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THE "BIOTYPES" OF THE RICE BROWN PLANTHOPPER, *NILAPARVATA LUGENS*

BY

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From previous studies, the biological nature of the so-called biotypes of *N. lugens* is obscure. Experiments on biotypes 1, 2 and 3 from the Philippines demonstrated that they lacked significant breeding barriers. Inbred biotype cultures showed considerable variation and overlap between each other in virulence. A field population from the Philippines was similarly variable and included individuals which could be attributed to different biotypes. It is concluded that the use of the term biotype in this species is biologically misleading and undesirable.

The Brown Planthopper, *Nilaparvata lugens* Stål, is a major pest of rice in Asia, the rise to importance of which coincided with the introduction of high yielding, rapidly maturing, cultivars of rice (Smith, 1972; Nickel, 1973). Heavy infestations cause rapid desiccation of the plants (hopperburn) and may result in total loss of the crop (Dyck, 1977). As well as its direct feeding damage, *N. lugens* also acts as the vector of the virus diseases — "grassy stunt" (Ling, 1967) and "ragged stunt" (IRRI, 1978).

Resistance to *N. lugens* attack has been known for some years in several rice varieties of the *indica* group (Pathak *et al.*, 1969; Athwal *et al.*, 1971; Khush *et al.*, 1977; Lakshiminarayana & Khush, 1977). However, it soon became apparent, at least in some areas, that the insect could overcome the plant resistance. The result has sometimes been described erroneously as a breakdown of resistance. The resistance had not broken down: it was still effective against the original populations of the Brown Planthopper, but not against the new forms.

These different forms of *N. lugens*, with the ability to damage varieties of rice previously resistant to it, have been termed "biotypes" and identified individually by numbers (Pathak, 1975; IRRI, 1976; Cheng, 1977; Saxena & Sogawa, 1977; Pathak & Khush, 1977). It has been claimed that some of the biotypes differ in small morphological and chemical features (IRRI, 1978; Sogawa, 1978). However, the major differences between them concern their ability to infest rice cultivars bearing certain genes for resistance. Four such resistance genes have been identified in rice giving five possible biotypes of the pest (Khush *et al.*, 1977; Lakshiminarayana & Khush, 1977) (Table I).

The precise nature of the biotypes of *N. lugens* is not clear. Conflicting suggestions, based on little experimental evidence, have been made concerning

TABLE I

The biotypes of N. lugens, *showing rice variety susceptible to each and associated nomenclature and dominance status of resistance genes of host plant. TNI, with no resistance genes, is susceptible to all biotypes. After Khush et al. (1977) and Lakshminarayana & Khush (1977)*

Biotype	Rice variety	Resistance gene
1	TNI	None
2	MUDGO	BPH 1 (dominant)
3	ASD7	bph 2 (recessive)
4	Rathuheenati	BPH 3 (dominant)
5	Babawee	bph 4 (recessive)

the degree of genetic differentiation between them. We have made broadly based investigations on the morphology, cytology, biochemistry and behaviour of some of the biotypes in addition to genetic studies. This paper reports results mainly on mate choice experiments and experiments on the major basis for determining biotypes - their relative abilities to infest and damage different rice varieties, which we here term virulence.

METHODS

Biotypes 1, 2 and 3 from the cultures maintained at the International Rice Research Institute (IRRI), Philippines, were used. Some experiments were made at IRRI, but others were done in Cardiff on subcultures from IRRI. A field population from the Philippines (Victoria, Laguna, Luzon) collected on the cultivar, IR22 (susceptible to all biotypes and lacking resistance genes, hence similar to TNI), was also studied for biotype characteristics.

Mate choice experiments. Male and female *N. lugens* communicate by substrate transmitted signals during courtship (Ichikawa & Ishii, 1974). Mate choice experiments were done simply by placing three rice plants in separate pots in series with their leaves just touching. In female choice experiments, a single female was placed on the base of the centre plant and one male of the same biotype on the base of one of the outside plants and one male of the test biotype on the other. After courtship singing commenced, the males moved towards the female and the successful mating combinations were recorded. For male choice experiments the procedure was similar, but a single male was placed on the central plant and one female on each of the outer plants. Isolation indices were calculated after Merrell (1950).

