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AQUATIC HETEROPTERA OF STREAMS AND SPRINGS OF UKRAINIAN STEPPE ZONE: SPECIES COMPOSITION, SEASONAL CHANGES IN ABUNDANCE AND BIOMASS

M.A. GRANDOVA
I.I. Schmalhausen Institute of Zoology,
National Academy of Science, Ukraine.
E-mail: nepa@mail.ru

There were found 22 species of water bugs from 8 families in springs and creeks of south Ukraine. *Velia saulii* was found in the steppe zone of Ukraine for the first time. The most rich in species composition were limnocrenes (15), less species were found in streams (11) and rheocrenes (9), helocrenes were populated very poorly (1).Species composition of rheocrenes remains almost unchanged during the year. In limnocrenes quantitative characteristics depend on the area and time of existence, the species composition of intermittent limnocrenes in spring and autumn can be markedly different. Seasonal changes in species composition, abundance and biomass in streams are similar to those for small intermittent rivers.

Key words: aquatic Heteroptera, Gerromorpha, Nepomorpha, spring, stream, steppe zone, Ukraine.

Водные полужесткокрылые ручьев и родников степной зоны Украины: видовой состав, сезонные изменения численности и биомассы.
Грандова М.А.
В родниках и ручьях юга Украины было найдено 22 вида водных клопов из 8 семейств. Впервые в степной зоне Украины обнаружена *Velia saulii.* Наиболее богатый видовой состав в лимнокренах (15), несколько меньше найдено в ручьях (11) и реокренах (9), беднее всего заселены гелокрены (1). Видовой состав реокренов остается практически неизменным в течение года. В лимнокренах количественные характеристики зависят от его площади и времени существования, видовой состав пересыхающих лимнокренов весной и осенью может заметно отличаться. Сезонные изменения видового состава, численности и биомассы в ручьях сходны с таковыми для малых пересыхающих рек

Ключевые слова: водные полужесткокрылые, Gerromorpha, Nepomorpha, родник, ручей, степная зона, Украина

Водні напівжорскокрилі струмків і джерел степової зони України: видовий склад, сезонні зміни чисельності та біомаси.
Грандова М.А.
В джерелах і струмках півдня України було знайдено 22 види водних клопів з 8 родин. Вперше в степовій зоні України виявлена *Velia saulii.* Найбільш багатий видовий склад в лімнокренах (15), дещо менше знайдено в струмках (11) і реокренах (9), найбідніше заселені гелокрени (1). Видовий склад реокренов залишається практично незмінним протягом року. У лімнокренах кількісні характеристики залежать від його площі і часу існування, видовий склад пересихаючих лімнокренов навесні і восени може помітно відрізнятися. Сезонні зміни видового складу, чисельності та біомаси в струмках подібні з такими для малих пересихаючих річок.

Ключові слова: водні напівжорсткокрилі, Gerromorpha, Nepomorpha, джерело, струмок, степова зона, Україна

Heteroptera are one of the important components of aquatic biocenosis. However, special studies of seasonal changes in species composition and biotopic distribution of water bugs in the ukrainian steppe zone were not carried previously. There was only some general faunal and environmental information in the works of V.N. Gramma and A.G. Shatrovskiy (Gramma, 1987, Gramma, Shatrovskij, 1992) relating to the Black Sea Reserve. In previous work, we have examined changes in abundance, biomass and species composition of water bugs in small (Grandova, 2013, Grandova, Puchkov, 2013) and large rivers (Grandova, in press) and associated water bodies. In this paper we considered a range of aquatic Heteroptera of the streams and springs in the ukrainian steppe zone. There are two infraorders, Gerromorpha and Nepomorpha. Depending on the type of water body one of them may dominate. The factor of decisive importance is the flow rate forming the bottom and aquatic vegetation patterns.

Springs and creeks are among the most numerous water bodies in the steppe zone of Ukraine. Their role is particularly important away from large and small rivers, where the springs are refugia for many aquatic organisms (Dyadichko, 2009). Creeks and springs differ both in ecological characteristics (salinity, type of water emergence, rate of shading and overgrowing of vegetation and so on), and the species composition of organisms living in them, including water bugs.

