MULTIANNUAL VARIABILITY OF ROTIFER PRODUCTION IN SFÂNTU GHEORGHE BRANCH

FLORESCU Larisa, MOLDOVEANU Mirela

Abstract. Rotifers are minute metazoans, widespread in aquatic ecosystems involving both classical and microbial food web (microbial loop). The assessment of biomass and production are useful in order to have an overview of the whole community, in terms of its trophic and ecological significance. A detailed knowledge of a community production can highlight the key species (or groups) involved in "top-down" control of matter and energy flow in trophic networks. The studies conducted in the period 2008-2010 in Sfântu Gheorghe branch, revealed differences among the three seasons in terms of rotifer secondary production. Spring and summer showed high values of secondary production compared to the autumn season when it was installed a decline period. Bray-Curtis similarity analysis confirmed that the distribution of rotifers production was mainly determined by the seasons and to a lesser extent by hydro-geomorphological differences among areas. Based on ANOVA analysis it was evaluated the significance degree of the differences among the studied areas and seasons. The rotifers production of the three years of study ranged from 0.07 to 24.85 µg wet weight L^{-1}/24h, typical to lotic ecosystems, characterized by a poor production. The study has also demonstrated that, the secondary production was influenced by variations of specific richness (R^2 = 0.104, p = 0.000218). The B/P turnover ratio showed the time of generations ranged from 1.374-7.831 days, while the P/B ratio varied from 0.124 to 0.949. The opposite relation between these two ratios emphasizes that the high renewing time of biomass is characterized by a low rate of productivity.

Keywords: rotifers, secondary production, Sfântu Gheorghe branch.

Rezumat. Variabilitatea multianuală a producţiei rotiferelor în Braţul Sfântu Gheorghe. Rotiferele sunt organisme cu durată scurtă de viaţă, foarte larg răspândite în ecosistemele acvatice cu implicare atât în reţeaua trofică clasică cât şi în reţeaua trofică microbiană (bucla microbiană). Evaluarea biomasei şi estimarea producţiei sunt utile pentru a avea o imagine de ansamblu a întregii comunităţi în ceea ce priveşte importanţa ei trofică şi semnificaţia ecologică a acesteia. O cunoaştere detaliată a producţiei unei comunităţi poate scoate în evidenţă şi aşa numitele specii (grupe) cheie care exercită un control „*top-down*" în circuitul materiei şi energiei în reţelele trofice. Studiile desfăşurate în perioada 2008-2010 în Braţul Sfântu Gheorghe, au evidenţiat diferenţe între cele trei sezoane în ceea ce priveşte producţia secundară a rotiferelor. Primăvara şi vara au prezentat valori ridicate ale producţiei secundare comparativ cu sezonul de toamnă când s-a instalat o perioada de declin. Analiza de similaritate Bray-Curtis, a confirmat că distribuţia producţiei rotiferelor a fost în special determinată de sezoane şi într-o măsură mai mică de diferenţele hidrogeomorfologice dintre zone. Pe baza analizelor ANOVA s-a putut evalua gradele de semnificaţie a diferenţelor apărute dintre zonele studiate şi sezoniere. Producţia rotiferelor celor trei ani de studiu a variat între 0,07-24,85 µg subst. umedă L^{-1}/24h, tipic ecosistemelor lotice, care sunt caracterizate de o producţie slabă. Studiile au mai demonstrat că producţia secundară a fost influenţată de variaţiile bogăţiei specifice (R^2 = 0,104, p = 0,000218). Raportul de turnover B/P_{24h}, a arătat că în cei 3 ani de studiu timpul de reînnoire a unei generaţii a variat de la 1.374-7.831 zile în timp ce raportul P_{24h}/B 0,124-0,949 se comportă exact invers timpului de turn over, ceea ce se poate interpreta prin faptul că timpul mare de reînnoire a biomasei este caracterizat de o viteză redusă a producţiei.

Cuvinte cheie: rotifere, producţie secundară, braţul Sfântu Gheorghe.

