SHORT NOTE

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Cytogenetic analysis of some aradid species (Heteroptera: Aradidae)

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Abstract. Known sex chromosome mechanisms in Aradidae are XX : XY or compound $X(X_nY)$. The present paper adds data obtained from studying testes of adults and stage IV and V larvae of four aradid species. The number of chromosomes and their behaviour during spermatogenesis (in Aradinae for the first time) were documented and illustrated: *Aradus cinnamomeus* Panzer – 2n = 35 (32 + X_1X_2Y); *Aradus corticalis corticalis* (L.) – 2n = 28 (26 + XY); *Aradus conspiculus* Herrich-Schaffer 2n = 28 (26 + XY); *Aneurus avenius* Dufour – 2n = 27 (24 + X_1X_2Y). Mechanisms which could have played a role in karyotype evolution in the family are discussed in the context of this study and data from literature.

Introduction

Within the Aradidae there are about 1,800 known species and 211 genera (Kormilev & Froeschner, 1987). On the basis of select morphological characters, the Aradidae are placed in the infraorder Pentatomomorpha. However, in contrast to all other Pentatomomorpha the Aradidae have no abdominal trichobothria and hold a unique place in the infraorder. The relationships between eight aradid subfamilies (Usinger & Matsuda, 1959) are discussed by different authors (Kumar, 1967; Vasarhelyi, 1986; Grozeva & Kerzhner, 1992).

Karyological investigations in the family are very scarce; the chromosome numbers of only one isodermine species, 9 species of Aneurinae, 3 carventine species and two species of Mezirinae (Table 1) are known. There is no available description of the karyotype, although the spermatogenesis and oogenesis in the Aneurinae were investigated by Jacobs (1986) in a study of the type of sex determination mechanism (X_1X_2Y or XY_1Y_2). The sex chromosome mechanism of studied aradid species is not very uniform; those studied are XX : XY mechanism or compound X (X_nY) chromosome mechanism. There are no m-chromosomes in the Aradidae thus far studied.

It is known that spermatogenesis of *Aradus cinnamomeus* is completed during the last larval stage (Southwood & Leston, 1959). It is likely that this is also true for other aradid species and this hypothesis was confirmed in our investigations. Karyological studies of this family are hindered by difficulties in collecting specimens in the stage that is most suitable for chromosome analysis.

Material and methods

Material for the present study was collected in Bulgaria (*Aradus conspiculus* Herrich-Schaeffer – 12♂), Estonia [*Aradus corticalis corticalis* (L.) – 18♂ and *Aradus cinnamomeus* Panzer – 15♂] and Ukraine (*Aneurus avenius* Dufour – 13♂).

Only adults of the first two of these mentioned species and only stage IV and V larvae of the latter two species were studied. Specimens were fixed in 2.5 : 1 methanol and propionic acid (after Jacobs, 1986). Spermatogenesis was investigated on squash-preparations of gonads that were stained by lactoacetorcein.

Results

Behaviour of the chromosomes during male meiosis was studied. All stages that are typical for most Heteroptera were observed. After diplotene the nucleus enters a "diffuse stage". During this stage, the nucleus returns to an interphase-like state. The first division of meiosis is reductional for the autosomes and equational for the sex chromosomes, as is the case in most Heteroptera (Ueshima, 1979). At metaphase II the pseudo bi- or trivalent of the sex chromosomes lies in the circle of the autosomes.

TABLE 1. Chromosome numbers of aradid species.

