Cytogenetic studies on seventeen spider species from Israel

O. Yu. Gorlova[1,2], I. P. Gorlov[1,2], E. Nevo[1] and **D. V. Logunov[3]**

[1]Institute of Evolution, University of Haifa, Mt. Carmel, Haifa 31905, Israel*

[2]Institute of Cytology and Genetics, Novosibirsk 630090, Russia

[3]Zoological Museum, Institute for Systematics and Ecology of Animals, Frunze Street, Novosibirsk 630091, Russia

Summary

Karyotypes are reported for 17 spider species in six families from Israel. Chromosome counts (2n) for males are as follows: Salticidae — *Philaeus chrysops, Euophrys pseudogambosa, Evarcha patagiata, Menemerus semilimbatus,* 28; *Menemerus illigeri*, 14; *Aelurillus politiventris*, 21; Lycosidae — *Alopecosa albofasciata*, 28; *Evippa praelongipes*, 26; *Lycosa nordmanni*, 22; Gnaphosidae — *Nomisia ripariensis, Pterotricha dalmasi, P. procera, Haplodrassus signifer*, 22; Miturgidae — *Prochora lycosiformis*, 24; Philodromidae — *Thanatus meronensis, Philodromus aureolus*, 28; Thomisidae — *Heriaeus setiger*, 23. Some peculiarities were found: (a) extremely low chromosome count (2n=12+XX) and metacentric chromosomes in *Menemerus illigeri*, (b) the presence of a heteromorphic bivalent composed of both metacentric and acrocentric elements in a karyotype of *Evippa praelongipes*, (c) heterozygosity for secondary constriction in a male of *Haplodrassus signifer*. C-staining revealed minute centromeric blocks of heterochromatin in *Alopecosa albofasciata*.

Introduction

Karyotypes of about 300 spider species have been described so far (Cokendolpher, 1989; Gorlov *et al*., 1995; Maddison, 1982; Sokolov, 1960, 1962; Suzuki, 1952; Tsurusaki *et al*., 1993; Tugmon *et al*., 1990; Wise, 1983; etc.).

The study of spiders' karyotypes is important for several reasons, e.g.

(1) Comparison of karyotypes of different species allows us, in some cases, to determine their taxonomic position more precisely, and also may be useful to clarify phylogeny.

(2) Studies of chromosomes can provide us with examples of unusual karyotypes, analysis of which may improve our knowledge about principles of karyotypic organisation.

Karyotypes of spiders inhabiting Israel have hardly been described at all. However, this region is very interesting from a zoogeographical point of view, because five climatic zones are represented in the territory of Israel and species diversity is very high (Levy, 1977, 1990, 1995).

This paper contains the first results of studies on karyotypes of common Israeli spiders, belonging to the families Salticidae, Lycosidae, Gnaphosidae, Miturgidae, Philodromidae and Thomisidae. The karyotypes of 16 species out of the 17 studied are reported for the first time (the karyotype of *Philodromus aureolus* has been studied previously by Hackman (1948)).

*Address for correspondence: O. Yu. Gorlova, Institute of Cytology and Genetics, 10 Acad. Lavrentiev str., Novosibirsk 630090, Russia.

Material and methods

Male spiders were collected during March–August 1995 from the following localities: Nahal Oren canyon (Mount Carmel), Makhtesh Ramon and Upper Nahal Zin (both in Central Negev). Altogether 118 specimens were collected, of which 68 were successfully karyotyped. To date, 32 specimens have been identified and their karyotypes are reported herein (see Table 1).

Meiotic chromosome preparations were made using the method of Cokendolpher & Brown (1985), with some modifications. C-staining was performed by the method described by Buno *et al*. (1994), with minor modifications.

Species from the spider families Gnaphosidae and Miturgidae were determined by Drs V. I. Ovtsharenko and N. I. Platnick (New York, USA), *Evippa praelongipes* was determined by Dr Yu. M. Marusik (Magadan, Russia), and remaining groups by Dr D. V. Logunov (Novosibirsk, Russia).

Results and discussion

Table 1 provides data on the karyotypes of the 17 Israeli spider species, including localities from which specimens were collected.

