European Arachnology 2005 (Deltshev, C. & Stoev, P., eds)
Acta zoologica bulgarica, Suppl. No. 1: pp. 151-159.

The diel vertical migrations of herbage-dwelling spiders in clayey semi-desert of the northern Caspian Sea basin, West Kazakhstan (Araneae)

Tatyana Piterkina[1]

Abstract: The diel periodicity of vertical migrations of the herbage-dwelling spiders in the natural biotopes of the clayey semi-desert in the northern Caspian Sea basin (West Kazakhstan) is investigated. Steppe biotopes (microdepressions) and desert ones (microelevations) are shown to have much in common: the abundance and the family composition of the spider population of both biotopes are similar, they differ a bit only in summer. The amplitude of diel fluctuations in the spider abundance is rather significant. In spring and autumn the peaks of abundance in both types of biotopes are at night, when the temperature of the air is minimal. In summer, in addition to night peaks of abundance there are daytime rises due to increase of activity of "southern" taxa – Thomisidae in desert associations, and Thomisidae+Salticidae in steppe ones. The diel rhythmic of vertical migrations of hortobiotic spiders is a complicated phenomenon which is determined by a number of factors. Partly it is conditioned by environmental factors, and partly – by the vertical migrations of their preys – phytophagous insects. So, the ecological niches of different spider taxa are separated in time according to their adaptations to climate conditions. It brings about a decrease of the competition between taxa.

Key words: desert, steppe, herbage-dwelling spiders, diel activity, temporal distribution

Introduction

The characteristic feature of invertebrates inhabiting the herbage layer is their extremely high diel mobility. This mobility is determined by their regular vertical migrations whereas the character of movements in the species remains individual (Chernov, Rudenskaya 1975). In most papers devoted to the diel dynamics of spiders, the main attention is paid to herpetobionts (Dondale *et. al*. 1972, Seyfarth 1980, Gramotenko 1984, Fujii 1997). The diel activity of hortobiotic spiders has been poorly studied (Mikhailov 1985).

Different anthropogenic effects that disturb natural succession processes and the complexity of ecosystem elements themselves make investigations of dynamic processes difficult. We analyzed the diel and seasonal dynamics of herbage-dwelling spiders in the clayey semi-desert of the northern Caspian Sea Lowland. It is situated in the interfluve of the Volga and Ural rivers. The semi-desert of the Volga River basin is especially appropriate for such investigations due to vast areas of virgin lands, which are exposed to a constant but very weak and thus reversible anthropogenic impact; and the zonal ecosystems are rather simply organized here because of severe and contrasting conditions and plain relief. In addition, the hydrological, soil and geobotanical conditions of this territory are well studied (Kamenetskaya 1952, Rode 1971, Doskach 1979 and others). Besides, we have preliminary data of spider population on this territory (Mikhailov 1985). So, we consider that the semi-desert of the northern Caspian Sea basin is a quite suitable model territory for investigating the dynamics of spiders.

[1] Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, 33, Leninskii Prospect, Moscow 119071, Russia. E-mail: piterkina@ yandex.ru

This work is only a part of a project investigating the fauna and ecology of spiders of clayey semi-desert of the northern Caspian Sea Lowland.

Study Area

The region of our investigation is located in the flat plain of the northern Caspian Sea Lowland (an altitude of 21-25 m a.s.l.) at the border between Russia and Kazakhstan (49°23'N; 46°47.5'E). It is the most arid territory in the Caspian Sea semi-desert, despite its northernmost location. Groundwater, at a depth of 5-10 m, is highly mineralized. The main part of the plain has a complex soil-vegetable cover. This cover is related to the microrelief, and its components have an area of no more than some tens of square meters. Microelevations are occupied by solonetzic soils, which have nonpercolative type of water regimes (it means that water never percolates through the soil and gets to the ground water, i.e. salts and different nutrients are never washed out from the soil to the ground water) (Rode 1971). A plant cover of desert type is developed here (*Kochia prostrata* and *Artemisia pauciflora* associations), so microelevations are desert biotopes. Microdepressions (up to 0.4 m depth) are with dark-chestnut and meadow-chestnut soils, they periodically have percolative type of water regimes (salts and nutrients are periodically washed out from the soil). Microdepressions are occupied by motley grass (*Stipa* spp., *Festuca valesiaca, Agropyron cristatum*, etc.) - these are steppe biotopes.

