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Chromosomal Variation among Brown Planthopper, *Nilaparvata lugens* (Stål), Biotypes in Korea

한국산 벼멸구 생태형의 염색체 변이

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ABSTRACT Salient chromosomal variations during the first meiotic division in primary spermatocytes of the three brown planthopper, *Nilaparvata lugens* (Stal), biotypes were observed. The meiotic index was highest in biotype 3 (58.6), followed by biotype 1 (39.4) and biotype 2 (23.6). Total chromosomal aberration including agmatoploidy, aneuploidy, loose pairings of sex chromosomes, and cytoplasmic shrinkage was found high in the order of biotype 1 (60.6%), 2 (47.9%), and 3 (38.1%). However, percent agmatoploidy was highest in biotype 2 (19.6%) whereas in biotypes 3 and 1, it was 9.5% and 2.5%, respectively. The number of cells with isolated sex chrosomomes was observed highest in biotype 2.

KEY WORDS Brown planthopper, *Nilaparvata lugens*, biotypes, chromosomal variation

초 록 벼멸구 수컷 정소에서 염색체의 변이정도를 생태형 별로 관찰하였다. 세포 분열 지수는 생태형 3에서 가장 높았고 그 다음으로 생태형 1, 생태형 2이었다. Agmatoploidy, aneuploidy, 성염색체의 loose pairings과 같은 염색체의 구조적 변화는 생태형 1, 생태형 2, 생태형 3순으로 높았다. 감수분열 제1분열기 중기는 성염색체가 상염색체로부터 현격하게 분리되어 있는 세포의 수는 생태형 2에서 가장 높았다.

검 색 어 벼멸구, 생태형, 염색체 변화

The triumphant attempt to regulate *N. lugens* infestation through varietal resistance has resulted in dramatic alterations in the ecology and physiology of the pest populations. The dissimilar selection pressure provided by the host varieties coupled with the pest's innate biological feats: small size, short life cycle and generation time, high fecundity, and a wide range of distribution has caused rapid differentiation of *N. lugens* populations into variant forms termed biotypes.

These biotypes are a major threat to the stability of resistant rice varieties. Failure to recognize their existence in nature can have far reaching and frustrating consequences in pest management.

Systematic studies of the *N. lugens* biotypes play important roles in pest management by providing tools in the analysis of *N. lugens*-rice variety relationships. The analysis would serve

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Table 1. Meiotic index of the primary spermatocytes among the three *N. lugens* biotypes

Biotype	No. of specimens	No. of cells*		Meiotic index
		Dividing	Nondividing	
1	2	364.4 c	781.2 c	39.4 b
2	2	827.3 b	2922.5 a	23.6 c
3	2	3339.0 a	2530.0 b	58.6 a

*Avg. of 10 replicates. In a vertical colum, means followed by a common letter are not sighificantly different at 5% level by t-test.

Table 2. Chromosomal aberrations in males of the three *N. lugens* biotypes

Haploid no.	No. of cells observed*		
	B1	B2	B3
n=15	16	24	26
n=18	0	1	0
n=17	0	1	0
n=16	1	7	4
% agmatoploidy	2.5	19.6	9.5
n=14	9	8	5
n=13	8	3	4
n=12	3	0	2
n=11	2	1	0
n=10	1	0	0
n= 9	0	1	0
n= 8	0	0	1
% aneuploidy	57.5	28.3	28.6
% abnormality	60.0	47.9	38.1

*Based on the total numbers of diakinesis cells from each of 14 individuals per biotype.

Table 3. Chromosomal and cellular variations in males of the three *N. lugens* biotypes

Biotype	No. of cells observed	Loose pairing of sex chromosome		Cytoplasmic shrinkage	
		No.	%	No.	%
1	40	13	32.5	33	82.5
2	46	5	10.9	4	8.7
3	42	1	2.4	2	4.8

*Based on the total numbers of diakinesis cells from each of 14 individuals per biotype.

as a critical basis in programs of breeding *N. lugens* resistant rice varieties. Recent investigations have demonstrated the existence of subtle variations in morphology, cytology, and protein electrophoresis pattern among the *N. lugens* biotypes(Saxena & Barrion 1983, Saxena & Rueda 1982, Saxena & Mujer 1984).

So far, three Korean *N. lugens* biotypes have been identified based on their differential varietal reactions: biotype 1 on Chucheong rice variety(no gene for resistance), biotype 2 on Cheongcheong rice variety(bph 1 resistance gene), and biotype 3 on Milyang 63(bph 2 resistance gene)(Lee at al. 1982, 1985).

The present study was conducted to compare the chromosomal features of the three *N. lugens* biotypes.