Family Salticidae

Karyotypes of 6 Israeli salticid species were studied. Four of them, *Philaeus chrysops* (Poda, 1761), *Euophrys pseudogambosa* Strand, 1915, *Evarcha patagiata* (O. P.-Cambridge, 1872) and *Menemerus semilimbatus* (Hahn, 1827), possess 13 bivalents and two sex chromosomes

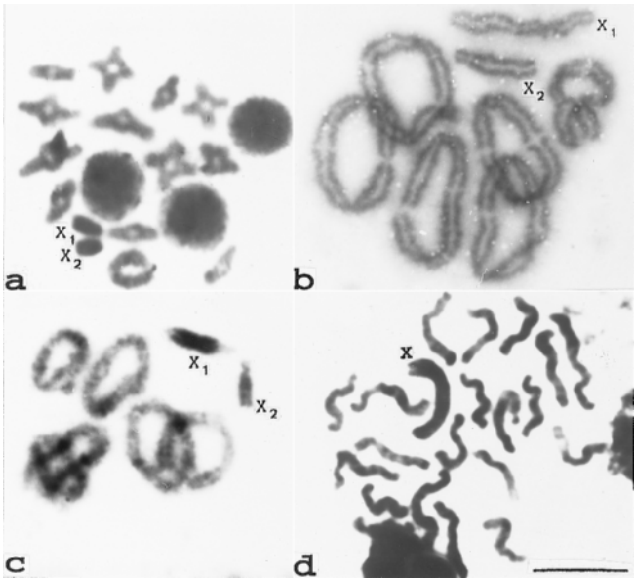

Fig. 1: Chromosomes of salticid spiders. **a** Diakinesis of *Menemerus semilimbatus*; **b, c** Routine and C-stained diakinetic chromosomes of *Menemerus illigeri*; **d** Early mitotic metaphase of *Aelurillus politiventris*. X_1, X_2, X=sex chromosomes. Scale line=10 μm.

Species	No. of autosomes/ no. of specimens	Sex determining mechanism	Locality
Salticidae			
Philaeus chrysops	26/2	XX	N.O.
Euophrys pseudogambosa	26/2	XX	N.O.
Evarcha patagiata	26/1	XX	N.O.
Menemerus illigeri	12/1	XX	M.R.
Menemerus semilimbatus	26/1	XX	N.O.
Aelurillus politiventris	20/1	X	N.O.
Lycosidae			
Alopecosa albofasciata	26/5	XX	N.O.
Evippa praelongipes	24/1	XX	M.R.
	[A heteromorphic bivalent is composed of both metacentric and acrocentric elements]		
Lycosa cf. *nordmanni*	20/2	XX	M.R.
Gnaphosidae			
Nomisia ripariensis	20/2	XX	N.O., U.N.Z.
Pterotricha dalmasi	20/5	XX	M.R.
Pterotricha procera	20/1	XX	U.N.Z.
Haplodrassus signifer	20/1	XX	U.N.Z.
Miturgidae			
Prochora lycosiformis	22/4	XX	N.O.
Philodromidae			
Thanatus meronensis	26/1	XX	N.O.
Philodromus aureolus	26/1	XX	N.O.
Thomisidae			
Heriaeus setiger	22/1	X	N.O.

Table 1: Karyotypes of 17 Israeli spider species. Localities: N.O.=Nahal Oren, Mount Carmel, M.R.=Makhtesh Ramon, U.N.Z.=Upper Nahal Zin.

usually of different length. All chromosomes were acrocentric and usually carried a single chiasma. A typical karyotype is shown in Fig. 1a. These species therefore typify the 2n=26+XX chromosomal count recognised to be the most common in the family (Mittal, 1965; Maddison, 1982; Datta & Chatterjee, 1983). A count of 2n=22+XX has hitherto been reported by Pinter & Walter (1971) as the lowest for the family, in *Phidippus audax* (Hentz, 1845), *P. johnsoni* (Peckham & Peckham, 1883) and *P. regius* C. L. Koch, 1846.

The karyotype of *Menemerus illigeri* (Savigny & Audouin, 1825) was found to consist of 6 pairs of long metacentric chromosomes. A majority of bivalents had two terminally located chiasmata, with these bivalents showing a circle-shaped configuration (Fig. 1b). C-staining has shown that sex chromosomes are almost completely heterochromatic except for small terminal regions. Small heterochromatin blocks were found on several autosomes (Fig. 1c). Hitherto, only acrocentrics have been reported from salticids (Hackman, 1948; Suzuki, 1954; Sokolov, 1962; Maddison, 1982; Tugmon *et al*., 1990). It appears that the karyotype of *M. illigeri* has evolved mainly as a result of multiple Robertsonian fusions.