INTRODUCTION

The zooplankton community plays an important role in aquatic ecosystems being involved in the biogeochemical cycles. Thus, as main grazers of primary production, detrito-bacterial aggregates consumers or predators and also as food for fish, the zooplankton participates in the carbon and nutrient cycles (MOLDOVEANU & IONICĂ, 2011, LEGENDRE & LE FEVRE, 1995). To estimate the amount of matter and energy that cycles in ecosystems, it is necessary to know the biological production of these communities (MACFADYEN, 1948). Knowledge of populations' productivity allows the evaluation of the energetic role and their contribution in providing nutrients to upper trophic levels. Also, the turnover can contribute to the knowledge of their ecological importance in energy flow and nutrient cycling (LOHRENZ et al., 1992). The zooplankton communities are characterized by a certain complexity, due to seasonal variations, abiotic parameters, predators or competitive pressures. As a result, the distribution of planktonic rotifers cannot be described as having a random character (RUTTNER-KOLISKO, 1974).

Sfântu Gheorghe branch is the oldest branch of the Danube River and delineates the southern side of the Danube Delta. Being difficult to navigate on this branch, between 1985 and 1990, hydrotechnical engineering was carried out. The branch suffered major changes by cutting-off six important meanders and building of straight canals. Given the new configuration, the cut-off meanders became inoperative in terms of water flow, the current very weak, so, in time, they transformed into puddles and thus will be subject to clogging (GÂŞTESCU & ŞTIUCĂ, 2006). As a result of these interventions, there have resulted several types of ecosystems that develop biocoenoses whose structure and functionality will vary: natural sectors, cut-off meanders and new build canals.

The aim of this work was to analyse the functional parameters of rotifer communities under variable pressure in time and space exercised by some natural and anthropogenic factors.

MATERIAL AND METHODS

For this study, 7 sampling stations with coastal and medial points were established: 1, 4 and 7 in natural sectors, 2, 5 in meanders and 3, 6 in canals (Fig. 1).

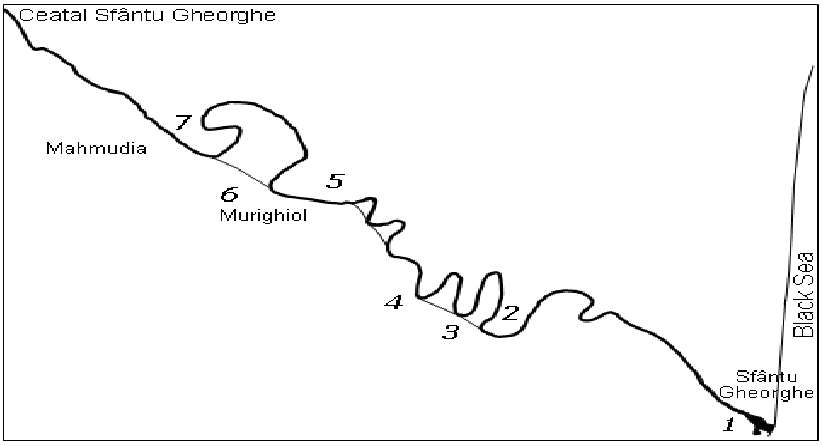


Figure 1. Sfântu Gheorghe branch with the sampling points.

The rotifers samples were taken seasonally (spring, summer and autumn), from 2008 to 2010, on whole water column with a Patalas Schindler plankton trap. The rotifers samples were collected by filtering 50 litters of water through standard plankton net (65 µm Ø mesh) and the samples were fixed with 4% formaldehyde.

For the species identification a Zeiss inverted microscope was used according to the following references: RUDESCU (1960), VOIGHT (1956). The density was calculated as individuals L^{-1} and for the biomass calculations it was used the wet weight of the organism (µg wet weight L^{-1}) according to DUMONT et al. (1975). The production per day was assessed based on the method described by Edmondson and Winberg (WINBERG, 1971; EDMONDSON & WINBERG, 1971) and expressed in µg wet weight L^{-1} /24h. For statistical analysis a free version of PAST software (HAMMER et al., 2001) and a trial version of XLSTAT were used.

RESULTS AND DISCUSSIONS

Secondary production of rotifers presented different percentages in total zooplankton production in the three studied areas. In natural sectors, the rotifers accounted for over 60% of the total production, but only in spring and autumn. In meanders, the cladocerans were those that prevailed throughout the research period while the rotifers showed low values (9-11%). In channels, the rotifers were found only in the spring season in high percentages (over 60%). The comparative analysis of the spatial and seasonal distribution of secondary rotifers production showed clear differences among seasons, the highest values being reported in spring and summer. Instead, the spatial distribution shows close values of the rotifers production (Fig. 2).

