Original scientific paper
UDC 574.587:595.7(496.5:282)

COMMUNITY STRUCTURE OF THE EPT GROUP (INSECTA) IN THE MAIN ALBANIAN RIVERS

Bledar Pepa[1*], Anila Paparisto[2], Hajdar Kicaj[1]

[1]Department of Biology, Faculty of Technical and Natural Sciences, "Ismail Qemali" Vlora University, Kosovo nn, 9404 Vlora, Albania
[2]Department of Biology, Faculty of Natural Sciences, Tirana University, Boulevard Zogu I 1, 1001, Tirana, Albania

[*]e-mail: bled_pepa@hotmail.com

Abstract

In recent decades, monitoring of benthic fauna in Albanian rivers is an important environmental component at a time when their flow and watershed area have been greatly modified by anthropogenic influences. Given the importance of these organisms in aquatic bio-ecological studies defined in the EU (European Union) directive, this study completes the taxonomic panorama of studies in the main rivers of our country.

This research was conducted in a period from 2007 to 2019 aimed to give an overall assessment of the EPT group (*Ephemeroptera-Plecoptera-Trichoptera*) of benthic macro-invertebrates distributed in the seven rivers of Albania, namely: Drin, Mat, Shkumbin, Osum, Devoll, Drinos and the Shushica-Vlora River. The collection of the benthic macro invertebrates was realized by using the Kick-net sampling methodology (rectangular net, 500 micron mesh). A total of 33 stations with different ecological and geophysical typologies have been selected in all rivers. Using the Kick-net sampling a total of 8154 specimens' representatives of 28 families were collected.

Caddisflies, or *Trichoptera* order, were dominant both in number of species (8 species) and in abundance (74.3% of all individuals). Meanwhile Mayflies (*Ephemeroptera*) and Stoneflies (*Plecoptera*) contributed much less to species richness and abundance. The presence of 20 EPT families of macro-invertebrates in the the Shushica River study testifies the highest degree of biodiversity. The river with the lowest diversity of EPT species represents (8 families) is the Drini River. Representatives of 28 insect families collected with Kick-net were: *Ephemerellidae*, *Baetidae*, *Heptagenidae*, *Caenidae*, *Oligoneuridae*, *Potamanthidae*, *Ephemeridae*, *Isonychidae*, *Leptophlebiidae*, *Siphlonuridae*, *Leuctridae*, *Perlodidae*, *Perlidae*, *Chloroperlidae*, *Nemuridae*, *Capniidae*, *Brachycentridae*, *Hydropsychidae*, *Hydroptilidae*, *Glossosomatidae*, *Philopotamidae*, *Rhyacophilidae*, *Beraeidae*, *Leptoceridae*, *Polycentropidae*, *Helicopsychidae*, *Sericostomatidae*, and *Goeridae*.

We can conclude that taxonomic panorama of the main rivers of our country is represented by small differences of taxon diversity between the rivers in the northern, middle and southern part of our country. The changes are not only due to the typological conditions of the rivers but also due to the influence of the anthropogenic factor mainly in the urban area.

***Key words**: EPT, River, Benthic, Macroinvertebrates.*

1. Introduction

Albania is considered as an area with very high biodiversity, but also as an area where biodiversity is under high threat from human activity [1]. In our country there are over 152 rivers and streams, which form 8 large rivers that flow towards the Adriatic coast [2]. Their aquatic flora and fauna is not fully known. Of interest in these water bodies are rare and endemic species. In Albanian waters are found: over 310 species

and subspecies of fish [3], of which 60 are included in the red list as rare, threatened or endangered; over 400 species of mollusks [4], 15 species of amphibians and 37 species of reptiles [5], 320 species of birds [6], and 4,640 species of insects [7].

With the intensification of ecological studies on aquatic fauna, interest has been shown in the class of insects and orders of the EPT group (orders E - Ephemeroptera, P - Plecoptera, T - Trichoptera) [8]. In the larval state these creatures live in benthic aquatic environments where they are known as bioindicators of water quality [9]. For their ecological importance, together with other benthic organisms, they are already an important component of the water monitoring systems of the EU Water Framework Directive (Directive 2000/60 / EC) [10], as well as of the US agency of Environment EPA [11]. WFD implementation requires the use of benthic macro invertebrates as part of biological monitoring of surface waters, as biological indicators for monitoring of water quality (Directive, 2000/60/EC 2000; [10]).

Often non-concentrated sources of pollution in a river basin are better assessed by benthic invertebrates (EPTs) than by general chemical assessment [12, 13]. Rapid changes in the physico-chemical conditions of water bodies make physico-chemical analyzes, unlike indicators based on aquatic organisms, unable to explain the water quality of a river as they hide long-term pollution [9]. According to (USEPA [11]) physico-chemical assessments are mainly used for a surface water assessment.

According to Plafkin *et al.*, [13], a large number of benthic macro invertebrates are very susceptible to contamination. Their tolerance values range from 0 - 10. EPT group are often used as indicators of water quality due to their sensitivity to environmental change [14], where presence or absence of certain EPT taxa or their overall richness is highly informative and can be tightly linked to habitat quality [15]. The greatest diversity of these insects occurs in clear and well-oxygenated waters [16]. The presence of EPT species denotes that parameters in the habitat is within the tolerance limit of the species.

Among the EPT, Plecoptera (stonefly) is the most sensitive to changes in water quality [17]. Apart from Plecoptera, Trichoptera larvae and Ephemeroptera (mayflies) nymphs are also good bio indicators of the freshwater quality and ecological changes [18] and their distributions are strongly related by their tolerance to some environmental factors [19].

In the countries of the Balkan region there are a number of studies focused on the fauna and benthic macroinvertebrates of river waters, as in Kosovo [20], where several new species of the order Trichoptera have been identified, as well as in Macedonia [21].

