J. Biosci., Vol. 22, Number 3, June 1997, pp 367–374. © Printed in India.

Karyology of a few species of south Indian acridids. II Male germ line karyotypic instability in *Gastrimargus*[§]

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MS received 26 April 1996; revised 20 September 1996

Abstract. ***Gastrimargus africanus orientalis,*** **an acridid grasshopper has revealed the existence of karyotypic mosaicism in the male germ line cells of a few individuals with 2*n* = 23, 19, 21, 25 and 27 chromosomes. Details of this chromosomal instability are presented in this paper.**

Keywords. **Karyology; south Indian acridids; male germ line; karyotypic instability; *Gastrimargus africanus orientalis.***

1. Introduction

The karyotype is an important asset of a species. In spite of 'polymorphism', the architecture and composition of a species karyotype is relatively stable.

The karyology of acridid grasshoppers presents a very stable phenotype over a wide range of species. It is often quoted as an example for "karyotypic conservatism" (White 1973; Ashwath 1981; Yadav and Yadav 1993). But *Gastrimargus,* an acridid, illustrates a facet of 'karyotypic dynamism' with a rare phenomenon of aneuploids in the male germ line and the same is presented in this paper.

2. Materials and methods

The individuals of *Gastrimargus africanus orientalis* Saussure were collected from Mandya (Karnataka) during 1993-95. A total of 128 individuals (94 males and 34 females) were analised. Adult testis/ovarian follicles and intestinal caecae were removed and fixed in 3:1 methanol and glacial acetic acid. Squash preparations were made without colchicine and hypotonic treatments, and the material was stained with Heidenhain's iron haematoxylin stain. Well spread mitotic and meiotic stages were analysed and photographed.

3. Results and discussion

The karyology of every species is unique to itself and provides an identity to the species (Channaveerappa and Ranganath 1994). The study of karyotypic evolution in different

[§]We dedicate this paper to our teacher Prof. L Siddaveere Gowda on the eve of his 60th birthday.
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groups of animals, has revealed that the karyotype is not absolutely stable, instead changes do occur on an evolutionary time scale. In this regard, *Gastrimargus* has attracted the attention of cytologists eversince 1963. Rajasekarasetty (1963) reported that in addition to normal complement of $2n = 23$, the metaphase I of a few cells had 9 bivalents and an X-chromosome, indicating the diploid number as $2n = 19$. But the later studies of Ashwath (1981), Ashwathanarayana *et al* (1981) in *G. a. orientalis;* Fossey and Liebenberg (1991) in four species of *Gastrimargus,* namely *G. africanus, G. crassicollis, G. vitripennis* and *G. wahlbergi;* John *et al* (1985) in G. *musicus* and Yadav and Yadav (1993) in *G. transversus* have not revealed a situation similar to the one, reported by Rajasekarasetty (1963).

The present analysis of G. *a. orientalis* has revealed that both the somatic and the germ line cells of all females (N=34) analysed had a karyotype of $2n = 24$ (22AA + XX). On the other hand, 82 of the 94 males analysed had $2n = 23$ (22AA + X) in both somatic and germ line cells (figure 1). This is typical of acridid grasshoppers with XX female and XO male systems. The autosome complement includes 3 pairs of long, 6 pairs of medium and 2 pairs of short chromosomes. The X-chromosome is

