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Karyotypes of ten species of Psylloidea (Homoptera) and some karyotaxonomical remarks

With 10 figures

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Summary

Karyotypes of (*Livia juncorum, Aphalara maculipennis, Craspedolepta latior, Arytaina genistae, Psylla alpina, P. betulae, Calophya rubra, Bactericera reuteri, Trichochermes walkeri, Trioza vitiensis*) have been examined for the first time. The above species were found to share the same karyotype with 2n = 24 + X in males except *L. juncorum* with 2n = 22 + X. Based on all the 49 Psylloidea species karyotyped so far some karyotaxonomical problems are discussed.

Zusammenfassung

Die Karyotypen (*Livia juncorum, Aphalara maculipennis, Craspedolepta latior, Arytaina genistae, Psylla alpina, P. betulae, Calophya rubra, Bactericera reuteri, Trichochermes walkeri, Trioza vitiensis)* werden erstmalig untersucht. Neun Arten besitzen denselben Karyotyp 2n = 24 + X; eine Art (*L. juncorum*) 2n = 22 + X. Auf Grund der bisher erforschten 49 Arten der Psylloidea werden ausgewählte karyotaxonomische Probleme diskutiert.

Introduction

Up to 1992 karyotypes of only 14 juping-plant-lice species belonging to the families Spondyliaspididae (7), Psyllidae (6) and Triozidae (1) have been known. Among them 6 species were described from Europe (SUOMALAINEN & HALKKA, 1963), 7 from North America (WALTON, 1944, 1960; RIEMANN, 1966), while one species from India (BHATTACHARYA, 1972). Over recent years karyotypes of further 25 psyllid species from the families Aphalaridae, Psyllidae, Homotomidae and Triozidae were analyzed (MARYAŃSKA-NADACHOWSKA et al., 1992; MARYAŃSKA-NADACHOWSKA & HODKINSON, 1993; MARYAŃSKA-NADACHOWSKA et al., 1993). The present paper continuates the series of publications devoted to the Psylloidea karyotypes and includes the firstly obtained data on 10 species. These latter belong to 9 genera, 6 subfamilies

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and 4 families (Aphalaridae: Liviinae, Aphalarinae; Psyllidae: Arytaininae, Psyllinae; Calophyidae: Calophyinae; Triozidae: Triozinae). No representative of the family Calophyidae, the subfamily Liviinae and genera *Aphalara, Bactericera, Calophya, Livia* and *Trichochermes* was cytologically known previously.
The systematics follows WHITE & HODKINSON (1985).

Material and methods

Field collections of the material were made in Poland and Finland by E. GŁOWACKA, in Bulgaria by S. GROZEVA, in Switzerland by D. BURCKHARDT, in U.S.A. by P.G. DA SILVA. Larvae and young males while alive were fixed in the 1:3 acetic acid : alcohol and the material was stored in a refrigerator in the fixative until use. Karyological analysis was carried out on gonads dissected from insects, stained with acetic-orcein and squashed. The following list includes all individuals in which the chromosomal number was determined: *Livia juncorum* (2), *Aphalara maculipennis* (4), *Craspedolepta latior* (3), *Arytaina genistae* (4), *Psylla alpina* (1), *P. betulae* (4), *Calophya rubra* (4), *Bactericera rueteri* (5), *Trichochermes walkeri* (3), *Trioza vitiensis* (5).

Results

Aphalaridae LÖW
Liviinae LÖW
***Livia juncorum* (LATREILLE, 1798)**; $2n♂ = 22 + X$
Host plant: *Juncus* sp.
Material examined: Finland, Tvärminne

At first metaphase (MI) stages we observed 12 elements, among them 11 autosomal bivalents and an X- univalent; all chromosomes seemed to be rather small and gradually decrease in size. At first anaphase (AI) the X-chromosome was seen moving to one pole behind the autosomes (Fig. 1a). As result two types of second metaphases (MII) were found to form, one with 11 autosomes, another with 11 autosomes and the X-chromosome (Fig. 1b).

Aphalarinae LÖW
***Aphalara maculipennis* LÖW, 1886**; $2n♂ = 24 + X$
Host plant: *Polygonum* sp.
Material examined: Finland, Pojö

At MI 12 autosomal bivalents forming a gradually decreasing range and an X-univalent were observed. At AI the X-chromosome was always seen spliting into chromatids and moving to one pole beyond the autosomes (Fig. 2a); then it enters one of two daugther nuclea followed by appearence of MII nucleus with $n = 13$ whereas another MII nucleus includs 12 autosomes, only (Fig. 2b).

