



Karyotype Evolution and B Chromosome Polymorphism in Wild Grasshopper Populations

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Abstract

Grasshoppers have been favored material for chromosome studies for more than a century, because their chromosomes are large, few and easily prepared from the testis. The family Acrididae combines a remarkably conserved basic karyotype with frequent polymorphism in natural populations, and this combination makes it a convenient group in which to ask how chromosome complements change. This short communication brings together two strands of that literature which are usually treated apart. The first concerns rearrangement of the standard, or A, chromosomes: centric fusions, pericentric inversions and the fusions between the X chromosome and autosomes that create new sex chromosome systems. The second concerns B chromosomes, the dispensable supernumerary elements that persist in many species through transmission advantage and that have been followed for decades in populations of *Eyprepocnemis plorans* and *Myrmeleotettix maculatus*. The note argues that both kinds of variation are best understood as outcomes of conflict and accommodation within the genome, played out in meiosis, and that wild populations remain the only place where the resulting dynamics can be observed. It closes with practical remarks on how such polymorphisms are scored and on what combined cytological and genomic study could add.

Keywords: B chromosomes, Karyotype evolution, Acrididae, Centric fusion, Chromosomal polymorphism, Meiotic drive

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1. Introduction

Few animal groups have contributed as much to cytogenetics as the short-horned grasshoppers. Their meiotic chromosomes can be read in a simple squash of the testis, and the classical accounts of chiasma formation, sex chromosome behavior and chromosomal polymorphism rest heavily on them (White, 1973; Hewitt, 1979). Two features of the group stand in apparent tension. The basic karyotype is highly conserved across hundreds of species, yet individual populations often carry visible variants: fused chromosomes, inversions, extra heterochromatic segments and supernumerary chromosomes. This communication considers what that tension implies about how karyotypes evolve, with particular attention to B chromosomes. It is a commentary on published work and presents no new observations.

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2. A Conserved Karyotype and Its Departures

The standard complement of the Acrididae consists of eleven pairs of rod-shaped autosomes and an X chromosome, giving $2n = 23$ in males, which are X0, and 24 in females. Most departures from this arrangement are centric fusions, which join two rod chromosomes into one two-armed element and lower the count without changing the number of major arms. The gomphocerine grasshoppers of the genus *Chorthippus* and their allies, with three pairs of large metacentric chromosomes and seventeen chromosomes in the male, are the familiar case (Hewitt, 1979). When the X chromosome is the fusion partner the unfused autosome becomes a neo-Y, and neo-XY systems have arisen in this way many times across the Orthoptera (Castillo et al., 2010).

Fusions are not only fixed differences between species. In the South American grasshopper *Dichroplus pratensis* several autosomal fusions are polymorphic within and between populations, and their distribution has been read as support for the theory that asymmetries of female meiosis favor one chromosome form over another (Bidau and Martí, 2004). That theory, formulated for mammals by Pardo-Manuel de Villena and Sapienza (2001), holds that the egg pole of the spindle captures centromeres of differing strength unequally, so that the direction of karyotypic change is set by drive and not by the fitness of carriers. Whether a new rearrangement spreads, persists as a polymorphism or is lost also depends on its effects on fertility in heterozygotes, a question long central to chromosomal models of speciation (White, 1973). Figure 1 groups the forms of variation met in natural populations.

3. B Chromosomes as a Population Polymorphism

B chromosomes are additional to the standard set, are absent from some individuals of a species, do not pair with A chromosomes at meiosis and are inherited in a non-Mendelian way. First noticed as supernumeraries in hemipteran insects early in the twentieth century, they are now known from a great range of plants and animals (Jones and Rees, 1982). Östergren (1945) proposed that they are parasitic, maintained by mechanisms of accumulation in spite of harm to the carrier, and that interpretation, set against the alternative that they confer some benefit, has framed the subject since (Camacho et al., 2000). Table 1 summarizes the features by which B chromosomes and A chromosome rearrangements are compared in this note.