Materials and Methods

Sweeping was done in different seasons (spring, summer and autumn) so as to reveal seasonal particularities of vertical migrations of grass-dwelling spiders. Sweeping (4x25 sweeps) was done every 4 hours, i.e. at 0, 4, 8, 12, 16 and 20 o'clock during 2 consecutive days. Two types of zonal biotopes were investigated: steppe and desert ones, i.e. microdepressions and microelevations. Seventy-two samples per 100 sweeps were analyzed, about 3700 specimens of spiders were collected. The majority of the spiders were immature which is quite typical for the spider community of the herbage layer (Veselova, Mikhailov 1986). So, the identification of species was not always possible.

Results

Spiders of 13 families were caught by sweeping (Table 1). Spiders of 5 main families and 21 species were identified (Table 2). The total abundance of spiders in different seasons varied greatly but seemed to be similar in both biotopes: it was low in the spring and autumn but two or three times higher in the summer (Fig. 1). The family composition of spider communities of the herbage in both biotopes was also quite similar (Table 1). Namely, the basis of the spring population was Oxyopidae (only immature spiders were caught) and Araneidae with the dominating species *Gibbaranea bituberculata* (Walckenaer, 1802). The autumn population of both biotopes had also much in common. It mostly consisted of Clubionidae (*Cheiracanthium* sp. 1) on microelevations; on microdepressions only immature specimens were caught. Araneidae with *Cercidia levii* Marusik, 1985 were abundant on microdepressions (the immature individuals were found on microelevations). The Thomisidae with *Xysticus marmoratus* Thorell, 1875 and *X. striatipes* L. Koch, 1870 dominated in both biotopes. The summer population of the two biotopes had some differences: besides the common prevailing families Thomisidae (on microelevations immatures only; on microdepressions *Thomisus albus* (Gmelin, 1789) and *X. cristatus* (Clerck, 1758) were caught) and Clubionidae (immatures only), in steppe biotopes Salticidae were also abundant – one third of the population, with *Evarcha michailovi* Logunov, 1992 dominating.

Table 1. Correlation (%) of the families of hortobiotic spiders collected by sweeping (May – September 2004).

Family	Spring		Summer		Autumn	
	Microelevations	Microdepressions	Microelevations	Microdepressions	Microelevations	Microdepressions
Thomisidae	3.2	0.7	65.0	36.9	11.4	23.1
Philodromidae	5.7	3.9	5.0	6.7	5.4	11.6
Araneidae	18.8	20.6	6.9	3.3	27.3	16.8
Oxyopidae	33.4	33.9	0.2	0.1	5.9	7.3
Clubionidae	2.4	9.3	12.2	15.6	32.5	23.6
Salticidae	1.1	7.4	6.2	32.4	-	3.4
Linyphiidae	10.7	8.6	1.9	1.9	1.6	1.0
Dictynidae	5.1	4.9	0.9	1.2	5.0	3.9
Theridiidae	5.1	5.6	0.9	1.5	9.6	8.7
Uloboridae	14.2	5.1	0.1	0.3	0.9	0.3
Gnaphosidae	-	-	0.5	0.1	0.4	-
Lycosidae	-	-	0.1	-	-	0.3
Titanoecidae	0.3	-	0.1	-	-	-

Table 2. List of hortobiotic spiders in five dominating families collected by sweeping (May – September 2004).

