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Meiotic Karyotypes and Structure of Testes of Nineteen Species of Jumping-lice (Hemiptera, Psylloidea) from South Africa

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The karyotypes of 19 species of Psylloidea from South Africa belonging to subfamilies Paurocephalinae, Euphyllurinae, Diaphorininae, Euphalerinae, Acizziinae, Ciriacreminae (Psyllidae), Calophyinae (Calophyidae) and Triozinae (Triozidae) were studied for the first time. In 16 species the modal diploid number of chromosomes was found to be 2n=24+X, while 3 species have other chromosome numbers. In *Colophorina* sp. the chromosomal set consists of 2n=22+X while in *Peripsyllopsis speciosa* 2n=8+X; the latter being one of the lowest numbers of chromosomes described in psyllids so far. On the other hand, *Pauropsylla tricheata* is the first species characterized by a chromosomal number higher than the modal one, 2n=26+X. The male gonads of 18 species were described. In 15 of these each testes consisted of two follicles and spermatocystes were arranged in one row. This structure is typical for the majority of psyllid species. Polymorphism in the number of testicular follicles in *Calophya shini* (2-3 follicles) was revealed. In two species, *Trioza carvalhoi* and *T. thibae*, each testis consists of a single follicle with spermatocystes arranged in two rows.

Key words: Psylloidea, karyotypes, structure of testes.

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Jumping plant-lice (Psylloidea) currently include nearly 3000 described species (BURCKHARDT & BASSET 2000) and are distributed in all parts of the world, although mainly in the Oriental region and in the tropics. However, their biogeographical diversity is unequal for all families. The systematics of Psylloidea is still a matter of discussion. The last 20 years have brought numerous papers on the classification of the superfamily based mainly on analyses of characters of larvae and adult insects, geographical distribution and their relationships with host plants (WHITE & HODKINSON 1985; HOLLIS 1987a, 1987 b; BURCKHARDT 1987a, 1987b, 1988; BURCKHARDT & LAUTERER 1987, 1997; BURCKHARDT & MIFSUD 1998; HODKINSON & BIRD 2000; MIFSUD & BURCKHARDT 2002). However, numerous taxonomic questions and phylogenetic relationships within Psylloidea remain unresolved. Studies of chromosome variation and differences in morphology of the internal male reproductive system are a source of new data which may be useful in clarifying some taxonomic and phylogenetic problems.

In psyllids, karyotypes of 153 species (i.e. approximately 5% of the world fauna of these insects) belonging to 52 genera are known (MARYAŃSKA-NADACHOWSKA 2002). Most of the karyological data concern representatives of Psyllidae and Triozidae, whereas Calophyidae, Homotomidae and Carsidaridae have been relatively poorly studied. Species belonging to Phacopteronidae have not been studied at all.

Data on the number of follicles and arrangement of their spermatocyte cysts exist for 141 psyllid species (GŁOWACKA *et al*. 1995; MARYAŃSKA-NADACHOWSKA *et al*. 1996; GŁOWACKA & MARYAŃSKA-NADACHOWSKA 1997; GŁOWACKA & MARYAŃSKA-NADACHOWSKA 1998). Additionally, for a further 29 species only the number of follicles is known (MARYAŃSKA-NADACHOWSKA *et al*. 2001a, 2001b).

In this paper karyotypes of nineteen species and the testes structure of eighteen species belonging to three families of Psylloidea are described.

Material and Methods

Field collection of the material was carried out in South Africa by E. GŁOWACKA. Species belonging to subfamilies Paurocephalinae, Euphyllurinae, Diaphorininae, Euphalerinae, Acizziinae, and Ciriacreminae (all belonging to Psyllidae), Calophyinae (Calophyidae) and Triozinae (Triozidae) were studied. For 19 species data on karyotypes, number of testicular follicles and spermatocyst arrangement inside follicles were obtained (Table 1).

Specimens for karyological and anatomical studies were fixed in an ethanol-glacial acetic acid solution (3:1). For karyological analysis male gonads were extracted from the abdomen, separated and squashed in a drop of 45% acetic acid. Afterwards, cover slips were removed by the dry ice technique (CONGER & FAIRECHILD 1953). Slides were air- dried and stained by a standard Feulgen-Giemsa procedure.

