobenthos. The sites were clubbed into three group's namely as upper course, middle course and lower course which was based on altitudinal variation and bottom substrate.

On the basis of environmental variables the river length in the valley is divisible into three broad habitats, the upper, the middle and lower sections. Study sites were selected in all the three zones of the river.

- The sites at the upper course of the river (altitude >1864 m a.s.l.) were characterized by

- Fast current and higher dissolved oxygen content and bottom having boulders , pebbles, cobbles, gravel , sand and silt and were designated from $US_1$ to $US_4$.
- The sites named $MS_1$ to $MS_4$ at the middle course of the river (altitude range1598 to 1592 m.a.s.l) were characterized by low dissolved oxygen in the water and the bottom was muddy and sandy. In this section human settlements were present on the both sides of this stretch. The sites designated from DS1 to $DS_4$ at the lower course of the river (altitude 1588masl to 1581masl) shows a further decrease in the concentration of dissolved oxygen and velocity. The substratum is sandy and muddy. In both middle and lower course, extraction of sand is carried out on regular basis.

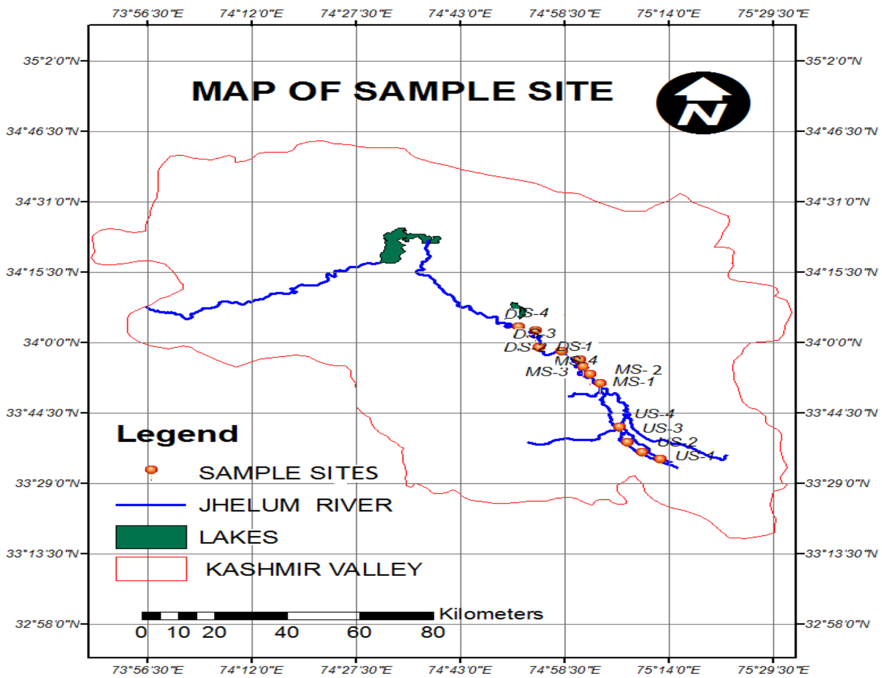


**Fig 1:** Map of Study Area showing different study sites in the River Jhelum

Water samples were collected on a monthly basis and carried to the laboratory in plastic cans for detailed analysis. However, for dissolved oxygen the samples were taken in glass bottles having 250ml capacity. The temperature was measured using a portable thermometer whereas other parameters were determined in the laboratory within 24 hours of sampling. The analysis was done as per standard methods given by [24]. For the collection of macrozoobenthos at selected sites Ekman's dredge was used in muddy bottoms, while Surber Type sampler was used at hard stony bottom. At each study site three samples were procured monthly. Surber type sampler was used from site 1 to 4 (upper course), where the bottom substratum is sandy, with boulders. The sampler was pressed against the bottom where it enclosed an area of 1600cm2. The gravel and sand were disturbed so that the benthos present got detached and collected in net fixed at a right angle to the frame opposite to the water current. The stones from inside the frame were removed and checked for any zoobenthos. In the middle and lower course stretches Ekman's dredge (15x 15cm) was operated from the boat. The samples were sieved through a series of sieves with 0.5, 01and 02 mm mesh. The macroinvertebrates retained were preserved in 70% alcohol and later on identified with the help of standard works of [25-29].

