Inbreeding in a natural population of the grasshopper *Chorthippus nevadensis*

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Using supernumerary segments as chromosome markers, a high rate of inbreeding has been detected in a natural population of *Chorthippus nevadensis*. This could be related with the low mobility of these brachypterous grasshoppers.

INTRODUCTION

The most evident form of polymorphism in grasshopper populations is that caused by the presence of supernumerary chromosome segments, since they have been detected in most the species exhaustively studied cytologically. The great majority of supernumerary segments are heterochromatic, as indicated by their positive heteropycnosis in first meiocytes. However, they show four different types of response to C-banding, which demonstrates the heterogeneity of the heterochromatin they contain (Camacho *et al.*, 1984). In the present report we analyse cytologically a population sample of *Chorthippus nevadensis* for the presence of supernumerary segments in three chromosome pairs. This demonstrates the existence of inbreeding in this population.

MATERIALS AND METHODS

Chorthippus nevadensis is a brachypterous grasshopper recently described by Pascual (1978a) which is endemic in the Sierra Nevada (Granada, Spain) at altitudes ranging from 1900 m to 3300 m (Pascual, 1978b). During the summers of 1981, 1982 and 1983 six, nine and 71 adult males, respectively, were collected at Alto del Chorrillo (2700 m) within an area of about 900 m². The cytological techniques used were those described in Camacho *et al.* (1984).

RESULTS AND DISCUSSION

Three chromosome pairs carrying supernumerary segments have been observed in the sample. These segments were small C-bands interstitially located in the L₂ and M₆ chromosomes besides a larger extra segment darkly C-banded and distally located in the S₈ chromosome (fig. 1). Table 1 summarises the frequencies of the different karyomorphs and chromosome types found.

The population sample obtained in 1983 was numerous enough to test the Hardy-Weinberg equilibrium for the L₂ and M₆ chromosomes. This population sample differed significantly from the equilibrium situation for both the L₂ and the M₆ chromosomes: $G = 17.90$, $P = 2.5 \times 10^{-5}$ for the L₂ and $G = 9.84$, $P = 1.9 \times 10^{-3}$ for the M₆. The G statistic, although is more accurate than X^2 test, gives an order of magnitude error in the probability level since the expected proportion of rare homozygotes is only 0.43. A better approach is to calculate the exact probability of finding n or more of the rare homozygotes, using the binomial distribution. Thus the chance of seeing four or more L₂-segmented homokaryotypes was $P = 9.2 \times 10^{-4}$ and that of seeing three or more M₆-segmented homokaryotypes was $P = 9.1 \times 10^{-3}$. Thus, in both cases there was a significant deficiency of heterozygous karyomorphs, paralleled by an excess of both homozygotes, which denotes the existence of inbreeding in this population. An estimation of the coefficient of inbreeding starting from the deficiency of heterozygotes resulted in the

Figure 1 Supernumerary segments (arrows) in *Chorthippus nevadensis*. Early diplotene cell showing heterozygosity for the L_2 , M_6 and S_8 bivalents.

Table 1 Supernumerary segments in *Chorthippus nevadensis*. B = basic, S = segmented chromosome. q_s = frequency of segmented chromosome

Chromosome	Year of sampling	Karyomorphic frequencies	q_s
L_2	1981	3BB: 3BS	0.0775
	1982	6BB: 2BS: 1SS	
	1983	64BB: 3BS: 4SS	
M_6	1982	8BB: 1BS	0.0775
	1983	63BB: 5BS: 3SS	
S_8	1982	7BB: 2BS	

following values: $F = 0.7$ for the L_2 and $F = 0.5$ for the M_6 . The existence of inbreeding in this species could be favoured by the low mobility of the adult individuals, which show a substantial reduction of their wings. This fact could also be responsible for the inbreeding detected in other species, such as the British and French populations of *Chorthippus parallelus* (John and Hewitt, 1966; Hewitt and John, 1968; Westerman, 1969, 1970), although we have observed that Spanish populations of this species show frequencies for the extra segments in the M_7 and S_8 chromosomes which do not differ significantly from those expected in the Hardy-Weinberg equilibrium (Cabrero, 1985).

There are two other brachypterous species of Orthoptera in which the observed frequencies for the karyomorphs of extra segments disagree with those expected in the equilibrium, indicating the possible existence of inbreeding. First, some populations of *Metrioptera brachyptera* show a sig-

nificant excess of homokaryotypes for the supernumerary segments in the L_4 chromosome (Southern, 1970). Secondly, in *Baetica ustulata* the frequencies of the ten different karyomorphs for the M_5 chromosome (which is polymorphic for the presence of supernumerary segments) differ significantly from those expected under the Hardy-Weinberg equilibrium (Fernández-Piqueras *et al.*, 1984). The data of these authors would seem to demonstrate the existence of inbreeding in this species, given the significant excess in the frequency of the four homokaryotypes and deficiency in the frequency of the six heterokaryotypes (see their table 3). However, this inference may not be sound because the karyomorphic frequencies were calculated after pooling individuals collected during three different years from three different altitudes in the Sierra Nevada (Granada, Spain): these results could be a consequence of the Wahlund's principle.

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