The main rivers of our country are under the constant influence of stressors such as organic pollution, industrial, agricultural, increased erosion, urbanization, etc., so the study of the populations of their benthic creatures clearly reflects the changes that have occurred over time [22]. The lack of a coordinated monitoring program of Albanian rivers using benthic macroinvertebrates in biomonitoring increases the need for its implementation [23].

Independent studies aimed at assessing the ecological status of river waters based on benthic macroinvertebrates, have been conducted in recent years in many rivers of Albania [24, 25, and 26]. The assessments as well as academic studies were made in the framework of compiling their management plans of Drin River, Shkumbin River, Vjosa River [27].

The purpose of this study is to make a systematic contribution to the recognition of the EPT group in the main rivers of Albania and to make a comparative assessment of the distribution of taxes in them. Its main objective is to assess the impact of various factors, including anthropogenic ones, on the populations that make up the EPT group. The study includes 7 main rivers of Albania and the study period is extended from 2007 - 2019.

2. Materials and Methods

2.1 Study area

The study includes almost all geographical areas and sub-areas of Albania. The study takes into account the seven main rivers of Albania from the northern to the southern part. The analyzed rivers are: Drini (5 stations), Mati (5 stations), Shkumbini (5 stations), Devolli (4 stations), Osumi (4 stations), Drinos (5 stations), and Shushica River (5 stations) (Figure 1). Although the study was not conducted simultaneously across all rivers, the number of stations surveyed in each of them is enough for determination of this group. The EPT group that was analyzed in this study is represented by a large number of species, which in larval form live for a long time in the river bed. The nymphs of these species go through several stages until final growth. Cases in some species that reach up to 50 larval stages in a single species are not excluded [28, 29]. This systematic comparative study proves the condition of these populations. All sampling was carried out at the end of the summer period where the concentrated organic pollution is directly reflected in the composition of the benthic community. The stations for each river taken in the study are given in the following Figure 1.

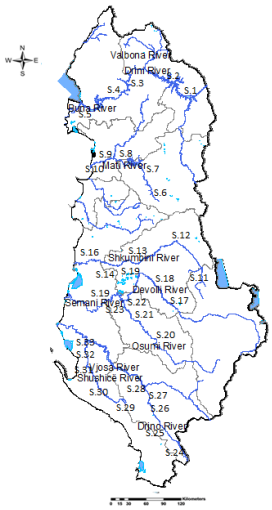

Figure 1. Location of sampling stations of rivers: Drini River (S.1 - Kukes, S.2 - Fierze, S.3 - Koman, S.4 - Bacallek - Shkoder, S.5 - Pulaj - Velipoje); Mati river (S.6 - Burrel, S.7 - Shkopet, S.8 - Rubik, S.9 - Milot, S.10 - Shenkoll); Shkumbini River (S.11 - Proptisht, S.12 - Librazhd, S.13 - Elbasan; S.14 - Peqin, S.15 - Rrogozhine); Devolli River (S.16 - Gramsh, S.17 - Banje, S.18 - Dragot, S.19 - Kozare); Osumi River (S.20 - Polican, S.21 - Uznove, S.22 - Berat, S.23 - Dimal); Drinos River (S.24 - Libohove, S.25 - Lazarat, S.26 - Gjirokaster, S.27 - Picar, S.28 - Uji I Ftohte); Shushica River (S.29 - Terbac, S.30 - Brataj, S.31 - Kote, S.32 - Drashovice, S.33 - Armen)

2.1.1 River Drin

The Drin River is presented as the largest water network of Albania and the entire eastern coast of the Adriatic and Ionian Seas. It has a length of 285 km. The Drin hydrographic basin is part of the joint Drin-Bune basin with an area of 19,582 km^2, of which 14,173 km^2 belong to the Drin and 5,187 km^2 belong to the Buna River. Of the total area of the Drini basin, 5,973 km lie in the territory of Albania, while the rest lies in Kosovo, Macedonia and Greece. The river Drin from Struga in Macedonia at an altitude of 694 m above sea level from where it originates, to the union with Buna has a length of 285 km. Drini i Bardhë originates in the Bjeshkët e Namuna of Kosovo and from the source to the meeting with Drini i Zi in Kukës has a length of 136 km and a catchment area of 4,964 km^2. The water temperature of the Drin River in January is on average 5.3 ^{0}C, while in August it averages 20.8 ^{0}C [30].

2.1.2 River Mat

The Mat River is 115 km long and has a basin area of 2,441 km^2. It lies in the north of Albania. The Mat River originates from Mount Martanesh near the village of Klos. Further, it flows expanding into a large valley where the catchment basins of Ulza and Shkopet are formed, on which there are two hydropower plants. After that, the river joins the waters of the Fan River and flows into the Adriatic Sea, north of Rodon Bay. The river flows with an average speed of 103 m^3/sec and an average flow of 42.6 L/sec/km^2. Water has low mineralization on average 222 mg/L. The water temperature fluctuates from 5.3 ^{0}C in January to 19.9 ^{0}C in August [2].

2.1.3 River Shkumbin

Shkumbini is one of the largest rivers in Central Albania. This river is 181 km long, its basin area is 2,444 km^2 and the average altitude above sea level is 753 m. The Shkumbin River estuary is in the Adriatic Sea, in the southern part of the Karavasta lagoon. Shkumbini originates from the eastern slopes of Valamara and Guri i Kamjes Mountains. In the Shkumbin basin there is a variety of limestone, from where many important karst springs spring, such as that of Krasta with 500 L/s. The average multi-year flow of Shkumbin is 61.5 m^3/sec. It transports an average of 5.8 million tons of solids per year. Temperatures range from 6.3 ^{0}C in January to 22 ^{0}C in August. The mineralization of water is about 317 mg/L [2].