Aelurillus politiventris (O. P.-Cambridge, 1872) showed 10 pairs of autosomes and one sex chromosome (Fig. 1d). The presence of only one sex chromosome is not common among Salticidae: of about 50 salticid species karyotyped, only four cases with n=11+XO are currently known: *Myrmarachne formicaria* (De Geer, 1778), reported by Hackman, 1948; *Myrmarachne bengalensis* Tikader, 1973, reported by Datta & Chatterjee, 1983; *Rhene indica* Tikader, 1973, reported by Datta & Chatterjee, 1983; and *Marpissa* sp. II, reported by Srivastava & Shukla, 1986.

Family Lycosidae

The karyotype of *Alopecosa albofasciata* (Brullé, 1832) was recognised as being typical of lycosid species: 2n=26+XX (males) (cf. Hackman, 1948; Gorlov *et al*., 1995). After C-staining, all meiotic bivalents showed minute centromeric blocks of heterochromatin, with both sex chromosomes being uniformly heterochromatic (Fig. 2).

An unusual karyotype was found in a single specimen of *Evippa praelongipes* (O. P.-Cambridge, 1870): there were 11 pairs of acrocentrics and one heteromorphic bivalent composed of both a metacentric and an acrocentric element (Fig. 3a,b). Thus, this specimen seems to be hemizygous for one chromosomal arm.

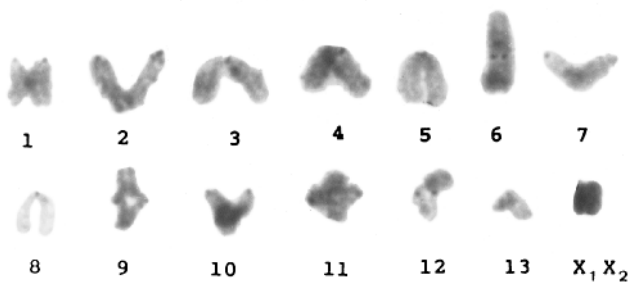

Fig. 2: C-stained bivalents of *Alopecosa albofasciata* (Lycosidae).

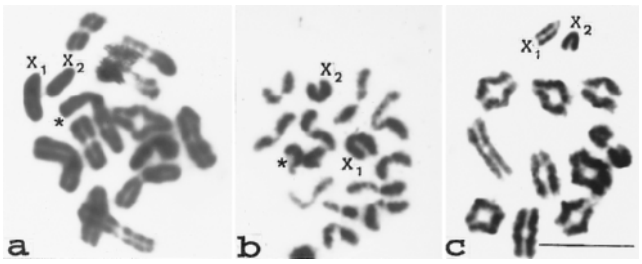

Fig. 3: Chromosomes of lycosid spiders. **a, b** Diakinesis and metaphase II of male *Evippa praelongipes*; a single metacentric chromosome is indicated with an asterisk; **c** Diakinetic chromosomes of male *Lycosa nordmanni*. X_1, X_2=sex chromosomes. Scale line=10 μm.

Lycosa cf. *nordmanni** (Thorell, 1875) also possessed a karyotype untypical of the genus: it showed 10 pairs of bivalents, not 13 as in other species (see Wise, 1983; Wise & Taylor, 1995), and a pair of sex chromosomes (Fig. 3c).

Family Gnaphosidae

Karyotypic data on Gnaphosidae are rather sparse in the literature (e.g. Hackman, 1948; Suzuki, 1952; etc.). According to Tugmon *et al*. (1990), only 13 different species have been examined. Four gnaphosid species from Israel were studied: *Nomisia ripariensis* (O. P.-Cambridge, 1872), *Pterotricha dalmasi* Fage 1929, *P. procera* (O. P.-Cambridge, 1874) and *Haplodrassus signifer* (C. L. Koch, 1839). They all showed the most common karyotype for the family: 2n=20+XX, with sex chromosomes being approximately of the same length. A single specimen of *H. signifer* was found to be heterozygous for secondary constriction on one of the autosomes (Fig. 4a).