Family, species	Microelevation	Microdepression
Araneidae		
Argiopa lobata (Pallas, 1772)	+	-
Cercidia levii Marusik, 1985	-	+
Gibbaranea bituberculata (Walckenaer, 1802)	+	+
Mangora acalypha (Walckenaer, 1802)	+	-
Neoscona adianta (Walckenaer, 1802)	-	+
Oxyopidae		
Oxyopes globifer Simon, 1876	+	-
O. lineatus Latreille, 1806	-	+
Clubionidae		
Cheiracanthium pennyi O. P.-Cambridge, 1873	-	+
Cheiracanthium sp. 1	+	+
Cheiracanthium sp. 2	+	+
Clubiona genevensis L. Koch, 1866	-	+
Thomisidae		
Ozyptilla pullata (Thorell, 1875)	+	-
Thomisus albus (Gmelin, 1789)	-	+
Xysticus cristatus (Clerck, 1757)	+	+
X. marmoratus Thorell, 1875	+	+
X. striatipes L. Koch, 1870	+	+
Xysticus sp.	+	-
Salticidae		
Evarcha michailovi Logunov, 1992	-	+
Heliophanus flavipes (Hahn, 1832)	-	+
H. koktas Logunov, 1992	-	+
H. lineiventris Simon, 1832	-	+