Biotype determination. A modification by P. K. Pathak of the method developed at IRRI (1978) was used. Individual newly emerged females, up to 12 hr old, were starved for 4 hr, weighed and placed in a parafilm envelope which was then attached to a living rice stem. After 24 hr in a constant temperature cabinet (25° and 12 hr light), the insect was removed and weighed again. Any honeydew

produced during the 24 hr collected in the envelope, which was cut off, weighed, blotted dry and weighed again. The weight loss or gain of the insect was found to be highly correlated with the amount of honeydew produced in 24 hr and so the latter measure alone was used, with considerable saving of time and labour.

Using the above method, the amounts of honeydew produced by individual adult females of biotypes 1, 2 and 3 reared on TN1, Mudgo and ASD7 respectively, were determined for each biotype on the three cultivars. These were compared with the amounts of honeydew produced by a sample of insects from the field population collected on IR22 and tested on Mudgo and ASD7.

RESULTS

Our unpublished data on the morphology, cytology, biochemistry and acoustic behaviour of the biotypes show no significant differences between biotypes 1, 2 and 3, from the Philippines, and do not confirm previously reported differences (IRRI, 1978).

Mate choice. The results of male and female mate choice experiments (Table II) show that for both, isolation indices were not significantly different from one. Thus, no breeding barriers exist between these biotypes and mating occurs

TABLE II

Results of male and female mate choice experiments between Philippine biotypes 1, 2 and 3. Merrell's isolation indices in all experiments not significantly different from 1 using χ^2 test

Female Choice					
Females	Males		Heterogametic matings	Homogametic matings	Merrell's Isolation Index
Biotype 1	Biotype 1	Biotype 2	11	13	1.07
Biotype 2	Biotype 1	Biotype 2	20	16	
Biotype 1	Biotype 1	Biotype 3	12	16	0.84
Biotype 3	Biotype 1	Biotype 3	20	22	
Biotype 2	Biotype 2	Biotype 3	11	9	1.00
Biotype 3	Biotype 2	Biotype 3	14	16	
Male Choice					
Males	Females				
Biotype 1	Biotype 1	Biotype 2	16	11	1.42
Biotype 2	Biotype 1	Biotype 2	18	13	
Biotype 1	Biotype 1	Biotype 3	7	12	0.82
Biotype 3	Biotype 1	Biotype 3	11	10	
Biotype 2	Biotype 2	Biotype 3	15	10	1.26
Biotype 3	Biotype 2	Biotype 3	9	9	

