Folia biologica (Kraków), vol. **53** (2005), No 1-2

Intra Individual Variation in the Number of B Chromosomes in the Yellow-necked Mouse, *Apodemus flavicollis* (Mammalia, Rodentia)

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Accepted January 25, 2005

VUJOŠEVIĆ M. JOJIĆ, V., BLAGOJEVIĆ J. 2005. Intra individual variation in the number of B chromosomes in the yellow-necked mouse, *Apodemus flavicollis* (Mammalia, Rodentia). Folia biol. (Kraków), **53**: 75-78.

The yellow-necked mouse, *Apodemus flavicollis,* is characterized by a frequent occurrence of B chromosomes. The frequency of intra individual mosaicism of Bs was studied in 995 animals collected at six localities in Serbia. It was found that 329 (33.06%) possessed B chromosomes. Among these, 87 animals (26.44%) were mosaics. A total of 32 mosaic animals with more than one B chromosome were analyzed for distribution of Bs which was found to be quite different between groups of animals with different numbers of Bs and increases with their number. The frequency of mosaics differs between localities and ranges from 0.22 to 0.55.

Key words: B chromosomes, *Apodemus flavicollis*, mosaics.

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B chromosomes, which are supernumerary to the standard chromosome complement, are found in numerous species of all major taxonomic groups except birds. Due to fact that Bs are not essential for normal growth and development of individuals carrying them, these chromosomes are defined as dispensable (JONES & REES 1982). The term B chromosome includes very heterogenous types of chromosomes which share many characteristics but never without exceptions. Only dispensability is common to all B chromosomes (REES 1974). This feature allows Bs to follow their own evolutionary pathway with respect to the standard karyotype (CAMACHO *et al.* 2000).

In mammals Bs have been scored in only 55 species (VUJOŠEVIĆ & BLAGOJEVIĆ 2004). The genus *Apodemus* is an exception with almost one third of the species having B chromosomes. B chromosomes have been studied in the yellow-necked mouse, *Apodemus flavicollis,* from more than 20 populations from the territory of former Yugoslavia. Bs were present in almost all of these in different frequencies ranging from 0.11 to 0.64 (VUJOŠEVIĆ & IVKOVIĆ 1987; VUJOŠEVIĆ *et al.* 1991; VUJOŠEVIĆ & BLAGOJEVIĆ 1994). Additionally, Bs were found in different frequencies in various parts of the distribution of *A. flavicollis* (WOLF *et al.* 1972; SOLDATOVIĆ *et al.* 1975; KRAL *et al.* 1979; ZIMA & KRAL 1984; SABLINA *et al.* 1985; GIAGIA *et al.* 1985; ZIMA & MACHOLÀN 1995; BOESKOROV *et al.* 1995; KARTAVTSEVA 2002; WÓJCIK *et al*. 2004).

The intraspecific frequency of Bs varies between populations and between individuals within populations as well. Additionally, the existence of intra individual variability is also characteristic of B chromosomes. Although this feature has been found in a number of plant and animal species (JONES & REES 1982) in most cases this phenomenon is only registered without considering any details. The aim of this study was to investigate the frequency and distribution of intra individual mosaicism of Bs in *Apodemus flavicollis*.

Material and Methods

A total of 995 animals (505 males and 490 females) were collected using ''Longworth'' traps at six different localities in Serbia: Mt Avala (DQ-64) 173, Mt Cer (CQ-75) 132, Donji Dobrić (CQ-74) 43, Mt Goč (DP-82) 19, Mt Jastrebac (EP-30) 520 and Lešnica (CQ-64) 108. Chromosome preparations were done directly from bone

marrow using standard procedures. The distribution of mosaic Bs was studied in all animals in which more than 30 metaphase figures were accessible for analyses. For comparison mosaic animals were divided into groups according to the maximum number of Bs.

Results and Discussion

Among 995 animals analysed, 329 (33.06%) possessed B chromosomes (Table 1). The frequency of animals with Bs was not significantly different between males and females. Among B carriers, 87 animals (26.44%) were mosaics. A total of 32 mosaic animals, with a maximum number of Bs higher than one, were analysed for differences in distribution of Bs among bone marrow cells (Table 2, Fig. 1). The distribution of mosaics was quite different among groups of animals with different maximum numbers of Bs and increased with their number. Differences in the frequency of mosaics among B carriers occurred between localities and ranged from 0.22 to 0.55. (Mt Avala 0.44, Mt Cer 0.32, Donji Dobrić 0.55, Mt Goč 0.33, Mt Jastrebac 0.22, Lešnica 0.24)

Intra-individual variability of Bs has been studied only in a few species of mammals. Variation in the number of Bs among cells of the same individual is common in silver foxes. It was established that 45% of animals were mosaics (BELAYEV *et al.* 1974a). The same authors (BELAYEV *et al.* 1974b) found that this variation is due to the existence of different cell clones. The number of Bs was inde-

Table 1

Number of animals with different number of Bs and frequency of animals mosaic for different number of Bs

Non-mosaic	N	0B	1B	2B	3B	4B
	908	666	190	42	9	1
Mosaics	N	0-1B	0-2B	0-3B	0-4B	0-5B
	87	26	35	12	13	1
Frequency of mosaics		0.12	0.45	0.57	0.93	1.00