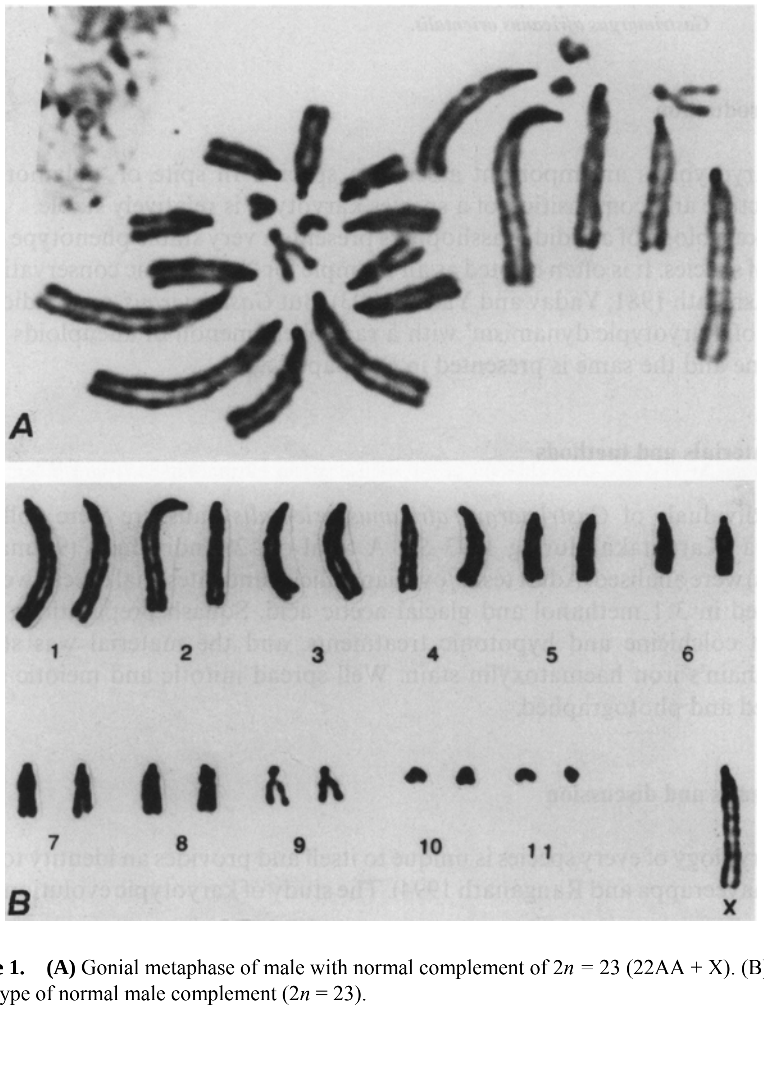

Figure 1. (A) Gonial metaphase of male with normal complement of $2n = 23$ (22AA + X). (B) Karyotype of normal male complement ($2n = 23$).

slightly larger th an the largest autosomal pair. This is similar to the earlier reports on the karyotype of *G. a. orientalis* (Ashwathanarayana *et al* 1981). Further, the present study has revealed that except the 6th, 9th, 10th and 1lth pair of autosomes, rest of the autosomes and the sex chromosomes are acrocentric, while these pairs are polymerphic with acrocentric, metacentric and submetacentric representatives, which will be reported elsewhere.

The chromosomal constitution of the other 12 males of *Gastrimargus* under study is interesting. The somatic cells (intestinal caecae had $2n$ = 23. The germinal tissue of four males had four types of cells, viz., $2n$ = 23, 19, 21 and 25 (figures 2 and 3), while the other 8 males had five types of cells. In addition to the above four types, also had cells with $2n$ = 27 (figures 2 and 3). Thus the germinal tissue of these 12 males of *Gastrimargus*