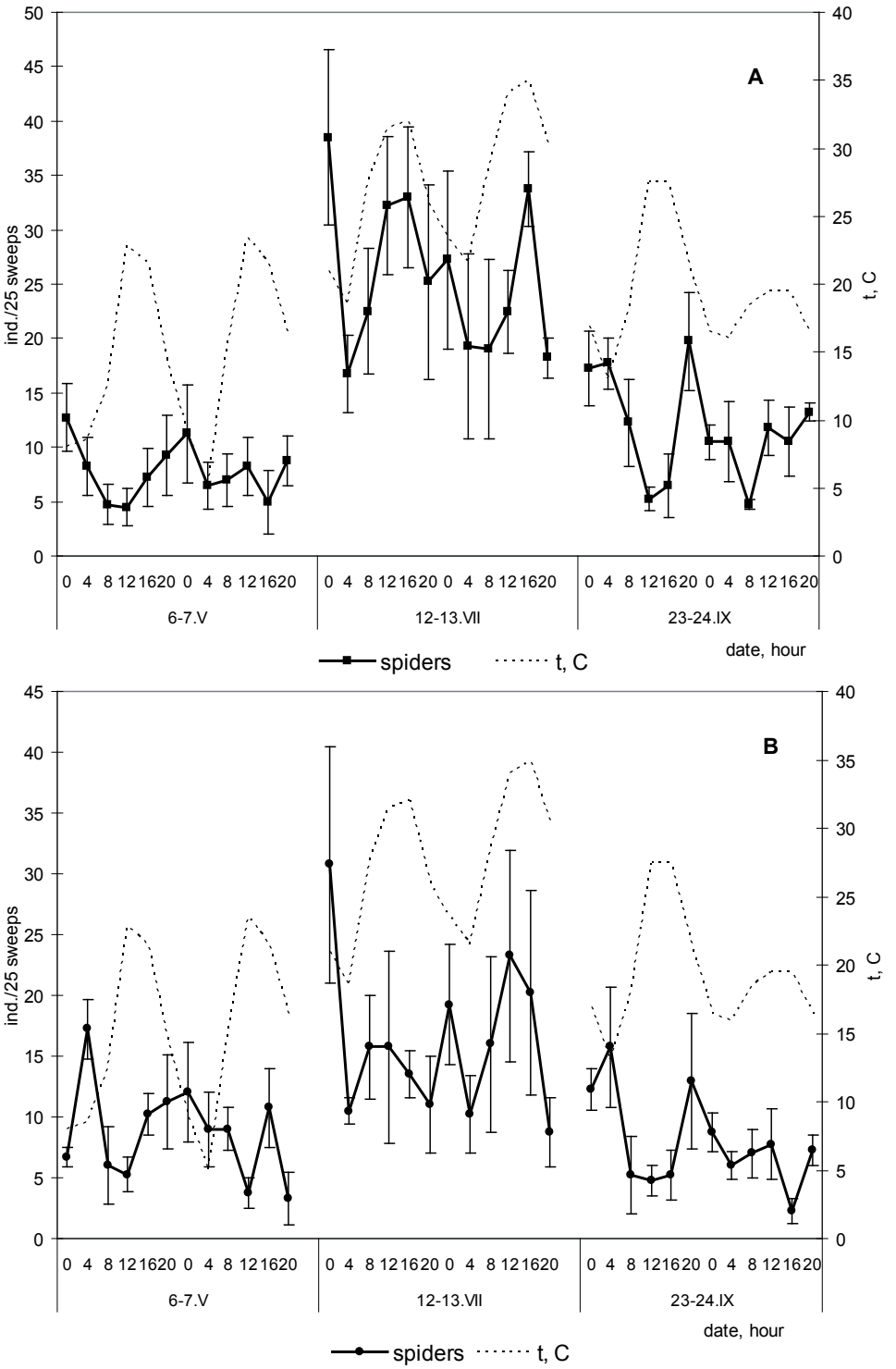

Fig. 1. Diel fluctuation of the abundance of hortobiotic spiders and air temperature in microelevations (A) and microdepressions (B).

Sweeping is known to record the abundance of individuals that have migrated to the upper layers of the herbage and thus have become available for catching (Beklemishev 1934). The plants growing on microelevations are very short and scattered. In this case, we suggest that spiders migrate (in vertical direction) to the herbage from soil cracks. In the dense grass cover of microdepressions, spiders may migrate both from soil cracks and the lower part of the herbage. The results of the sweeping in both biotopes are rather similar (Fig. 1). In the spring and autumn, the diagram of dynamics of diel vertical migrations had a peak at night hours and a decrease in the daytime. It is quite typical for many components of the herbage complex (Chernov, Rudenskaya 1970) especially under arid and semi-arid climatic conditions (Avanesova 1983). The comparison of abundance and temperature curves shows some inverse relationship (Fig. 1): the abundance of spiders is maximal at minimal night temperatures, and vice versa. But in the summer, the hottest period, when the day temperatures reach up to 40°C and night temperatures are about 20°C, there are daytime peaks in the abundance of spiders. These peaks are restricted to the hottest hours (12-16) of the day. The abundance of spiders in daytime was not less than that at night (Fig. 1). Night peaks were quite expected. It worth emphasizing that the amplitude of diel fluctuations in the spider abundance was rather significant, which is typical for cenoses of open space. The investigations of activity of arachnids in the herbage under the forest canopy showed that the fluctuations in their abundance were more even because of the more stable microclimatic conditions there (Williams 1962).

The analysis of the diel activity rhythms of each family has revealed the following results (Fig. 2). Oxyopidae, which were dominant in the spring, were active at night on microelevations and in the early morning and late evening, on microdepressions. Very likely, this is related to the fact that different species inhabited these sites, but we cannot firmly state it, since all the spiders caught in the spring were immature. However, adult Oxyopidae caught in the summer and autumn were different in different biotopes: *Oxyopes globifer* Simon, 1876, on microelevations and *O. lineatus* Latreille, 1806, on microdepressions. The Araneidae, abundant in spring and autumn, had no distinct peaks in their activity (they are the only non-wandering spiders) but nevertheless, their catching efficiency was higher during daytime. The Clubionidae are abundant only at night. They were almost absent during daytime, which confirms some previous observations about their nocturnal activity (Dondale *et. al*. 1972, Marc 1990 and others). The Thomisidae are diurnal but their abundance rose somewhat at night. All salticids are distinctively diurnal. In the summer, in the herbage of the microdepressions they were abundant from 8 till 16 o'clock.

The typical ground-dwelling spiders such as Lycosidae, Gnaphosidae and Titanoecidae were found to be also capable of vertical migrations to the grass layer. Probably, when sampling on microelevations we could catch them accidentally from the ground surface because of the sparse vegetation. However, representatives of these families were also collected in the microdepressions, and besides, most of them were caught only during night hours. We think that these facts prove the vertical migrations of herpetobiotic species. Moreover, some other authors also showed night rises of herpetobiotic spiders to the herbage (Chernov, Rudenskaya 1975, Kupershtein, Egorova 1978, Mikhailov 1985).