The density (number of individuals/m2) of the different taxa was calculated by using formula:

$$\text{Number of individuals/m}^2 = \frac{N \text{ X } 10000}{A \text{ X } S}$$

Where N is the number of individuals in the Surber or Ekman sampler, A is the area of sampler and S is the number of samples.

### 2.1 Statistical Analysis

The data was analyzed using SPSS (16 version) ANOVA (Analysis of Variance) was carried out on the variables. A linear relationship between the variables of interest, Pearson Correlation analysis was also done.

## 3. Results

### 3.1 General trend of Macro invertebrates across different stretches

The data revealed significant variation ($P<0.05$) in mean values of all environmental variables between three divisions of stream (i.e. upper course, middle course and lower course of the river), except water temperature which showed insignificant differences (P>0.05) (Table 1). The results showed significantly greater mean value of altitude masl (1864.5±0.577, F=1.26, P<0.001), velocity $cms^{-1}$ (73.711 ± 0.95, F=35.03, P<0.001) , conductivity µS (329±62, F=131, P<0.001 ), transparency cm (92±17,F=230, P<0.001) and dissolved oxygen $mgl^{-1}$ (9.7±0.5, F=46.5, P<0.001) and alkalinity $mgl^{-1}$ (175±35,F=27.8, P<0.001) at upper course in comparison to lower course which showed significantly low values. However, the case was different for depth cm, chloride $mgl^{-1}$ and total phosphorus $\mu gl^{-1}$ which showed an inverse relationship with other parameters which was significant greater at sites of lower course (380.25±150.13, F=12.7, p=0.002) Chloride $mgl^{-1}$ (13±4,F=101, P<0.001) and least at upper course of river (54.5±1.91).

**Table 1:** Mean value and SD of some environmental variables in the River Jhelum

| | Upper course | Middle course | Down course | F-ratio | *p*-value |
|---|---|---|---|---|---|
| Altitude (m) | 1864.5±0.577 | 1594.75±4.4 | 1583.25±2.06 | 1.26 ($F_{2,11}$) | <0.001 |
| Air temperature $^0$C | 16 ± .00 | 17 ± 0.57 | 18 ± .00 | 39.0 | <0.001 |
| Water temperature $^0$C | 11 ± 0.00 | 13 ± .00 | 14 ± .00 | 0.0 | NS |
| Velocity ($cms^{-1}$) | 73.7 ± 0.95 | 44.5± 9.6 | 33±7.41 | 35.03 | <0.001 |
| Depth (cm) | 54.5 ± 1.91 | 334.25±82.09 | 380.25±150.13 | 12.73 | 0.002 |
| Conductivity ($\mu Scm^{-1}$) | 329 ± 62 | 219 ± 41 | 228 ± 46 | 131 | <0.001 |
| Transparency (cm) | 92 ± 17 | 42 ± 20 | 42 ± 19 | 230 | <0.001 |
| Dissolved oxygen (mg/l) | 9.7±0.5 | 8.7±0,5 | 7±.00 | 46.5 | <0.001 |
| Alkalinity (mg/l) | 175 ± 35 | 144 ± 31 | 145 ± 29 | 27.8 | <0.001 |
| Chloride (mg/l) | 7 ± 2 | 10 ± 3 | 13 ± 4 | 101 | <0.001 |
| Total Phosphorus-$PO_4$ (µg) | 104 ± 25 | 141 ± 62 | 178 ± 71 | 39.6 | <0.001 |

The mean population density of macrozoobenthos in the Jhelum was recorded as 50,188 ± 26,377 ind/m2 (Fig.2a, b). A total of 42 taxa, comprising three taxonomical groups, viz., Anellida, Arthopoda and Mollusca (Table were found during the course of the study. The data depicted significant differences between the three river segments in Shannon-Wiener diversity and overall abundance of the benthos, except in case of Hirudinaria and Arthropoda (Table 3).

