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On the Communities of Freshwater Gastropods on Aquatic Macrophytes in Some Water Basins of Southern Bulgaria

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Abstract. The research was conducted through the period 2008 - 2009 in the Upper Thracian Lowland: Maritsa River in the city of Plovdiv, flood area near the bridge at UFT; Eastern Rhodopes: Varbitsa River at around 3 km south of the town of Kardzhali; Perperek River, within the village of Perperk; a pond in the village of Chernoochene. The material was collected from total of 3427 g herbage biomass from 7 plant species. On the aquatic macrophytes we generally found approximately the same diversity of species of freshwater gastropods during the cold and during the warm seasons. During the warm period we found a total of 6 species, and during the cold - 7 species. Most species we found on *C. demersum*, and *E. canadensis*. Overall for the studied water basins and seasons, the species *R. auricularia, Ph. acuta* and *G. albus* were most numerous and prefer to live on *C. demersum*. We calculated a narrow ecological niche of the species in most cases, where slightly wider ecological niches were registered for *R. auricularia* and *G. albus*. Largest diversity of snail communities we found on *C. demersum* and *E. canadensis*. The value of the diversity index was very low for the other species of macrophytes. We calculated low values of Sörensen's index between most of the freshwater macrophytes in relation to communities of gastropods. High similarity between the communities we indicated for *C. demersum* and *P. pussilus*, and *C. muricatum*, and *Lemna* sp., and very high between *P. pussilus*, and *Lemna* sp. We found an aggregated distribution on the macrophytes of the following species of gastropods: *R. auricularia, Ph. acuta, P. corneus, P. planorbis, G. albus* and occasional one for *V. piscinalis, A. lacustris,* and *L. stagnalis*.

Key words: snails, Pulmonata, Prosobranchia, habitats, South Bulgaria.

Introduction

In Bulgaria there is lack of detailed investigations regarding the ecology of the freshwater molluscs, while in the same time the foreign literature is quite rich on such kind of researches. Some of the most significant aspects of the ecology of freshwater gastropods are their relations with the aquatic plants and the biotope as a basin.

Studies on the relationship between freshwater gastropods and aquatic plants show several major features: freshwater macrophytes as a food for the gastropods (LACH *et al*., 2000), as a substratum on which the algae are growing, serving a food for the gastropods (HIGGINS & HANN, 1995; SEMENCHENKO *et al*., 2008) and as a micro habitats for the gastropods (BRÖNMARK, 1985).

The aim of our study was to examine the role of the aquatic vegetation as a habitat of the freshwater snails in several basins of south Bulgaria.

Material and methods

The research was conducted through the period 2008 - 2009 in the Upper Thracian Lowland: Maritsa River in the city of Plovdiv, flood area near the bridge at UFT, N42˚09` E24˚43`; Eastern Rhodopes: Varbitsa River at around 3 km south of the town of Kardzhali, N41˚34` E25˚23`; Perperek River, within the village of Perperk, N41˚45` E25˚21`; a pond in the village of Chernoochene, N41˚40` E25˚32`.

The field trips were made from 19.02.2009 until 12.11.2009. The molluscs were collected by hand or with a sack, along with the aquatic vegetation and were transported to the laboratory. For determination of the plants species the guide of DELIPAVLOV & CHESHMEDJIEV (2003) was used.

The material was collected from total of 3427 g herbage biomass from the following plant species: *Ceratophyllum demersum* L. – Rigid Hornwort (1123 g), *Ceratophyllum muricatum* Cham. (100 g), *Elodea canadensis* Michx. – Pondweed (809 g),), *Lemna* sp. – Duckweed (110 g), *Myriophyllum spicatum* L. - Water Milfoil (350 g), *Potamogeton natans* L. – Floating Pondweed (685 g), *Potamogeton pussilus* L. – Small Pondweed (250 g).

The material was separated from the plants by hand and by running water. The shells of the molluscs were measured and determined by GLÖER & MEIER-BROOK (2003) and a reference collection.