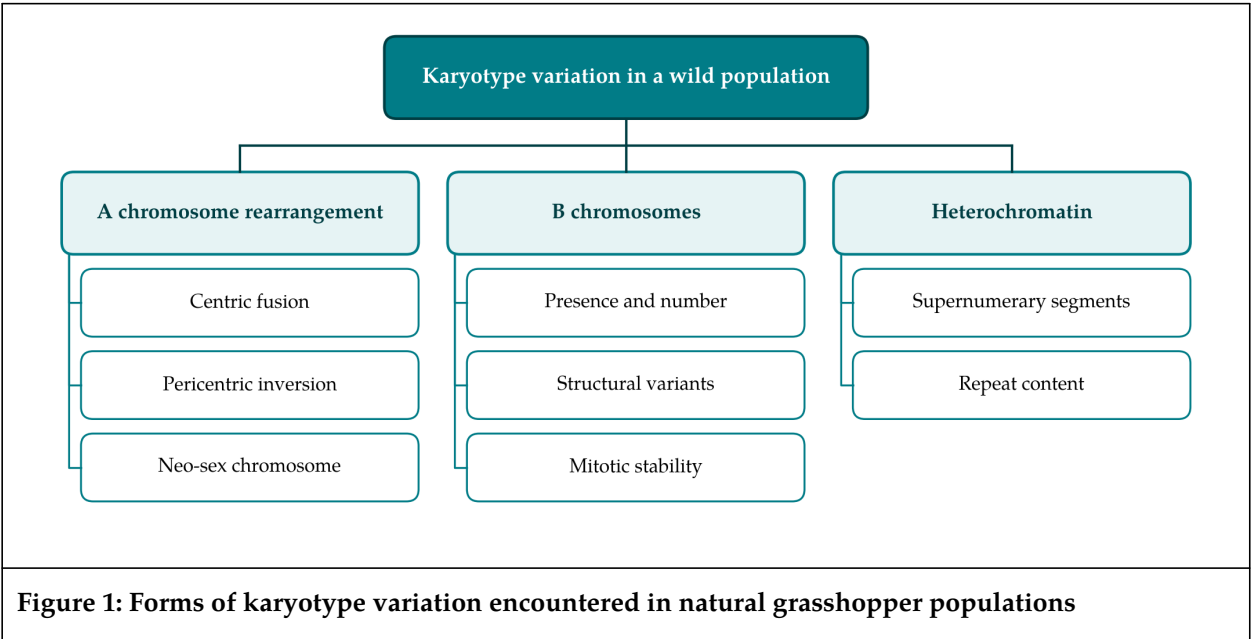


Figure 1: Forms of karyotype variation encountered in natural grasshopper populations

Grasshoppers supplied two of the best studied systems. In *Myrmeleotettix maculatus* the frequency of B chromosomes varies geographically within Britain, and classical work related their mechanics in meiosis to their distribution (John and Hewitt, 1965). In *Eyprepocnemis plorans*, around the western Mediterranean, the B chromosome occurs in many structural variants, and long-term study led to a model in which a B

invades through drive, is neutralized as the A genome evolves suppression of that drive, and then drifts toward loss unless a new variant that has recovered drive replaces it (Camacho et al., 1997). On this view a population sampled at one moment shows a single frame of a long contest, and the apparent neutrality of a B in a given locality says little about its past.

Table 1: A chromosome rearrangements and B chromosomes compared as sources of karyotype polymorphism in grasshoppers

Aspect	A chromosome rearrangement	B chromosome
Cytological sign	Altered shape or number with arm number conserved	Extra element, often heterochromatic, unpaired with A set
Inheritance	Mendelian unless distorted in female meiosis	Non-Mendelian; accumulation or loss
Proposed driver	Centromere drive (Pardo-Manuel de Villena and Sapienza, 2001)	Transmission advantage (Östergren, 1945)
Cost to carrier	Reduced fertility of some heterozygotes	Reduced fertility at high B numbers
Typical fate	Fixation, loss or stable cline	Suppression of drive, decay, replacement by new variant
Model system	<i>Dichroplus pratensis</i>	<i>Eyprepocnemis plorans</i>

Molecular work has since altered the picture of what a B is. B chromosomes were long regarded as inert blocks of repetitive DNA, and in grasshoppers they are indeed rich in satellite and ribosomal sequences. They are not empty, however. Reviews across kingdoms show that they originate from the A chromosomes of the same or a related species and accumulate sequences from several sources (Houben et al., 2014), and the B of *E. plorans* carries protein-coding genes, some of them transcribed (Navarro-Domínguez et al., 2017). A selfish element with active genes has, at least in principle, the means to influence its own transmission.