2.1.4 River Devoll

The Devoll River is the main tributary of the Seman River. It originates from the southeastern slopes of the Morava Mountains and has a length of 196 km. Its morphometric parameters are: catchment area 3,139 km^2, average height 950 m, average flow 49.5m^3/sec, flow module 15.8L/sec/km^2 [30].

Due to the nature of the extension, the river Devoll is affected along its entire length by the presence of discharges of organic matter, agricultural chemicals and waste of various natures, which come from urban and rural areas of the districts Devoll, Korca, Gramsh, and Cerrik. In the area below the Gramsh settlement is the former Chek in military plant, which has influence through the dumping of raw waste into the Devoll River Heavy metal scraps are passively dumped into the river by this plant. With the resumption of works in the HPP of Banja there is an increase of the erosive phenomenon.

2.15 River Osum

The Osum River is one of the main tributaries of the Seman River. This river starts from Vithkuq Mountain and has the following morphometric parameters: length 161 km, catchment area 2,150 km^2, average height 825 m, average flow 32.5 m^3/sec, section and flow module 17.5 1/sec/km^2 [30].

On both sides of the river there are several urban regions: Çorovoda, Poliçani, Ura Vajgurore e Beratit,

and a large number of rural areas. Being in direct contact with the urban areas of Skrapar, Poliçan, Berat, and Ura Vajgurore, this river serves as the main carrier of discharges of organic matter (oil), chemicals, as well as waste and inerts throughout the catchment area.

2.1.6 River Drinos

The sources of the Drinos River are located in the western part of Mount Elatos in Greece. It flows in the southern part of Albania and represents as one of the main tributaries of the Vjosa River. Its length is about 84 km, hydrological basin 1,324 km^2, and average height 745.5 m.

This river flows between two mountain ranges, on one side Shëndëlli - Lunxhëri - Bureto and on the other Malësia e Kurveleshit - Mali i Gjerë - Stugarë. During this flow from the right and left bank of this river descend streams with temporary and continuous flow such as the stream Vriseras, Suha, Numica, etc., which bring to the river Drinos very solid material [31].

2.1.7 River Shushicë

This river has a length of 81.6 km, an area of 715 km^2 and an average height of 540 m. The average annual flow at the estuary is 24.2 m/cubic/sec while the maximum absolute recorded flow is 1500 m/cubic per second and the bed width is 400 - 600 m. This river starts east of the village of Kuç and further joins the many cold streams and the Dry stream and then takes the name Shushica. On the right side of the stream is the stream of Smokthina, Vajza and Vlahina. At its bottom the bed expands and then flows into the Vjose River. The banks of the river look high despite the wide bed [30].

2.2 Sampling methodology

Classically, EPT are collected with a standardized kick-net method. Sampling material for this group as for all benthic macroinvertebrates was realized respecting some standard EN 13946:2003 BS 6068-5.33 [32], EN 14407:2004 BS 6068-5.35 [33], EN 14407 [34], and based on the methodology proposed by [35 - 39].

The benthic organisms were sampled from the bottom of the river at the depth 30 - 50 cm, using a kick-net with dimension 30 cm x 40 cm and mesh of 500 microns [35]. This kick net was placed vertically in the river's bed, while in the distance of one meter from the kick net, we dag with feet for 30 seconds [40]. Sampling was repeated 3 times for each station. After sampling the kick net was well-splashed with water to remove the excess dreg, until only the benthic macro-invertebrates remain on it. Then the material is passed from the net into a rectangular vessel and then into a 300 mL volume transport bottle.The sampled macro invertebrates were stored and preserved with an alcohol solution (95%) [41]. Sorting and identification of benthic macro invertebrates in laboratory was realized respecting the standard EN ISO 10870-2012; and based also on the methodology proposed by Campaioli *et al.*, [35], and Braukmann [42].

In the laboratory sorting consists on disaggregating of macro invertebrate individuals from the substrate [43]. The substrate disaggregation is realized carefully using a stereomicroscope.

2.3 Biodiversity calculation with Sympson's diversity index

Simpson (D) is a diversity index that provide important information on the commonness and rarity of species within the community (equation 1). The diversity quantifying is an important tool for understanding the community structure [44]. Diversity within the benthic macro invertebrate community was described and statistically analyses using the Simpson's diversity index ("D"), calculated: "p" is the proportion of individuals in the "i" taxon of the community and "s" is the total i number of taxa in the community. This index places relatively little weight on rare species and more weight on common species [45]. Its values range from 0, indicating a low level of diversity, to a maximum of 1-1/s.

$$D = 1 - \sum_{i=1}^{s} (p_i)\,2 \qquad \text{eq. 1}$$

2.4 Data processing and statistical analysis

Descriptive statistic were considerate study the variability and spatial distribution of the families of EPT group. The relationship between the families in the river was analysed by Spearman Rho, confirmed at $P < 0.005$ statistical significance level.

Factor analysis (FA) was used to assess the most probable related under rivers and Principal Component Analysis (PCA) related the associations of the families extracted from the correlation matrix. The statistical analysis was possible using the MINITAB 17 software package.

3. Results and Discussion

3.1 The presence of families in each of the rivers

As shown in Table 1 in all the study regions in the seven rivers from south to north of Albania were found 28 families of the EPT group (Insecta). In each river the number of families met respectively is: Shushica River - 20 families; Osum River - 17 families, Shkumbin and Mat River with 15 families; Devoll River -12 families; Drinos River -11 Families and Drin River with 8 families. Shushica River is presented with the largest number of taxes for the fact that the whole area of its flow is not

affected by anthropological activity. The Drin River is presented with the smallest number of families due to the fact that its bed in almost all stations is deep, partly lake and with a benthic structure that does not favor the development of these organisms.