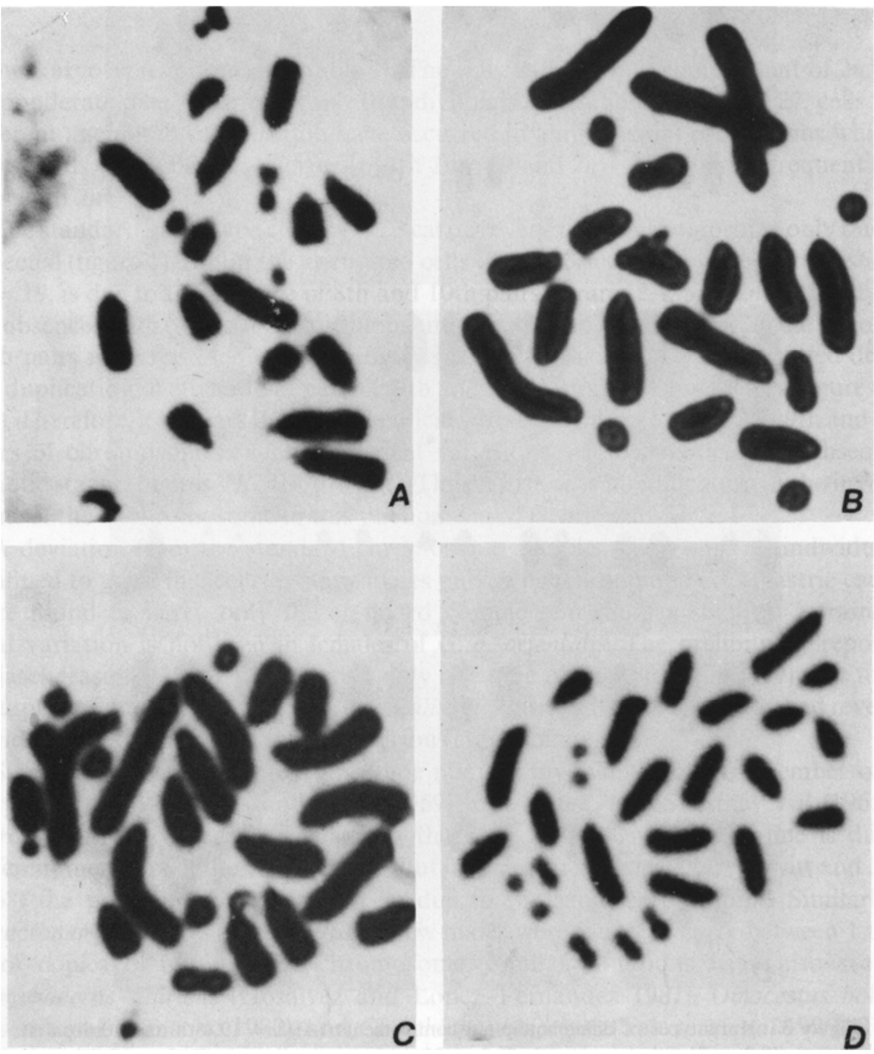

Figure 2. Metaphase plates with different diploid number of chromosomes. (**A**) $2n$ = 19. (**B**) $2n$ = 21.(**C**) $2n$ = 25. (**D**) $2n$ = 27.