Discussion

The vertical migrations of invertebrates in the herbage layer have not still been sufficiently explained. Following Mikhailov (1985), we suggest that the spider migrations are a display of their activity. Another question – what determines such an activity? Very likely, the diel activity rhythms are an endogenous feature of a taxon, which has been formed during the evolution process (Tshernyshov 1960). But these rhythms are certainly controlled by the environment and modified depending on the needs of the species. Differences in diel activity of spiders of different taxa is conditioned by their morphological or ethological features.

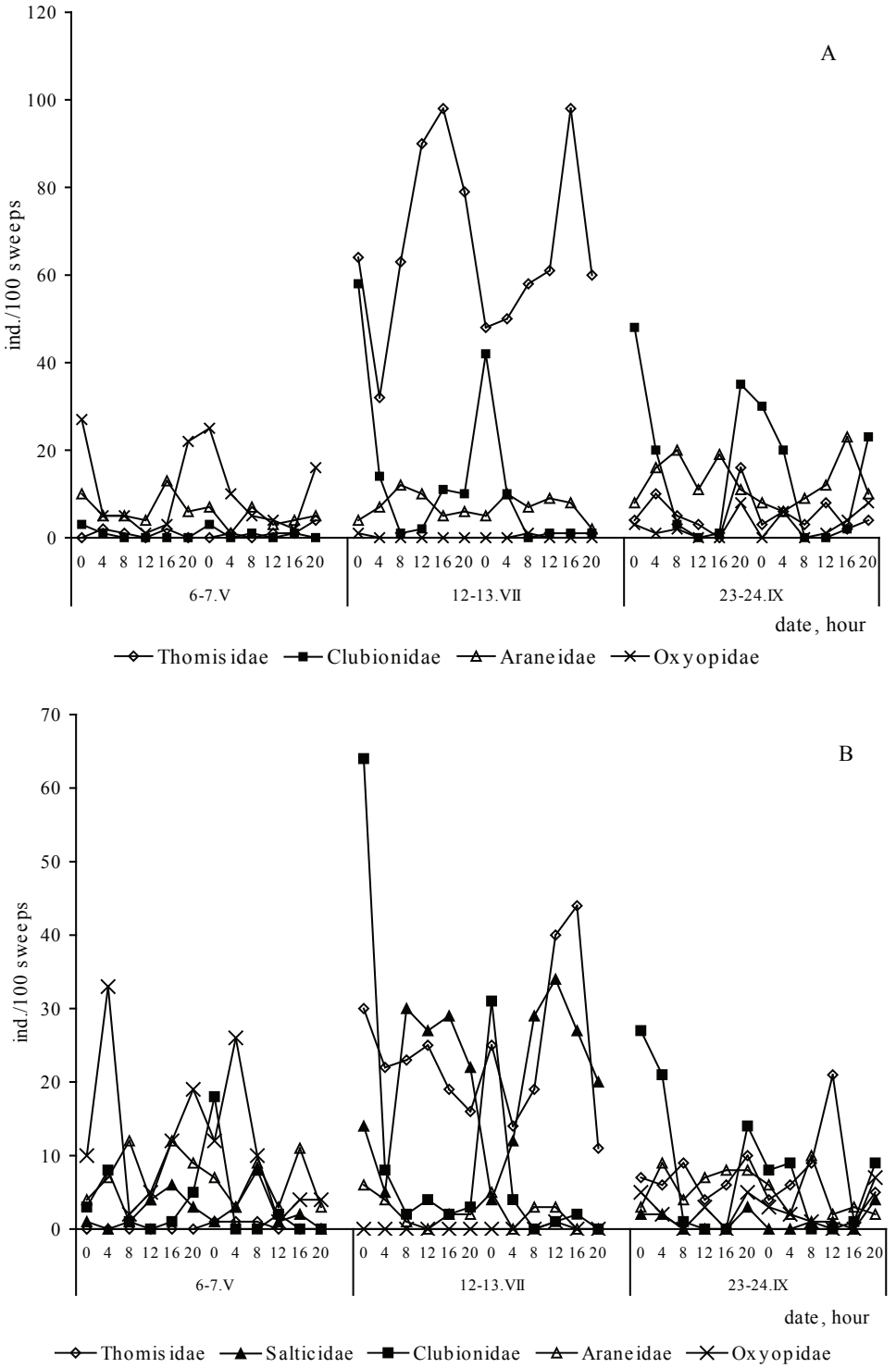

Fig. 2. Temporal distribution of the dominating families of hortobiotic spiders in the microelevations (A) and microdepressions (B).

The Thomisidae and Salticidae are "southern" elements in the araneofauna. Their high abundance and diversity are especially typical for arid and semi-arid conditions (Cloudsley-Thompson 1983). They have a diurnal type of activity and have developed some adaptive features against overheating. Namely, Thomisidae have a thick chitinous-cloth and an intensive coloration of the body. Salticidae's bodies usually have even more expressed pigmentation and glitter scales that protect them from harmful solar radiation. Darkling beetles (Tenebrionidae), the most adapted and abundant group of Coleoptera under arid conditions, are known to have similar adaptive features. They were described as having some special structure of their skin coverings and physiological mechanisms that protect their body from overheating (Ghilarov 1964, Toms 1993). The salticids probably have similar adaptive features. The Clubionidae and Oxyopidae have pale coloration and thin chitin, which cannot protect them from overheating and water loss. They are mostly nocturnal. Araneidae didn't show distinct diel rhythms. It's the only family whose representatives spin webs and stay on them. So, to avoid overheating they hide in the shadow or in special shelters not far from their webs.

