European Arachnology 2002 (F. Samu & Cs. Szinetár eds.), pp. 251-258.
 ISBN 963 214 791 X
(Proceedings of the 20th European Colloquium of Arachnology, Szombathely 22-26 July 2002)

A survey of spider species with Crimeo-Caucasian disjunct ranges (Arachnida, Araneae)

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Abstract
This paper presents a survey of seven spider species with a Crimeo-Caucasian distribution range: *Lepthyphantes khobarum* Charitonov, 1947; *Panamomops fedotovi* (Charitonov, 1937); *Stemonyphantes agnatus* Tanasevitch, 1990; *Pardosa buchari* Ovtsharenko, 1979; *Pirata hurkai* Buchar, 1966; *Tegenaria taurica* Charitonov, 1947; *Xysticus spasskyi* Utotschkin, 1968. The Crimean peninsula is the westernmost record for these species. Four of them (*S. agnatus*; *P. buchari*; *P. hurkai*; *X. spasskyi*) are new records for the Crimean and Ukrainian faunas. Altitudinal distribution, habitats and collection data for the Crimea and Caucasus are provided. The origins of these species as components of the Crimean and Caucasian fauna are discussed. *L. khobarum* and *S. agnatus* evolved in the Miocene (25-5 million years ago); *P. buchari* during the Pliocene glaciation (some 3.4-3.2 million years ago); *P. fedotovi, P. hurkai, T. taurica* and *X. spasskyi* in the Quaternary Period, approximately one million years ago.

Key words: Araneae, Crimeo-Caucasian disjunct ranges, habitats, faunogenesis

INTRODUCTION

Approximately 600 spider species are known from the Crimea (unpublished personal data) and 834 from the Caucasus (Mikhailov 2002). Approximately 300 of these species are widespread in the Crimea, Caucasus and adjacent regions (Mikhailov 1997, 1998, 1999, 2000; personal data). Only seven species are known from both the Crimea and the Caucasus but from nowhere else (i.e. they have Crimeo-Caucasian disjunct ranges). In this paper I consider when and where these species emerged in the faunas of the Crimea and Caucasus. A brief introduction to the palaeogeography of the region is required in order to understand these processes.

The mountainous Crimea and Caucasus Major appeared as islands in the Sarmat Sea 10-5.4 million years ago (Muratov 1973; Muratov et al. 1980; Ilkhan 1977; Didukh 1992); Caucasus Minor, Asia Minor and Balkan compounded the single massif. The Sarmat Sea covered the territories of the Recent southern Ukraine and the northern Crimean lowland (Novosad 1992). The climate of these territories was influenced by the sea. Temperatures during "July" were not below 20-25°C, and in "January" they did not fall below 8-10°C (Dolukhanov 1988). The vegetation type, from the coast to peaks, was *praeshibliak* of evergreen and deciduous plants: *Juniperus foetidissima, J. hemisphaerica, Arbutus andrachne, Cistus tauricus, Rhus coriaria* (Didukh 1992; Novosad 1992). Halophytic and littoral vegetation developed (Novosad 1992).

The southern Ukraine and the northern Crimean lowland rose above sea level 5.4-3.5 million years ago (Novosad 1992), and Asia Minor and Balkan became separated. During that time a land bridge between the Crimea and the north Caucasus probably existed (Andrusov 1926; Arkhangelskyi 1928; Vulf

1929; Novosad 1992). The climate was tropical, with alternate dry/cool and rainy seasons (Muratov 1960). The average temperature for "January" was not below 18°C; precipitation did not fall below 2000 mm per annum (Dolukhanov 1988). High-altitudinal vegetation zones based on *praeshibliak* developed (Didukh 1992).

The land bridge between the Crimea and southern Ukraine emerged 3.5-1.6 million years ago (Muratov 1970). Narrow straits connecting the Euxinian and the Caspian basins along the northern slope of the Caucasus Major mountain range arose twice (Dolukhanov 1988). Along these straits Turan and Kazakhstan halophyte and littoral species penetrated the Crimea and Caucasus (Novosad 1992). The climate became colder and dryer; 3.2 million years ago the average temperature for "January" fell to 5-10°C, and 2.5 million years ago it fell to 0°C (Dolukhanov 1988).