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Craspedolepta latior W. WAGNER, 1944; 2n♂ = 24 + X
Host plant: *Artemisia vulgaris*
Material examined: Finland, Tvärminne

At MI there are 12 bivalents and an unpared X chromosome, all chromosomes are rather large (Fig. 3a). The bivalents gradually decrease in size. The X chromosome is similar in size to the medium-sized elements, that also one can see in Fig. 3b, where two MII plates both with X-chromosome and without one are presented.

Psyllidae LÖW
Arytaininae CRAWFORD
Arytaina genistae (LATREILLE, 1804); 2n♂ = 24 + X
Host plant: *Sarothamnus scorparius*
Material examined: Poland, Pińczów

At MI there are 12 bivalents and an unpared X-chromosome; all chromosomes are rather large and form a gradually decreasinge range in size (Fig. 4a). The X-chromosome is similar in size to the medium-sized autosomes; at AI it is seen moving beyond the autosomes to one pole (Fig. 4b).

Psyllinae LÖW
Psylla alpina FÖRSTER, 1848; 2n♂ = 24 + X
Host plant: *Alnus viridis*
Material examined: Switzerland, Valais Tanay

No meiotic stages and only one spermatogonial metaphase were available for study. This latter is seen to show 25 chromosomes of a slightely different size, an X-chromosome being undetectable (Fig. 5).

Psylla betulae LINNAEUS, 1758; 2n♂ = 24 + X
Host plant: *Butula verrucosa* and *B. pubescens*
Material examined: Finland, Täktom near Hanko

At spermatocyte MI plates 12 autosomal bivalents and an X-univalent were observed, all chromosomes being rather large. At the early MI stage about 2 larger bivalents seem to be determined, however the distinguished size of these bivalents probably is attributed to their differential spiralization (Fig. 6a). At AI plates the X-chromosome is seen spliting into chromatids and moving to one pole behind autosomes (Fig. 6b).

Calophyidae VONDRAČEK
Calophyinae VONDRAČEK
Calophya rubra (BLANCHARD, 1852); 2n♂ = 24 + X
Host plant: *Schinus molle*
Material examined: U.S.A., California, Cal Alamada Co, UC Campus. A pest introduced from South America.

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At MI there are 12 autosomal bivalents and an X-univalent (Fig. 7a). The chromosomes are very small, they gradually decrease in the size and the X is one of the smallest member of the set. At AI stage an X-univalent is always visible as lagging and moving to one pole beyong the autosomes (Fig. 7b). As result two types of MII, with 12A and 12A + X, respectively, are formed (Fig. 7c).

Triozidae LÖW
Triozinae LÖW
***Bactericera reuteri* (ŠULC, 1913)**; 2n♂ = 24 + X
Host plant: *Potentilla anserina*
Material examined: Finland, Täktom near Hanko

At MI the 12 bivalents and an X-univalent are present (Fig. 8a). All chromosomes are rather large; among them two autosomal bivalents seem to differ from the rest in size. The X-chromosome is an univalent and a smallest element of the set. In Fig. 8b one can see an early AI stage with the lagging X-chromosome. Fig. 8c shows the late AI stage as well as two telophase nuclea.

***Trichochermes walkeri* (FÖRSTER, 1848)**; 2n♂ = 24 + X
Host plant: *Rhamnus catharctica*
Material examined: Bulgaria, Melnik

In Fig. 9 one can see a diakinesis with the 12 autosomal bivalents and an X-univalent; all chromosomes are of the middle size, the X-chromosome being one of the smallest member of the set.

***Trioza vitiensis* (KIRKALDY, 1907)**: 2n♂ = 24 + X
(= *Trioza eugeniae* CRAWFORD, 1915)
Host plant: *Sysygium* sp.
Material examined: U.S.A., California, Cal Alamada Co, UC Campus

At MI there are 12 bivalents and an X-univalent; all chromosomes are rather small, the X chromosome is near in size to the larger members of the set (Fig. 10).