Family Miturgidae

The karyotype of *Prochora lycosiformis* (O. P.-Cambridge, 1872) was found to consist of 11 pairs of autosomes and two sex chromosomes of slightly different length. In most cells the sex chromosomes showed the same degree of heteropycnosis as the autosomes (Fig. 4b).

Family Philodromidae

The karyotypes of *Thanatus meronensis* Levy, 1977 and *Philodromus aureolus* (Clerck, 1757, *sensu* Levy, 1977) (2n=26+XX) do not differ from each other, and are typical of the pattern reported hitherto for the family (Hackman, 1948; Suzuki, 1952; Tugmon *et al*., 1990). As an example, the karyotype of *P. aureolus* is shown in Fig. 4c. Sex chromosomes were found to be more darkly stained (more heteropycnotic) than autosomes.

*According to A. A. Zyuzin (pers. comm.), this is a new species related to both *Lycosa nordmanni* (Thorell, 1875) and *L. tarantula* (Linnaeus, 1758), but closer to the former. The species will be described by A. Zyuzin in a separate paper.

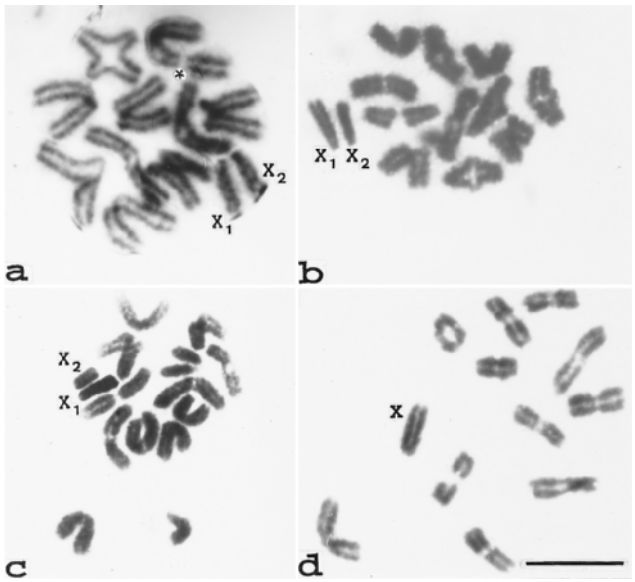

Fig. 4: **a** Diakinesis of *Haplodrassus signifer* (Gnaphosidae); bivalent heterozygous for a secondary constriction is marked with an asterisk; **b** Diakinesis of *Prochora lycosiformis* (Miturgidae); **c** Diakinesis of *Philodromus aureolus* (Philodromidae); **d** Diakinesis of *Heriaeus setiger* (Thomisidae). X_1, X_2, X=sex chromosomes. Scale line=10 μm.

Family Thomisidae

The karyotype of *Heriaeus setiger* (O. P.-Cambridge, 1872) was typical of crab spiders: 2n=22+X (Fig. 4d) (see Gorlov *et al*., 1995).

Conclusions

The karyotypes of the spider species studied were, in most cases, typical of their respective families. The most notable exception was *Menemerus illigeri*, which differs in both the chromosomal count and morphology from other salticids (even other species of *Menemerus*), probably as a result of multiple rearrangements, mainly Robertsonian fusions. Hemizygosity for a chromosomal arm found in *Evippa praelongipes* is also of great interest, because this finding shows spiders to be resistant to excess or deficiency of chromatin.

Acknowledgements

We wish to thank Drs V. I. Ovtsharenko and N. I. Platnick (New York, USA) and Dr Yu. M. Marusik (Magadan, Russia) for kind help in determining the specimens used in the current study, and Dr A. A. Zyuzin (Almaty, Kazakhstan) for discussing the taxonomic status of the *Lycosa* species. We are grateful to Dr E. Yu. Ivanitskaia for help in collecting spiders.

References

BUNO, I., TORROJA, E., LOPEZ-FERNANDEZ, C., BUTLIN, R. K., HEWITT, G. M. & GOSALVEZ, J. 1994: A hybrid zone between two subspecies of the grasshopper *Chorthippus parallelus* along the Pyrenees: the west end. *Heredity, Lond.* **73**: 625–634.