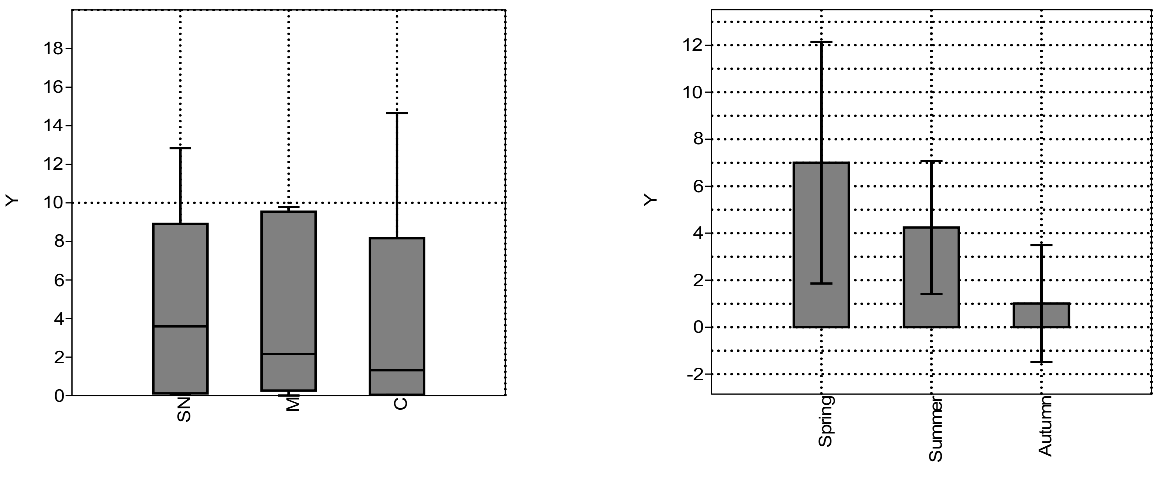


Figure 2. Box plot of the rotifers production: the middle line-median, the bottom of the boxes-25th percentile and the top -75th percentile. The T bars -the minimum or maximum values.

A detailed dendrogram based on Bray-Curtis similarity analysis (single link) of areas and seasons of the three years of study was made. The similarity clusters associated the areas and periods with high levels of similarity and thus provide the opportunity to establish a complex overview of community in terms of the approached parameter. The highest similarity degrees were found between natural areas (spring 2008) and channels (spring 2008) (79.03%), meanders (spring 2009) and channels (spring 2009) (77.65%), natural sectors (spring 2008) and natural sectors (autumn 2008) (77.32%) (Fig. 3). The Bray-Curtis dendrogram showed that the distribution of rotifers production was mainly due to the seasons and to a lesser extent to the hydro-geomorphological differences between areas.