4. What Wild Populations Still Offer

The two strands share a logic. A centromere that wins at female meiosis and a B chromosome that accumulates in the germ line both spread because of how they are transmitted, and both provoke a response from the rest of the genome. Laboratory crosses can measure transmission in a single generation. Only natural populations show the frequencies, clines and replacements that result over many generations, and the theoretical treatment of B chromosomes has depended on such field data from the start (Camacho et al., 2000).

Scoring these polymorphisms is straightforward but has known pitfalls. Males are examined at diplotene or first metaphase in testis squashes, where B chromosomes can be told from the X by size and by their behavior, though both may be heteropycnotic; females require embryos or somatic tissue. Where Bs are mitotically unstable, the number varies among follicles of one testis and a single count misleads. C-banding and fluorescence in situ hybridization with ribosomal and satellite probes distinguish B variants that look alike in plain stain. Combining such cytology with sequencing of the same individuals would allow drive, suppression and gene content to be studied together, which has so far been achieved for very few populations.

5. Conclusion

Wild grasshopper populations preserve a conserved chromosome set while continually generating variants of it. Centric fusions, neo-sex chromosomes and B chromosomes differ in structure but share a dependence on meiotic transmission, and each is better explained by conflict within the genome than by adaptation of the organism alone. Long-term sampling of natural populations, joined to molecular characterization of the variants found, remains the most direct way to test that interpretation.

Conflict of interest

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References

- Bidau, C.J. and Martí, D.A. (2004). B chromosomes and Robertsonian fusions of *Dichroplus pratensis* (Acrididae): Intraspecific support for the centromeric drive theory. *Cytogenetic and Genome Research*, 106(2-4): 347-350.
- Camacho, J.P.M., Sharbel, T.F. and Beukeboom, L.W. (2000). B-chromosome evolution. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, 355(1394): 163-178.
<https://doi.org/10.1098/rstb.2000.0556>
- Camacho, J.P.M., Shaw, M.W., López-León, M.D., Pardo, M.C. and Cabrero, J. (1997). Population dynamics of a selfish B chromosome neutralized by the standard genome in the grasshopper *Eyprepocnemis plorans*. *The American Naturalist*, 149(6): 1030-1050.
- Castillo, E.R., Marti, D.A. and Bidau, C.J. (2010). Sex and neo-sex chromosomes in Orthoptera: A review. *Journal of Orthoptera Research*, 19(2): 213-231.
- Hewitt, G.M. (1979). *Grasshoppers and Crickets*. Animal Cytogenetics, Vol. 3: Insecta 1, Orthoptera. Gebrüder Borntraeger, Berlin.
- Houben, A., Banaei-Moghaddam, A.M., Klemme, S. and Timmis, J.N. (2014). Evolution and biology of supernumerary B chromosomes. *Cellular and Molecular Life Sciences*, 71(3): 467-478.
<https://doi.org/10.1007/s00018-013-1437-7>
- John, B. and Hewitt, G.M. (1965). The B-chromosome system of *Myrmeleotettix maculatus* (Thunb.). I. The mechanics. *Chromosoma*, 16: 548-578.
- Jones, R.N. and Rees, H. (1982). *B Chromosomes*. Academic Press, London.
- Navarro-Domínguez, B., Ruiz-Ruano, F.J., Cabrero, J., et al. (2017). Protein-coding genes in B chromosomes of the grasshopper *Eyprepocnemis plorans*. *Scientific Reports*, 7: 45200.
<https://doi.org/10.1038/srep45200>
- Pardo-Manuel de Villena, F. and Sapienza, C. (2001). Female meiosis drives karyotypic evolution in mammals. *Genetics*, 159(3): 1179-1189.
- White, M.J.D. (1973). *Animal Cytology and Evolution*, 3rd ed. Cambridge University Press, Cambridge.
- Östergren, G. (1945). Parasitic nature of extra fragment chromosomes. *Botaniska Notiser*, 2: 157-163.