Materials and methods. Our study was based on the own material from the author's expeditions (2007-2013) collected at Odessa, Mykolaiv, Cherson and Donetsk province, complemented by collections of V. Dyadichko, A. Martynov and M. Son.

In the western (Right-Bank Ukraine) part of the region the springs and wells are more frequent than streams, streams are more numerous in the eastern (Left-Bank Ukraine) part, especially at the Donets Ridge. The water in the springs and streams may be fresh or brackish (up to 5-10 ‰), and salinity may vary depending on the season and rainfall. Since the majority of water bugs of the region are tolerant to the small fluctuations in salinity, the author does not consider separately fresh and brackish water objects. All the investigated springs belong to the cold temperature regime type.

For the study of quantitative characteristics we used the material from the creek in the environs of Odessa, which is flowing into the Kuyalnik estuary near Krasnoselka and Kubanka villages. The length is about 4 km, the width up to 15 m, the maximum depth is 1.2 m, the average depth is about 0.5 m, the bottom is clayey and silty, somewhere sandy or stony, in the quiet places with the thick layer of silt. The vegetation consists of *Chara* spp., filamentous algae, *Carex* spp., *Scirpus* spp., *Phragmites* spp., *Typha* spp., different Poaceae., *Lemna* spp., *Wolffia* sp., species of Ranunculaceae. In the course of the year the current velocity varies very much, in summer the creek usually completely dries up, the water remains only in the limnocrene pools in the middle part of the creek.

Quantitative samples were taken approximately every two-three weeks with the help of a Balfour-Browne hand net (Golub, Tsurikov, Prokin, 2012) or hydroenthomological drag (Dyadichko, 2007), and also using meiobenthic methods for nymphs of younger stages (Kurashov, 2007). For further processing of quantitative samples we used standard techniques for macrozoobenthos and meiobenthos (Kurashov, 2007, Bubnova, Holikova, 1983). Modified fish-traps were also used for general collecting. In total, about 4000 specimens of aquatic Hemiptera were studied.

The system follows Aukema and Rieger (1995) and Nieser (2002).

Results and discussion. In the creeks and springs of the ukrainian steppe zone there were found 22 species of water bugs, which represented 34 % of the total number of water bug species known in Ukraine (Puchkov & Puchkov, 1996). These bugs belong to 8 families, including Nepomorpha: Aphelocheiridae - 1 species, Corixidae - 9 species, Naucoridae - 1 species, Nepidae - 1 species , Notonectidae - 2 species, Pleidae - 1 species, Gerromorpha: Gerridae - 7 species, Veliidae - 1 species (tab. 1). *Velia saulii* Tamanini, 1947 was found in the steppe zone of Ukraine for the first time. This species inhabits mainly small rheocrene springs where parts with a swift current, (several meters long) are interspersed with cup-shaped pools with the area of 1-2 m^2. In the region it was found at

Table 1.

Specific composition of streams and springs of Ukrainian steppe zone
Видовой состав водных клопов ручьев и родников степной зоны Украины

Family	Species	Helocrenes	Limno-crenes	Rheo-crenes	Streams
Aphelocheiridae	*Aphelocheirus aestivalis* (Fabricius, 1794)	–	–	+	–
Nepidae	*Nepa cinerea* Linnaeus, 1758	–	+	+	–
Notonectidae	*Notonecta glauca* Linnaeus, 1758	–	+	–	–
	Notonecta viridis Delcourt, 1909	–	+	+	+
Pleidae	*Plea minutissima* Leach, 1817	–	+	–	+
Naucoridae	*Ilyocoris cimicoides* (Linnaeus, 1758)	–	+	+	+
Corixidae	*Corixa affinis* Leach, 1817	–	+	–	–
	Corixa punctata (Illiger, 1807)	–	+	–	–
	Hesperocorixa linnaei (Fieber, 1848)	–	+	–	–
	Sigara assimilis (Fieber, 1848)	–	+	–	+
	Sigara iactans Jansson, 1983	–	+	–	–
	Sigara lateralis (Leach, 1817)	–	+	–	+
	Sigara mayri (Fieber, 1960)	–	–	–	+
	Sigara stagnalis (Leach, 1817)	–	+	–	+
	Sigara striata (Linnaeus, 1758)	–	+	–	–
Gerridae	*Aquarius paludum* (Fabricius, 1794)	–	–	+	+
	Gerris argentatus Schummel, 1832	–	–	+	+
	Gerris costae (Herrich-Schaeffer, 1850)	–	–	+	–
	Gerris lacustris (Linnaeus, 1758)	+	+	+	+
	Gerris odontogaster (Zetterstedt, 1828)	–	+	–	–
	Gerris thoracicus Schummel, 1832	–	–	–	+
Veliidae	*Velia saulii* Tamanini, 1947	–	–	+	–
Total	**22**	**1**	**15**	**9**	**11**