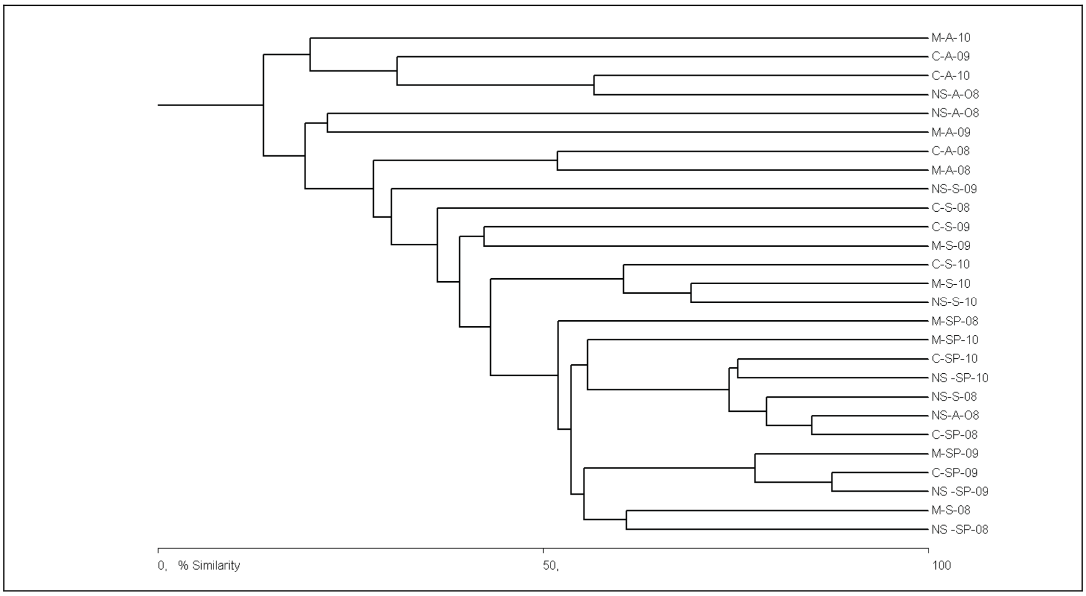


Figure 3. Bray Curtis dendrogram of the rotifers production in the studied period 2008-2010.
NS-natural sectors, M- meanders, C-canal, SP-Spring, S-Summer, A-autumn 08-2008, 09-2009, 10-2010.

Based on ANOVA (single factor) analysis, the Bray Curtis dendrogram results were statistically confirmed. There was found a significant difference ($p = 0.05$, $F = 2.981$) among the three sampling seasons. Applying ANOVA to evaluate differences among areas showed no significant differences.

The rotifers production ranged from 0.07 to 24.85 μg wet weigh L^{-1}/24h. In the histogram of the rotifers production the most frequent were the small values, under 6.91 μg wet weigh L^{-1}/24h (Fig. 4). In lotic ecosystems, due to unfavourable conditions, the rotifers are found in low densities resulting a production much lower than in lentic ecosystems (ODUM, 1971; LAIR, 2005).

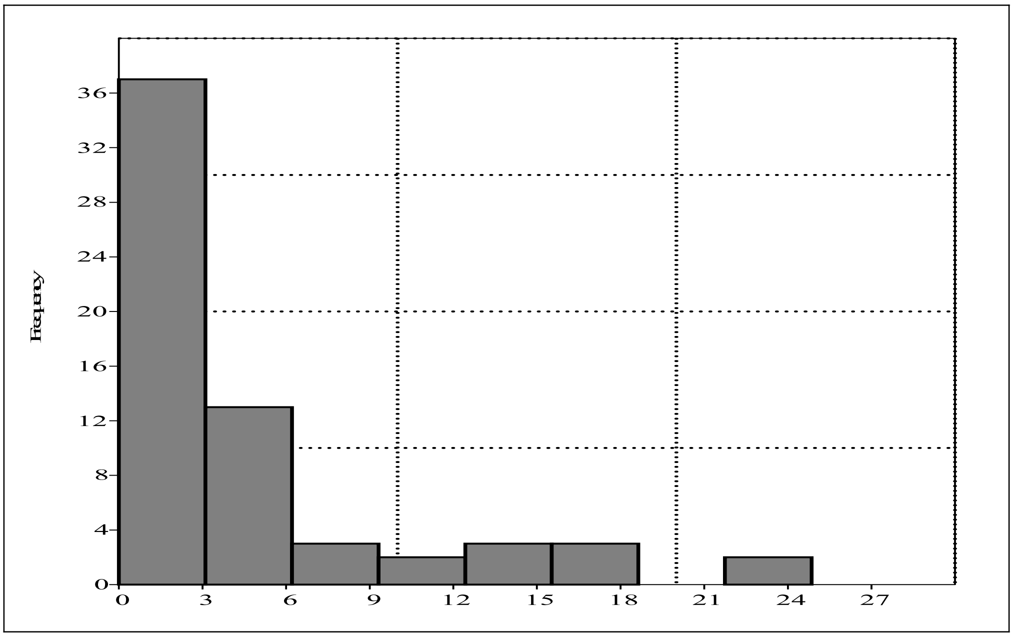


Figure 4. Histogram of the rotifers seasonal production.

The turnover of B/P (biomass/production) based on annual average values shows that, in the three years of study, the generation time ranged from 1.374 to 7.831 days (Table 1). 2008 is characterized by close values of B/P in the three sampling periods, which are no longer found in the other two years. The highest values of turn-over time were found in spring 2009 (7.831 days) and autumn (5.983). On the other hand, summer is the most active period in the rotifers productivity, defined by the shortest generation time throughout entire research period (1.374-2.491 days).

