

A chromosomal study of 11 species of *Psyllinea* (Insecta: Homoptera)

E.S. Labina

Zoological Institute, Russian Academy of Sciences, Universitetskaya nab. 1, St. Petersburg 199034, Russia.

E-mail: labina_e@mail.ru

Abstract. Meiotic karyotypes in males of 10 species (assigned to 5 genera and 3 subfamilies) of the family Psyllidae and one species of the family Triozidae are described for the first time. The first data on the genus *Crastina* are presented. All the species were shown to exhibit the usual (modal) psyllid karyotype of $2n = 24 + X$ except for *Craspedolepta villosa* and *Crastina myricariae*, in which $2n = 22 + X$ and $2n = 24 + XY$ are found respectively.

Key words: *Psyllinea*, karyotypes, sex chromosome systems.

INTRODUCTION

Psyllids or jumping plant-lice (Homoptera, Sternorrhyncha, Psyllinea) are widely distributed mono- or oligophagous phloem-sucking insects feeding on dicotyledonous plants. This suborder includes approximately three thousands species (Burckhardt, Kofler, 2004). Many psyllids are known to be pests of cultivated plants.

Although in the last few decades there has been considerable study of the taxonomy and phylogenetic relationships of psyllids, there is still much room for research in this area. Studies of karyotype and internal male reproductive system morphology are essential in obtaining further data for systematic research.

The karyotypes are presently known for 189 species of *Psyllinea*, i.e. 6.3% of the world psyllid fauna (reviewed by Maryanska-Nadachowska, 2002; see also Maryanska-Nadachowska, Glowacka, 2005; Labina et al., 2006). Most of the data obtained refer to the largest psyllid families Psyllidae and Triozidae. In the re-

maining three families only few species were investigated: 3 in Calophyidae, 2 in Carsidaridae, and 4 in Homotomidae. In the family Phacopterionidae no species has been examined cytogenetically.

Psyllids possess holokinetic chromosomes that are characteristic for Homoptera as a whole. The psyllid karyotypes show high uniformity. One hundred and sixty of the studied species (i.e., approximately 85%) exhibit 24 autosomes and one or two X-chromosomes in male and female complements respectively. This karyotype is considered ancestral for *Psyllinea* (Kuznetsova et al., 1995). In the psyllid species with diverging karyotypes the number of autosomes varies from 6 to 26, and sex chromosomes are either of XX/X0 or XX/XY types. Deviations occur in single species referred to groups with predominantly modal karyotypes and yet can also be characteristic for discrete genera and subfamilies. Spondiliaspidinae and Rhinocolinae with extremely low number of autosomes ranging from 6 to 12 with XX/X0 are a good case of point.



Table 1. Chromosome numbers and sex chromosome systems in males of 11 species of Psyllinea.

Taxa	2n	Collection localities	Number of preparations
Psyllidae Löw			
Aphalarinae Löw			
<i>Craspedolepta costulata</i> Loginova, 1962	2n = 24+X	Russia, Altai Resp.	1
<i>Craspedolepta villosa</i> Loginova, 1962	2n = 22+X	Russia, Altai Resp.	1
<i>Crastina myricariae</i> Loginova, 1964	2n = 24+XY	Russia, Altai Resp.	1
Arytaininae Crawford			
<i>Arytaina maculata</i> (Löw, 1886)	2n = 24+X	Italia, Sicily	1
<i>Arytainilla barbagalloi</i> Rapisarda, 1989	2n = 24+X	Italia, Sicily and Calabria	2
<i>Cyamophila appendiculata</i> (Klimaszewski, 1962)	2n = 24+X	Russia, Altai Resp.	2
<i>Cyamophila glycyrrhizae</i> (Becker, 1864)	2n = 24+X	Russia, Altai Resp.	1
<i>Livilla magna</i> Hodkinson et Hollis, 1987	2n = 24+X	Italia, Sicily	1
<i>Livilla spectabilis</i> (Flor, 1861)	2n = 24+X	Italia, Sicily	1
Psyllinae Löw			
<i>Psylla colorata</i> Löw, 1888	2n = 24+X	Bulgaria, vicinity of Sofia	3
Triozidae Löw			
Triozinae Löw			
<i>Triozia agrophila</i> Low, 1888	2n = 24+X	Russia, Altai Resp.	1

The objective of this paper is to provide additional information on the karyotypes of Psyllinea by communicating data on karyotypes of 11 further species assigned to the families Psyllidae and Triozidae.