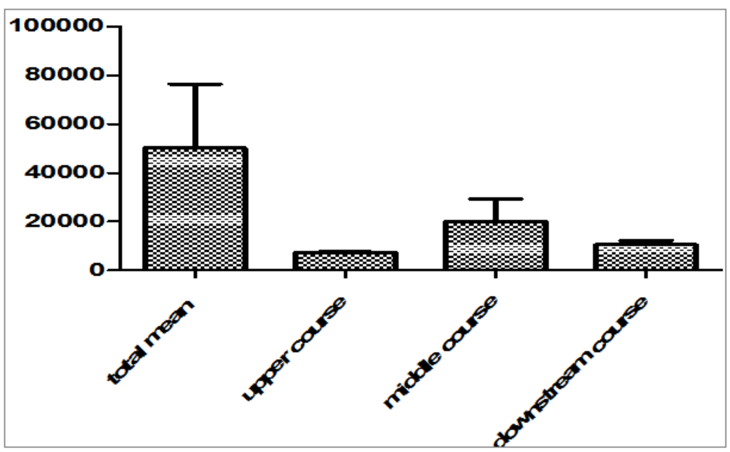


**Fig 2a:** Total mean population density (individual /m$^2$) and standard deviation of macro invertebrates in river Jhelum

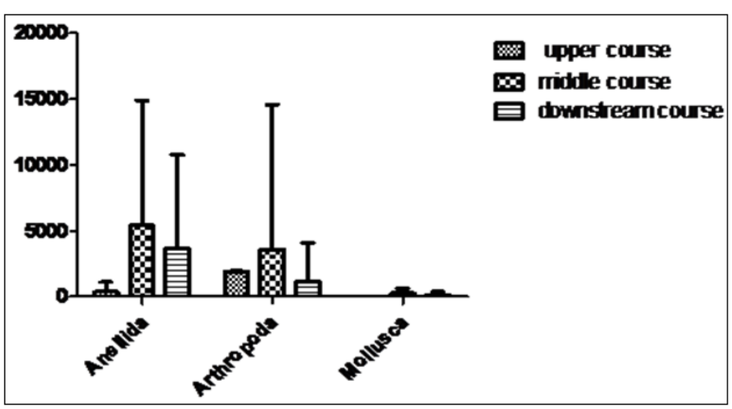


**Fig 2b:** Population density (individual /m$^2$) of different Phyla at different stretches in river Jhelum

### 3.2 Effect of Physical Variables on distribution of Benthos

The data presented in Table 4 indicate that the benthos of upper course was dominated by the arthropoda group (93.3%) particularly Ephemeropterans, Plecopterans and Tricopterans (EPT), in the middle section both annelids and arthropods contributed almost equally (54% & 44%, respectively), while in the lower course section benthos was mainly contributed by annelida (71%). The Diptera contributed about 99% and 95% of the total arthropoda at middle and lower course sections of river, respectively. Statistically, abundance of EPT showed a positive correlation with the altitude($r=0.99$), velocity ($r=0.96$), conductivity($r=1$), dissolved oxygen($r=0.77$) and alkalinity ($r=1$) while as they show a negative relation with other parameters. Depth influences abundance of Annelida, Diptera and Mollusca as positive correlation between them was observed (Table 5).

### 3.3 Comparison of Macro benthos in stream and Main River

In the river system, small fast flowing rocky streams are characterized in the headwater regions which merge, increasing the size and depth as moving downwards thereby forming a river. The upper course stretch had the turbulent and is the headwater stream which merges with different streams at Khannabal forming river. The data reveal that the upper course had about 74% shredders and scrappers in its total benthos which is decreased as we move along the river (Table 4). The sites of upper course of river was least correlated with the sites of middle course ($r=.002$) and with lower course ($r=.03$), while the middle course and lower course were strongly correlated with each other ($r=.93$).