Species	2n	MI	References
Aradinae			
Aradus cinnamomeus	35	$16 + X_1X_2Y$	New data
A. corticalis corticalis	28	$13 + XY$	New data
A. conspiculus	28	$13 + XY$	New data
Isoderminae			
Isodermus gayi	23	$10 + X_1X_2Y$	Ueshima, 1963
Aneurinae			
Paraneurus ruandae multifarius	32	$15 + XY$	Jacobs, 1986
P. brincki brincki	27	$12 + X_1X_2Y$	Jacobs, 1986
P. brincki marieps	26	$12 + X_1X_2Y$	Jacobs, 1986
P. nodosus	27	$12 + X_1X_2Y$	Jacobs, 1986
P. congolensis	40	$18 + X_1X_2X_3Y$	Jacobs, 1986
Breviscutaneurus breviscutatus	16	$7 + XY$	Jacobs, 1986
B. medioscutatus	24	$11 + XY$	Jacobs, 1986
B. helenae	22	$10 + XY$	Jacobs, 1986
Aneurillus foliaceus	24	$11 + XY$	Jacobs, 1986
Aneurus avenius	27	$12 + X_1X_2Y$	New data
Carventinae			
Adamanotus uncotibialis	16	$7 + XY$	Jacobs, 1990
Dundocoris nigromaculatus	20	$9 + XY$	Heiss & Jacobs, 1989
Trichocarventus klapperichi	28	$13 + XY$	Heiss & Jacobs, 1989
Mezirinae			
Dysodius lunatus	31	$14 + X_1X_2Y$	Schrader, 1947
Mezira pacifica	27	$12 + X_1X_2Y$	Ueshima, 1963

Subfamily Aradinae

Aradus cinnamomeus Panzer: 2n = 35 ($32 + X_1X_2Y$)

At metaphase I (MI) of spermatogenesis 16 autosomal bivalents and three univalent sex chromosomes are visible (Fig. 1). The autosomal bivalents are all similar in size. At this stage it is difficult to identify the sex chromosomes. Their number was determined by analysing chromosome behaviour during the second meiotic division. At MII autosomes are situated in a circle with the sex chromosomes associated in a pseudo-trivalent at the center (Fig. 2).

Aradus corticalis corticalis (L.): 2n = 28 ($26 + XY$)

At MI of spermatogenesis 13 autosomal bivalents and two univalent sex chromosomes are visible (Fig. 3). Autosomal bivalents with well-visible chromatids decrease gradually in size. The sex chromosomes are nearly the smallest autosomal bivalents.

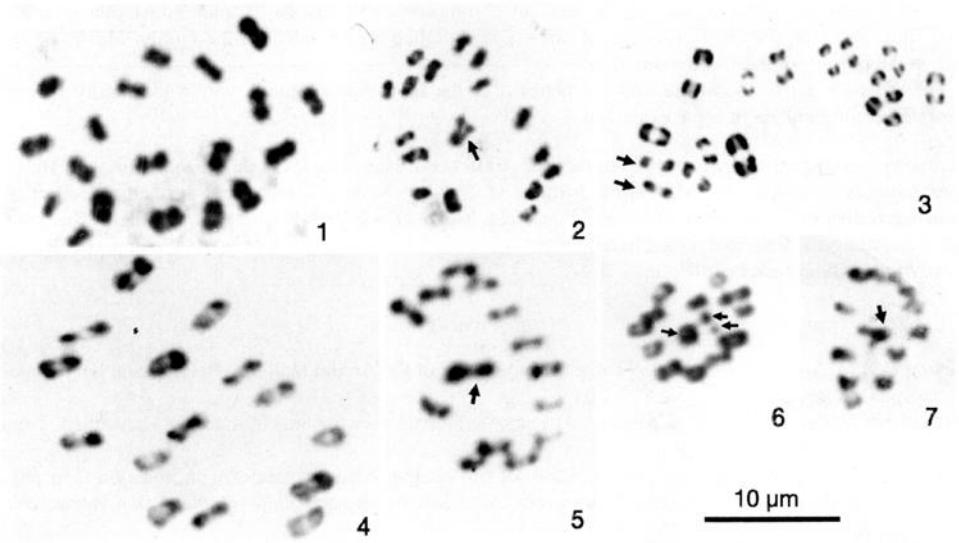
Aradus conspiculus Herrich-Schaeffer: 2n = 28 ($26 + XY$)

The karyotype of this species is similar that of *A. corticalis corticalis* (Fig. 4). At MII, 13 autosomes which form a circle, and the pseudo-bivalent of sex chromosomes, arranged in the center, are visible (Fig. 5).