MATERIALS AND METHODS

For chromosomal preparations, newly emerged males were collected from stock culture in Entomology Departeent, Agricultural Sciences Institute of Korea, and fixed in Carnoy's fixative. The testes were dissected out, stained in a drop of 2% lacto-aceto orcein and squashed by the methods of Saxena and Barrion (1982) and Goh et al.(1988). Spermatocytial cells and their chromosomes were examined under 1250 times oil immersion objectives of the research microscope. Camera lucida drawings were made and photomicrographs were taken directly from temporary slide preparations.

RESULT AND DISCUSSION

The mean number of dividing cells was highest in biotype(B) 3, followed by B2, and lowest in B1. On the other hand, the mean number of non-dividing cells was highest in B2, followed by B3, and lowest in B1. The meiotic index, therefore, was highest in B3, followed by B1, and least in B2(Table 1). Since spermatogenesis is mainly a meiosis-based process of gamate formation, the meiotic indices can be directly correlated with the reproductive potential of male *N. lugens*. Thus, in terms of gametic cell production, B3 could be considered as the most prolific

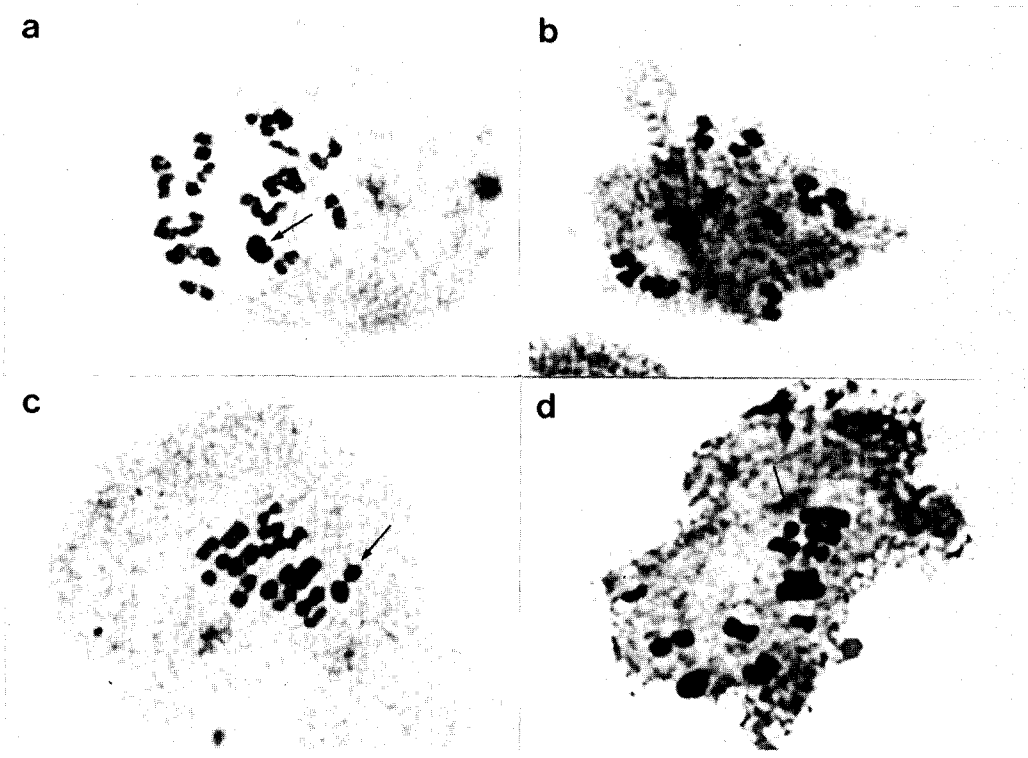

Fig. 1. Cellular and chromosomal aberrations in males of *N. lugens*.
a=agmatoploidy (n=18); b=aneuploidy (n=12), c=loose pairing of sex chromosomes; and d=cytoplasmic shrinkage. Sex chromosomes are pointed by arrow. Magnification, 1250× (oil immersion).

population followed by B1, while B2 had the least reproductive fitness.

Spontaneous cellular and chromosomal aberrations in *N. lugens* biotypes included agmatoploidy or increase in chromosome number, aneuploidy or decrease in chromosome number, loose pairings of sex highest in B2(19.6%) followed by B3 (9.5%) and least in B1 (2.5%) (Table 2). Aneuploidy (Fig. 1b) was highest in B1 (57.5%) and almost equal in B2 (28.3%) and B3 (28.8%) (Table 2). More loose pairings of sex chromosomes (Fig. 1c) were observed in B1 (32.5%) than B2 (10.9%) and B3 (2.4%) (Table 3). Likewise, more testicular cells with

Table 4. Frequency of metaphase 1 cells with sex chromosomes isolated from autosomes in three *N. lugen* biotypes

Biotype	No. of cells(%)*	
	Isolated	Total observed
1	18(25.7)	70
2	47(65.3)	72
3	8(10.8)	74

*Based on total numbers of diakinesis cells from each of 14 individuals per bitype.