Data obtained was mathematically processed with the program BioDiversity Professional (McAleece *et al.*, 1997). Qualitative and quantitative analyzes were performed according to the different seasons (warm season - spring and summer, cold season - autumn and winter), habitat and collecting areas. The following indices were calculated: the index of quantitative diversity of Simpson, quantitative similarity of Sörensen, breadth of ecological niche of Levin, and preference index of Ivlev. Cluster analysis of Brey-Curtis was also used to investigate the relations between snail communities.

The reciprocal value of the Simpson's Diversity index is calculated by the following formula (MAGGURAN, 1988):

$$S = \frac{1}{\sum p_i^2},$$

where S – Simpson's Diversity index; p_i – proportion of species i.

The Sørensen similarity index was calculated by the following formula (SØRENSEN, 1948):

$$QS = \frac{2C}{A+B},$$

where A and B are the number of species in samples A and B, respectively, and C is the number of species shared by the two samples.

The ecological niche breadth was calculated using Levin's formula (HURLBERT, 1978):

$$B = \frac{1}{R\sum P_i^2},$$

where B – ecological niche breadth; R – number of species in the complex; P_i – proportion of species i.

The cluster analysis was performed using the Bray-Curtis index and group average linking. Bray-Curtis index is calculated by the following formula (BRAY & CURTIS, 1957):

$$BC_{ij} = \frac{S_i - S_j + 2C_{ij}}{S_i + S_j},$$

where C_{ij} is the sum of minimum abundances of the various species (abundance at the site where the species is the rarest). S_i and S_j are the total number of specimens captured at both sites.

We used Ivlev's electivity index (JACOBS, 1974) to indicate habitat selection. Electivity varies from -1.0 to +1.0, where -1.0 indicates avoidance and +1.0 preferences for a particular habitat. The formula is:

$$Ei = \frac{r_i - p_i}{r_i - p_i - 2r_i p_i},$$

where r_i is the proportion of snails observed over habitat i and p_i is the proportion of habitat i in the study area.

Results and Discussion

Qualitative analysis - composition of freshwater gastropods species

Communities of plants, basins and seasons, in which have not been found any freshwater gastropods were not included in the statistical analysis. During the study these were: 02.07.2009, 210 g P. *natans* and 455 g *C. demersum* from Perperek River, 05.09.2009, 100 g *M. spicatum* and 245 g *C. demersum*, 07.11.2009, 76 g *M. spicatum* of the pond in the village of Chernoochene and 91 g *P. natans* from Perperek River.

Overall, we found approximately the same diversity of species of freshwater gastropods during the cold and the warm seasons. During the warm period we registered total of 6 species (*Physella acuta, Planorbarius corneus, Radix auricularia, Planorbis planorbis, Acroloxus lacustris, Gyraulus albus*), and in the cold one - 7 species (*Lymnaea stagnalis, Physella acuta, Planorbarius corneus, Radix auricularia, Planorbis planorbis, Valvata piscinalis, Gyraulus albus*) on various species of aquatic plants.

Regarding the water basins, most species were found in the flood area of Maritsa River (6 species), followed by Varbitsa River (4 species), and Perperek River (2 species) and poorest was the pond at Chernoochene Village (1 species).

Most species were found on *C. demersum* (6 species: *L. stagnalis*, *Ph. acuta*, *P. corneus*, *R. auricularia*, *P. planorbis*, *A. lacustris*, *G. albus*), followed by *E. canadensis* (5 species: *Ph. acuta, P. corneus, R. auricularia, P. planorbis, V. piscinalis*). On *P. natans* and *P. pusillus* the same number of species was registered (2 species) as on *P. natans* were found *R. auricularia* and *A. lacustris*, and on *P. pusillus* - *R. auricularia* and *G. albus*. On the other species of aquatic vegetation one species on each was found, as follows: on *C. muricatum* - *G. albus*, *Lemna* sp. - *G. albus*, and *M. spicatum* - *R. auricularia*.