MATERIAL AND METHODS

For investigation, adult males collected in Italy, Bulgaria and Russia were used. The species studied are listed in the Table 1, with taxonomic assignment, the place of collection, and the number of specimens from which chromosome preparations were obtained. Specimens were dropped live in freshly prepared Carnoy's fixative (glacial acetic acid: 96 % ethanol 1:3). The abdomen was separated from the body and dissected in a drop of 45% acetic acid. Testis follicles were extracted on a slide and squashed under a coverslip. After the examination with a phase-contrast microscope, the preparations with different stages of meiotic

divisions were made permanent with the use of the dry ice (Conger, Fairchild, 1953). The preparations were frozen on a block of dry ice, and the coverslip was removed with a sharp blade, after which the preparations were fixed in freshly prepared Carnoy and air-dried. The preparations were routinely stained using the Feulgen-Giemsa technique modified by Grozeva and Nokkala (1996) as described in an earlier paper of this series (Kuznetsova et al., 1997). In every species from 1 to 3 specimens and from 2 to 10 metaphases I and II with well spread chromosomes were studied.

RESULTS

Male meiotic karyotypes of 11 species are presented for the first time. Diploid chromosome numbers and sex determining chromosome systems are listed in Table 1.

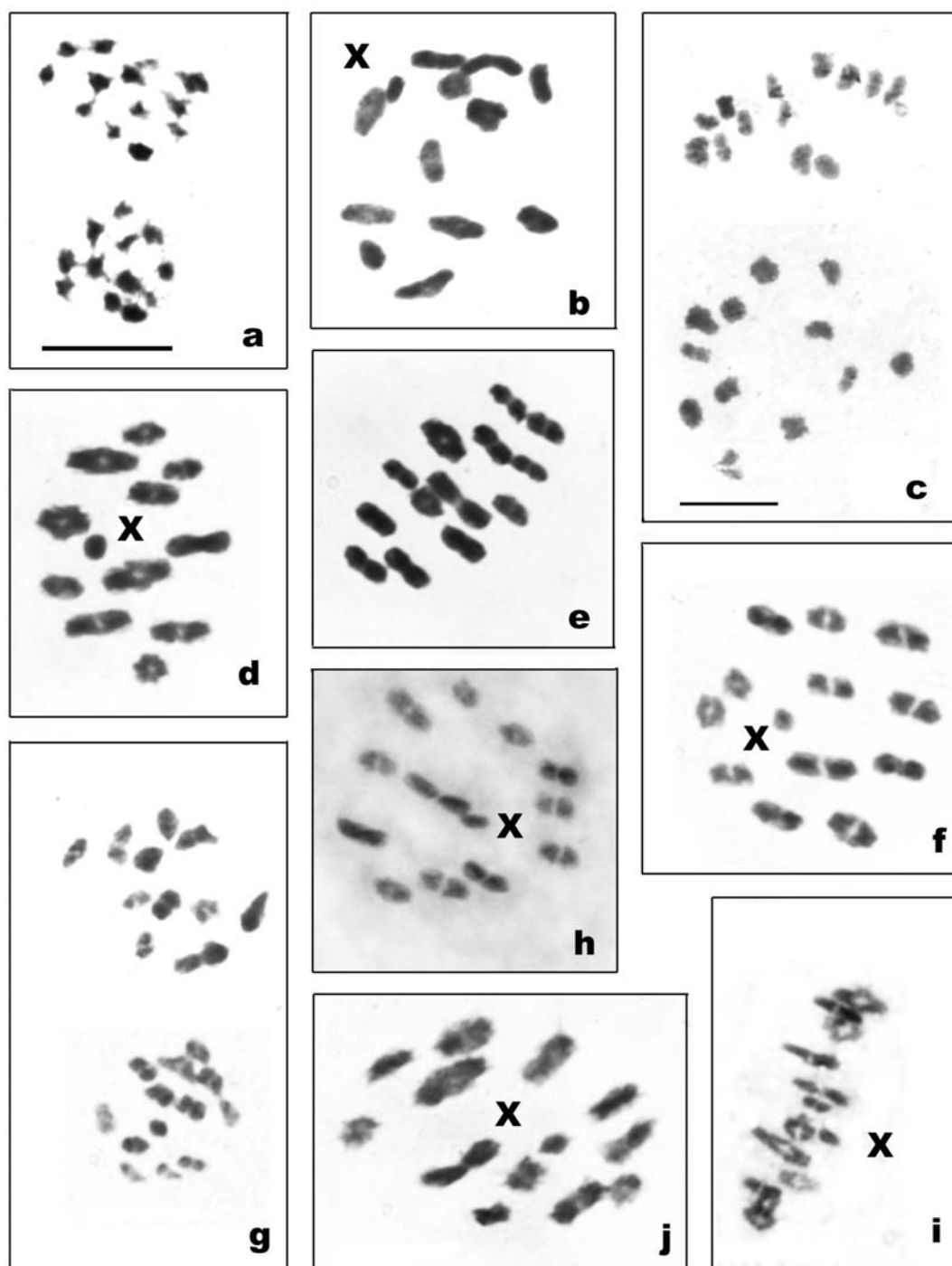


Fig. 1, a-j. Male meiotic karyotypes of psyllid species. **a** - *Arytaina maculata*, second metaphase. **b** - *Arytainilla barbagalloi*, first metaphase. **c** - *Craspedolepta costulata*, second metaphase. **d** - *C. villosa*, first metaphase. **e** - *Crastina myricariae*, first metaphase. **f** - *Cyamophila appendiculata*, first metaphase. **g** - *Cyamophila glycyrrhizae*, second metaphase. **h** - *Livilla magna*, first metaphase. **i** - *Psylla colorata*, first metaphase. **j** - *Trioza agrophila*, first metaphase. Bar = 100 μ m.

Supplementary information on male meiotic karyotypes is as follow:

Arytaina Förster, 1848

In *A. maculata*, spermatocyte sister metaphases II (MII) include 13 and 12 double-stranded chromosomes, with and without X-univalent, respectively (Fig. 1, a). Thus, this species possesses the karyotype $2n = 24 + XX/X0$. The chromosomes form a gradual size series, and the X is not recognisable among the autosomes.

Arytainilla Loginova, 1972

In *A. barbagalloi*, spermatocyte first metaphase (MI) includes 12 autosomal bivalents and a univalent X chromosome (Fig. 1, b). Thus, this species has $2n = 24 + XX/X0$. The bivalents form a gradual size series, and the X chromosome is close in size to the larger semi-bivalents. The bivalents each show only one chiasma, which can be terminal or subterminal.