For anatomical studies, complete reproductive organs were dissected and histological slides were prepared according to the method elaborated by GŁOWACKA (1975).

Results and Discussion

The karyotypes of nineteen species are described for the first time (Table 1), and for 16 of these, the diploid number of chromosomes is 2n = 24+X. At meiotic first metaphases (MI) 12 autosomes and the X univalent are visible. Chromosomes of the set gradually decrease in size in every species (Fig. 1b-e & i). Karyotypes with a lower

Table 1

Chromosome numbers, number of follicles and arrangement of the spermatocyte cysts in species of Psylloidea from South Africa

Taxa	Chromosome numbers	Number of testicular follicles	Number of spermatocyste rows
Psyllidae Löw			
Paurocephalinae Becker-Migdisova			
Paurocephala hottentoti Pettey, 1924	24 + X	2	1
Paurocephala bicarinata Pettey, 1924	24 + X	2	1
Paurocephala sp. n	24 + X	2	1
Euphyllurinae Becker-Migdisova			
Euphyllura longiciliata Silvestri, 1915	24 + X	2	1
Diaphorininae Vondraček			
Diaphorina acokantherae Pettey, 1924	24 + X	2	1
Diaphorina helichrysi Capener, 1970	24 + X	2	1
Diaphorina loranthi Capener, 1973		2	
Diaphorina petteyi Capener, 1970	24 + X	2	1
Diaphorina virgata Capener, 1970	24 + X	2	1
Peripsyllopsis speciosa (Capener, 1973)	8 + X	2	1
Euphalerinae Becker-Migdisova			
Euphalerus isitis (Cotes, 1893)	24 + X	2	1
Colophorina sp. n.	22 + X	2	1
Acizzinae White & Hodkinson			
Acizzia uncatoides Ferris & Klyver, 1932*	24 + X	3	1
Ciriacreminae Enderlein			
Ciriacremum capense Enderlein, 1923	24 + X	2	1
Calophyidae Vondraček			
Calophyinae Vondraček			
Calophya schini Thuthill, 1959	24 + X	2, 3	1
Triozidae Löw			
Triozinae Löw			
Trioza afrobsoleta Hollis, 1984	24 + X	2	1
Trioza carvalhoi Hollis, 1984	24 + X	1	2#
Trioza thibae Hollis, 1984	24 + X	1	2#
Pauropsylla tricheata Pettey, 1924	26 + X	2	1

* Described for the first time from Italy (MARYAŃSKA-NADACHOWSKA *et al.* 1994; GŁOWACKA *et al.* 1995); # two or more rows