The land between the Crimea and the Caucasus in Kerch-Taman region probably became submerged 1.6 million – 800 thousand years ago (Kozyi 1954; Muratov 1960; Shnyukov et al. 1986; Novosad 1992). At this time, the coastal contours similar to those observed currently in the Crimea and the Caucasus were established. The average temperature for "January" was 5°C and "July" 25°C; precipitation was greater than 2500 mm per annum (Dolukhanov 1988).

A series of glaciations occurred 620-500 thousand years ago (Dolukhanov 1988). Displacement of vegetation zones to south, resulted in the penetration of boreal and nemoral species into the Crimea and Caucasus. In the Crimea the only refuge for the Miocene-Pliocene (Tertiary) flora and fauna was the Southern Coast of Crimea (Didukh 1992).

A period of warming occurred 500-350 thousand years ago. The average annual temperature in western Europe was 2°C higher than at present, in the Russian plain it was 6°C higher (Dolukhanov 1988). Nemoral vegetation was widely distributed (Didukh 1992). Exchange between the faunas of nemoral ecosystems from the Crimea, Caucasus and middle Europe was possible.

Another glaciation occured 350-250 thousand years ago. The ranges of nemoral and Mediterranean species were reduced. In the Crimea, nemoral species and *praeshibliak* vegetations with *Arbutus andrachne, Pistacia mutica, Quercus iberica, Paliurus spina-christi, Rhus coriaria* were conserved only in refugia along the southern coast of Crimea, which were protected from the north by mountains and moistened by the sea. The most thermophilic Crimean plant *Arbutus andrachne* can survive under an average January temperature of -1°C. Currently this isotherm is stretched at 700 m a.s.l. on the south macroslope, but during the glacial period it was located at 100-200 m a.s.l. (data from Ena 1986, cited in Didukh 1992). The Crimea and Caucasus were populated by boreal species from the north (for example, *Pinus kochiana* and *Betula pendula* in the Crimea).

An interglacial period occurred 130-120 thousand years ago (Dolukhanov 1988). In Europe the average temperature was 1.5-2°C higher than at present; the winters were not frosty. Dry-steppe species penetrated from Central Asia to the west. As a result of combining boreal and steppe species the specific vegetation of Crimean *yaila* was formed. In the second half of that Riss-Wurm Interglacial Period, when the climate became more humid, the Recent nemoral vegetation with *Quercus petraea, Cornus mas, Dentaria glandulosa* appeared in the Crimea. In the European lowland the southernmost range of the deciduous forests was 1-2° further south than at present. Crimean and Caucasian nemoral forests could merge with the forests of northern regions (Didukh 1992).

A new glaciation began 115 thousand years ago. Crimean and Caucasian areas of nemoral vegetation were definitely isolated. During that period the Recent steppe vegetation was formed in southern Ukraine and in the Crimean lowland (Didukh 1992). Ten thousand years ago the glaciation was finished

and the Recent flora and fauna were established.

MATERIAL AND METHODS

This paper is based on literature-derived data and the study of new material collected by the author from the Crimea during 1997-2001. Specimens used in this study are deposited in the following museum/personal collections: CB – personal collection of Dr. J. Buchar (Praha, Czech Republic); CR – personal collection of M. Rezac (Praha, Czech Republic); EMZ – personal collection of E.M. Zhukovets (Minsk, Belarus); TNU – Zoology Department, V.I. Vernadsky Taurida National University, N.M. Kovblyuk (Simferopol, Ukraine); VAG – personal collection of Dr. V.A. Gnelitsa (Sumy, Ukraine); ZMMU – Zoological Museum of Moscow State University, Dr. K.G. Mikhailov (Russia). The following abbreviations are used: m – male, f – female.

For each species, the current name (after Platnick 2000), references to all descriptions/redescriptions, material examined, habitats and collection data for the Crimea and Caucasus, and information about sibling species and their distribution are provided. Altitudinal distribution, collection data and geographical distribution of sibling species are provided in Table 1. These data when compared with the palaeogeography data for the Crimea and the Caucasus permit the generation of hypotheses regarding the origins of these species as components of the Recent faunas.