In Varbitsa River due to lack of study during the cold seasons we present only the species diversity during the warm period (4 species: *Ph. acuta*, *R. auricularia*, *A. lacustris*, *G. albus*). The species *Ph. acuta* was collected from *C. demersum* and *P. natans*, as well as *R. auricularia* and *A. lacustris* from the same plant species. Only on *C. demersum* we found *G. albus*. In the pond in the village of Chernoochene we found only *R. auricularia* on *C. demersum* and *M. spicatum* during the warm season and no any gastropods were collected in the cold one because the pond was drained by by the owners. In Perperek River we found the species *G. albus* and *R. auricularia* during the warm season and only *G. albus* in the cold season. *G. albus* was collected from *C. demersum* and *Lemna* sp. during the cold season. It was found together with *R. auricularia* during the warm season on *P. pusillus* and alone on *C. muricatum*. In the flood part of Maritza in Plovdiv 5 species were found during the cold season (*L. stagnalis, Ph. acuta, P. corneus, R. auricularia, V. piscinalis*) and 4 during the warm (*P. corneus, Ph. acuta, R. auricularia, P. planorbis*). During the warm season from *E. canadensis* the species *P. corneus, Ph. acuta, R. auricularia, P. planorbis* were collected and the same species were collected from *C. demersum*. During the cold season from *E. canadensis* were found *Ph. acuta, P. corneus, R. auricularia, V. piscinalis*, and on *C. demersum* the species *L. stagnalis*, *Ph. acuta, P. corneus, R. auricularia* have been identified.

Quantity and ecological niche breadth of the gastropods on the freshwater macrophytes.

Overall for seasons and collection sites by single or small-numbered specimens were represented the species *V. piscinalis* (N = 1), *A. lacustris* (N = 4), *L. stagnalis* (N = 1), *P. corneus* (N = 7) and *P. planorbis* (N = 8). Two of the numerous species included in the statistical analysis were on *C. demersum*: *R. auricularia* - 52.54% of all identified individuals and *Ph. acuta* - 86.76%. The first species was found in large numbers also on *P. natans* (42.39%), and the second with much lower numbers on *E. canadensis* (13.24%). *G. albus* had a higher percentage on *P. pussilus* (36.46%) compared with *Ceratophyllum* (31.25%). In summary we found a narrow ecological niche (index of Levin) of all the species close to one, in most cases with value lower than 1.5. Slightly wider ecological niches were calculated for *R. auricularia* and *G. albus* with values of 2.19 and 3.43, respectively (Table 1).

Table 1. Number of gastropods registered and their ecological niche breadths on the freshwater macrophytes collected.

	V. piscinalis	*A. lacustris*	*R. auricularia*	*L. stagnalis*	*Ph. acuta*	*P. corneus*	*P. planorbis*	*G. albus*
C. demersum	0	3	176	1	177	6	7	30
C. muricatum	0	0	0	0	0	0	0	9
E. canadensis	1	0	11	0	27	1	1	0
M. spicatum	0	0	3	0	0	0	0	0
P. natans	0	1	142	0	0	0	0	0
P. pussilus	0	0	3	0	0	0	0	35
Lemna sp.	0	0	0	0	0	0	0	22
Total	**1**	**4**	**335**	**1**	**204**	**7**	**8**	**96**
Levin	**1,00**	**1,60**	**2,19**	**1,00**	**1,30**	**1,32**	**1,28**	**3,43**

Table 2. Quantitative index of Simpson's diversity, calculated according to seasons and macrophytes.

