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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, Ciriacreminiae (Psylidae), 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 tricheta 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 spermatocytes 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 spermatocytes arranged in two rows.

Key words: Psylloidea, karyotypes, structure of testes.

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 Psylidae and Triozidae, whereas Calophyidae, Homotomiidae 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. GLOWACKA. Species belonging to subfamilies Paurocephalinae, Euphyllurinae, Diaphorininae, Euphalerinae, Acizziinae, and Ciriacreminiae (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 GLOWACKA (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

| Taxa                                      | Chromosome numbers | Number of testicular follicles | Number of spermatocyste rows |
|-------------------------------------------|--------------------|--------------------------------|-------------------------------|
| Psyllidae Löw                             |                    |                                |                               |
| Paurocephalinae Becker-Migdisova          |                    |                                |                               |
| Paurocephala hottentotii 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 Becke-Migdisova              |                    |                                |                               |
| Euphalerus isitis (Cotes, 1893)            | 24 + X             | 2                              | 1                             |
| Colophorina sp. n.                        | 22 + X             | 2                              | 1                             |
| Acizziinae White & Hodkinson              |                    |                                |                               |
| Acizia uncatoidea Ferris & Klyver, 1932*   | 24 + X             | 3                              | 1                             |
| Ciriacreminiae Enderlein                   |                    |                                |                               |
| Ciriacrema capense Enderlein, 1923         | 24 + X             | 2                              | 1                             |
| Calophyidae Vondraček                     |                    |                                |                               |
| Calophya schini Thuthill, 1959             | 24 + X             | 2, 3                           | 1                             |
| Triozidae Löw                             |                    |                                |                               |
| Triozinae Löw                             |                    |                                |                               |
| Triozoa afroboleta Hollis, 1984            | 24 + X             | 2                              | 1                             |
| Triozoa carvalhoi Hollis, 1984             | 24 + X             | 1                              | 2#                            |
| Triozoa thibae Hollis, 1984                | 24 + X             | 1                              | 2#                            |
| Pauropsylla trichata Pettey, 1924          | 26 + X             | 2                              | 1                             |

* Described for the first time from Italy (MARYAŃSKA-NADACHOWSKA et al. 1994; GLOWACKA et al. 1995); # two or more rows
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 fo-ersteri, 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* (GROZENA & 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

Fig. 1a-i. a. *Colophorina* sp. n. first metaphase of meiosis; b. *Euphalerus* sp. early first metaphase of meiosis; c. *Diaphorina petezi* 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.
chromosomes characterize all karyotyped species belonging to the subfamily Rhinocolinae and to the Australian subfamily Spondyliaspidinae (MARYAŃSKA-NADACHOWSKA et al. 2001a). In Diaphorinae, 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 specioza by 2n=8+X. These three genera in the subfamily Diaphorinae 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 spermatocytes inside each follicle is known. Two follicles with one row of spermatocytes prevail in most species (Glowacka et al. 1995; Glowacka & Maryńska-Nadachowska 1997; Maryńska-Nadachowska & Glowacka 1998; Maryńska-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 Psyllioidea. In 15 species each testis consists of two follicles (Fig. 2) placed symmetrically on both sides of the abdomen. Spermatocytes 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 number of follicles was found (2 and 3 follicles). In 7 species each testis consists of a single follicle (Fig. 4). Such oligomerization in representatives of Triozidae is described for 2 species belonging to subfamilies Rhinocolinae, Spondyliaspidinae and Carsidarinae and is typical for these taxa. On the other hand the arrangement of spermatocytes inside follicles is different and specific for each mentioned subfamily (Glowacka et al. 1995; Maryńska-Nadachowska et al. 2001a). The subfamilies 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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