## 4. Discussion

Rivers and streams are characterized by variation in the physico-chemical variables along different stretches of the river. Any change either through natural or anthropogenic sources influences water quality as well as the biotic interactions. Sites of the upper course of the river was characterized by fast flowing waters which decreases as we move downwards and is related to the gradient as the river slope decreases in downward direction and the concentration of dissolved oxygen was always high which may be due to high altitude, low temperature, high turbulence, low human interference and also attributed to the substrate composition of boulders, pebbles or cobble's which increases the turbulence of the water. Although the conductivity helps in assessing the trophic status of water body, but at sites of upper stretch higher values in conductivity and alkalinity was mainly due to the catchment rocks which with interaction of water for some time renders substances into it [30]. In addition, the channel width also play an important role in changing the physico-chemical features as it is directly related with low velocity, decrease in dissolved oxygen, increased depth and diminished substrate size. This assertion is in agreement with our findings as we move along different stretches of river Jhelum, the middle and lower course which showed a decrease in dissolved oxygen and low velocity while as the depth increases and the substrate composition changes from pebbles to muddy and sandy [31-32]. Lower value of transparency at middle and lower stretches might be attributed to the suspended materials brought by the torrential streams from their catchment areas [33-35]. Chloride content and phosphorus present in the aquatic ecosystem was highly correlated with the degree of organic pollution and eutrophication [36]. It is thought that the majority inputs of nutrients into an ecosystems comes from the domestic sewage, detergents, residual fertilizer rich in agricultural runoff and industrial wastes [37] which in concurrence with our results as we move along the gradient towards lower course anthropogenic activities increases thereby increasing the values . All along the river mostly in the middle and down the course of the river, the untreated sewage pours into the river and also the garbage is dumped near the river banks which ultimately deteriorate the aquatic ecosystem.

Macro benthos abundance varied between 7223 and 19924 ind/m2 with minimum at upper course and maximum at middle course of the river, but reverse was recorded with regard to diversity which could be attributed to the fact that the anthropogenic alterations decreases species diversity and increases dominance of pollution tolerant taxa due to the abundant organic matter [38-40]. High diversity in natural pristine rivers at high altitude were related to the low stress while the low diversity at lower course signifies the environmental stress due to human activities [41].

The present study revealed that the EPT group was more conspicuous in the upper course of the river Jhelum, while the annelids (71.1% ds ≥ 54.1% ms ≥ 6.5% us) and chironomids (0.4% us; 43.8%ms; 18.7% ds) were abundant in the middle and lower sections of the river (Table 4). This clearly indicates that the EPT groups thrive better in clear waters having least anthropogenic disturbances, while the abundance of Annelida and chironomidae is directly related to the quantity of organic matter in the water [42]. A different invertebrate composition in sandy and organic habitats has also been reported by [43]. Barbour et al considered Ephemeropterans sensitive to environmental stress and inferred that their presence signified clean condition [44]. The variability in the biotic data at different sites might be due to the substrate type, velocity, depth and altitude [45-48].

The Shanon diversity index showed a decreasing trend from upper course to down course which is clearly related with the fact that the diversity of the zoobenthic community decreased with increase in the pollution, while at the same time the population density of the tolerant species increased with increased environmental stress. This is also supported by the lowered dissolved oxygen concentration in the river with increase in distance from the head waters [32]. Tubificids and Chironomids were used as indicators of pollution as they were reported in waters rich in organic matter which favors pollution tolerant species. [49-50] the present study is in complete conformity with the findings of these workers.

During the present study the leeches (Hirudinaria) were found in good numbers only in the upper course of the river. These organisms are generally found attached to the sides, in cracks and under surfaces of a variety of substances such as rocks and logs. They are less abundant in the waters of great depth because of the lack of vegetation or attachment surface. In the middle & down course of the river, they were recorded only in the peripheral areas, when the water level was low. Minimum population density of mollusks in upper course may be due to the absence of clayey or muddy bottom [51].

It may be concluded that the diversity and abundance of zoobenthos in the River Jhelum are influenced not only by pollution level; however, bottom substratum also affects its distribution. At the sites of upper course, altitude, geology and the substratum of the river plays an important role in the distribution of macroinvertebrates though the organic pollution, impairment and increase in encroachment acted strongly on the abundance of benthos at sites of middle and lower stretches.