As said before, environment conditions influence the diel activity of spiders. Thus, temperature is one of the main factors, especially in semi-arid zones, where the amplitude of its diel fluctuations is rather high. Fig. 1 shows that certain dependence exists. The activity of spider populations in the spring and autumn is inversely related to the temperature. In the summer, these two graphs almost follow each other. The second environmental factor affecting the diel spider activity is air humidity. As a rule, the invertebrates follow the maximum of moisture: in the daytime hours, it is near the ground surface and by night it goes up (Heiger 1931, cit. in Chernov, Rudenskaya 1975, Melnichenko 1949). To our mind another very important factor which determines the activity of spiders, obligate predators, is the migration of their preys – phytophagous insects. Night rises in the abundance of phytophags were noted by numerous authors. The night activity of phytophags is specified by movements in search of the optimal combination of microclimatic conditions and is connected with the highest intensity of feeding (Chernov, Rudenskaya 1970, Avanesova 1983). Similar rhythmics of diel activity of preys and predators was found in the springtail *Isotoma violacea* and spiders of the genus *Pardosa* (Lycosidae) on the snow surface in Greenland (Fox, Stroud 1986). A relationship between the peaks of activity in predators and their prey of different taxa was also revealed in the meadows of Ontario (Dondale *et. al*. 1972).

The daytime peaks in spider activity are likely to be explained by trophic relations as well. In tundra forests spiders are known to keep their activity at minimal night temperature, whereas insects lose their agility. Under these conditions, spiders easily hunt unmoving preys (Ol'shvang 1974). In the semi-arid zone, the situation might be quite similar: many insects spend the hottest hours torpid on plants. Thus, spiders of some taxa, being adapted to arid conditions, keep their activity and hunt slow-moving prey. Besides, there are some taxa of diurnal phytophags: some Diptera, Homoptera, etc. (Chernov, Rudenskaya 1970, Dondale *et. al*. 1972). So, we can conclude that the high abundance of spiders and, hence the high competition between them, cause a differentiation of niches of different taxa according to their adaptation to climate conditions. Such a differentiation makes possible the use of habitat resources in full measure.