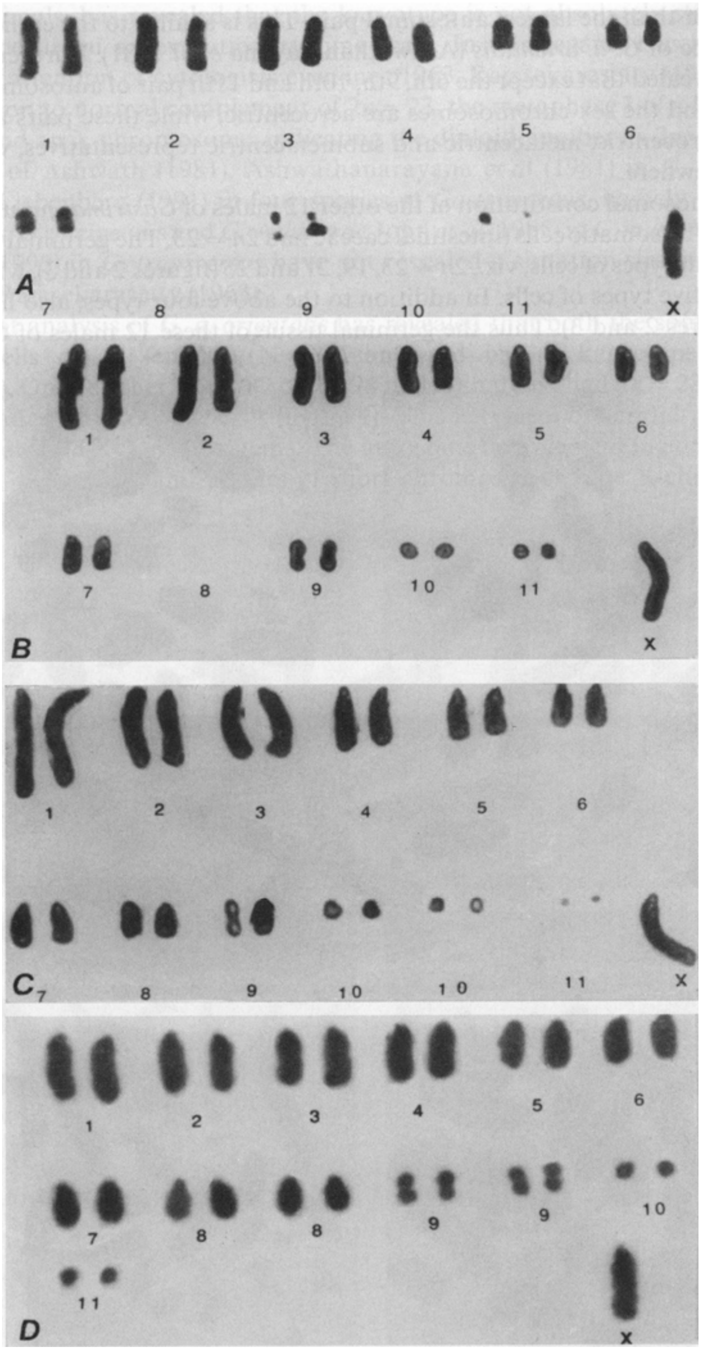

Figure 3. Karyotypes of different diploid complements. (A) $2n$ = 19 (8th and 10th pairs absent). (B) $2n$ = 21 (8th pair absent). (C) $2n$ = 25 (10th pair duplicated). (D) $2n$ = 27 (8th and 9th pairs duplicated).

Table 1. The incidence of cells with different numbers of chromosomes in 12 males of *G. a. orientalis.*

No. of individuals analysed	No. of cells with different diploid complements					
	$2n = 19$	$2n = 21$	$2n = 23$	$2n = 25$	$2n = 27$	Total
8	36 (15·65)	39 (16·95)	80 (34·78)	38 (16·52)	37 (16·08)	230
4	23 (25·27)	20 (21·97)	35 (38·46)	13 (14·27)	—	91

The values within brackets are the percentages.

Note: Variant karyotypes are observed in all the follicles of testis in each individual.

show 'karyotypic mosaicism' (table 1). The cells with normal complement of $2n = 23$ preponderate over other category. In individuals which had up to $2n = 27$, cells with different aneuploid composition have occurred in almost equal proportions while in individuals which had $2n = 25$, cells with $2n = 19$ and $2n = 21$ are more frequent than cells with $2n = 25$.

The standard karyotype with $2n = 23$ carries every pair of chromosome only once as expected (figure 1). But in the aneuploid cells of *G. a. orientalis* it varies. For instance, $2n = 19$, is due to the absence of 8th and 10th pairs (figures 2A, 3A); $2n = 21$ is due to the absence of 8th or 9th pair of chromosomes (figures 2B, 3B). In $2n = 25$, the 8th or the 10th pairs were represented twice (figures 2C, 3C) while $2n = 27$ has resulted due to the duplication of 8th and 9th pairs or 9th and 10th pairs of chromosomes (figures 2D, 3D). Therefore, it appears that the numerical variation centres around 8th, 9th and 10th pairs of chromosomes. Such numerical variations are also noticed in subsequent meiotic stages (figures 4A-4D, 5A-5C). Thus far there is no indication of the involvement of the X-chromosome in this phenomena in *G. orientalis.*

A deviation from the standard chromosome complement within an individual is confined to germ line cells of a few males only, while its somatic cells (gastric caecae) were found to carry only the Standard complement. So far such an intraindividual variation is not seen in females of *G. a. orientalis.* The preliminary report of Rajasekarasetty (1963) had revealed only one type of aneuploid ($2n = 19$) that too in metaphase I and anaphase of G. *a. orientalis.* In contrast, the present study had revealed a wide range of aneuploid through various stages of meiosis.