COKENDOLPHER, J. C. 1989: Karyotypes of three spider species (Araneae: Pholcidae: *Physocyclus*). *Jl N. Y.ent. Soc.* **97**(4): 475–478.

COKENDOLPHER, J. C. & BROWN, J. D. 1985: Air-dry method for studying chromosomes of insects and arachnids. *Ent.News* **96**(3): 114–118.

DATTA, S. N. & CHATTERJEE, K. 1983: Chromosome number and sex-determining system in fifty-two species of spiders from North-East India. *CIS Chromosome Inf. Serv.* **35**: 6–8.

GORLOV, I. P., GORLOVA, O. Yu. & LOGUNOV, D. V. 1995: Cytogenetic studies on Siberian spiders. *Hereditas* **122**: 211–220.

HACKMAN, W. 1948: Chromosomenstudien an Araneen mit besonderer Berücksichtigung der Geschlechtschromosomen. *Acta zool. fenn.* **54**: 1–101.

LEVY, G. 1977: The philodromid spiders of Israel (Araneae: Philodromidae). *Israel J. Zool.* **26**: 193–229.

LEVY, G. 1990: Spiders of the genus *Lachesana* and a new storenoid genus from Israel. *Zool. J. Linn. Soc.* **98**: 327–362.

LEVY, G. 1995: Revision of the subfamily Gnaphosinae in Israel (Araneae: Gnaphosidae). *J. nat. Hist.* **29**: 919–981.

MADDISON, W. P. 1982: XXXY sex chromosomes in males of the jumping spider genus *Pellenes* (Araneae: Salticidae). *Chromosoma* **85**: 23–37.

MITTAL, O. P. 1965: Karyological studies on the Indian spiders. II. An analysis of the chromosomes during spermatogenesis in five species belonging to the family Salticidae. *Res. Bull. Panjab Univ.* (Sci., N.S.) **15**: 315–326.

PINTER, L. J. & WALTER, D. M. 1971: Karyological studies. I. A study of the chromosome mechanism of three species of the genus *Phidippus* (Araneae: Salticidae, Dendryphantinae). *Cytologia* **36**(1): 183–189.

SOKOLOV, I. I. 1960: Studies on nuclear structures in spiders (Araneina). I. Karyological peculiarities in spermatogenesis. In: *The problems of cytology and protistology:* 160–186. Nauka, Moscow-Leningrad. (In Russian.)

SOKOLOV, I. I. 1962: Studies on nuclear structures in Araneina. II. Sex chromosomes. *Tsitologiya* **4**(6): 617–625. (In Russian.)

SRIVASTAVA, M. D. L. & SHUKLA, S. 1986: Chromosome number and sex-determining mechanism in forty-seven species of Indian spiders. *CIS Chromosome Inf. Serv.* **41**: 23–26.

SUZUKI, S. 1952: Cytological studies in spiders. II. Chromosomal investigation in the twenty-two species of spiders belonging to the four families, Clubionidae, Sparassidae, Thomisidae and Oxyopidae, which constitute Clubionoidea, with special reference to sex chromosomes. *J. Sci. Hiroshima Univ.* (Ser. B.) **13**: 1–52.

SUZUKI, S. 1954: Cytological studies in spiders. III. Studies on the chromosomes of fifty-seven species of spiders belonging to seventeen families, with general consideration on chromosome evolution. *J. Sci. Hiroshima Univ.* (Ser. B.) **15**(2): 23–136.

TSURUSAKI, N., IHARA, Y. & ARITA, T. 1993: Chromosomes of the funnel-web spider *Agelena limbata* (Araneae: Agelenidae). *Acta arachn. Tokyo* **42**(1): 43–46.

TUGMON, C. R., BROWN, J. D. & HORNER, N. V. 1990: Karyotypes of seventeen USA spider species (Araneae, Araneidae, Gnaphosidae, Loxoscelidae, Lycosidae, Oxyopidae, Philodromidae, Salticidae and Theridiidae). *J. Arachnol.* **18**: 41–48.

WISE, D. 1983: An electron microscope study of the karyotypes of two wolf spiders. *Can. J. Genet. Cytol.* **25**(2): 161–168.

WISE, D. & TAYLOR, J. L. 1995: On the mechanism of homologous synapsis in lycosid spiders. *Genome* **38**: 443–449.