only one station in the national park «Granite Stepove Pobuzhzha « (Mykolaivska province, Pervomajskiy district), in the small spring near the village Kuripchino. Rarity of the species and its stenobiontic character allow to recommend it for inclusion in the regional Red Book.

Species composition in springs and streams is poorer than in small and large rivers (28 and 33 species, respectively). Nevertheless, due to the large variety of environmental conditions provided by springs, there one can found Heteroptera of very different environmental requirements. There are krenobionts (*V. saulii*), rheophils (*A. aestivalis*), limnophils (*C. affinis, C. punctata*), species preferring the beds of large rivers (*A. paludum*), although, as in the most other water bodies of the region, the widespread polytopic species are the dominant ones. Of special note is *G. costae,* a species that, despite of its registering in Odessa at the beginning of the last century (Kirichenko, 1915), was marked by us only in the Left-Bank part of the south of Ukraine.

The greatest number of species (15) was found in limnocrenes. Here the low flow rate, higher temperature as compared with other types of springs and an abundance of vegetation create favorable conditions for both infraorders of water bugs. Less species (11) were found in streams. In rheocrenes more often the representatives of the family Gerridae were met, however, only there *A. aestivalis* and *V. saulii* were found. Helocrenes in general were inhabited very poorly, the only species which was found there was the superplastic widespread pond skater *G. lacustris.*

Species composition of rheocrenes thanks to relative constancy of environmental conditions throughout the year remains almost unchanged. Influence of seasonal changes on Heteropera living in limnocrenes depends on their location and size. Due to the fact that many of them completely dry up in the summer, the species composition in the spring and fall may differ considerably. In the streams the abundance, biomass and species composition of aquatic Heteropera are subjected to the seasonal

fluctuations, which are similar to the changes occurring in the small rivers. Therefore for periodization of the calendar year was used the same scheme as for the small and intermittent rivers, with some changes (Dyadichko, 2008, Grandova, 2013). The main difference between the streams of the steppe zone from the small intermittent rivers is faster warming and faster drying up in the spring and early summer, so that the beginning of the spring and summer periods is shifted to earlier dates, and spring periods do occur faster. In addition, due to the lack of permanent water bodies which serve as refugia during dry period of the small rivers, the abundance of water bugs in the fall remains quite low.

We distinguish 5 periods:

1. The early-spring period continues from the ice melting at the end of February – the beginning of March till the beginning of water vegetation growth at the end of March – April.

2. The spring period begins at the end of March, when water vegetation starts growing. It lasts till the depression of the water level and the beginning of *Phragmites spp.* and *Typha spp.* growth at the end of April.

3. The late-spring period lasts through the end of April and May. It is characterized by medium water level in the riverbed, vegetation of *Phragmites* spp. and *Typha* spp., and flowering of marsh iris.

4. The summer-autumn period continues from June till the beginning of October. The current is practically absent, than the stream completely dries up, the water remains only in the limnocrene pools.

5. The late autumn-winter period lasts from the filling of the riverbed in October – November till water freezing in December – the middle of February. Often streams freeze to the bottom, remaining unfrozen only in the outlets.

Early spring period is characterized by low abundance and low species diversity. During this period, in the streams and springs only 5 species of aquatic bugs were found. Four of them belong to the family Corixidae. The fifth one is *N. cinerea* hibernating in springs. In the quantitative samples at the beginning of early spring period in the creek there were only a few non-quantifiable individuals of water bugs.