Craspedolepta Enderlein, 1921

In *C. costulata*, sister MII include 12 and 13 double-stranded chromosomes, with and without the X-univalent, respectively (Fig. 1, c). Thus, this species has $2n = 24 + XX/X0$. The chromosomes form a gradual size series, and the X is not recognisable among the autosomes.

In *C. villosa*, MI includes 11 autosomal bivalents and a univalent X chromosome (Fig. 1, d). Thus, this species has $2n = 22 + XX/X0$. The bivalents represent a gradual size series, and the X chromosome is close in size to the middle-sized semi-bivalents. The bivalents show each one terminal or subterminal chiasma and form a kind of ring, with the X-chromosome in its centre.

Crastina Loginova, 1964

In *C. myricariae*, MI showed 13 bivalents suggesting XY chromosome system (Fig. 1, e). However none of bivalents was heteromorphic, then, the

XY bivalent was not distinguished from the autosomal bivalents in the numerous MI nuclei studied. This species karyotype is determined as $2n = 24 + XY$. The bivalents form a gradual size series, and show each one terminal or subterminal chiasma.

Cyamophila Loginova, 1976

C. appendiculata and *C. glycyrrhizae* show karyotypes $2n = 24 + XX/X0$. In the first species, MI includes 12 autosomal bivalents with one terminal or subterminal chiasma each, and a univalent X chromosome. The bivalents form a gradual size series (Fig. 1, f). The bivalents form a ring, with the X-chromosome in its centre. The X is close in size to the smaller semi-bivalents. Fig. 1, g presents sister MII of *C. glycyrrhizae* showing 12 and 13 double-stranded chromosomes, with and without X-univalent, respectively. The chromosomes represent a gradual size series.

Livilla Curtis, 1836

In *L. magna* and *L. spectabilis*, MI nuclei include 12 autosomal bivalents and a univalent X chromosome as shown for the first species in Fig. 1, h. The bivalents form a gradual size series. The X chromosome is close in size to the larger semi-bivalents. The largest bivalent and the X lie in the centre of a ring formed by the remaining bivalents. The bivalents show each one terminal or subterminal chiasma. The karyotypes of both species are determined as $2n = 24 + XX/X0$.

Psylla Geoffroy, 1792

In *P. colorata*, MI includes 12 autosomal bivalents and a univalent X chromosome suggesting $2n = 24 + XX/X0$ (Fig. 1, i). The bivalents form a gradual size series and show each one terminal or subterminal chiasma. The X chromosome is close in size to the middle-sized semi-bivalents.