Discussion

Although the species examined in this work seem to be not a few in number and they assign to the unrelated taxa all of them apart from one were found to share the same karyotype, 2n = 25 (24+X). *L. juncorum* having the lower chromosome number, 2n = 23 (22+X) is the only exception. As regards the species with the same karyotype pattern no reliable differences, with the exception of some in the chromosome size have been found between them using the routine method of chromosome staining. Some species such as *T. vitiensis* and, especially, *Calophya rubra* seem to have much more small chromosomes in comparison with all the other above species. At the present time we can not identify a cause of this phenomenon. Besides, the species, including the closely relative ones, although even have the same chromosome number

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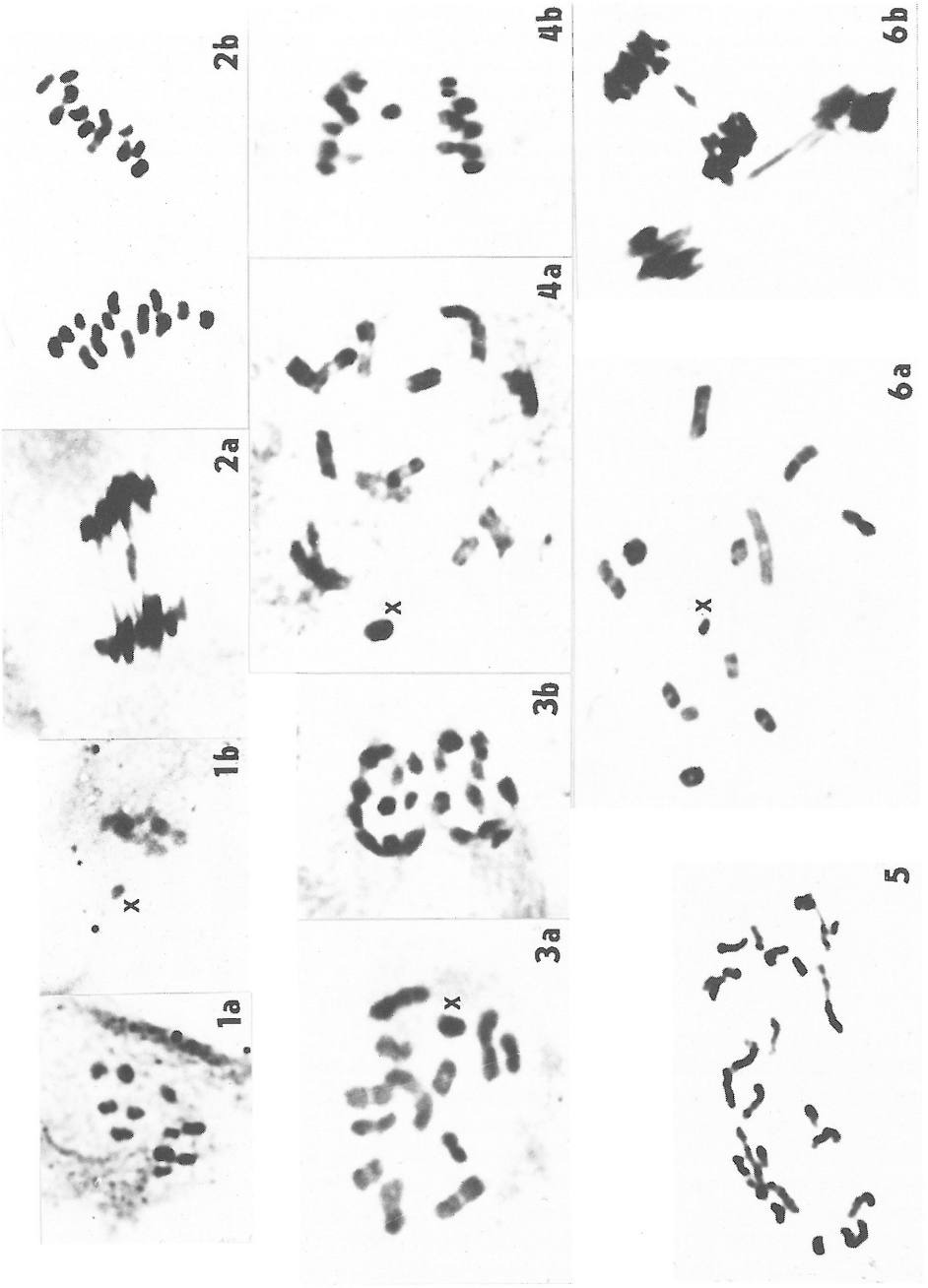