With constant distribution throughout the rivers are the families: *Ephemerellidae*, *Baetidae*, *Heptagenidae* (except the Drin River), *Chloroperlidae*, and *Hydropsychidae*.

The species found in only one river are: family *Capniidae* (Trichoptera) (Mat River); *Leptophlebiidae*, *Siphloneuridae* (Ephemeroptera), *Sericostomatidae*, *Polycentropodidae*, *Brachycentridae* (Trichoptera) (Shushice River, as a river with many new species), *Leptoceridae* (Trichoptera), (Osum River), and *Goeridae* (Trichoptera) (Drin River).

3.2 The values of Simpson diversity index for rivers

Table 2 provides a summary of the calculated values of the Simpson diversity index for all rivers in the study. As can be seen, the highest values of this index belong to the Osum River (0.832) and the Drinos River (0.800). This indicates a higher degree of biological diversity. Both of these rivers belong to the southern part of the country.

Meanwhile, the lowest value of the Simpson index is found in the Drin River, which indicates that the structure of the benthic community has a low level of biodiversity (0.529). In this river, this state of biodiversity of the populations of the EPT group is explained by the unfavorable conditions of the river typology, such as the instability of the benthos, the lake structure of the Fierze-Koman-Vau I Dejes part with depth and the changes of the flow during the dry season in his bed.

Table 1. Presence of families by each river

Nr	The EPT families	Shkumbini	Osumi	Devolli	Mati	Shushica	Drinos	Drini
1	*Ephemerellidae*	√	√	√	√	√	√	√
2	*Baetidae*	√	√	√	√	√	√	√
3	*Heptageniidae*	√	√	√	√	√	√	-
4	*Caenidae*	√	√	√	√	√	√	√
5	*Oligoneuridae*	√	√	√	√	√	√	-
6	*Potamanthidae*	√	-	-	√	-	-	-
7	*Ephemeridae*	-	√	-	-	√	-	-
8	*Isonychidae*	-	√	-	-	√	-	-
9	*Leptophlebiidae*	-	-	-	-	√	-	-
10	*Siphlonuridae*	-	-	-	-	√	-	-
11	*Leuctridae*	-	√	√	√	-	-	-
12	*Perlodidae*	√	-	-	√	-	-	-
13	*Perlidae*	√	√	√	-	√	-	-
14	*Chloroperlidae*	√	√	√	√	√	√	√
15	*Nemuridae*	-	√	-	√	√	√	-
16	*Capniidae*	-	-	-	√	-	-	-
17	*Hydropsychidae*	√	√	√	√	√	√	√
18	*Hydroptilidae*	√	√	√	-	-	√	-
19	*Glossosomatidae*	√	√	√	-	√	√	-
20	*Philopotamidae*	√	√	-	√	√	-	√
21	*Rhyacophilidae*	√	-	-	√	√	√	√
22	*Beraeidae*	√	√	√	-	√	-	-
23	*Leptoceridae*	-	√	-	-	-	-	-
24	*Helicopsychidae*	-	-	-	√	-	-	-
25	*Sericostomatidae*	-	-	-	-	√	-	-
26	*Polycentropodidae*	-	-	-	-	√	-	-
27	*Brachycentridae*	-	-	-	-	√	-	-
28	*Goeridae*	-	-	-	-	-	-	√
Total		**15 families**	**17 families**	**12 families**	**15 families**	**20 families**	**11 families**	**8 families**

Table 2. Simpson diversity index classification for all rivers in the study

River	Shkumbini	Osumi	Devolli	Mati	Shushica	Drinos	Drini
D	0.746	0.832	0.675	0.759	0.692	0.800	0.529

3.3 Descriptive Statistics: Shkumbini, Osumi, Devolli, Mati, Shushica, Drinos, and Drini River

The most important parameters, such as mean, median, minimum, maximum, coefficient of variation (CV%), Standard Deviacion, Skewness and Kurtosis are shown in Table 3.

In the following descriptive statistics we find that for each river the data are much deviated from the normal distribution. In all rivers there are high values of the coefficient of variance (CV > 75%) as well as high values of skewness and kurtosis, thus showing us a great asymmetry during the distribution of data. The lack of data in the first quartile (Q1, 25%) (0.00) also indicates their low concentration, highlighting that many taxes are present with fewer individuals. These deviations from these statistical parameters are related to large changes in the number of individuals in EPT group populations due to environmental impact and river typology.

The distribution of data in Table 3 is illustrated by the boxplot shown in Figure 2. In each river are recorded out layers with large values of some taxes (4 to maximum 6 taxon for each river). Thus in the Shkumbin, Osum and Devoll rivers the family with the highest data deviation is Hydropsychidae (order Trichoptera). The stations of these rivers belong to the region of central Albania. This family has midle tolerance value to organic pollution, which is related to the presence of urban areas near these stations. In the rivers Mat, Shushica and Drin, outlayers indicate the presence of a high number of individuals of the family Baetidae (Order Ephemeroptera) compared to other taxa. The Mat and Drin rivers belong to the region of Northern Albania. Considering the fact that large urban areas are not identified in the stations of these rivers, the presence of this tax is justified by the specific typology of these rivers.