Table 1. Dynamics of annual mean of turnover time (B/P) and turnover rate (P/B) of rotifers community in Sfântu Gheorghe branch.

	Spring			**Summer**			**Autumn**		
	2008	**2009**	**2010**	**2008**	**2009**	**2010**	**2008**	**2009**	**2010**
B/P	3.93	7.831	2.597	1.374	1.195	2.491	3.423	5.983	5.815
P/B	0.261	0.129	0.401	0.742	0.949	0.124	0.631	0.192	0.249

The annual averages of turnover rate (P/B) ranged between 0.124 and 0.949 and behaved opposite then the turnover time, which can be interpreted that the renewing time of biomass is described by a low rate of production.

The productivity in an ecosystem is strongly related to biomass and taxonomical composition of the communities. Rotifers represent a major component in zooplankton production by a quick generation time (B/P) and also high turnover rate (P/B) (PARK & MARSHALL, 2000). The analysis of Person correlation emphasised a significant relationship between biomass and rotifer productivity ($R = 0.29$, $R^2 = 0.164$, $p = 0.001$). The changes of the abundance and biomass are influenced by productivity and mortality dynamics (KIORBOE & NIELSEN, 1994). Also, a high significant connection ($R = 0.40$, $R^2 = 0.164$, $p = 0.0001$) between production and turnover rate (P/B) was found. In Sfântu Gheorghe branch, during the survey, the daily P/B weight growth rate and production presented the same trend (Fig. 5).