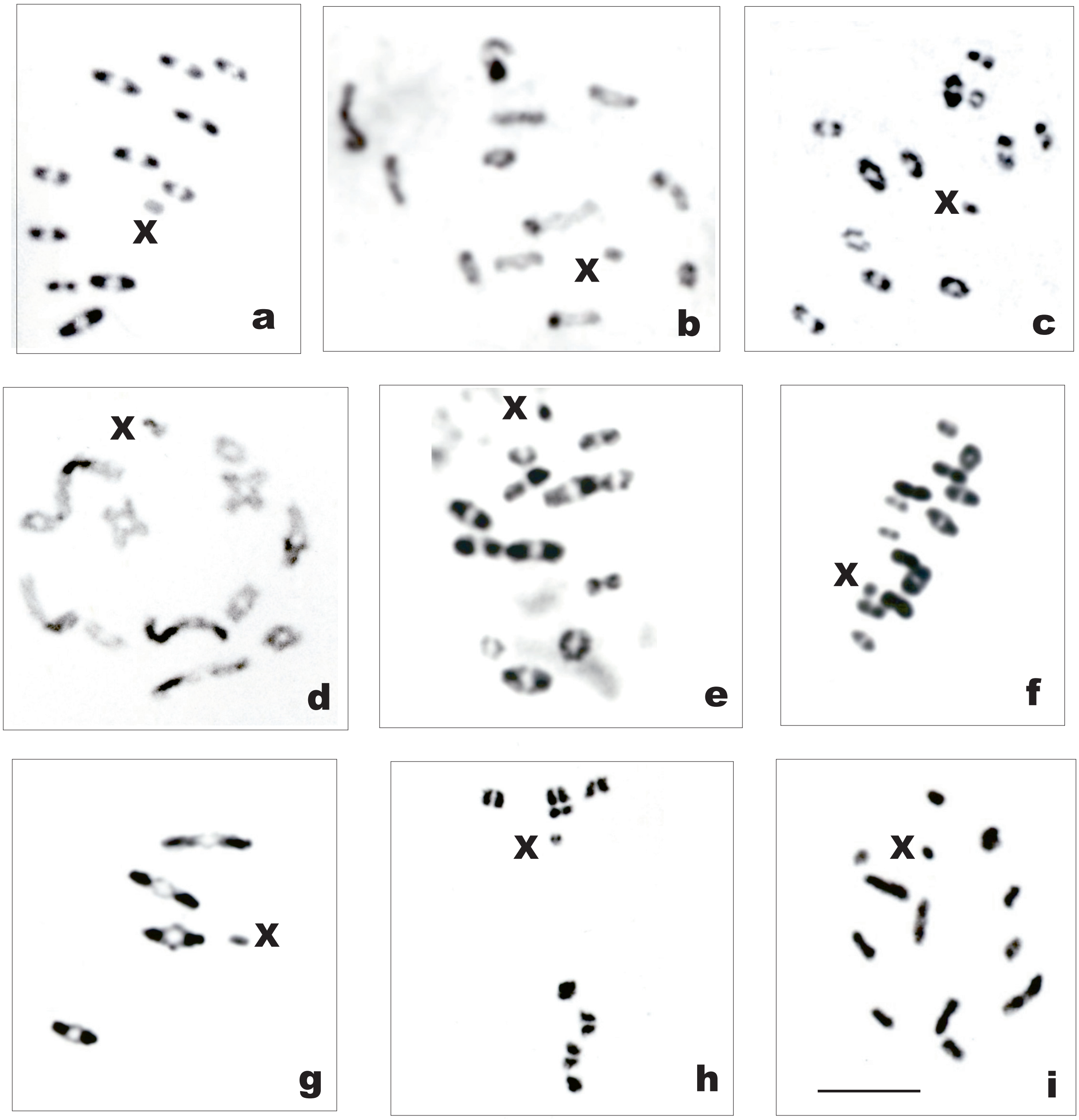
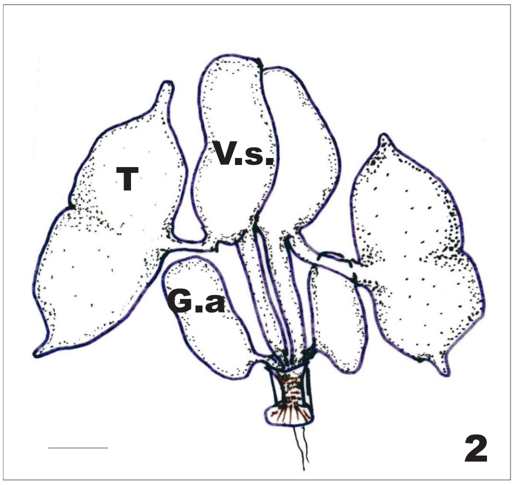


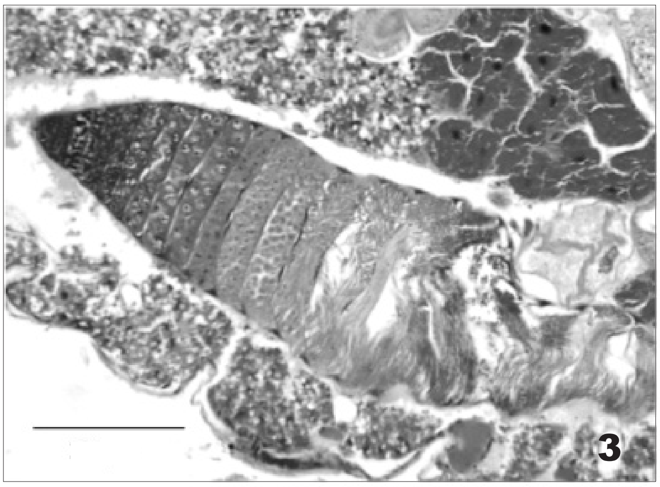
Fig. 1a-i. a. *Colophorina* spn. first metaphase of meiosis; b. *Euphalerus* sp. early first metaphase of meiosis; c. *Diaphorina petteyi* first metaphase of meiosis; d; and e. *Paurocephala bicarinata*. d. diakinesis; e. first metaphase of meiosis; f. *Pauropsylla tricheata* first metaphase of meiosis; g and h. *Peripsyllopsis speciosa*. g. first metaphase of meiosis; h. second metaphase of meiosis; i. *Trioza carvalhoi* first metaphase of meiosis. Bar = 100 μm.

