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the root tips of *A. formosana* and *A. consanguineum* the chromosome numbers 2n=28 (Figures 4-5) and 2n=14 respectively.

Table 1. The Chromosome Numbers of Taiwan *Arisaema*.

Species	Chromosome Numbers	Examiners	Date of Examination
A. consanguineum Schott**	14	Huang	May, 1961
A. consanguineum Schott var. kelung-insularis (Hay.) Huang	—	—	—
A. formosana Hay.	28	Huang	June, 1961
A. grapsospadix Hay.	—	—	—
A. heterophyllum Bl.	c.140	*Ito	1942
A. ringens (Thunb.) Schott	28	*Ito	1942
A. taihokensis Hosokawa	28	*Kishimoto	1941

* data from Darlington & Wylie 1955.
** The material used for this species may have been mislabelled.

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B-Chromosomes and Pollen Size in Maize[1]

PETER A. PETERSON AND ALAN MUNSON[2]

Abstract. Pollen grain size was used to measure the effect of the presence of a low number of B-chromosomes. The pollen grains of forty-two plants distributed among two classes —those with one to five B-chromosomes and those without B-chromosomes were measured. No significant differences could be detected between the mean pollen grain size of B and non-B-chromosome classes. There is an indication of an effect on the variance in pollen grain size of the B-chromosome class.

INTRODUCTION

Accessory chromosomes often called supernumerary or B-chromosomes are found among a wide range of plants and animals. The persistence and distribution of these accessory chromo-

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somes represent superficial support for their possible importance in a population.

Müntzing (1959) has summarized the numerous investigations on the importance of these B-chromosomes. (Hereafter, accessory chromosomes will be referred to as B-chromosomes). The non-randomness of their distribution and the correlation of B-chromosomes with certain soil conditions as well as geographical location (Fröst, 1958b; Bosemark, 1956) poses a question about their effect on plants in a general population.

This has led to the suggestion that B-chromosomes have a positive value. (Positive here implies a stimulating effect). There have been reports (Bosemark, 1957a; Fröst, 1954) of slight increases in yield and vigor with plants possessing B-chromosomes. Further support for a positive effect comes from studies on *Centuria scabiosa.* The B's in this species maintain themselves in a population despite small losses in successive generations and the lack of a mechanism such as non-disjunction that would enhance their retention. This type of evidence indicates that in a natural population there is a selection for B-chromosomes.

Another example of the positive effects of B's is the action of such chromosomes on pigment production in *Haplopappus* (Jackson and Newmark, 1960).

The deleterious effects of B-chromosomes on various traits have been emphasized by a number of workers (Randolph, 1941; Müntzing, 1943, 1954, 1959; Fröst, 1958a, 1959).

In this report, a study was undertaken to determine the effect of B-chromosomes on pollen size. Pollen grain size is considered a sensitive indicator of any possible genetical effect of B-chromosomes since it is a direct manifestation of the genotype of the gametophyte. There are several cases of genotypic control of the expression of pollen grain physiology and morphology. For example the waxy (*wx*) allele in the presence of iodine causes red coloration of the pollen grains in contrast to the purple staining pollen of the starchy (*Wx*) allele (Demerec, 1924). Another example of genotypic control of gametophytic expression occurs in the presence of the *sp* allele. Small pollen results and such grains are readily perceived among normal pollen grains following the quartet stage of meiosis (Manglesdorf, 1931).

Two aspects of B-chromosome influence on phenotypic changes in pollen grain size were examined. These include the effect of B-chromosomes on mean pollen grain size and, secondly, the effect of B-chromosomes on the variation of pollen grain size within each sample of pollen grains with and without B-chromosomes.

In the latter determination, the variation in sizes of pollen grains in individual anthers with B-chromosomes segregating would be compared with the variation in a sample of pollen grains from an anther without B-chromosomes. In this procedure, a direct effect of B-chromosomes could be determined since compensatory types of changes could be detected in the mean size of a sample. Using the variation within a sample, however, as an estimate of B-chromosome effect on pollen grain size, the possible averaging-out of individual pollen grain measurements that might result in an unchanged mean would be obviated. In this case, therefore, the variation itself would be an estimate of the effect of B-chromosomes.