Trioza Förster, 1848

In *T. agrophila*, MI includes 12 autosomal bivalents and a univalent X chromosome suggest-

ing $2n = 24 + XX/XO$ (Fig. 1, j). The bivalents with one terminal or subterminal chiasma each form a gradual size series, and the X chromosome is close in size to the smaller semi-bivalents. The bivalents form a ring, with the X-chromosome in its centre.

DISCUSSION

Of 11 species studied, 10 refer to 5 genera of 3 subfamilies of the family Psyllidae and only *Triozia pallida* belongs to the subfamily Triozinae of the family Triozidae. Nine species representing different taxonomic groups showed $2n = 24 + XX/XO$. *Craspedolepta villosa* and *Crastina myricariae* were shown to have $2n = 22 + XX/XO$ and $2n = 24 + \text{neo-XY}$, respectively. It is known that the karyotype $2n = 24 + XX/XO$ predominates in the large families Psyllidae and Triozidae (and is thus modal for these families), occurs in all so far studied representatives of the small families Calophyidae, Carsidaridae, and Homotomidae (Maryanska-Nadachowska, 2002; Maryanska-Nadachowska, Glowacka, 2005; Labina et al., 2006), and represents the putative initial karyotype for Psyllinea as a whole (Kuznetsova et al., 1995). The deviations from this karyotype occurring in Psyllidae are sometimes characteristic for the taxa of generic, tribal or subfamily ranks. The karyotype $2n = 22 + X$ has been recorded so far only for this family, where it occurs in three subfamilies (Riemann, 1966; Maryanska-Nadachowska, Glowacka, 2005; Labina et al., 2006), and is found for the first time in the subfamily Aphalarinae in *Craspedolepta villosa*. In the latter, bivalents form a gradual size series suggesting that the chromosome number reduction is a result of the fusion between two small autosomal pairs of the initial karyotype with $2n = 24 + XX/XO$.

The present paper provides the first contribution to the genus *Crastina* (Aphalarinae). *C. myricariae* was shown to have $2n = 24 + XY$. The sex bivalent is chiasmatic that suggests a neo-XY system. In some psyllid species referring to

the genera with predominantly modal karyotype the occurrence of the pseudobivalent is often accompanied by reduction of the number of autosomal pairs as in *Psylla corcontum* (Šulc, 1910), *Cacopsylla sorbi* (Linnaeus, 1758), and *C. mali* (Schmidberger, 1836) (Grozeva, Maryanska-Nadachowska, 1995; Maryanska-Nadachowska et al., 1992, 1996; Suomalainen, Halkka, 1963). As in *C. myricariae*, the neo-Y chromosome of these species chiasmatically associates with the originally autosomal part of the neo-X. It is notable however that the karyotype of *C. myricariae* retains the modal number of autosomes. The similar karyotype occurs in several species of the genus *Bactericera* Puton, 1876 from the family Triozidae (Labina et al., 2006). It was speculated that in this genus the karyotype $2n = 24 + \text{neo-XY}$ emerged through the fission of an autosomal bivalent in the originally modal karyotype ($2n = 24 + X$) followed by the X-autosome fusion (Kuznetsova et al., 1997). It can be presumed that the origin of the neo-XY is the same in *Bactericera* and *Crastina* suggesting independent arising of this sex chromosome system in different taxa of Psyllinea.

In MI of all species reported in this paper bivalents formed a gradual size series and formed each one terminal or subterminal chiasma. It is characteristic for holokinetic chromosomes to form only one or two chiasmata (Halkka, 1964; Nokkala et al., 2004) and such is the case in Psyllinea. Three chiasmata were recorded in the largest bivalent of the only psyllid species, *Baeopelma foersteri* (Flor, 1861). In this case however the cells with 3 chiasmata in this bivalent were unable to complete cytokinesis and eliminated because, while chiasmata near the telomeres were successfully released, chiasma in the middle was unable to resolve as a result of parallel orientation of chiasmatic loops (Nokkala et al., 2004).

In the first metaphase of the species studied the X-chromosome tended to take up central position, the phenomenon never reported so far in

Psyllinea, however repeatedly described in Heteroptera (Grozeva, Nokkala, 2001). It is noteworthy that in Auchenorrhyncha, which are closer to Psyllinea, the sex chromosomes behave differently being located far from autosomal bivalents in MI (Kuznetsova, 1985).

ACKNOWLEDGEMENTS

The author is grateful to V.G. Kuznetsova for valuable advice and assistance, A. Maryanska-Nadachowska for collecting of material from Italy and providing laboratory facilities in 2006, and S. Grozeva for collecting of material from Bulgaria. The present study was partly supported by the Russian Foundation for Basic Research, Grant 05-04-48387.