Significant variations in chromosome number involving Standard member of the karyotype is rare. Lewis and John (1959) in a locust, and Sharma *et al* (1965) in *Chrotogonus trachypterus,* had shown that polysomy in male germ line is due to different members of the complement. But in *Chorthippus parallelus* (Hewitt and John 1968) the polysomy was found to be due to the same chromosome. Similarly in *Atractomorpha similis* (Peters 1981), a few males were found to carry between 1 to 10 extra copies of a particular chromosome. Similar situations were also seen in *Gomphocerus Sibiriens* (Gosalvez and Lopez-Fernandez 1981), *Omocestus bolivari* (Viseras and Camacho 1982), and *Chorthippus binotatus* (Talavera *et al* 1990). These earlier findings revealed the occurrence of 'additional copies' of the chromosome of a normal complement. On the contrary, in the present investigations in G. *a. orientalis,* deviation was due to not only to extra representation but also was due to lack of total

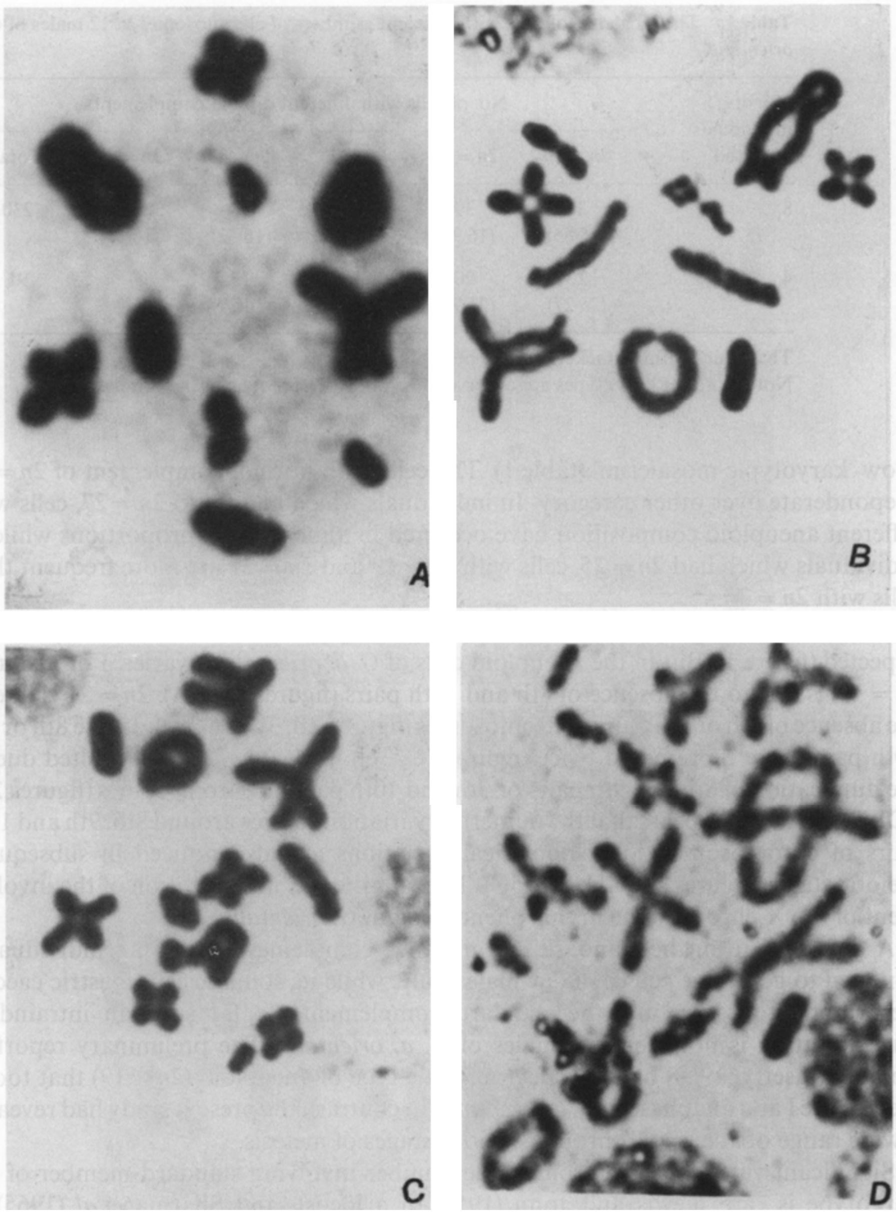