Due to rapid warming the early spring period of 2011 lasted about two weeks, and by the beginning of spring period quantitative indicators increased significantly. On March 24, 2011 the abundance reached 355 ind./m^2 and biomass was 3176 mg/m^2 (fig. 1). Corixidae adults dominated (mainly *S. lateralis* and *S. stagnalis*), but a small number of Gerridae have been already found (*G. thoracicus*). In the early spring period mating of most living in streams Heteroptera occurs, including Corixidae, Notonectidae, Gerridae.

During the spring period the water level in the mainstream and thus available habitat area reaches its maximum value, in addition, there appear small temporary water bodies, some of them also actively populated by water bugs. As a result, the relative abundance and biomass of aquatic Hemiptera per area unit decreases. During this period in streams Corixidae dominated, but significant contribution to the biomass was also made by Notonectidae. So, in April, 2011 the abundance of Corixidae in the model stream was 14.17 ind./m^2 with the biomass 227 mg/m^2, and biomass of Notonectidae reached 152 mg/m^2. Dominated by *S. lateralis* and *S. stagnalis*, of Notonectidae - *N. viridis.*

By the end of the spring period, the abundance continues to fall due to the death of overwintered adults, following after the mating and laying eggs. Appearance of the first nymphs observed in late spring early period.

In the spring period, as well as following it the late spring period, the greatest diversity of species is registered. Most of the springs and streams are full-flowing during both of these periods, as the result the part of the water bugs migrates here to breed, and then a new generation of adults moved back in floodplain ponds of large and small rivers. In the spring period in the springs and streams there were found 16 species of aquatic Hemiptera, in late spring period 22 species, belonging to 7 of 8 registered families.

At the beginning of the late spring period, the abundance starts to increase, but still remains low. So, in mid-May 2011 the number in the model stream was 10.7 ind./m^2 biomass - 66.7 mg/m^2. *S. lateralis* and *S. stagnalis* dominated, however a significant contribution to the quantitative indicators was added by *G. thoracicus, P. minutissima, N. viridis.*

By the end of the late spring period, the abundance increases dramatically due to the

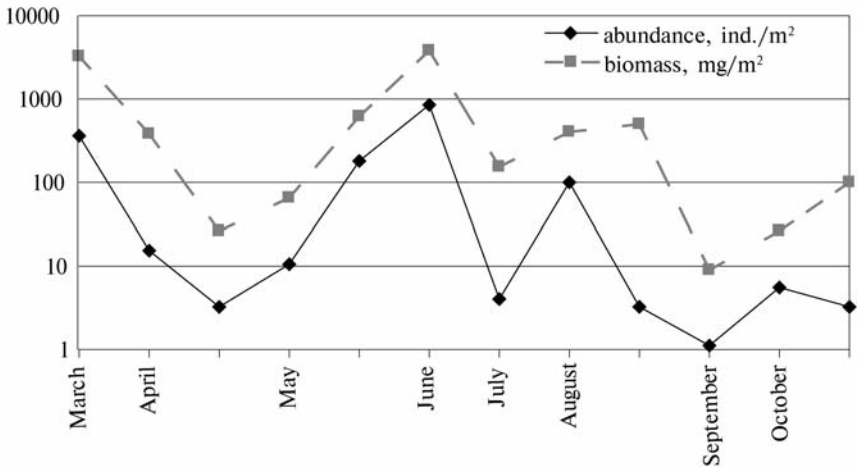

Fig. 1 Seasonal changes of quantitative characteristics of water bugs in streams of ukrainian steppe zone.
Рис. 1 Сезонные изменения количественных характеристик водяных клопов ручьев и родников степной зоны Украины.

emergence of a large number of nymphs. Nymphs hatched at the beginning of this period reach the 3-4 instars. So, at the end of May, 2011, in the model creek the abundance reached 185 ind./m^2 and the biomass was 624 mg/m^2, with the contribution of nymphs in the abundance coming to 89%, in the biomass coming to 83%. Basis of these indicators were nymphs of Corixidae (71% by abundance and 52% by biomass), but a significant contribution to biomass was also added by nymphs of Notonectidae and Gerridae, especially the older instars.