The author makes the following assumptions:

I. Spider species have constant ecological preferences.

Consequence 1. The Recent distributions of each species, especially those with a limited range, are associated with the favourability of ecological conditions at the time when they originated.

Consequence 2. Vegetation is a good indicator of ecological conditions. Spider species were formed during the same period, when the vegetation they inhabit was formed and isolated.

II. Spiders primarily expand their ranges by migration across land (narrow and disjunct ranges are not peculiar for aeronautic spider species).

Table 1. Altitudinal distribution and collecting time of Crimeo-Caucasian species and geographical distribution of their sibling species (after Charitonov 1937; Kharitonov 1941, 1947; Buchar 1966; Utochkin 1968; Ovtsharenko 1979; Tanasevitch 1987, 1990; Buchar & Thaler 1998; Zyuzin & Logunov 2000; personal data from Crimea).

	Altitude, m a.s.l.		Collecting time, month		Distribution of sibling species
	Crimea	Caucasus	Crimea	Caucasus	
Lepthyphantes khobarum	0-1200	1400-2750	mf: I-III; m: X, XII; f: V-VI.	mf: X-XI; m: VI; f: V, VII, IX	Caucasus: Azerbaijan; in caves from Yugoslavia, Greece, Bulgaria
Panamomops fedotovi	400-1100	750-2000	mf: VIII, X; m: V; f: VII, XII	mf: IV-V	middle Europe
Stemonyphantes agnatus	50-300	0-2000	mf: I-V, XI-XII; m: X.	mf: IV-V, X; f: VIII	Turkey
Pardosa buchari	900-1500	1400-3500	mf: VI-VII; f: VIII-IX	mf: VII-IX; f: VI	Caucasus: Azerbaijan
Pirata hurkai	500-600	500-1800	mf: VI-VII; f: VIII	mf: VI	Palaearctic
Tegenaria taurica	?	?	mf: IX-X; f IV-V	?	Caves from the Caucasus: Georgia; eastern Europe
Xysticus spasskyi	300-400	500-2500	mf: VI; m: VII	m: ?; f VII	Palaearctic

Consequence 1. Species (or their ancestors) have populated a given area by way of land, from areas where closely related species are currently distributed.

The characteristics of a range consist of three components (Gorodkov 1984, 1992; Logunov et Marusik 2000):

1. longitudinal (geographical) component, for example, Palaearctic, Crimeo-Caucasian.
2. latitudinal component (biogeographical/ vegetation/landscape zones), for example, boreal, nemoral, subtropical.
3. altitudinal component, for example, alpine, mountainous, plain.

As this paper concerns only those species with Crimeo-Caucasian disjunct ranges, in part, the discussion considers only two of these range components – latitudinal and altitudinal.

RESULTS

There are seven spider species with a Crimeo-Caucasian distribution: *Lepthyphantes khobarum* Charitonov, 1947; *Panamomops fedotovi* (Charitonov, 1937); *Stemonyphantes agnatus* Tanasevitch, 1990; *Pardosa buchari* Ovtsharenko, 1979; *Pirata hurkai* Buchar, 1966; *Tegenaria taurica* Charitonov, 1947; *Xysticus spasskyi* Utotschkin, 1968. The Crimean peninsula is the westernmost record for these species. Four spider species (*S. agnatus*; *P. buchari*; *P. hurkai*; *X. spasskyi*) are new for the Crimean and Ukrainian faunas.

Linyphiidae

Lepthyphantes khobarum Charitonov, 1947

Type locality: Crimea, Alushta Distr., south slope of Karaby massif, Tuvak cave (Kharitonov 1947: 49).

Kharitonov 1947 (f); Deeleman-Reinhold 1985 (f); Tanasevitch 1987 (mf), 1990 (mf).

Material examined (Ukraine, the Crimea):

Yalta, Martiyan Cape Reserve: Carpineto-Juniperetum (excelsae) ruscosum nudum, pitfall traps: 1m 7-15.01.2000, 1m 1f 15-29.01.2000, 1m 29.01.-5.02.2000. Arbuteto-Juniperetum (excelsae) cistoso-achnatherosum, pitfall traps: 2m 1f 7-15.01.2000, 1f 29.01.-5.02.2000, 1f 5-12.02.2000, 3f 26.02.-4.03.2000, 1f 4-11.03.2000, 1f 25.03.-1.04.2000, 1m 17-31.12.2000 (all in VAG), 1m 24.02.-10.03.2001, 1m 2f 10-24.03.2001 (all in ZMMU). Pineto-Quercetum (pubescentis) juniperoso (excelsae) – brachypodiosum, pitfall traps: 1f 29.01.-10.02.2001.