**5. Acknowledgement**
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**Table 2:** List of macroinvertebrates recorded during investigation period.

| S. No | Phylum | Class | Taxa |
|---|---|---|---|
| 1 | Anellida | Oligochaeta | *Limnodrilus hoffmeister* |
| 2 | | | *Limnodrilus udekemainus* |
| 3 | | | *Tubifex tubifex* |
| 4 | | | *Lumbriculus sp* |
| 5 | | | *Pristina sp* |
| 6 | | | *Aeolosoma sp* |
| 7 | | | *Nais sp* |
| 8 | | | *Branchiura sowerbyii* |
| 9 | | Hirudinaria | *Erpobdella octoculata* |
| 10 | | | *Placobdellamontifera* |
| 11 | | | *Placobdella hollensis* |
| 12 | | | *Glossophenia complanata* |
| 13 | Arthropoda | Crustacea | *Gammarus pulex* |
| 14 | | Arachinida | *Hygrobatoidea* |
| 15 | | Insecta | *Baetis sp.* |
| 16 | | | *Baetilla sp* |
| 17 | | | *Epeorus sp* |
| 18 | | | *Caenis sp* |
| 19 | | | *Rhyacophila obscura* |
| 20 | | | *Rhyacophila basalis* |
| 21 | | | *Limnephilus sp* |
| 22 | | | *Lepidostoma sp* |
| 23 | | | *Neumora sp* |
| 24 | | | *Perilidae sp* |
| 25 | | | *Elimidae sp.* |
| 26 | | | *Dytiscus sp.* |
| 27 | | | *Gomphus* |
| 28 | | | *Chironomus sp* |
| 29 | | | *Diamesinae sp* |
| 30 | | | *Procladius sp* |
| 31 | | | *Tabanus sp* |
| 32 | | | *Simulium sp* |
| 33 | | | *Culex* |
| 34 | | | *Psychoda sp* |
| 35 | | | *Bezzia sp* |
| 36 | Mollusca | Gastropoda | *Gyraulus sp* |
| 37 | | | *Lymnaea ovata* |
| 38 | | | *Lymnaea collumella* |
| 39 | | | *Lymnaea auricularia* |
| 40 | | | *Planorbis sp* |
| 41 | | Pelecypoda | *Corbicula sp* |
| 42 | | | *Sphaerium sp* |

**Table 3:** Population density of benthos (ind/m$^2$) and Shannon Wiener diversity using ANNOVA

| | Upper course | Middle course | Down course | F-ratio | *p*-value |
|---|---|---|---|---|---|
| Abundance(ind/m$^2$) | 7220 ±703 | 19924±9339 | 10495±1693 | 5.7 | 0.024 |
| Annelida | 464 ± 62 | 11521 ±1266 | 8237±2240 | 58.3 | 0.00 |
| Oligochaeta | 45 ± 14 | 10884± 530.7 | 7533±2515.7 | 55.9 | 0.00 |
| Hirudinaria | 431 ± 72 | 637±824.6 | 703±506 | 0.258 | 0.778 |
| Arthopoda | 6853 ±569 | 8859±9501.4 | 2070±1981.2 | 1.54 | 0.265 |
| Crustacea | 902 ± 96 | 44 ± 88.9 | 81±80.6 | 119.06 | 0.00 |
| Ephemeroptera | 2895 ±126 | 15 ± 29.6 | 3.7±7.4 | 1.96 | 0.00 |
| Tricoptera | 1535±75 | 4 ± 7.4 | 11.1±22.2 | 1.51 | 0.00 |
| Plecoptera | 536±51 | 0 | 0 | 452.3 | 0.00 |
| Coleoptera | 391±56 | 0 | 0 | 192.3 | 0.00 |
| Odonata | 0 | 4 ± 7.4 | 0 | 1.0 | 0.405 |
| Diptera | 485±126 | 8793 ±9572.3 | 1966±2029.8 | 2.4 | 0.140 |
| Arachnida | 0 | 0 | 3.7±7.4 | 1.0 | 0.405 |
| Mollusca | 1 ±1 | 274 ±144.5 | 188±125.3 | 6.3 | 0.019 |
| Shannon- Wiener diversity | 1.8± 0.13 | 1.0±0.21 | 0.9±0.16 | 35.0 | 0.00 |