Acknowledgements: I thank Dr M. K. Sapanov and Dr M. L. Sizemskaya for the chance to work at the Dzhanibek Research Station; Dr Yu. M. Marusik and Dr D. V. Logunov for their help in the identification of some problematic species. I am especially grateful to Dr K. G. Mikhailov and Academician Yu. I. Chernov for their help, permanent attention and valuable advice in preparing this work. The study was financially supported by the Russian Foundation for Basic Research and by the Program for Support of Leading Academic Schools.

Received: 11.12.2005
Accepted: 27.04.2006

References

Avanesova G. A. 1983. The diel activity rhythms of insects under arid conditions. Mekhanizmy povedeniya. Materialy III Vsesoyuznoi konferentsii po povedeniyu zhivotnykh [Mechanisms of behaviour. Proceedings of III all-Soviet conference on animal behaviour], **1**: 71-72. (In Russian)

Beklemishev V. N. 1934. The diel migrations of invertebrates in the complex of terrestrial biocenoses. - In: Alexeev A. I. (ed.): Trudy Biologicheskogo nauchno-issledovatel'skogo instituta pri Permskom universitete [Proceedings of the Biological research institute at Perm University], Perm, **6** (3-4): 119-208. (In Russian)

Chernov Yu. I., L. V. Rudenskaya 1970. Entomological cutting as a method of quantitative estimation of invertebrates – dwellers of the grass cover. - *Zoologicheskii zhurnal*, **49** (1): 137-144. (In Russian)

Chernov Yu. I., L. V. Rudenskaya 1975. Complex of invertebrates, dwellers of grass stand, as a layer of animal population. - *Zoologicheskii zhurnal*, **54** (6): 884-894. (In Russian)

Cloudsley-Thompson J. L. 1983. Desert adaptations in spiders. - *Journal of Arid Environment*, **6**: 307-317.

Dondale C. D., J. H. Render, R. B. Semple 1972. Diel activity periodicities in meadow arthropods. - *Canadian Journal of Zoology*, **50** (8): 1155-1163.

Doskach A. G. 1979. Prirodnoe rayonirovaniye Prikaspiyskoi polupustyni [Natural zoning of Ciscaspia semidesert]. Moscow, Nauka, 143 p. (In Russian)

Fox A. D., D. A. Stroud 1986. Diurnal rhythms in a snow-surface springtail (*Isotoma violacea*, Collembola) and its predators in Eqalungmiut Nunaat, West Greenland. - *Pedobiologia*, **29** (6): 405-412.

Fujii Y. 1997. Ecological studies on wolf spiders (Araneae: Lycosidae) in a northwest area of Kanto plain, Central Japan: diel activity and habitat preference observed by pitfall trapping. - *Acta arachnologica*, **46** (1): 5-18.

Ghilarov M. S. 1964. The main directions of insect adaptations to the life in the desert. - *Zoologicheskii zhurnal*, **53** (3): 443-454. (In Russian)

Gramotenko V. P. 1984. Daily activity of herpetobiotic spiders on alfalfa. Problemy pochvennoi zoologii. Tezisy dokladov VIII Vsesoyuznogo soveshaniya [Problems of soil zoology. Abstracts of VIII all-Soviet conference]. Ashkhabad: Institut zoologii Akademii nauk Turkmenskoi SSR i dr., **1**: 75-76. (In Russian)

Kamenetskaya I. V. 1952. Natural vegetation of Dzhanibek station. - In: Sukachev V. N., S. V. Zonn, A. A. Rode (eds): Trudy kompleksnoi nauchnoi ekspeditsii po voprosam polezashitnogo lesorazvedeniya [Proceedings of complex research expedition on problems of field-protective forestation]. Moscow, AN SSSR Publ. House, **2** (3): 101-162. (In Russian)

Kupershtein M. L., N. S. Egorova 1978. Daily vertical distribution and activity of carabids and spiders on wheat crops. Problemy pochvennoi zoologii [Problems of soil zoology], Minsk: 130-131. (In Russian)

Marc P. 1990. Nycthemeral activity rhythm of adult *Clubiona corticalis* (Walckenaer, 1802) (Araneae, Clubionidae). - *Acta Zoologica Fennica*, **190**: 279-285.