Yalta, Massandra Park: *Pistacia mutica* – silva rara, pitfall traps, 1f 25.02.-12.03.2001. Planting of *Bambusa*, pitfall traps, 1m 10.-24.03.2001.

Crimea State Natural Reserve: Nikitskaya Yaila plateau (Scrinita), steppe (*Festuca, Rosa*), pitfall traps: 1f 19-31.03.2001, 1f 25.05.-2.06.2001, 1m 17-27.10.2001. Nikitskaya Yaila plateau (Scrinita), *Pinus pallasiana, Quercus petraea, Carpinus betulus, Acer* forest, pitfall traps: 1m 30.09.-17.10.2001. Bukovsky's cordon, *Fagus* wood, under stones: 1f 12.06.2000 (all in VAG).

Habitats: The Crimea: in caves (Kharitonov 1947) and in the litter of *Fagus, Pinus, Quercus, Carpinus, Juniperus, Pistacia, Arbutus* forests and grasslands. The Caucasus: in the litter of *Abies, Picea, Fagus, Alnus, Quercus* forests and grasslands (Tanasevitch 1987, 1990).

Sibling species: *L. intirmus* Tanasevitch, 1987 from the Caucasus: Azerbaijan; *L. spelaeorum* Kulczynski, 1914 in caves in Western Yugoslavia, Greece, Western Bulgaria (Tanasevitch 1990).

Comments: 1). Platnick (2000) indicated that *L. khobarum* has a distribution range of "Russia, Central Asia". The references indicate that this species is not known in Central Asia. 2). The altitudinal distribution and phenology of *L. khobarum* in the Crimea and Caucasus seems to be different. We found small differences in bulbus structure in Crimean specimens, when compared with the drawings of Tanasevitch (1987: 312, figs 19-22). It is probable that the specimens from the Caucasus belong to a species closely related to *L. khobarum*. This problem requires further investigation.

Panamomops fedotovi (Charitonov, 1937)

Type locality: Crimea, Crimean State Natural Reserve, Alushta Distr., altitude 700-1100 m a.s.l., in dead cover of beech-forest (Charitonov 1937: 136).

Charitonov 1937 (mf); Tanasevitch 1978 (mf), 1990 (mf).

Material examined: Ukraine, the Crimea, Simferopol, western slope of Bitak Mt., Stipeto-Festucetum asphodelosum, pitfall traps: 1m 14-26.05.2000 (VAG).

Habitats: The Crimea: in the litter of *Fagus* wood (Charitonov 1937) and grasslands. The Caucasus: in the litter of *Fagus, Quercus, Platanus, Carpinus* forest (Tanasevitch 1987, 1990).

Sibling species: *P. inconspicua* Miller & Valesova, 1964 from middle Europe (Tanasevitch 1987).

Stemonyphantes agnatus Tanasevitch, 1990

Type locality: Caucasus, Georgia, Abkhazia, near Sukhumi, Verkhniaya Kelasury Vil., broad-leaved forest (Tanasevitch 1990: 36).

Tanasevitch 1990 (mf).

Material examined (Ukraine, the Crimea):

Yalta, Massandra Park: Planting of *Bambusa*, pitfall traps: 4f 8-16.03.2000 (TNU), 3m 16-23.03.2000 (VAG), 1m 23-30.03.2000, 3m 1f 31.03.-6.04.2000, 2f 12-20.04.2000, 1f 20-27.04.2000 (all in TNU), 1m 11-18.05.2000 (VAG), 3m 8-22.10.2000 (TNU), 1m 22.10.-12.11.2000 (VAG), 1m 1f 28.11.-13.12.2000, 1m 1f 13-24.12.2000 (all in TNU),, 1m 2f 24-31.12.2000, 7m 12f 31.12.-29.01.2001, 4m 5f 29.01.-11.02.2001 (all in VAG), 7m 4f 11-25.02.2001 (ZMMU), 5m 6f 25.02.-10.03.2001, 2m 1f 10-24.03.2001, 1m 1f 24.03.-3.04.2001, 1m 3-15.04.2001 (all in TNU), 2f 15-28.04.2001, 2f 28.04.-9.05.2001. Planting of *Cupressus*, pitfall traps: 2m 23-30.03.2000 (all in VAG). *Pistacia mutica* – silva rara, pitfall traps 1f 11-25.02.2001 (TNU).