REFERENCES

- Burckhardt D., Kofler, A. 2004.** Weitere Funde von Blattflöhen aus Osttirol, Kärnten und dem Burgenland (Österreich) (Insecta: Hemiptera, Psylloidea) // *Beitr. Entomofaunistik*. 5: 9-16.
- Conger A.D., Fairchild L.M. 1953.** A quick-freeze method for making smear slides permanent // *Stain Technol.* 28: 289-293.
- Grozeva S., Maryanska-Nadachowska A. 1995.** Meiosis of two species of *Cacopsylla* with polymorphic sex chromosomes in males (Homoptera, Psyllidae) // *Folia Biol.* (Krakow). 43 (3-4): 93-98.
- Grozeva S., Nokkala S. 1996.** Chromosomes and their meiotic behaviour in two families of the primitive infraorder Dipsocoromorpha (Heteroptera) // *Hereditas*. 125: 31-36.
- Grozeva S., Nokkala S. 2001.** Chromosome numbers, sex determining systems, and patterns of the C-heterochromatin distribution in 13 species of lace bugs (Heteroptera, Tingidae) // *Folia Biol.* (Krakow). 49 (1-2): 29-41.
- Halkka O. 1964.** Recombination in six hemipteran families // *Evolution*. 18: 81-88.
- Kuznetsova V. G. 1985.** Phylogenetical analysis of the chromosome variability and karyosystematics of the leaf-hoppers of the family Dictyopharidae (Homoptera, Auchenorrhyncha) // *Entomol. Obozr.* 64 (3): 539-553.
- Kuznetsova V. G., Maryanska-Nadachowska A., Glowacka E., Da Silva P. G. 1995.** Karyotypes of ten species of Psylloidea (Homoptera) and some karyotaxonomical remarks // *Beit. Entomol.* 45: 383-391.
- Kuznetsova V. G., Nokkala S., Maryanska-Nadachowska A. 1997.** Karyotypes, sex chromosome systems, and male meiosis in Finnish psyllids (Homoptera: Psylloidea) // *Folia Biol.* (Krakow). 45 (3-4): 143-152.
- Labina E.S., Maryanska-Nadachowska A., Kuznetsova V.G. 2006.** Meiotic karyotypes in males of 19 species of Psylloidea (Homoptera) referred to the families Psyllidae and Triozidae // *Folia Biol.* (Krakow). 53 (3-4): 27-34.
- Maryanska-Nadachowska A. 2002.** A review of karyotype variation in jumping plant-lice (Homoptera, Psylloidea) and check-list of chromosome numbers // *Folia Biol.* (Krakow). 50 (3-4): 135-152.
- Maryanska-Nadachowska A., Glowacka E. 2005.** Meiotic karyotypes and structure of testes of nineteen species of jumping-lice (Hemiptera, Psylloidea) from South Africa // *Folia Biol.* (Krakow). 53 (3-4): 143-148.
- Maryanska-Nadachowska A., Kuznetsova V.G., Warchalowska-Sliwa E. 1992.** Karyotypes of Psyllina (Homoptera). I. New data and check-list // *Folia Biol.* (Krakow). 40 (1-2): 15-25.
- Maryanska-Nadachowska A., Kuznetsova V. G., Yang C.-T., Woudstra I. H. 1996.** New data on karyotypes and the number of testicular follicles in the psyllid families Aphalaridae, Psyllidae, Carsidaridae and Triozidae (Homoptera, Psylloidea) // *Caryologia*. 49 (3-4): 279-285.
- Nokkala S., Kuznetsova V.G., Maryanska-Nadachowska A. 2000.** Achiasmata segregation of a B chromosome from the X chromosome in two species of psyllids (Psylloidea, Homoptera) // *Genetica*. 108(2): 181-189.
- Nokkala S., Kuznetsova V.G., Maryanska-Nadachowska A., Nokkala C. 2004.** Holocentric chromosomes in meiosis. I. Restriction of the number of chiasmata in bivalents // *Chromosome Res.* 12: 733-739.
- Riemann J.G. 1966.** Chromosome numbers in the hackberry psyllids *Pachypsylla* and *Tetragonacephala* (Homoptera: Psyllidae) // *Ann. Entomol. Soc. Amer.* 5: 1088-1093.
- Suomalainen E., Halkka O. 1963.** The mode of meiosis on the Psyllina // *Chromosoma*. 14: 498-510.

Received September 11, 2007.

Accepted by V.G. Kuznetsova, November, 19, 2007.

Published December 28, 2007.