Melnichenko A. N. 1949. Polezashitnie polosy stepnogo Zavolzhya i ih vozdeistvie na razmnozhenie zhivotnyh, poleznyh i vrednyh dlya sel'skogo hozyaystva [Shelter belts of the Steppe Zavolozhiya region and their influence on reproduction of animals which are useful and harmful for agriculture]. Moscow, MOIP, 359 p. (In Russian)

Mikhailov K. G. 1985. Fauna and ecology of spiders (Arachnida, Aranei) of clayey semidesert of western Ciscaspia. - In: Ovtsharenko V. I. (ed.): Fauna i ekologiya paukov SSSR. Trudy zoologicheskogo Instituta AN SSSR [Fauna and ecology of spiders of USSR. Proceedings of Zoological Institute AS USSR]. Leningrad, **139**: 63-71. (In Russian)

Ol'shvang V. I. 1974. Arthropods of the station "Kharp". - In: Gorchakovskii P. L., V. S. Smirnov (eds): Biomassa i dinamika rastitelnogo pokrova i zhivotnogo naseleniya v lesotundre. Trudy Instituta ekologii rastenii i zhivotnikh Uralskogo nauchnogo tsentra AN SSSR [Biomass and dynamics of plant-cover and animals composition in forest-tundra. Proceedings of Institute of Ecology of Plants and Animals at the Ural research centre AS USSR], **88**: 150-154. (In Russian)

Rode A. A. 1971. Natural conditions and experimental plantations of Dzhanybek station. - In: Rode A. A. (ed.): Zhivotnye isskusstvennikh lesnykh nasazhdenii v glinistoi polupustyne [Animals of artificial afforestations in clayey semi-desert]. Moscow, Nauka: 5-12. (In Russian)

Seyfarth E. A. 1980. Daily patterns of locomotor activity in a wandering spider. - *Physiological Entomology*, **5** (2): 199-206.

Toms S. V. 1993. Heat regulation and stability to high temperatures in desert insects. - *Uspekhi sovremennoi biologii*, **113** (5): 587-605.

Tshernyshev V. B. 1960. Problem of diurnal rhythm in insects. - *Zhurnal obshei biologii*, **21** (6): 455-460. (In Russian)

Veselova E. M., K. G. Mikhailov 1986. A structure of the spider (Arachnida, Aranei) population of the herb-undershrub layer in phytocoenoses of Volga-Kama interfluvium. - *Ecologiya*, **6**: 46-51. (In Russian)

Williams G. 1962. Seasonal and diurnal activity of harvestmen (Phalangida) and spiders (Araneida) in contrasted habitats - *Journal of Animal Ecology*, **31** (1): 23-42.

Денонощната вертикална миграция при хербиколните паяци, обитаващи глинестата полупустиня на Северния Каспийски басейн в Западен Казахстан (Araneae)

Т. Питеркина

(Резюме)

Изследвана е денонощната вертикалната миграция на хербиколните паяци, обитаващи естествени биотопи в глинестата полупустиня на Северния Каспийски басейн в Западен Казахстан. Степните биотопи (малки падини) и пустинните биотопи (малки възвишения) имат редица общи черти: обилието и доминантната структура на семействата паяци и на двете места е еднакво, с незначителни разлики само през лятото. Денонощните флуктуации в числеността на паяците са значителни. През пролетта и есента пиковете в числеността на паяците в двата типа биотопи е през нощта, когато температурата на въздуха е най-ниска. През лятото има пик и през деня, дължащ се на увеличаването на активността на "южните таксони" – видове от семейство Thomisidae в пустинните съобщества и такива от семействата Thomisdae и Salticidae в степните съобщества. Денонощната ритмичност във вертикалната миграция при хортобионтните паяци е сложен феномен, който се определя от редица абиотични фактори, както и от миграцията на фитофагните насекоми, които са сред основните жертви на паяците. По този начин екологичните ниши на различните видове паяци са разделени във времето според тяхната адаптация към климатичните условия. Това води до намаляване на антагонизма между таксоните.