Habitats: The Crimea: in the litter of a plantation of *Bambusa* and *Cupressus* and of *Pistacia mutica* forest. The Caucasus: in the litter of *Abies, Fagus, Pinus, Quercus, Ulmus, Carpinus, Acer, Parrotia* forests (Tanasevitch 1987, 1990).

Sibling species: *S. montanus* Wunderlich, 1978 and *S. abantensis* Wunderlich, 1978 both from Turkey (Tanasevitch 1990).

Lycosidae

Pardosa buchari Ovtsharenko, 1979

Type locality: Caucasus, Russia, Krasnodar Prov., Caucasus State Reserve, Pseashkho Mt., 2000 m a.s.l. (Ovtsharenko 1979: 48).

Ovtsharenko 1979 (mf); Buchar & Thaler 1998 (m); Zyuzin & Logunov 2000 (mf).

Material examined (Ukraine, the Crimea):

Simferopol Distr., near Pereval'noye Vil.: Malaya Burul'cha River, edge of *Fagus-Quercus-Carpinus* forest under the Yaila: 1f 15.06.1997. Yaila (plateau from mountainous region of Crimea): 6m 2f 5.06.1997. Near Mramornoye Vil., lake shore: 1f 21.06.1997. Chatyr-Dagh Massive: 1m 21.06.1997 (all in EMZ).

Crimean State Natural Reserve: Besedka Vetrov (= "Arbour of Winds"), under stones: 3m 9f 13.06.2000. Babugan Yaila: 4m 14.06.2000. Nikitskaya Yaila (Scrinita): *Pinus kochiana* forest, pitfall traps: 2m 3-14.07.2001, 7m 14-24.07.2001, 1m 1f 24.07.-6.08.2001, 1f 6-17.08.2001. *Zerna cappadocica* meadow, pitfall traps: 2m 12-23.06.2001, 20m 9f 23.06.-3.07.2001, 11m 3f 3-14.07.2001, 1m 3f 14-24.07.2001, 1m 24.07.-6.08.2001, 2f 6-17.08.2001, 1f 27.08.-8.09.2001. *Festuca-Rosa* steppe: 5m 1f 23.06.-3.07.2001 (all in TNU), 9m 7f (TNU) and 3m 3f (CR) 3-14.07.2001, 5m 21f 14-24.07.2001, 6f 24.07.-6.08.2001, 5f 6-17.08.2001, 1f 17-27.08.2001, 2f 27.08.-8.09.2001 (all in TNU).

Habitats: The Crimea: in mountainous steppe and meadows, and at the edge of *Fagus, Quercus, Pinus, Carpinus* forests. The Caucasus: in subalpine and alpine zones (*Salix, Betula* etc.) (Ovtsharenko 1979; Buchar & Thaler 1998).

Sibling species: *P. pirkuliensis* Zyuzin et Logunov, 2000 from the Caucasus: Azerbaijan (Zyuzin & Logunov 2000).

Pirata hurkai Buchar, 1966

Type locality: West Caucasus, Georgia, Abkhazia, Rica Lake, 925 m a.s.l. (Buchar 1966: 213).

Buchar 1966 (mf); Ovtsharenko 1979 (m); Mcheidze 1997 (mf).

Material examined: Ukraine, the Crimea, Crimean Natural State Reserve. Tar'er cordon, bank of Alma River, on the pebble riverbank: 6m 1f 30.06.2001 (TNU). Sosnovyi cordon, same habitat: 3m 3f 1.07.2001 (CB). Asport cordon, same habitat: 13 f 21.08.2001. On the road: 1f 1.07.2001 (all in TNU).