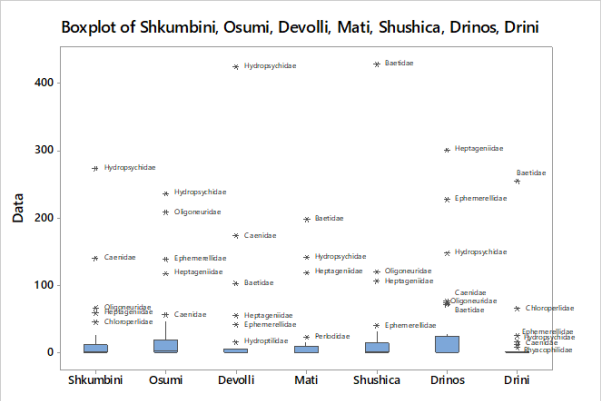

Figure 2. Boxplot diagram of data taxes in seven rivers

3.4 Correlation analysis of rivers

To study the relationship that exists between the the rivers under study and for a better classification of rivers influenced by various factors expressed in the distribution, several parameters such as: Spearman correlation coefficient, Factor Analyses and Dendrograma. The obtained results were initially subjected to statistical processing by testing the Spearman Rho correlation, which applies to data that do not obey the normal distribution. Correlation analysis is performed to examine the correlation between two variables (rivers) that affect or accompany each other. The significance of the correlation is attributed to the values of $p < 0.001$. The results of the Spearman Rho correlation coefficients (r) are presented in Table 4.

Table 3. Descriptive statistics analysis data through seven rivers

Variable	Mean	St.Dev	CV%	Min.	Q1	Median	Q3	Max.	Skewness	Kurtosis
Shkumbini	23.0	57.8	252	0.00	0.00	1.50	11.8	273	3.54	13.7
Osumi	32.5	63.7	196	0.00	0.00	3.50	18.8	236	2.34	4.71
Devolli	29.7	86.2	290	0.00	0.00	0.00	6.00	424	4.00	17.3
Mati	19.8	48.4	244	0.00	0.00	1.00	9.00	197	2.88	4.81
Shushica	29.7	83.5	281	0.00	0.00	2.00	14.0	428	4.38	18.2
Drinos	34.0	74.3	218	0.00	0.00	0.00	23.8	301	2.64	4.74
Drini	13.8	48.9	356	0.00	0.00	0.00	2.00	254	4.76	19.1

Legend: St. Dev - Standard of deviation, CV - coefficient of variation; min - minimum, max - maximum, Q1 - first quartile, Q3 - third quartile.

Table 4. Spearman Rho correlation coefficients between Shkumbin, Osum, Devoll, Mat, Shushica, Drinos and Drini rivers

River	Shkumbini	Osumi	Devolli	Mati	Shushica	Drinos
Osumi	0.635[1]					
Devolli	0.778[1]	0.755[1]				
Mati	0.531[2]	0.317	0.388[3]			
Shushica	0.538[2]	0.631[1]	0.492	0.219		
Drinos	0.751[1]	0.700[1]	0.783[1]	0.478	0.656[1]	
Drini	0.547[2]	0.364	0.412[3]	0.328[3]	0.416[3]	0.535[2]

Spearman Rho: P-Value; [1]$p < 0.001$, [2]$p < 0.005$, [3]$p < 0.05$.

As can be seen from Table 4 there is a high correlation and significance ($0.60 < r^2 \leq 1$, $^1P < 0.001$) between the 8 river pairs for the 33 sampling stations in this study. These pairs of rivers are: Osum with Shkumbin; Devoll with Shkumbin; Shkumbin with Drinos; Osum and Devoll; Shushica with Osum; Osum and Drinos; Devoll me Drinos as well as Shushica with Drinos.This high similarity for these river pairs is related to their geographical proximity (southern part of the country) as well as to the approximate climatic conditions of the area where the individuals of the EPT group are collected. Meanwhile 4 pairs of rivers show moderate and significant correlation ($0.53 < r^2 \leq 0.60$, $^2P < 0.005$). These river pairs are: Shkumbini with Mat; Shkumbini with Shushica, Shkumbini with Drini and Drini with Drinos. The pairs associated with this correlation can be explained by the typological differences of the rivers as well as by the relative geographical distance that exists between the Shkumbin River and the other 3 rivers or the two rivers Drin and Drinos that lie in the northern and southern extremes of Albania. Poor correlation ($0.33 \leq r^2 \leq 0.53$, $^3P < 0.05$) resulted in 4 pairs river. These pairs are: Mati and Devolli; Drini and Devolli; Mati and Drini as well as Shushica and Drini. Rivers with very low correlation between them are characterized by high variation of random families (fewer individuals) as well as changes in climatic conditions of the areas.

Figure 3 shows that for seven rivers are grouped 2 clusters. Shkumbini, Devolli, Osumi and Drinos are grouped in the first Cluster with a similarity of 73.64 %.

The great similarity between these four rivers reinforces the above argument for their extension in the same region (in the south of Albania). This is further reinforced when it is known that the Shkumbin and Devoll rivers are very close to each other in the study area. The second Cluster with a similarity of 85.57% includes the rivers Mat, Shushice and Drin. The Drin and Mat rivers belong to the northern region with approximate climatic features of their catchment area as well as approximate parameters of the benthic structure.

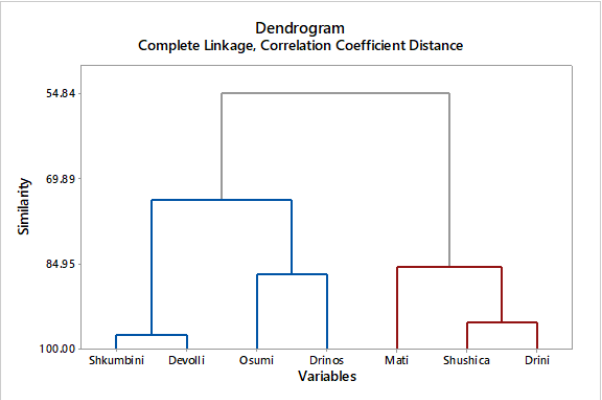

Figure 3. Dendrogram of the cluster analysis of the 7 rivers taken in the study with similarity level 70%

3.5 Factor analysis for the rivers under study

To reach more complete conclusions on taxa grouping by rivers taken in the study, the analysis of the main component of Factorial Analysis was studied. The most important components are identified and presented in the table below (Table 5).