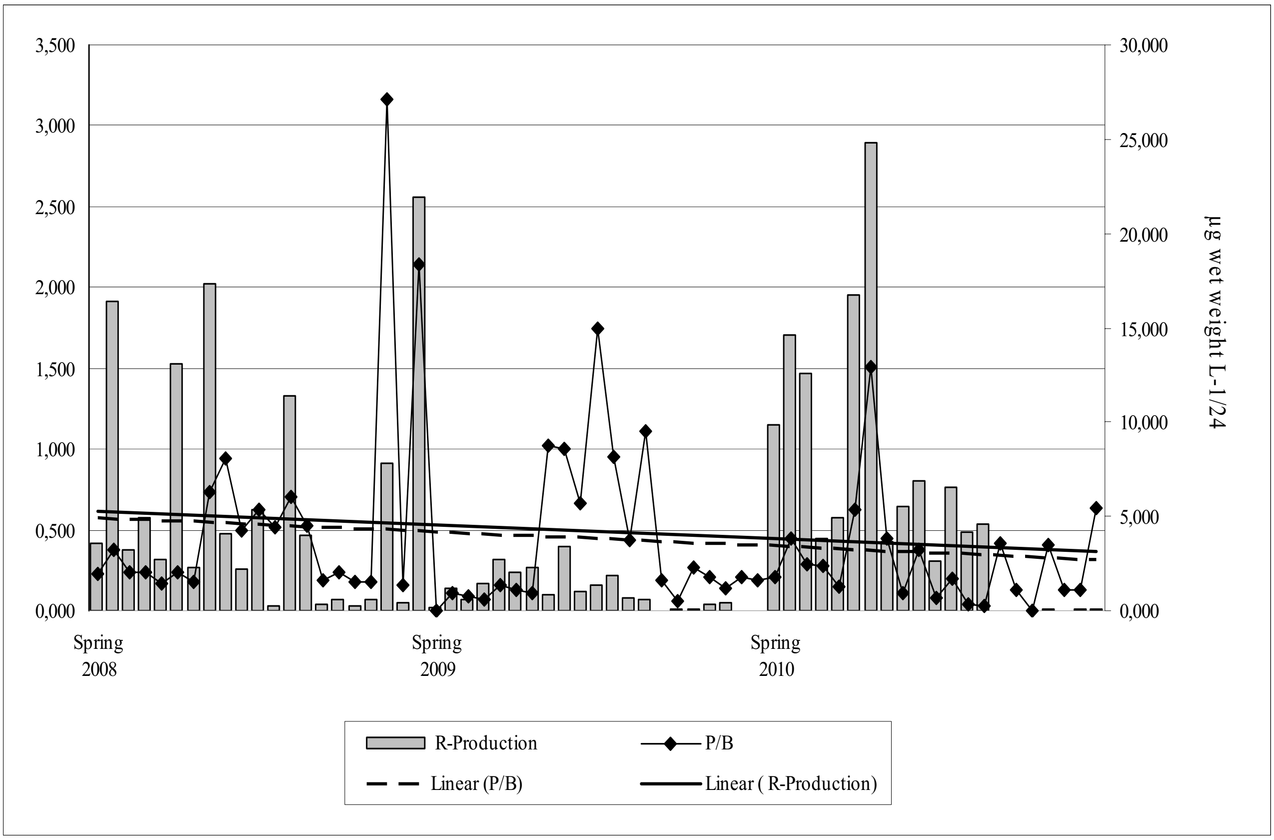


Figure 5. Dynamics of rotifers production and P/B ratio during the survey.

Previous research mentions that the deltaic zooplankton is characterized by high values of daily turnover rate ($P_{24\ h}$/B) (0.113 to 0.220), a situation favoured by the predominance of small organisms, with short generation times. The analysis of systematic groups and developmental stages reveals that the rotifers present short periods of biomass recycling (2.85 days - 3.86 days). At the other extreme, the juvenile forms of copepods have the longest recycling biomass time (20.01 to 39.92 days). The zooplankton found in the Danube Delta streams and channels had a turnover rate (P/B) around 0.13 and the turnover time of 8.39 days. The changing of the values of daily turnover rate and turnover time is achieved by appropriate changes in the taxonomic spectrum of zooplankton, to form an adequate trophic structure for the new features of planktonic primary producers (ZINEVICI & PARPALĂ, 2007).

Numerous studies have demonstrated a relationship between biodiversity and community functions leading to the conclusion that the species presents an important ecological role both by their number (species richness) and dominance (abundance). The functional diversity is a measure of diversity based on functional traits of species in a community (BARNET et al., 2007). Functional characteristics of a species are those traits that define it in terms of its ecological roles, how the environment interacts with other species (for example, the body size, their growth rates, metabolism, sensitivity to environmental conditions, their ability to move) (TELESH, 2001; OBERTEGGER & MANCA, 2011).

From this point of view, it could be appreciated that in Sfântu Gheorghe branch, both species richness and dominant species had an important contribution to rotifers production. In order to confirm this assumption, a linear regression was performed. A high significance level of species richness in determining the secondary production (R^2 = 0.104, p = 0.000218, significance ****) was observed.

The taxonomic analysis has revealed a taxonomic profile of the branch. The rotifer communities in Sfântu Gheorghe branch tend to be composed by closely related species, most of them, loricate. During the study period, 83 species belonging to 9 families were recorded (Table 2). Among the common species encountered, we mention *Brachionus calyciflorus* (PALLAS 1766), *Asplanchna priodonta* (GOSSE 1850), *Synchaeta oblonga* (EHRENBERG 1832).

Table 2. List of planktonic rotifer families and number of species recorded in Sfântu Gheorghe branch.

Families	Natural sectors	Meanders	Canals
Fam. Gastropodidae	1	1	1
Fam. Asplanchnidae	1	2	1
Fam. Brachionidae	29	32	24
Fam. Notommatidae	3	2	1
Fam. Testudinellidae	5	6	4
Fam. Habrotrochidae	1	2	4
Fam. Lecanidae	2	2	0
Fam. Synchaetidae	7	9	7
Fam. Trichocercidae	6	7	3

Brachionidae had the largest contribution in production, as they dominated both the number of species and high densities. An important contribution to rotifers production was also registered by Asplanchnide; even if there were only two species, they compensated by higher density and biomass of individuals. The dominant species in terms of biomass are also known as cosmopolitan species (Fig. 6).