Subfamily Aneurinae

Aneurus avenius Dufour: 2n = 27 ($24 + X_1X_2Y$)

At MI, 15 elements are visible: 12 autosomal bivalents and three sex chromosomes (Fig. 6). The sizes of the autosomes decrease gradually. During MII, a pseudo-trivalent of sex chromosomes (X_1X_2Y) is visible in the circle formed by the autosomes (Fig. 7).



Figs 1–7. Karyotypes of Aradidae (sex chromosomes marked by arrows). Figs 1–2: *Aradus cinnamomeus* Panzer – 2n = 32 + X_1X_2Y. 1 – metaphase I; 2 – metaphase II. Fig. 3: *Aradus corticalis corticalis* (L.) – 2n = 26 + XY, metaphase I. Figs 4–5: *Aradus conspiculus* Herrich-Schaeffer – 2n = 26 + XY. 4 – metaphase I; 5 – metaphase II. Figs 6–7: *Aneurus avenius* Dufour – 2n = 24 + X_1X_2Y. 6 – metaphase I; 7 – metaphase II.

Discussion

The karyotypes of 18 species whithin four aradid subfamilies have now been studied (Ueshima, 1979; Jacobs, 1986; Heiss & Jacobs, 1989; Jacobs, 1990). The tendency of related species to possess widely different chromosome numbers has been observed: from 2n = 16 (in Aneurinae and Carventinae) to 2n = 40 (in Aneurinae) (Table 1). This characteristic is not typical for other Pentatomomorpha (Ueshima, 1979).

It is difficult to say which mechanisms may have played a role in karyotype evolution in the family. Jacobs (1986) asserts that, rather than simple accidental fragmentation, a mechanism like chromatid autonomy (Schrader & Hughes-Schrader, 1956, 1958) may be responsible. The concept of chromosome autonomy has received serious criticism (Nokkala, 1985). No autosome polyploidy has been found in *Banasa* (Pentatomidae) (Thomas & Yonke, 1985) or Nabidae (Kuznetsova, 1993). Fragmentations have surely occurred (the chromosomes of the species with high chromosome numbers are visibly smaller), but this phenomena must be confirmed by further investigations.

Half of examined species show an XX : XY system and the rest have multiple sex chromosome systems (X_nY). The origin of multiple sex chromosomes is somewhat problematical. In insects with monocentric chromosomes, the number of autosomes decreases when the number of sex chromosomes increases as a result of Robertsonian translocations (White, 1973). Troedsson (1944) and Schrader (1947) suggested that simple fragmentation of holokinetic sex chromosomes is the major source of multiple sex chromosomes in Heteroptera. Schrader & Hughes-Schrader (1956) experimentally proved this theory by inducing fragmentation of sex chromosomes in some pentatomids by exposing them to X-rays. I believe that it may be safely assumed that, for the Aradidae, the origin of the multiple X (X_n) results from simple fragmentation of sex chromosomes. The comparative sizes and behaviour of sex chromosomes between species with XY and X_nY confirm this suggestion. Multiple X are smaller than simple X. At MII, multiple X lie close to each other.

No data regarding oogenesis is available and it is difficult to determine whether oogenesis involves a multiple X or multiple Y sex chromosome system. On the other hand, Jacobs (1986) studied mitoses in male and female embryos of two aneurine species and demonstrated the presence of a $X_1X_2Y/X_1X_1X_2X_2$ sex chromosome system. Therefore it is assumed, for the species discussed herein, that fragmentation takes place in X, but not in Y chromosomes.

The diversity of chromosome number and sex chromosome systems that is found in examined Aradidae illustrates that intensive processes of karyotype evolution are prevalent in the family. Many species are in the process of microdifferentiation.

In order to clarify the means and mechanisms of the karyotype evolution within the family species from other subfamilies must be examined.

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