number of chromosomes were found in *Colophorina* sp. n. (Euphalerinae), 2n=22+X (Fig. 1a), and in *Peripsyllopsis speciosa* (Diaphorininae), 2n=8+X (Fig. 1g & h). In *Pauropsylla tricheata* (Triozinae) the chromosomal set is higher, 2n=26+X. In this species autosomes formed 13 bivalents and a small X univalent at MI (Fig. 1f).

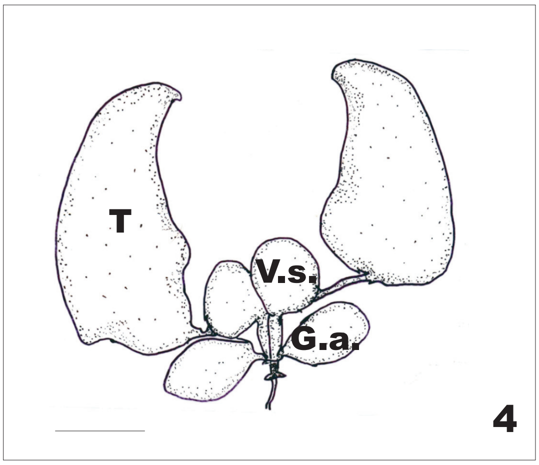
The chromosomal number 2n=24+X is the most common and described in the majority (95%) of 153 studied species. This is the modal and probably ancestral number for the whole superfamily Psylloidea. The occurrence of different chromosomal numbers at various taxonomic levels in psyllids is mainly the result of autosomal fusions, e.g. in species of the genera *Psyllopsis*, *Baeopelma foersteri*, *Craspedolepta bulgarica*, *Trioza remota*, *T. ilicina* etc., or fusion of autosomes and sex chromosomes (for details see Table 1 in MARYAŃSKA-NADACHOWSKA 2002). Fusions of both types reduce the numbers of chromosomes in the karyotypes, but only the latter fusion leads to a change in the chromosomal type of sex determination XO to the neo-XY, e.g. in *Cacopsylla mali* and *C. sorbi* (GROZEVA & MARYAŃSKA-NADACHOWSKA 1995).

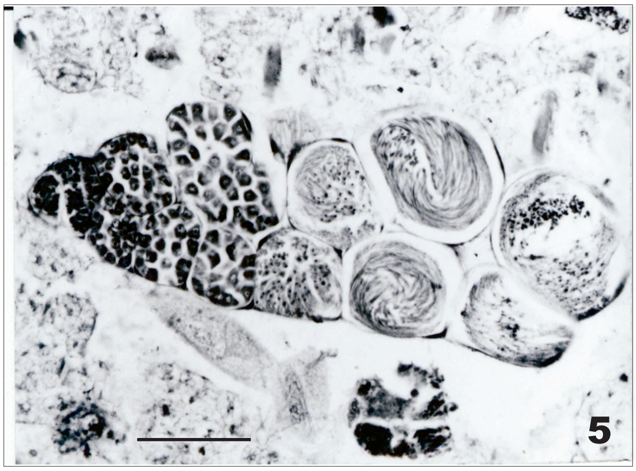
A reduction of number of chromosomes is also observed in *Colophorina* sp. n. (2n=22+X) and *Peripsyllopsis speciosa* (2n=8+X). Especially interesting is *Peripsyllopsis speciosa* which shows one of the lowest chromosomal numbers described so far in psyllids. Karyotypes with a low number of





Figs 2-3. Fig. 2. Structure of the male reproductive system in *Paurocephala bicarinata.* T – testis; V.s. – seminal vesicle; G. a. accessory gland. Fig. 3. Longitudinal section of the testis of the male reproductive system of *Paurocephala* sp. The testis with a row alignment of spermatocyste cysts. Bars = 100 μm.