Species	***C. demersum***	***C. muricatum***	***E. canadensis***	***M. spicatum***	***P. natans***	***P. pussilus***	***Lemna sp.***	**Total**
Cold season								
Total 6 species								
Valvata piscinalis	0	0	1	0	0	0	0	1
Radix auricularia	19	0	9	0	0	0	0	28
Lymnaea stagnalis	1	0	0	0	0	0	0	1
Physella acuta	24	0	15	0	0	0	0	39
Planorbarius corneus	1	0	1	0	0	0	0	2
Gyraulus albus	0	0	0	0	0	0	22	22
Total	45	0	26	0	0	0	22	93
Simpson div. index	2.21	0	2.3	0	0	0	1	3.16
Warm season								
Total species 6								
Acroloxus lacustris	3	0	0	0	1	0	0	4
Radix auricularia	157	0	2	3	142	3	0	307
Physella acuta	153	0	12	0	0	0	0	165
Planorbarius corneus	5	0	0	0	0	0	0	5
Planorbis planorbis	7	0	1	0	0	0	0	8
Gyraulus albus	30	9	0	0	0	35	0	74
Total	355	9	15	3	143	38	0	563
Simpson div. index	2.58	1	1.57	1	1.01	1.16	0	2.50
As a whole								
Total species 8								
Valvata piscinalis	0	0	1	0	0	0	0	1
Acroloxus lacustris	3	0	0	0	1	0	0	4
Radix auricularia	176	0	11	3	142	3	0	335
Lymnaea stagnalis	1	0	0	0	0	0	0	1
Physella acuta	177	0	27	0	0	0	0	204
Planorbarius corneus	6	0	1	0	0	0	0	7
Planorbis planorbis	7	0	1	0	0	0	0	8
Gyraulus albus	30	9	0	0	0	35	22	96
Total	400	9	41	3	143	38	22	656
Simpson div. index	2.54	1	2.02	1	1.01	1.18	1	2.65

Index of variety among seasons and macrophytes.

We found similar values of the Simpson's index for the two periods of the year, from which slightly higher diversity was calculated during the cold season than the warm one (values of 3.16 and 2.50).

The largest diversity we found on the species *C. demersum* (Simpson index = 2.54) and *E. canadensis* (S = 2.02). The index value

of diversity was very low for other species of macrophytes and was close to one (Table 2).

Quantitative index of faunistic similarity between communities on different types of macrophytes.

We calculated the low values of Sörensen index between most freshwater macrophytes in relation to gastropods communities (values lower than 25%). High similarity between the communities we found for *C. demersum* and *P. pussilus* (52.67%), and *C. muricatum*, and *Lemna* sp. (58.06%), and very high between *P. pussilus* and *Lemna* sp. (73.33%) (Table 3). In cluster analysis of communities as a whole we found the formation of two large cluster groups including three taxa of plants: *Lemna* sp.; *P. pussilus* and *C. muricatum*, and *C. demersum*, *E. canadensis* and *P. natans*. The community on *M. spicatum* was specific and was separated from the two other cluster groups (Fig. 1).

Table 3. Quantitative index of faunistic similarity (index of Sörensen) between communities of gastropods on different species of macrophytes represented as a percentage.

	C. demersum	*C. muricatum*	*E. canadensis*	*M. spicatum*	*P. natans*	*P. pussilus*	*Lemna sp.*
C. demersum	*	4.40	18.14	1.49	52.67	15.07	10.43
C. muricatum	*	*	0.00	0.00	0.00	38.30	58.06
E. canadensis	*	*	*	13.64	11.96	7.59	0.00
M. spicatum	*	*	*	*	4.11	14.63	0.00
P. natans	*	*	*	*	*	3.31	0.00
P. pussilus	*	*	*	*	*	*	73.33
Lemna sp.	*	*	*	*	*	*	*