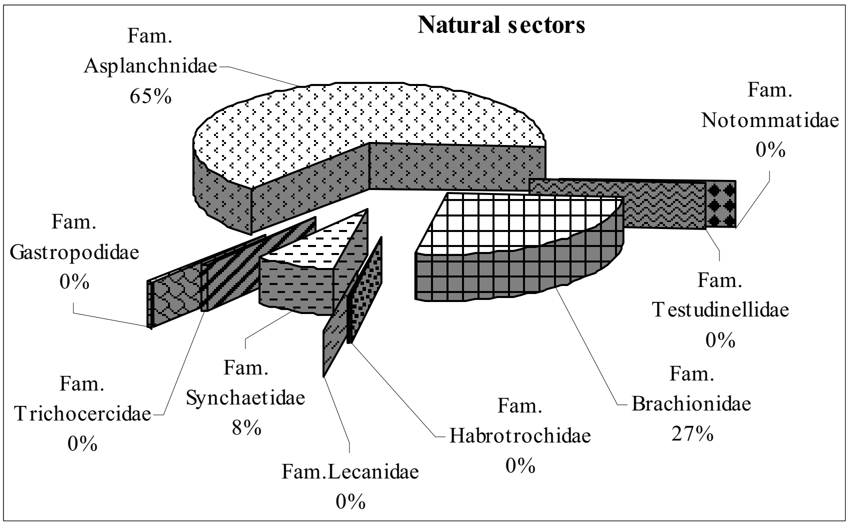
In order to identify the distribution tendency of rotifer production data, a Principal Component Analysis (PCA) was performed. The first result is a correlation matrix of rotifers production of the three areas. Notice the similarity degree of meanders and natural sectors (0.8), at a level of significance of 0.05 (two-tailed test) (Table 4).

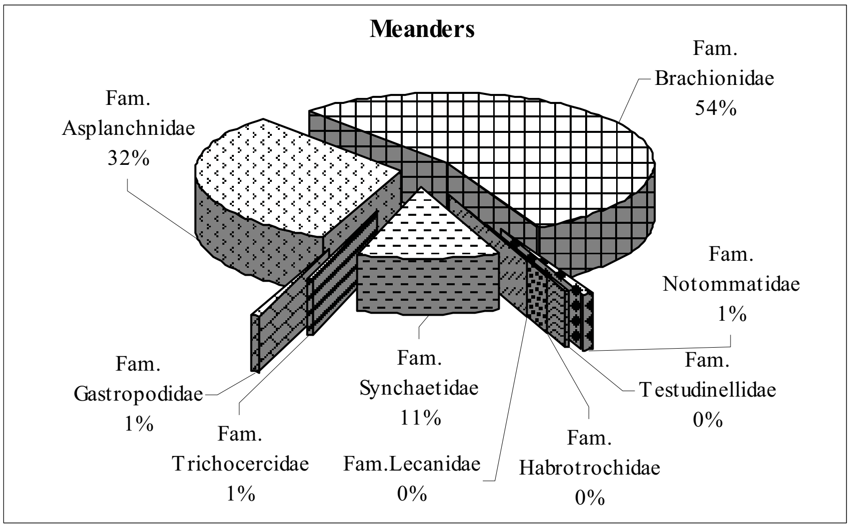
The goal of the Principal Component Analysis (PCA) was to look at the data on a two-dimensional map and to identify trends. We can see that *Anuaeropsis fissa* and *Polyarthra remata* share common characteristics and are linked with the second axis and to canal production. These species have not a contribution to the meanders and natural sectors. In contrast, all other species joins the first axis and represent an assemblage in terms of meanders and natural sectors production. The first and second axis explain 94.48% of the rotifer production variability in studied zones (Fig. 7).

Table 4. Correlation matrix of the rotifers production in the three studied areas.

	Natural sectors	Meanders	Canals
Natural sectors	1	**0.833**	-0.009
Meanders	**0.833**	1	0.034
Canals	-0.009	0.034	1

Legend: in bold, significant values (except diagonal) at the level of significance alpha=0,050 (two-tailed test).