Figs 4-5. Fig. 4. Structure of the male reproductive system in *Trioza carvalhoi*. T.– testis; V.s. – seminal vesicle; G. a. accessory gland. Fig. 5. Longitudinal section of the testis of the male reproductive system of *Trioza carvalhoi*. The testis with spermatocyte cysts arranged in two rows. Bars = 100 μm.

chromosomes characterize all karyotyped species belonging to the subfamily Rhinocolinae and to the Australian subfamily Spondyliaspidinae (MARYAŃSKA-NADACHOWSKA *et al.* 2001a). In Diaphorininae, karyotypes of 12 species belonging to 3 genera (MARYAŃSKA-NADACHOWSKA 2002; present data) are known. Species of the genus *Diaphorina* are characterized by 2n=24+X, *Psyllopsis* by 2n=22+X, and *Peripsyllopsis speciosa* by 2n=8+X. These three genera in the subfamily Diaphorininae have different numbers of chromosomes.

Pauropsylla tricheata (Triozinae) is the first species in Psylloidea that is characterized by a karyotype consisting of 13 pairs of autosomes creating a row gradually (not significantly) decreasing in size, and also the X univalent. The X chromosome is one of the smallest elements of the set (Fig. 1f). The chromosome number 2n=27 can be explained by the fission of one pair of autosomes in the modal karyotype (2n=25). More chromosomes than 2n=25 have been described only in two species, *Pachypsylla celtidismamma* and *P. celtidisvisiculum* (2n=26+X), by WALTON (1960). According to more recent studies both cases appear to be an example of karyotype polymorphism. For these two species RIEMAN (1966) and MARYAŃSKA-NADACHOWSKA and YANG (1997) described the basic karyotype 2n=24+X. In Psylloidea the presence of karyotypes with higher numbers of chromosomes than the modal are clearly rare. Mainly fusions play a role in chromosomal rearrangements and changes of karyotypes in psyllids.

The number of seminal follicles has been described for 176 psyllid species; the number in one testis varies from one to five, up to eight in case of polymerization. In 141 of these, the arrangement of spermatocysts inside each follicle is known. Two follicles with one row of spermatocysts prevail in most species (GŁOWACKA *et al*. 1995; GŁOWACKA & MARYAŃSKA-NADACHOWSKA 1997; MARYAŃSKA-NADACHOWSKA & GŁOWACKA 1998; MARYAŃSKA-NADACHOWSKA *et al*. 2001a, 2001b; KUZNETSOVA *et al*. 1997). Table 1 presents new data on the structure of testes in males of 18 species of Psylloidea. In 15 species each testis consists of two follicles (Fig. 2) placed symmetrically on both sides of the abdomen. Spermatocysts inside testicular follicles are arranged in one row (Fig. 3). In *Calophya schini* polymorphism in number of follicles was found (2 and 3 follicles). In *Trioza carvalhoi* and *Trioza thibae* each testis consists of a single follicle (Fig. 4). Such oligomerization in representatives of Triozidae is described for the first time. Spermatocysts inside follicles are arranged in two rows (Fig. 5), which has been found only in one species of *Trioza* sp. from Cuba, however its testes consist of two follicles (GŁOWACKA *et al*. 1995). One follicle in one testis was described in species belonging to subfamilies Rhinocolinae, Spondyliaspidinae and Carsidarinae and is typical for these taxa. On the other hand the arrangement of spermatocysts inside follicles is different and specific for each mentioned subfamily (GŁOWACKA *et al*. 1995; MARYAŃSKA-NADACHOWSKA *et al*. 2001a). The sufamilies Rhinocolinae and Spondyliaspidinae, beside oligomerization of testicular follicles, are characterized by karyotypes with low numbers of chromosomes 2n=11,13 and 2n=7, 9, 13 (one species 2n=20), respectively.

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