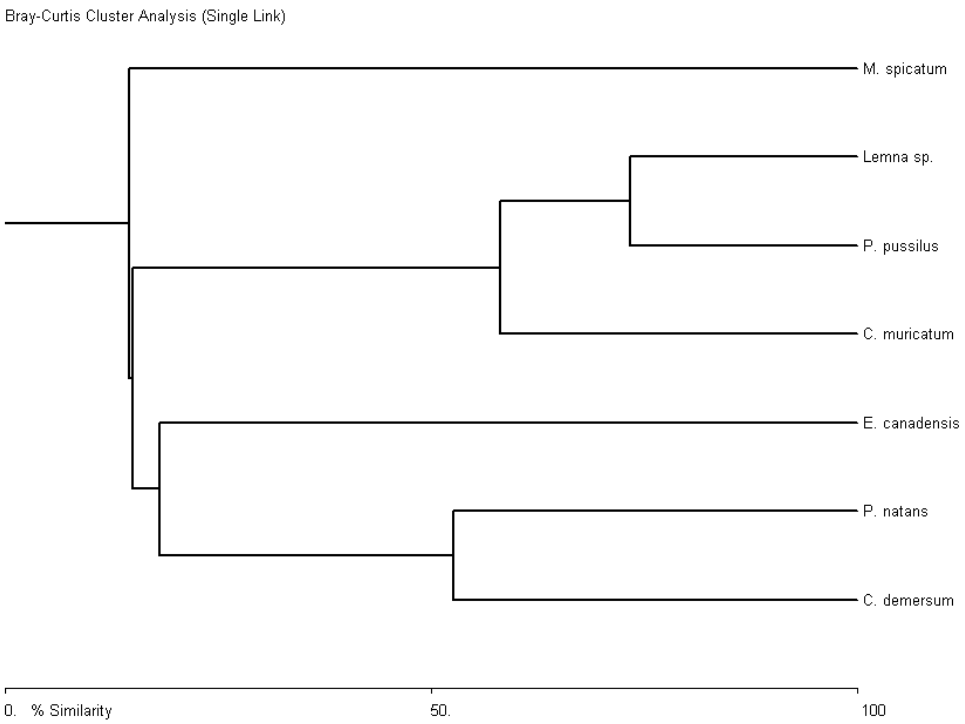

Fig. 1. Cluster analysis of gastropod communities on different species of aquatic macrophytes.

Distribution of the species of gastropods on the species of freshwater macrophytes

We determined an aggregated distribution on the macrophytes of the following gastropods: *R. auricularia, Ph. acuta, P. corneus, P. planorbis, G. albus* and occasional one for *V. piscinalis, A. lacustris*, and *L. stagnalis*.

Conclusion

On the aquatic macrophytes we found approximately the same diversity of species of freshwater gastropods during the cold and during the warm seasons. During the warm period we found a total of 6 species (*Ph. acuta, P. corneus, R. auricularia, P. planorbis, A. lacustris, G. albus*), and during the cold - 7 species (*L. stagnalis, Ph. Acuta, P. corneus , R. auricularia, P. planorbis, V. piscinalis, G. albus*) on various species of aquatic macrophites.

Most species we found on *C. demersum* (6 species: *L. stagnalis, Ph. acuta, P. corneus, R. auricularia, P. planorbis, A. lacustris, G. albus*), followed by *E. canadensis* (5 species: *Ph. acuta, P. corneus, R. auricularia, P. planorbis, V. piscinalis*).

Overall for the studied water basins and seasons, the species *R. auricularia, Ph. acuta* and *G. albus* were most numerous and prefer to live on *C. demersum*.

We calculated a narrow ecological niche (index of Levin) of the species in most cases with a value lower than 1.5. Slightly wider ecological niches were registered for *R. auricularia* and *G. albus*, respectively, with values of 2.19 and 3.43.

Largest diversity of snail communities we found on *C. demersum* (S = 2.54) and *E. canadensis* (S = 2.02). The value of the diversity index was very low for the other species of macrophytes.

We calculated low values of Sörensen's index between most of the freshwater macrophytes in relation to communities of gastropods (values lower than 25%). High similarity between the communities we indicated for *C. demersum* and *P. pussilus* (52.67%), and *C. muricatum*, and *Lemna* sp. (58.06%), and very high between *P. pussilus*, and *Lemna* sp. (73.33%).

We found an aggregated distribution on the macrophytes of the following species of gastropods: *R. auricularia, Ph. acuta, P. corneus, P. planorbis, G. albus* and occasional one for *V. piscinalis, A. lacustris*, and *L. stagnalis*.

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