Materials and Methods

Forty-two plants chosen at random from five ear progenies (1960-912, 936, 939, 942 and 943) arising from single crosses of a recurrent standard line to B-chromosome containing plants possessing 0, 1, 2, 4 or 5 B-chromosomes were used in the determination of pollen grain size (Table 1). These ear progenies have a common genetic background. B-chromosome number was determined from root tip studies of greenhouse germinated plants

Table 1. The distribution of B-chromosome containing plants used in the assessment of B-chromosome effect on pollen size

		Number of B-chromosomes				
		0	1	2	4	5
1960	912	7	13	..	..	..
	932	1	..	..	..	1
	939		..	3	2	..
	942	1	2	4	1	..
	943	1	6	..	..	..
Total plants	=	10	21	7	3	1
Total pollen grains Plants x30	=	300	630	210	90	30

that were later (3-4 leaf stage) transferred to the field. A section of tassel (4-6 cm) was collected from that part immediately below the location where the anthers were being extruded from the spikelets for that day. This segment from the main stalk of the tassel is expected to shed the following day.

Pollen of a single anther was stained in lactophenol aniline blue. Measurements of thirty individual pollen grains for each plant were made with a 10x optical micrometer. In the tables, the units presented as mean pollen grain size represent the values from the readings of the micrometer scale and these values should be multiplied x .0176 for the metric equivalent. Example: mean pollen grain size = .0947 mm; (scale reading = 5.574 x .0176 = .0947 mm.)

Results and Discussion

A number of comparisons were made regarding the effect of B-chromosomes on pollen grain size. No significant difference was found between the means in any comparisons (Table 2). This includes a comparison of the mean pollen grain sizes between the class without B's and the class containing from 1-5 B's (Table 2, A). In a comparison of 0-B and 1-B containing plants of one-ear progeny (1960-912), the difference in the mean pollen grain sizes of the two classes were not significant, (Table 2, B).

Table 2. Comparison of pollen size from plants with various numbers of B-chromosomes of 1960–912, 936, 939, 942 and 943

# of B's	# of plants	$\bar{x}$ = mean size of pollen	t value calculated	t value d.f.	t value tabular (10%)
A. All plants, 5 different ear progenies					
0	10	5.574	0.166	40	1.684
1-5	32	5.591			
B. 1960–912 only					
0	7	5.514	0.8782	18	1.734
1	13	5.595			
C. Comparison between 0 and 1, 1 and 2					
0	10	5.574			
			0.5190	29	1.699
1	21	5.626			
			0.7250	26	1.706
2	7	5.537			

Comparisons were made between the 0-B and 1-B and in addition, the 1-B and 2-B chromosome classes. The lower mean value of the 2-B-chromosome class suggests that there is no indication of a linear trend in the pollen grain size for the higher number of B-chromosomes (Table 2, C).

This lack of a significant difference in the mean size of pollen grains of plants with and without B's might be a result of the averaging-out of increases and decreases in the dimensions of individual pollen grains. This would result in an unchanged mean.

In view of the possibility that the presence of B-chromosomes might contribute to an increase in variance it was desirable to compare the within-plant variance for pollen grain size in the non-B and B-chromosome classes.

Table 3. Comparison of the within-plant variance between non-B and B-chromosome containing plants for pollen grain size

# of B's	d.f.	s^{2}	F value calculated	F value Tabular (10%)
0	290	0.09921		
			1.135	1.133
1-5	928	0.112604		

In a test of the homogeneity of variance with a one-tail F test, there is an indication of a slightly greater amount of variance in the B-chromosome class at the 10% level of significance. This will be further tested with a larger number of B-chromosomes.

In reference to effects of B-chromosomes on other criteria such as pollen fertility, yield and other plant characters, Müntzing (1943, 1954), Fröst (1958a, 1959) and Bosemark (1957a) have reported deleterious effects accompanying the presence of B-chromosomes.

Bosemark (1957a, b) using *Festuca pratensis* has reported stimulatory effects with low numbers of B-chromosomes. The findings presented in this report regarding the effect of a low number of B-chromosomes indicate no significant differences in the mean size of pollen grains. There is, however, an indication of a slighter greater amount of variance in the B-chromosome containing class.

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