Figure 4. Meiotic stages in aneuploids. Diakinesis with (**A**) 9, (**B**) 10, (**C**) 12 and (**D**) 13 bivalents + X.

representation of a pair(s) of chromosomes. In *G. a. orientalis,* thus far there is no indication of one of the members of a pair absent or represented in more copies. Therefore monosomic or trisomic cells etc., were not found. This important observation indicates that presumably only specific types of chromosome malsegregation of 8th, 9th and 10th pairs in specific germ cells do occur. With the present data, it is difficult to visualize the possible mechanism(s) that underline this karyotypic

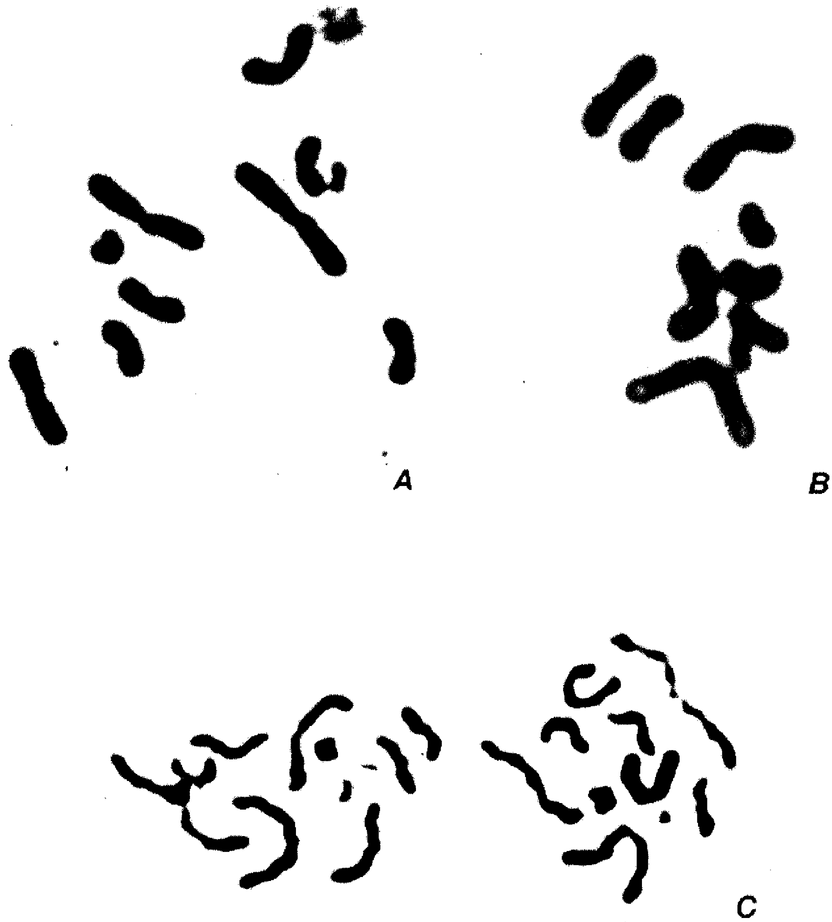

Figure 5. Meiotic stages in aneuploids. Metaphase II with (**A**) 10 chromosomes (9A + X) and (**B**) 9 chromosomes (9A). (**C**) Anaphase I with 11 and 10 chromosomes in two poles.

instability. Recently, Ford and Correll (1992) have studied the errors in mitotic divisions by using satellite DNA as probes and found to be due to non-disjunction, chromosome and chromatid lagging, chromatid mal segregation and monopolar segregation.