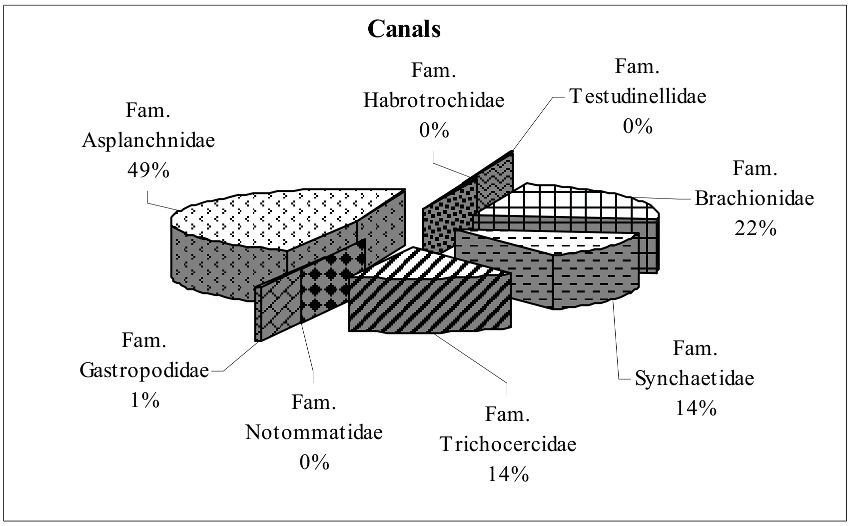


Figure 6. The contribution of rotifer families to secondary production in studied areas in Sfântu Gheorghe branch.

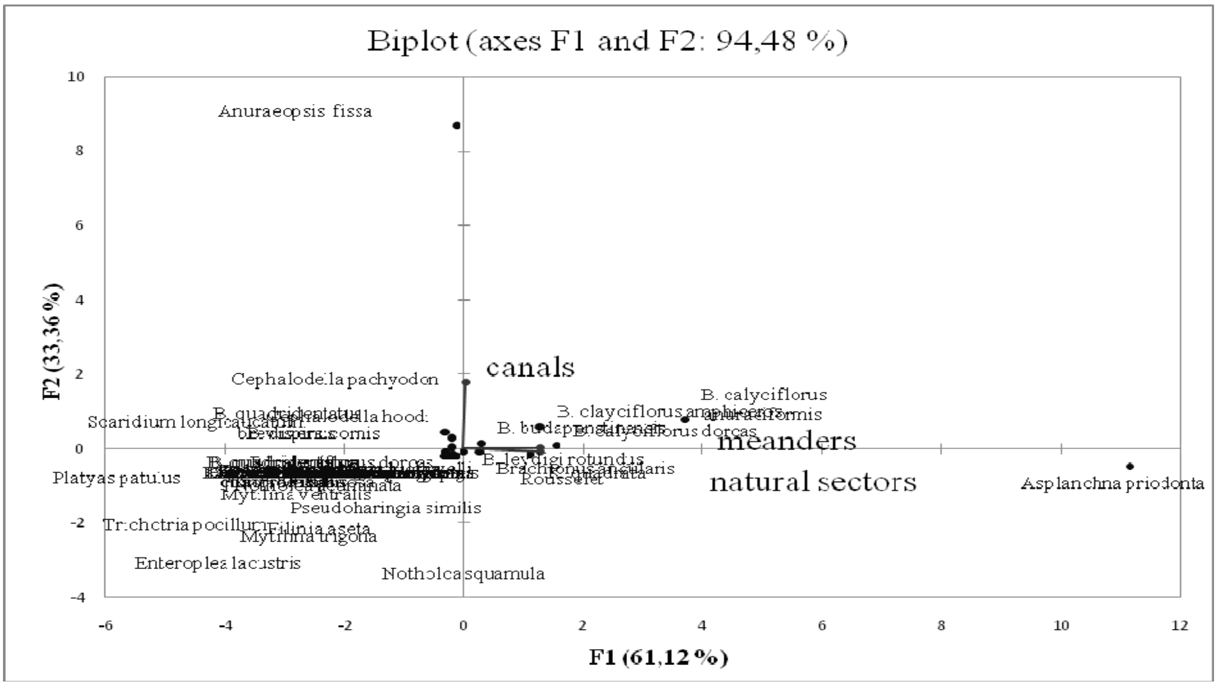


Figure 7. PCA biplot for species distribution in the three studied areas, based on their annual production averages.

CONCLUSIONS

During the study, 9 rotifer families were determined, whose production ranged from 0.07 to 24.85 µg wet weigh L^{-1}/24h. Most species have low values of production, typical to lotic ecosystems (under 6.91 µg L^{-1}/24h).

A comparison among the three seasons of study highlights that the highest values of production were found in spring and summer while the spatial review shows close values.

The highest similarities based on Bray Curtis analysis were described between natural areas (spring 2008) and channels (spring 2008) (79.03%), meanders (spring 2009) and canals (spring 2009) (77.65%), natural sectors (spring 2008) and natural sectors (autumn 2008) (77.32%).

The ANOVA analysis of variance showed a statistical difference among the three sampling seasons while in the study areas there were not exibit significant differences.

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