N – Total number of animals

Table 2

Number of cells with different number of Bs in mosaic animals

Group	N	Bs	Number of cells
0-2B	7	0B	106 (61.99%)
		1B	40 (23.39%)
		2B	25 (14.62%)
0-3B	12	0B	218 (21.80%)
		1B	476 (47.60%)
		2B	221 (22.10%)
		3B	85 (8.5%)
0-4B	13	0B	33 (12.27%)
		1B	37 (13.75%)
		2B	85 (31.60%)
		3B	87 (32.34%)
		4B	27 (10.04%)

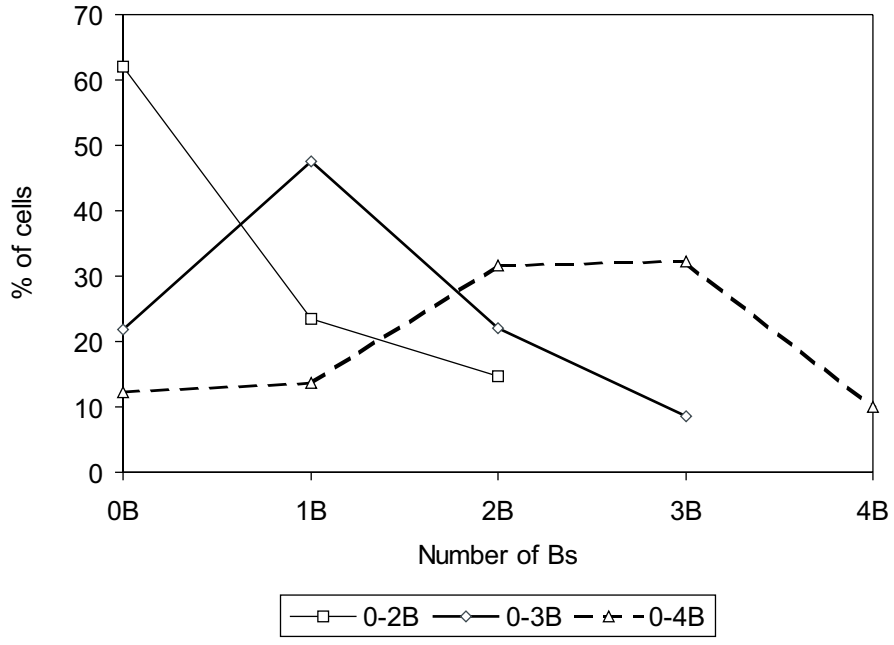

Fig. 1. Distribution of cells with different number of Bs among three mosaic groups.

pendent of somatic tissue type or season (VOLOBOUEV & RADJABLI 1974), but the mean number of Bs in cells from reproductive tissues was found to be higher than in somatic cells (RADJABLI *et al.* 1978). The frequency of mosaics was twice as high in the groups of foxes selected for behavior than in the nonselected group.

Parallel mosaicism of B chromosomes and sex chromosomes is characteristic of the marsupial *Echymipera kalubu* (HAYMAN *et al.* 1969). In this species Bs and sex chromosomes are absent from certain tissues, e.g. bone marrow, but present in the corneal epithelium. Mosaicism for number of Bs in the same tissue was found only in the testis of one animal.

BEKASOVA *et al.* (1980) found that among specimens of the Korean field mouse, *Apodemus peninusulae,* 40% of animals with Bs were mosaics. Individuals with 2 B chromosomes prevailed among stable B carriers (concerning both number and morphology of Bs), but this was the modal number for mosaics also. In the present study, the percent of mosaic animals was nearly twice smaller. Since there is increasing evidence that Bs in *A. flavicollis* induce effects which are important at the level of populations (BLAGOJEVIĆ & VUJOŠEVIĆ 1995, 2000, 2004; VUJOŠEVIĆ & BLAGOJEVIĆ 2000; ZIMA *et al.* 2003; WÓJCIK *et al*. 2004), then the presence of mosaics may also be important due to the production of mosaic phenotypes. In humans, somatic mosaicism has been implicated in about 30 monogenic disorders that show variable expressivity (GOTTLIEB *et al.* 2001). Specific DNA markers were found in specimens of *A. flavicollis* with Bs (TANIĆ *et al.* 2000) and recently, differential expression of 3 genes in animals with Bs was found in the same species (TANIĆ *et al.* 2004, in preparation). This also points to the necessity of studying differences in the levels of differential expression in animals that display the mosaic presence of Bs.

In all analyses of dynamics of B chromosomes in populations through time, mosaic animals are included together with animals with a stable number of Bs. In statistical analyses one of the approaches is to use the most frequent B number found in mosaic animals (ARAUJO *et al.* 2002). An alternative approach is to use the maximum number of Bs found in mosaics. The present data show that the maximum number of Bs is never the most frequent in mosaic animals, so the modal number of Bs in mosaics is recommended in statistical analyses.

Acknowledgements

This work was supported by the Ministry of Science and Environment Protection of Serbia, contract no. 1693.

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