Two main Factors represent 83.6% of the total variance are derived from the results of factorial analysis (Table 5) and are interpreted as resource categories that contribute to the distribution of taxes in the rivers under study.

As evidenced in above loadings the first factor (FA1) is the most powerful factor with representing 47.3% of the total variance and describes the high loading for the Shkumbin River (0.938), Devoll (0.898), Osum (0.889) and Drinos (0.719). The high loads of these taxa in FA1 indicate common features (they are part of the same geographical region and urban development) that favor the development of benthic organisms in these rivers. The second factor (FA2) represents 36.6% of the total variance and describes the high pollution loads for the Shushica (0.965), Drini (0.963) and Mati (0.767) rivers. The high loadings for these 3 rivers in FA2 is related to the fact that these stations are the closest in terms of river typology.

Tabela 5. Results of the factor analysis of the correlation matrix composed by the rivers under study (sorted varimax rotated factor loadings and communalities)

Variable	Factor1	Factor2	Communality
Shkumbini	**0.938**	0.000	0.881
Devolli	**0.898**	0.000	0.826
Osumi	**0.889**	0.000	0.803
Drinos	**0.719**	0.000	0.578
Shushica	0.000	**0.965**	0.945
Drini	0.000	**0.963**	0.927
Mati	0.000	**0.767**	0.892
Variance	3.3112	2.5405	5.8516
% Var	0.473	0.363	0.836

3.6 Cluster analysis of families

In the Figure 4 is representing dendrogram of cluster analysis of 28 taxons founded in 7 rivers with similarity level 65 %, with six different clusters:
- In the first Cluster with similarity of 87% are grouped the families *Ephemerellidae*, *Heptageniidae*, and *Hydroptilidae*. These families are found in almost all rivers and have low pollution tolerance values.
- Second Cluster with a similarity of 89.26% includes families: *Caenidae*, *Hydropsychidae*, and *Glossosomatidae*. All this three families have a tolerance rate around the average for organic pollution**.**
- In Cluster III with a similarity of 76.27% are grouped the families: *Oligoneuridae*, *Ephemeridae*, *Isonychidae*, *Nemuridae*, *Beraeidae*, and *Leptoceridae*. These families are located mainly in the two rivers with the largest number of taxa, Shushica (20 taxa) and Osum (17 taxa).
- In Cluster IV with 64.3% similarity are grouped the families: *Baetidae*, *Leptophlebiidae*, *Siphlonuridae*, *Rhyacophilidae*, *Sericostomatida*, *Polycentropodida*, *Brachycentridae*, and *Perlidae*. These taxa have in common their presence in the Shushice River as the river with the highest degree of biodiversity (20 taxa).
- In Cluster V with a similarity of 89.68% are grouped families *Chloroperlidae*, and *Goeridae*. These two families meet on the Drin River together and are characterized by a low number of individuals.
- In Cluster VI with a similarity of 82.12% are grouped families: *Potamanthidae*, *Leuctridae*, *Perlodidae*, *Capniidae*, *Philopotamidae*, and *Helicopsychidae*. These taxa belong to the order Plecoptera and Trichoptera and have low values of tolerance to organic pollution.

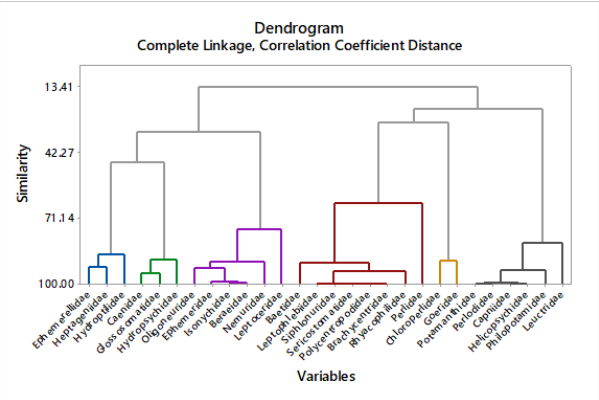

Figure 4. The dendrogram of cluster analysis of 28 taxons founded in 7 rivers with similarity level 65 %

3.7 Analysis of the similarity of families according to the first two components of the Principal Component Analysis

From an assessment of the similarity of the first two components of PCA (Figure 5) where it is presented with a cumulative 59.5% we notice that there are some groups more or less similar to the dendrogram shown in Figure 4. What is noticeable from this graphic representation is that the taxa of the EPT group form groups with representatives of the three orders. Taxa with a small number of representatives are grouped together. Taxa, which have a constant distribution in rivers as well as a relatively large number of individuals are mainly (*Baetidae*, *Hydropsychidae*, *Caenidae*, and *Ephemerellidae*).