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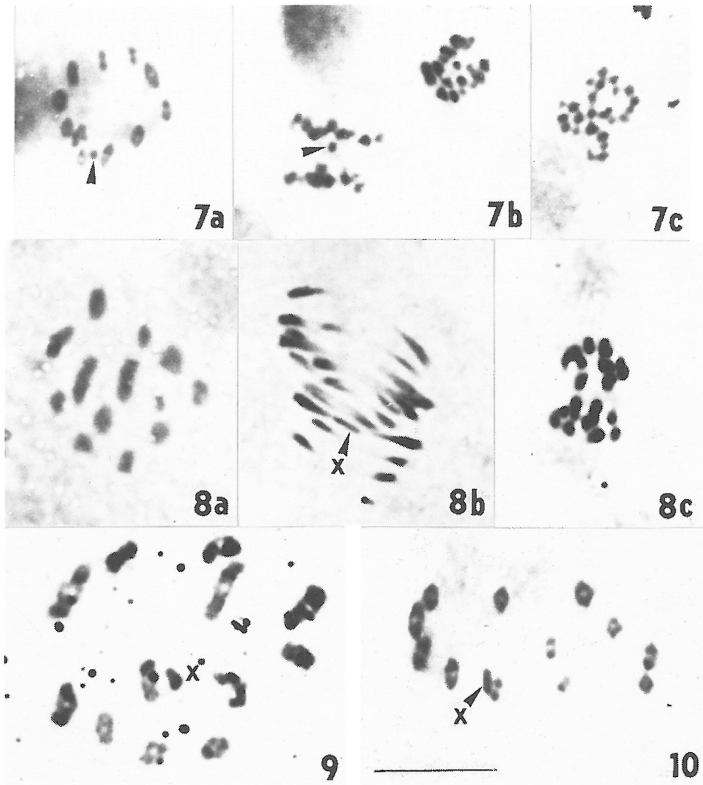
Fig. 1: *Livia juncorum:* (a) first anaphase, (b) second metaphase. - **Fig. 2:** *Aphalara maculipennis*: (a) first anaphase, (b) second metaphase. - **Fig. 3:** *Craspedolepta latior*: (a) first metaphase, (b) first anaphase. - **Fig. 4:** *Arytaina genistae*: (a) first metaphase, (b) first anaphase. - **Fig. 5:** *Psylla alpina*: spermatogonial metaphase. - **Fig. 6:** *Psylla betulae:* (a) first metaphase, (b) first anaphase. - **Fig. 7:** *Calophya rubra*: (a) first metaphase, (b) first anaphase, (c) second metaphase. - **Fig. 8:** *Bactaricera rueteri*: (a) first metaphase, (b) first anaphase, (c) late first anaphase. - **Fig. 9:** *Trichochermes walkeri*: late diakinesis. - **Fig. 10:** *Trioza vitiensis*: first metaphase. Bar equals 10μm and concerns all figures.



probably differ (and we have seen it not once) with respect to chromosome sizes because of the rearrangements, however this assumption to be proved needs in the special analysis.

The above noted uniformity of the chromosome numbers among species examined seems to reflect that characteristic of the Psilloidea as a whole. In this context it is any deviations which should be taken into account both when considering taxonomically unclear cases and when reconstructing phylogeny. It therefore seems opportune to rewiew the variations now known to occur in karyotypes at different taxonomic levels within the Psylloidea. Summarizing all information available the karyotypes of 49 species (which is about 2% of the known species of psyllids) from 24 genera and 6 families (from the whole of 8 families taken by WHITE & HODKINSON, 1985) of Psylloidea are known at present (for references see review by MARY-

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AŃSKA-NADACHOWSKA et al., 1992; MARYAŃSKA-NADACHOWSKA & HODKINSON, 1993; MARYAŃSKA-NADACHOWSKA et al., 1993; present paper). The families are studied to a different degree. A bulk of data belongs to the large families Aphalaridae (15 species, 10 genera, 6 subfamilies) and Psyllidae (16 species, 4 genera, 3 subfamilies). In the family Triozidae 8 species from 4 genera of the Triozinae, while in the family Spondyliaspididae - 7 species from 2 genera of the Pachypsyllinae have been karyotyped. Within the small families Homotomidae and Calophyidae only 2 species from the genus *Homotoma* and 1 species of the genus *Calophya*, respectively, have been karyologically studied. The data on the families Phacopteronidae and Carsidaridae are entirely lacking.

In a recent publication (MARYAŃSKA-NADACHOWSKA et al., 1992) we had surveyed the data available by that time and argued the the karyotypic patterns characteristic of the Psylloidea as whole. Although the number of karyotyped species has been increased since then more that twofold the newly obtained data support the previously made conclusions. The data suggest that the chromosome numbers in the Psylloidea range from 11 to 27 in the male set and sex chromosomes are of the XX/X0 and XX/XY - types, the wast majority of species having 2n = 25 (33 species, 68% of the karyotyped ones) and X0- sex chromosome system (95%). Although 49 species karyotyped up to date represent only a small proportion of the existing fauna it looks probable that the karyotype 2n = 25 (24+X), as found in all studied families including the most primitive Aphalaridae, was the ancestral one in the evolutionary stock which gave rise to the Psylloidea as a whole. All the usual processes of chromosomal evolution were likely to occur in the Psylloidea, but the fusions seemed to have been much more frequent or at least, more successful.