**Table 4:** Contribution (%) of different groups in the total zoobenthos in different sections of the River Jhelum

| Group | % Contribution | | |
|---|---|---|---|
| | **Upper course** | **Middle course** | **Down course** |
| Total. Annelida | 6.5 | 54.1 | 71.1 |
| Oligochaeta | 0.61 | 50.9 | 64 |
| Hirudinaria | 5.9 | 3.1 | 6.7 |
| Total. Arthropoda | 93.3 | 44.2 | 19.6 |
| Crustacea | 12.4 | 0.22 | 0.77 |
| Ephemeroptera | 40 | 0.07 | 0.03 |
| Tricoptera | 21.2 | 0.01 | 0.1 |
| Plecoptera | 7.4 | 0 | 0 |
| Coleoptera | 5.4 | 0 | 0 |
| Diptera | 6.7 | 43.8 | 18.7 |
| Total. Mollusca | 0.013 | 1.41 | 1.8 |

**Table 5:** Level of correlation between macro-invertebrate density and physico-chemical features

| | Altitude | Water Temperature | Velocity | Depth | Transparency | Conductivity | DO2 | Alkalinity | Chloride | Total phosphorus |
|---|---|---|---|---|---|---|---|---|---|---|
| Abundance | -0.67 | 0.43 | -0.49 | 0.60 | 0.59 | -0.72 | -0.09 | -0.68 | 0.32 | 0.19 |
| Annelida | -0.95 | 0.81 | -0.85 | 0.91 | 0.90 | -0.97 | -0.56 | -0.95 | 0.74 | 0.64 |
| Oligochaeta | -0.94 | 0.80 | -0.84 | 0.91 | 0.90 | -0.96 | -0.55 | -0.95 | 0.73 | 0.63 |
| Hirudinaria | -0.98 | 1.00 | -1.00 | 0.99 | 1.00 | -0.96 | -0.90 | -0.98 | 0.98 | 0.94 |
| Arthopoda | 0.26 | -0.54 | 0.48 | -0.35 | -0.37 | 0.20 | 0.79 | 0.25 | -0.63 | -0.73 |
| Crustacean | 1.00 | -0.93 | 0.95 | -0.99 | -0.98 | 1.00 | 0.75 | 1.00 | -0.89 | -0.81 |
| Ephemeroptera | 1.00 | -0.95 | 0.97 | -0.99 | -0.99 | 1.00 | 0.78 | 1.00 | -0.90 | -0.83 |
| Tricoptera | 1.00 | -0.94 | 0.96 | -0.99 | -0.99 | 1.00 | 0.78 | 1.00 | -0.90 | -0.83 |
| Plecoptera | 1.00 | -0.94 | 0.96 | -0.99 | -0.99 | 1.00 | 0.78 | 1.00 | -0.90 | -0.83 |
| Coleoptera | 1.00 | -0.94 | 0.96 | -0.99 | -0.99 | 1.00 | 0.78 | 1.00 | -0.90 | -0.83 |
| Odanata | -0.47 | 0.19 | -0.25 | 0.38 | 0.37 | -0.53 | 0.16 | -0.48 | 0.08 | -0.06 |
| Diptera | -0.61 | 0.35 | -0.41 | 0.53 | 0.52 | -0.66 | -0.01 | -0.62 | 0.25 | 0.11 |
| Archinida | -0.53 | 0.76 | -0.71 | 0.61 | 0.62 | -0.47 | -0.93 | -0.52 | 0.82 | 0.90 |
| Mollusca | -0.94 | 0.80 | -0.84 | 0.90 | 0.90 | -0.96 | -0.55 | -0.95 | 0.73 | 0.63 |

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