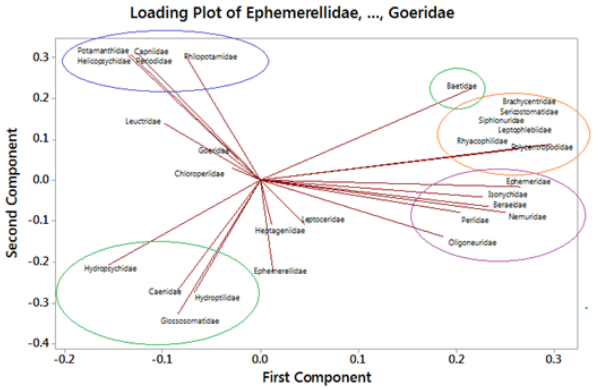

Figure. 5 Grouping of families according to the first two components of the Principal Component Analysis

4. Conclusions

The conclusions of this study conducted for the period 2007 - 2019 on macroinvertebrate families of the EPT insect group result as follows:
- In the seven river basins monitored in Albanian territory, 28 families of benthic macroinvertebrates have been identified.
- The rivers with the largest number of taxa are those of the southern region of Albania (Shushica dominates -20 taxa)
- The highest species diversity according to the Simpson Index Diversity is found in the Osum River (0.800) and the lowest in the Drin River (0.529).
- From Descriptive Statistics it is noticed that the data are deviated from a normal distribution, due to the fact that taxa have a large difference in the number of individuals.
- River pairs belonging to the southern region of Albania have higher correlation and significance ($0.60 \leq r^2 \leq 1$, $P < 0.001$).
- Taxa are grouped into six clusters based on these common criteria: approximate tolerance values, low number of individuals (dominant or random) and their presence in rivers with the highest degree of biodiversity.

5. References

[1] Stanner D., Bourdeau Ph. (Eds.). (1995). *Europe's Environment*. European Environment Agency, Copenhagen, Denmark, pp. 73-108.

[2] Kabo M. (Ed.), (1990). *Physical Geography of Albania* (Vol. I and II) (in Albanian). Academy of Sciences. Geographic Centre. Tirana, Albania, pp. 11-84.

[3] Rakaj M. (2002). *Study on the phytoplankton of Lake Shkodra (floristic composition, seasonal dynamics and nutritional level)* (in Albanian). PhD thesis, University of Tirana, Tirana, Albania.
[4] Beqiraj S. (2004). *Comparative study of taxonomic, ecological and biogeographic data for the coastal malacofauna of Albania (Vilun, Kuna, Patok, Karavsta and Narta lagoons)* (in Albanian). PhD thesis, University of Tirana, Tirana, Albania.
[5] Haxhiu I. (1982). *Determinant of amphibians of Albania* (in Albanian). University of Tirana, Tirana, Albania.
[6] Bino T. (1998). *Protection of waterfowl in Albania and in the Karavasta-Divjakë lagoon complex* (in Albanian). PhD thesis, University of Montpellier, Francë.
[7] Misja K. (2005). *Entomology of Albania* (in Albanian); SHBLU, Tirana, Albania, pp. 12-56.
[8] Paparisto A., Halimi E., Pinguli E., Keci E. (2008). *Preliminary survey of the Mayflies, Sonflies, and Caddisflies of three Albanian rivers*. AJNTS, (1), XIV, (23), pp. 49-58.
[9] Bedoya D., Novotny V., Manolakos ES. (2009). *Instream and offstream environmental conditions and stream biotic integrity: importance of scale and site similarities for learning and prediction*. Ecol. Model., 220, pp. 2393-2406.
[10] WFD. (2000). *The EU Water Framework Directive - 2000/60/EC of the European Parliament and of the Council of 23 October 2000 Establishing a Framework for Community Action in the Field of Water Policy*. Official Journal of the European Communities, L 327.
[11] USEPA. (2013). *National Rivers and Streams Assessment 2008-2009, 2013. A Collaborative Survey*. Office of Wetlands, Oceans & Watersheds and Office of Research and Development, EPA/841/D-13/001, Washington, USA.
[12] Karr J. R., and Chu E. W. (1997). *Biological monitoring and assessment: Using multimetric indexes effectively*. Office of Planning and Evaluation, U.S. Environmental Protection Agency, Report EPA/235-R97-001, Washington, USA.
[13] Plafkin J. L., Barbour M. T., Porter K. D., Gross S. K., and Hughs R. M. (1989). *Rapid bioassessment protocols for use in streams and rivers: Benthic macroinvertebrates and fish.* Assessment and Water protection Division, U.S. Environmental Protection Agency, Report EPA/440/4-89-001, Washington, USA.
[14] Schmidt-Kloiber A., and Hering D. (2015). *An online tool that unifies, standardises and codifies more than 20,000 European freshwater organisms and their ecological preferences.* Ecological Indicators, 53, pp. 271-282.
[15] Rosenberg D. M. and Resh V. H. (1993). *Freshwater bio monitoring and benthic macro invertebrates*. Chapman and Hall, New York, USA.
[16] Baptista D. F., Buss D. F., Egler M., Giovanelli A., Silveira M. P., Nessimian J. L. (2007). *A multimetric index based on benthic macroinvertebrates for evaluation of Atlantic Forest streams at Rio de Janeiro State, Brazil*. Hydrobiologia, 575. pp. 83-94.
[17] Lazaridou-Dimitriadou M. (2002). *Seasonal variation of the water quality of rivers and streams of eastern Mediterranean*. Web Ecology, 3, pp. 20-32.
[18] Chapman D. (1996). *Water quality assessments.* Chapman and Hall, New York, USA.
[19] Dudgeon D. (2008). *Tropical stream ecology.* Elsevier, Amsterdam, Netherlands.
[20] Ibrahimi H., Bilali A., Gashi A., Xerxa B., Grapi L., Musliu M. (2021). *The Impact of Inhabited Areas on the Quality of Streams and Rivers of a High Alpine Municipality in Southern Kosovo*. Inzynieria Ekologizma, 22, (3), pp. 42-50.
[21] Smiljkov S., Stamenković S. V., Prelik D., Paunović M. (2008). *Distribution of benthic macroinvertebrates in Mantovo Reservoir (South-East part of the R. Macedonia)*. Ballwois Conference proceedings, Ohrid, Macedonia, pp. 1-12.
[22] Miho A., Çullaj A., Hasko A., Lazo P., Kupe L., Bachofen R., Brandl H., Schanz F., Bara B. (2005). Environmental state of some rivers of Albanian Adriatic Lowland (in Albanian). <URL:http://www.fshn.edu.al/home/publikime-shkencore 12. Assessed 25 July 2022.
[23] Pepa B. (2014). *Determining the biological diversity of the benthic macro-invertebrates of the Shkumbin, Devoll and Osum rivers in the central part of Albania and the evaluation of these water bodies based on their use as a bioindicator* (in Albanian). PhD thesis, University of Tirana, Tirana, Albania, pp. 89-105.
[24] Pepa B., Keçi E., Paparisto A., Kiçaj H. (2018). *The Assessment Of Water Quality Of Shushica River (Vlora) Based On Preliminary Data Of Benthic Macro Invertebrates*. Supplement to "Thalassia Salentina" n° 40 periodic of the Stazione di Biologia Marina (Porto Cesareo - Italy), pp.121-128.
[25] Keçi E., Boçari A., Paparisto A., Pepa B. (2016). *Statistical Data on Macro Invertebrates' Seasonal Distribution in Erzeni River, Albania, During 2011 - 2013*. International Journal of Innovative Research in Science, Engineering and Technology, 5, 3. pp. 1-10.
[26] Paparisto A., Halimi E., Keçi E., Hamzaraj E., and Laknori O. (2009). *Using insects as Bio-indicators to asses Water Quality of Albanian Rivers*. J. Int. Environ. Appl. and Sci., 4, (3), pp. 246-252.
[27] Licaj P. (2007). *Preliminary data on the macrozoobenthos of the Vjosa River* (in Albanian), MSci. thesis, Faculty Of Natural Science, University of Tirana, Tirana, Albania.
[28] Mandaville S. M. (1999). *Bioassessment of Freshwaters Using Benthic Macroinvertebrates - A Primer*. Soil and Water Conservation Society of Metro Halifax. <URL:http://www.chebucto.ns.ca/ccn/info/Science/SWCS/ZOOBENTH/PRIMER1/e-1.pdf. Assessed 25 July 2022.
[29] Mackie G. L. (2001). *Applied Aquatic Ecosystem Concepts*. Kendall/Hunt Dubuque, USA.
[30] Pano N., Selenica A., Puka V., Hysi B. (1984). *Hydrology of Alba*nia (in Albanian). Ist. Hydromet., Ac. Dec., Tirana, Albania.
[31] Mezini B. (1985). *The Drino Valley and the surrounding mountains (physical-geographic view)* (in Albanian). The geographical study ERPS, Academy of Sciences of Albania, Tirana, Albania.
[32] University of Glasgow. (2003). *EN 13946:2003 BS 6068-5.33: Water quality - Guidance standard for the routine sampling and pretreatment of benthic diatoms from rivers*. <URL:http://www.safrass.com/partners_area/BSI%20Benthic%20diatoms.pdf. Assessed 25 July 2022.
[33] University of Glasgow. (2004). *EN 14407:2004 BS 6068-5.35: Water quality - Guidance standard for the identification, enumeration and interpretation of benthic diatom samples from running waters*.