The distribution of chromosome numbers in the Psylloidea is clearly asymmetric about the modal. Only in two species of *Pachypsylla* (Spondiaspididae) the chromosomes number is higher than the modal one (2n = 27 in males). All the other deviations from the modal are at the minus side (these latter are 2n = 24 (22+XY), 2n = 23 (22+X), 2n = 22 (20+XY), 2n = 21 (20+X), 2n = 17 (16+X), 2n = 15 (14+X), 2n = 13 (12+X) and 2n = 11 (10+X)); that is, up to 14 chromosomes below the modal number. All these deviations have probably resulted from the autosome fusions or, sometimes, from the X-autosome fusions. These latter, having occurred in ancestral karyotypes with XO, have probably given rise to the XY-sex system in *Psylla corcontum*, 2n=20+XY, *P. mali*, 2n=22+XY and in one of the forms of *Pachypsylla celtidisgemma*, 2n=20+XY (see MARYAŃSKA-NADACHOWSKA et al.,1992).

The same modal number being characteristic of all the studied families of the Psylloidea, the chromosome numbers do not give much information for considering classification of the Psylloidea at the family level and phylogenetic relationships between the families. On the other hand, within some families, the differences in karyotypes correlate with accepted subfamilies. For example, in the Aphalaridae, all the studied representatives of the subfamily Rhinocolinae have remarkably low chromosome numbers (2n = 13, *Agonoscena* and *Lisronia*; 2n = 11, *Rhinocola*) which are unique for the Psylloidea. Two more aphalarid subfamilies, the Diaphorininae and Liviinae, also differ from the other Aphalaridae in lower chromosome numbers (2n = 21 in the diaphorinins, *Psyllopsis* and *Ctenarytaina*; 2n = 23 in the liviin genus *Livia*), though studies of more species from these subfamilies are still desirable. As concerns the Rhynocolinae, another distinguishing feature of this group is the one-follicle reproductive system (GŁOWACKA et al., in press). Such a pronounced difference between the Rhinocolinae and the other subfamilies suggests that phylogenetic realtions of this group may need a revision.

In all the studied genera of the Psylloidea, including those in which many species have been

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already examined, only few species deviate from the chromosome number modal for a genus. For the majority of the genera this modal number is 2n = 25, XO. Only few genera (see above) have different modal numbers. It is worth mentioning that within some genera one or more species may notably differ in the karyotype from the others. For instance, four species in the genus *Psylla* share the modal karyotype 2n=25 (24+X), while *P. corcontum* has 2n = 22 (20+XY) (SUOMALAINEN & HALKKA, 1963). Similarly, five karyotyped species from the genus *Cacopsylla* have 2n = 25, while *C. mali* possesses 2n = 24 (22+XY) (MARYAŃSKA-NADACHOWSKA et al., 1992). Finally, *Trioza ilicina* is characterized with 2n = 15 (14+X), while five other representatives of this genus share 2n = 25 (MARYAŃSKA-NADACHOWSKA & HODKINSON, 1993; this paper).

For some taxa, probable explanations of the differences in the chromosome numbers may be suggested. All the Rhinocolinae species (2n = 13 and 11) seem to have long chromosomes of similar size while in psylloidean species with the modal chromosome number, the chromosomes are usually shorter and form a clear decreasing range. The Rhinocolinae has presumably accumulated 14 autosomal fusions in their evolution since they diverged from ancestral aphalarid psyllids with 25 chromosomes.

At the species level, the differences in karyotypes comprise characters which cannot be ignored. For example, *Pachypsylla celtidiscucurbita* RILEY (Spondyliaspididae) cannot be synonymizied with *P. celtidismamma* FLETCHER bacause they have pronouncedly different karyotypes (WALTON, 1944; RIEMANN, 1966).

In some localities, *Beopelma foersteri* (Psyllidae) has the karyotype with 2n = 15 (14+X) and one very large autosome pair (SUOMALAINEN & HALKKA, 1963; our unpublished data), whereas in other areas 2n = 25 (24+X) without an increased chromosome has been found (MARYAŃSKA-NADACHOWSKA et al., 1992; unpublished data). Similarly, 2n = 25 has been reported for *Cacopsylla ulmi* from Finland (SUOMALAINEN & HALKKA, 1963), whereas 2n = 17 has been observed in specimens from the south of Poland (MARYAŃSKA-NADACHOWSKA et al., 1992). Such differences may indicate that the corresponding species are artificial. It is in such situations that karyotaxonomical studies are most promising.

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