The significance of this karyotypic mosaicism is difficult to hypothesize. That this rare type of instability exclusively seen in a few cells of a few individuals of a population may be an evolutionary experimentation with male germline which can withstand the impact of such aneuplody. Further studies are in progress to understand the influence of karyotypic mosaicism in *G. a. orientalis* on spermatids, sperm morphology, fertility, etc.

Acknowledgements

Authors are grateful to the Chairman, Department of Studies in Zoology, Manasagangotri, Mysore for facilities. HC is indebted to the Director, Collegiate Education, Government of Karnataka and to the Principal, Government College for Women, Mandya for permission and to Dr H P Puttaraju for suggestions.

References

Ashwath S K 1981 *Contributions to the chromosome biology of Orthoptera,* Ph. D Thesis, University of Mysore, Mysore

Aswathanarayana N V, Ashwath S K, and Manjunatha K R 1981 On the occurrence of metacentrics in a South Indian grasshopper; *Curr. Sci.* **50** 293-294

Channaveerappa H and Ranganath H A 1994 Karyology of a few species of South Indian Acridids. I. The chromosomes of *Neorthocris acuticeps acuticeps* Bolivar.; Sci. *J. Mysore Univ.* **33** 91–96

Ford J H and Correll A T 1992 Chromosome errors at mitotic anaphase; *Genome* **35** 702-705

Fossey A and Liebenberg H 1991 A study of meiosis and B chromosomes in Southern African Gastrimargus species (Acrididae: Orthoptera); *Caryologia* **44** 137-143

Gosalvez J and Lopez-Fernandez C 1981 Extrachromatin in natural populations of *Gomphocerus sibricus* (Orthoptera: Acrididae); *Genetica* **56** 197-204

Hewitt G M and John B 1968 Parallel polymorphism for supernumerary segments in *Chorthippus parallelus* (Zetterstedt). I British populations; *Chromosoma* **25** 319-342

John B, King M, Schweizer D and Mendelak M 1985 Equilocality of heterochromatin distribution and heterochromatin heterogeneity in acridid grasshoppers; *Chromosoma* **91** 185-200

Lewis K R and John B 1959 Breakdown and restoration of chromosome stability following inbreeding in a locust; *Chromosoma* **10** 589-618

Peters G B 1981 Germ line polysomy in Grasshopper *Atractomorpha similis; Chromosoma* **81** 593-617

Rajasekarasetty M R 1963 Chromosomal dynamics in *Gastrimargus; Nature* (*London*) **197** 622—623

Sharma G P Prashad R and Gupta M L 1965 Chromosomal variation in the male germ cells of *Chrotogonus trachypterus* (Blanchard) (Orthoptera: Acridoidea: Pyrgomorphidae) from Ottu (Punjab); *Lα Cellule* **65** 295–314

Talavera M, Lopez-Leon M D, Cabrero J and Camacho J P M 1990 Male germ line polysomy in the grasshopper *Chorthippus binotatus:* extra chromosomes are not transmitted; *Genome* **33** 384–388

Viseras E and Camacho J P M 1982 Polysomy in *Omocestus bolivari:* endophenotypic effects and suppression of nucleolar organising region activity in the extra autosomes; *Can. J. Genet. Cytol.* **26** 547-556

White M J D 1973 *Animal Cytology and Evolution* 3rd edition (Cambridge: Cambridge Univ. Press)

Yadav J S and Yadav A S 1993 Distribution of C-heterochromatin in seventeen species of grasshoppers (Acridoidea: Orthoptera); *Nucleus* **36** 51-56

Corresponding editor: RAGHAVENDRA GADAGKAR