Table 5. Means of the distance of sex chromosomes from autosomes and autosome length in metaphasel cells in the three *N. lugens* biotypes*

Biotype	No. of metaphase analyzed	Distance(㎛) of sex chromosome from autosome	Length(㎛) of autosomal clump
1	44	1.26 b	75.49 ab
2	44	3.01 a	87.01 a
3	44	0.53 b	72.08 b

*In a vertical colum, means followed by a common letter are not sighificantly different at 5% level by t-test.

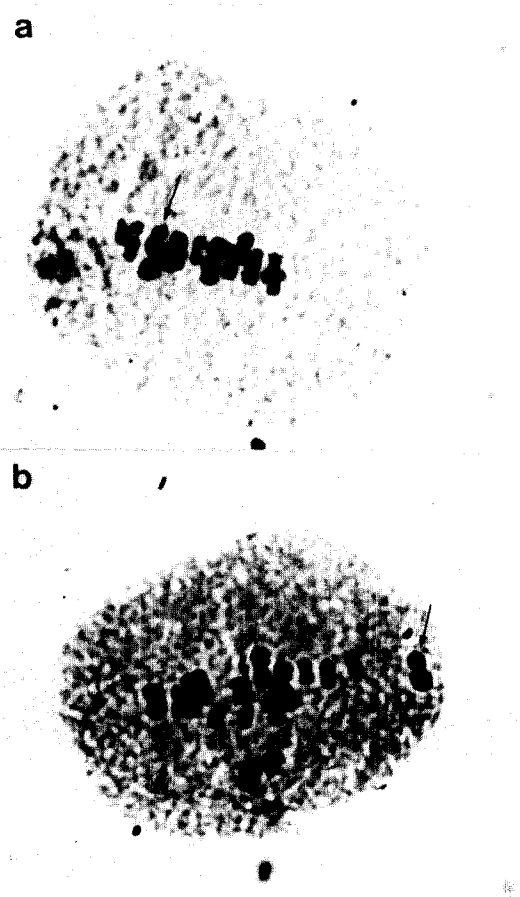

Fig. 2. Chromosomal behavior of *N. lugens* during metaphase I stage of spermatogenesis:
a. sex chromosomes and autosomes combined
b. sex chromosomes isolated from autosomes.
Sex chromosomes are pointed by arrow.
Magnification, 1250× (oil immersion).

shrinked cytoplasm (Fig. 1d) were observed in B1 (82.5%) than B2 (8.7%) and B3 (4.8%) (Table 3). Thus based on the totality of abnormalities observed, the three *N. lugnes* biotypes can be ranked as follows: B1>B2>B3.

The highest number of cells with isolated sex chromosomes (Fig. 2b) was observed in B2 (65.3%) followed by B1 (25.7%) and B3 (10.8%) (Table 4). The average distances of the sex chromosomes from autosomal groupings in B2 was significantly higher than those from B1 and B3. No significant differences were observed between B1 and B3. Likewise, the length of the autosomal clump was significantly longer in B2 than in B3 but not with B1 (Table 5).

Chromosome cytology has also contributed significantly to different levels of insect systematics, from the study of higher categories to the species level down to the investigation of races and local populations by emphasizing their cytotaxonomic differences (Boyes 1965). Subtle cellular and chromosomal variations exist between related species, sibling species, subspecies, and biotypes (Smith 1960). Chromosomal polymorphism is a fully documented mechanism of speciation among insects (Carson 1973). It is well known in natural populations of Orthoptera (White 1965), Dipera (Da Cunha 1955), Coleoptera (Smith 1956), Hemiptera (Hughes-Schrader & Schraded 1961) and Homoptera (Whitten & Taylor 1969).

In the case of the Korean biotypes of *N. lugens*, the highest meiotic index was observed in B3, followed by B2, and lowest in B1. Chromosomal aberrations, such as agmatoploidy, aneuploidy, loose pairings of sex chromosomes, and shrunk cytoplasm, were found in B1 than B2 and B3. The highest number of cells with isolated sex chromosomes was observed in B2, followed by B1 and B3. These cytological variations among *N. lugens* biotypes are evidences of de novo genetic isolating mechanisms. The cytological attributes of adults will provide effective criteria for differentiating *N. lugnes* biotypes.

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