<URL:http://www.safrass.com/partners_area/BSI%20Benthic%20diatoms%20(ID).pdf. Assessed 25 July 2022.

[34] CEN. (2014). *EN 14407: Water quality: Guidance for the identification and enumeration of benthic diatom samples from rivers and lakes*. <URL:https://standards.iteh.ai/catalog/standards/cen/8825f293-0bb5-40b2-81db-df729c7e30c0/en-14407-2014. Assessed 25 July 2022.

[35] Campaioli S., Gheti P. F., Minelli A., Ruffo S. (1994). *Manual for the recognition of Macroinvertebrates of Italian* freshwater (Vol. 1) (in Italian). Provincia Autonoma di Trento, pp. 9-14, pp. 27-190.

[36] Rundle S. D., Robertson A. L., Schmid-araya J. M. (2002). *Freshwater meiofauna. Biology and ecology*. Blackhuys Publishers, Leiden, Netherlands, pp 217-321.

[37] Bode R. W., Novak M. A., Abele L. A. (1997). *Biological stream testing*. NYS Department of Environmental Protection, Division of Water, Bureau of Monitoring and Assessment, USA.

[38] Barbour M. T., Gerritsen J., Snyder B. D., and Stribling J. B. (1999). *Rapid bioassessment protocols for use in streams and wadeable rivers*. USEPA, Washington, USA.

[39] Bailey R. C., Norris R. H., Reynoldson T. B. (2001). *Taxonomic resolution of benthic macro-invertebrate communities in bioassessments*. Journal of the North American Benthological Society, 20, (2), pp. 280-286.

[40] Herbst D. B., Silldorff E. L. (2009). *Development of a Benthic Macroinvertebrate Index of Biological Integrity (IBI) for Stream Assessments in the Eastern Sierra Nevada of California*. Sierra Nevada Aquatic Research Lab., University of California, USA.

[41] Beatty M. J., McDonald L. E., Westcott F. M., Chris J., Perrin J. C. (2006). Guidelines for sampling benthic invertebrates in British Columbia streams. Ministry of Environment Kootenay Region, Nelson, Canada.

[42] Braukmann U. (2000). *Hydrochemical and biological characteristics of regional stream types in Baden-Württemberg* (in German). Oberirdische Gewisser, Gewisserkologie, 56, pp. 1-501.

[43] Tachet H., Bournaud M., Richoux P. (1980). *Introduction to the study of freshwater macroinvertebrates* (in French). C.R.D.P., Lion, France.

[44] Magurran A. E. (2004). *Measuring biological diversity*. Blackwell Science, Oxford, UK.

[45] Krebs C. J. (1994). *Ecology: The Experimental Analysis of Distribution and Abundance* (4th Ed.). Harper Collins, New York, USA.