By the end of late spring — early summer appear the first individuals of a new generation of adults of Notonectidae, Corixidae, Gerridae and Pleidae, but the number of nymphs remains quite high. Compared with the spring period, when the nymphs mostly related to younger age at the beginning of the summer period dominated by older nymphs . So , 11.06.2011 modeling creek as throughout the year dominated Corixidae (more than 90 % by number), while the number of adults was 57 % of the total Corixidae, the number of nymphs 4-5 age groups — 21% , and the number nymphs 1–2 age — only 6%.

Over the summer period many springs completely dry up, and in the streams the water remains only in the outlets. For some species close to that living in our springs, estivation has been described (Cianferoni, Santini, 2012). Others are forced either to migrate in search of suitable habitat or die. Thus, in the summer period in these habitats is just a few species, and only some of them gives the second generation. During the period of research in springs in summer there were found only seven species belonging to 5 families.

In July and August in streams the second generation of Corixidae and Pleidae nymphs appears, but their abundance does not reach the values of the spring period. So, in mid-July 2011 the abundance of Corixidae nymphs was only 3 ind./m^2. In 2010, the summer was more affluent, so in August there was a lot of Pleidae nymphs (30 ind./m^2). As the streams dry up the Hemiptera quantitative characteristics increase slightly due to concentration of bugs in the vestigial parts of watercourses. For example, 01.08.2010 in the model stream the abundance was 101.67 ind./m^2 and biomass was 410 mg/m^2, when the area of the stream filled by water did not exceed a few tens of m^2 in the limnocrene in the middle of the stream and the current was completely missing. In general, the abundance and biomass of water bugs in the summer can fluctuate significantly and depends on the climatic conditions of the year. Significant increase of water bugs quantitative characteristics in the second half of the summer is typical for large

rivers and floodplain water bodies of small intermittent rivers. Such an increase was not observed in streams.

During autumn streams refill again. Water bugs re-populate the springs that have dried up in summer, but quantitative indicators remain low. Thus, in the model creek the abundance in October and November ranged from 3 to 6 ind./m^2, biomass did not exceed 100 mg/m^2. In September and October in streams appear isolated Corixidae nymphs of third generation, which in the warm fall quickly reach the adult stage and successfully overwinter.

Conclusion. Springs and streams are the most numerous types of watercourses of Ukrainian steppe zone. Away from the big and small rivers, they act as refugia for many aquatic insects. In floodplains they are actively populating during the late sping and summer by species migrating from other water bodies, and are constantly inhabied by stenobionts, not found in other habitats. In creeks and springs of the Ukrainian steppe zone were found 22 species of water bugs from 8 families (Nepomorpha: Aphelocheiridae (1), Corixidae (9), Naucoridae (1), Nepidae (1), Notonectidae (2), Pleidae (1), Gerromorpha: Gerridae (7), Veliidae (1). As in most other water bodies in the region the widespread polytopic species dominated. *Velia saulii* was found in the steppe zone of Ukraine for the first time. The most rich in species composition were limnocrenes (15), less species were found in streams (11) and rheocrenes (9), helocrenes were populated very poorly(1).

Depending on the type of spring patterns of seasonal changes in species composition and quantitative characteristics are different. Species composition of rheocrenes remains almost unchanged during the year. In limnocrenes quantitative characteristics of water bugs depend on the area and time of existence, the species composition of intermittent limnocrenes in spring and autumn can be markedly different. Seasonal changes in species composition, abundance and biomass in streams are similar to those for small intermittent rivers. However, spring and summer periodic changes are happening faster in streams. Due to the strong summer drying and lack of permanent flood waters which serve as the refugia during the small rivers drying, the abundance of second and third generation of polyvalent species is very low. A significant increase in the quantitative characteristics in the second half of the summer, typical for large rivers and floodplain water bodies of small intermittent rivers, is not registered in streams, and in the autumn period the abundance also remains low.

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