Habitats: The Crimea: on the stony banks of the mountainous Alma River in the mixed nemoral forest. The Caucasus: by the rivers in the *Abies* and *Fagus* forests (Buchar 1966; Ovtsharenko 1979).

Sibling species: *P. knorri* (Scopoli, 1763) from Western Palaearctic (Buchar, 1966).

Agelenidae

Tegenaria taurica Charitonov, 1947

Type locality: Crimea, Yalta Distr., Massandra cave (Esyunin & Farzalieva 2001: 261).

Kharitonov 1947 (mf); Mkheidze 1997 (mf); Esyunin et Farzalieva 2001 (mf).

Material examined: Ukraine, the Crimea. Yalta, on the wall in a flat, 1m 17.10.2001. Alushta Distr., E. edge of South Demerdji Mt. Massif, grotte, 1m 2f 12.10.2002 (all in TNU).

Habitats: The Crimea: in caves and buildings (Kharitonov 1947; personal data). The Caucasus: unknown.

Altitudinal distribution and phenology cannot be compared, because data from the Caucasus are not available.

Sibling species: *T. abchasica* Charitonov, 1941 from caves in the Caucasus: Georgia and *T. lapicidinarum* Spassky, 1934 from Ukraine including the Crimea and Polissya (northeastern Ukraine) (Kharitonov 1941; Yevtushenko 1991; Esyunin & Farzalieva 2001; personal data).

Comments: Esyunin & Farzalieva (2001) redescribed *T. taurica* from the syntypes (lectotype designated) and ignored Mkheidze's book. Perhaps the material of T.S. Mkheidze from Georgia belongs to another species. This problem requires further investigation.

Thomisidae

Xysticus spasskyi Utotschkin, 1968

Type locality: Caucasus, Krasnodar Prov., 1300 m a.s.l. (Utotschkin 1968: 35).

Utochkin 1968 (mf); Ovtsharenko 1979 (m); Mkheidze 1997 (m).

Material examined: Ukraine, the Crimea, Yalta, Nikita Vil., *Pinus pallasiana* forest, pitfall traps: 3m 3-11.06.2000, 4m 1f 11-17.06.2000, 2m 2f 25.06.-2.07.2000, 2m 2-9.07.2000 (all in TNU).

Habitats: The Crimea: in the litter of *Pinus pallasiana* forest. The Caucasus: in *Fagus* and *Abies* forests and in subalpine and alpine zones (Ovtsharenko 1979).

Sibling species: *X. sabulosus* (Hahn, 1832) and *X. gallicus* Simon, 1875 from Europe, the Caucasus, Middle Asia (Utochkin 1968).

DISCUSSION

A disjunct range and endemism are indications of the relict origin of a species. Apparently the seven species mentioned above, which inhabit the Crimea and Caucasus settled in these areas at different times and via different routes. These species can be divided into three categories according to time and mode of appearance:

1). *L. khobarum* and *S. agnatus* are Mediterranean species with Balkan / Asia Minor relations. Perhaps they are remnants from the subtropical fauna that inhabited the united massif of Balkan-Asia Minor-Caucasus and the Crimean Island in the Miocene (25-5 million years ago).

2). *P. buchari* is a boreo-montane species. It is probably a representative of the boreal fauna that existed during the Pliocene glaciation (some 3.4-3.2 million years ago).

3). *P. fedotovi*, *P. hurkai*, *T. taurica* and *X. spasskyi* – are subboreal (nemoral)-montane species with a mid-European origin. Perhaps

they populated the Crimea and Caucasus from the Russian Plain, when these areas became connected with each other at the beginning of the Quaternary Period, approximately one million years ago. At that time the subboreal (nemoral) species were widely distributed in the areas of the Crimea, Caucasus and the southern Russian Plain.

ACKNOWLEDGEMENTS

I would like to thank Mr. S.A. Dyadyushkin, Dr. K. G. Mikhailov and Mr. R. Slushaenko for their kind help in expeditions, Dr. Yu.M. Marusik for important remarks and corrections and Dr. K.G. Mikhailov for checking the draft. Special acknowledgements are due to Mr. P.E. Gol'din, who translated the earlier draft into English, and Dr. D. Penney who checked the English of the final draft.

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