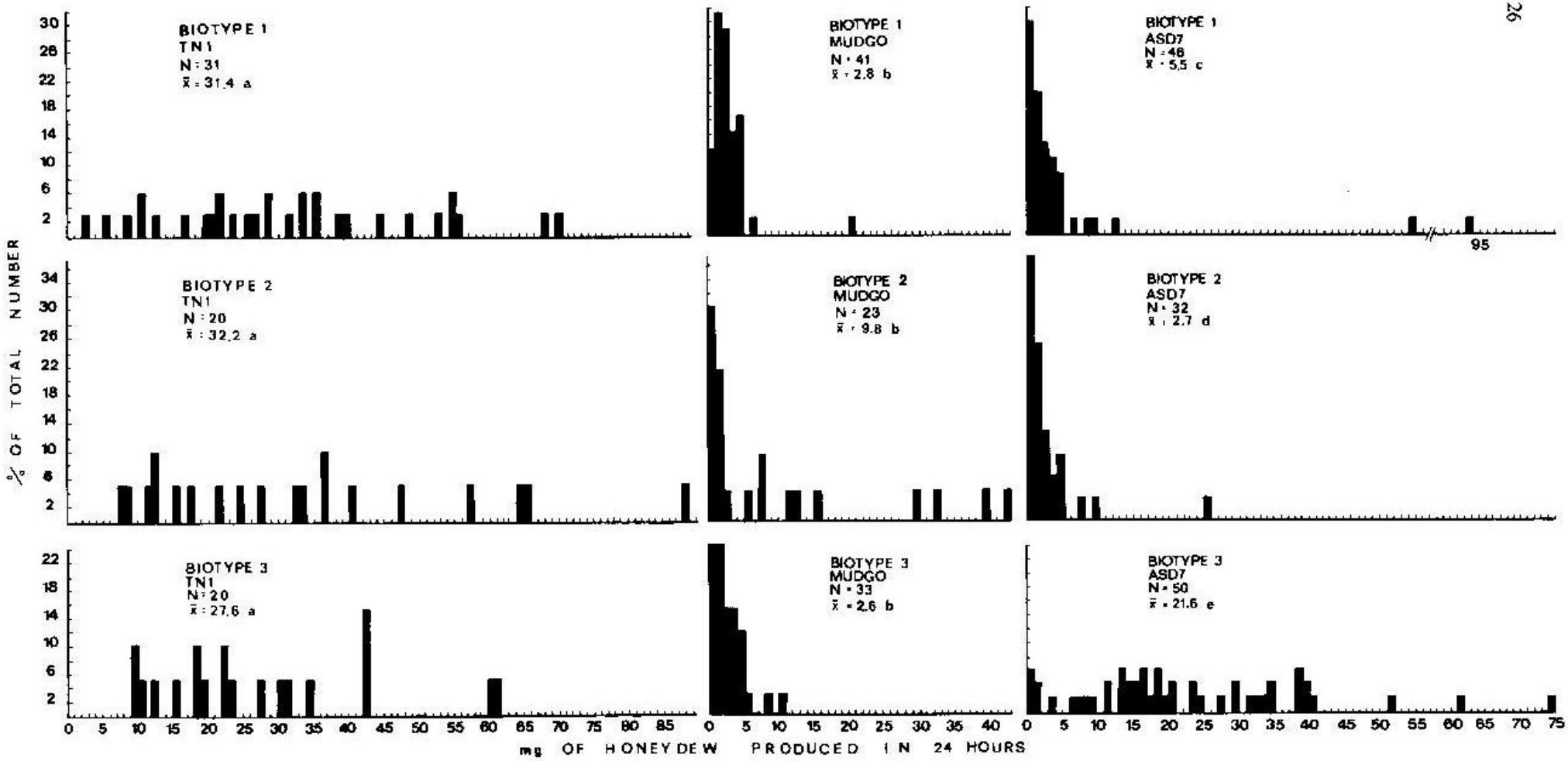

Fig. 1. Honeydew produced by individuals of biotypes 1, 2 and 3 on rice cultivars TN1, Mudgo and ASD7. Means followed by same letter either in rows or columns not significantly different at the 5% level using Kruskal-Wallis H test.

essentially at random (Merrell, 1950). It is thus clear that the biotypes, at least at IRRI, represent variants of one freely interbreeding biological species.

Biotype determination. Weights of honeydew produced by individual females of the three biotypes on TNI, Mudgo and ASD7 were measured by one of us (J.H.) and P. K. Pathak at IRRI. There was a very wide range of variation within each biotype and a large overlap between them (Fig. 1). Though means for each biotype on the three test cultivars were all significantly different from each other, those for biotypes 1, 2 and 3 on TNI and Mudgo, but not on ASD7, were not significantly different amongst themselves. This clearly emphasises the variability of the biotype populations.

In each biotype population, there were many individuals which might be attributed to a different biotype. Thus, the biotypes are not clearly separable and different from each other.

The results of similar measurements of honeydew production by females from a randomly collected field sample, although resembling biotype 1, clearly contained individuals which could be classified as either biotypes 2 or 3 when tested on Mudgo and ASD7 (Fig. 2).

DISCUSSION

It is currently widely assumed that the biotypes of *N. lugens* are separable by clear-cut patterns of virulence on certain test varieties of rice. However, most methods of biotype determination rely either on percentage survival (Pathak & Khush, 1977), or on the averaged honeydew produced by five or more individuals (IRRI, 1978) on the varieties TNI, Mudgo and ASD7. For large scale screening, heavy infestations of *N. lugens* are introduced on to seedling beds of the three cultivars and the pattern of damage then used to determine the biotype of the population (IRRI, 1976). These methods all tend to mask any individual variation present within the pest population.

The results reported here show that, even in the inbred biotype cultures maintained at IRRI, when a comparison is made of the distribution of virulence of individuals within each supposed biotype, a wide range of variation within, and overlap between them, is revealed (Fig. 1). When a field population was studied, it too was found to include individuals with the characteristics of more than one biotype (Fig. 2). It thus appears that the term biotype has little biological value.

When a clear gene for gene relationship exists between resistance on the part of a plant and virulence on the part of a pest, labelling of biotypes may be useful, as in the relationship between some fungal pests and their hosts (Flor, 1956). However, when biotypes, such as those of *N. lugens*, have wide ranges of variation and overlap widely with each other, the assigning of populations to particular biotypes is necessarily arbitrary and of little value. In addition, experiments on crossing IRRI biotypes 1, 2, and 3, clearly suggest that the inheritance of virulence is polygenic in nature (Den Hollander & P. K. Pathak, *in litt.*).

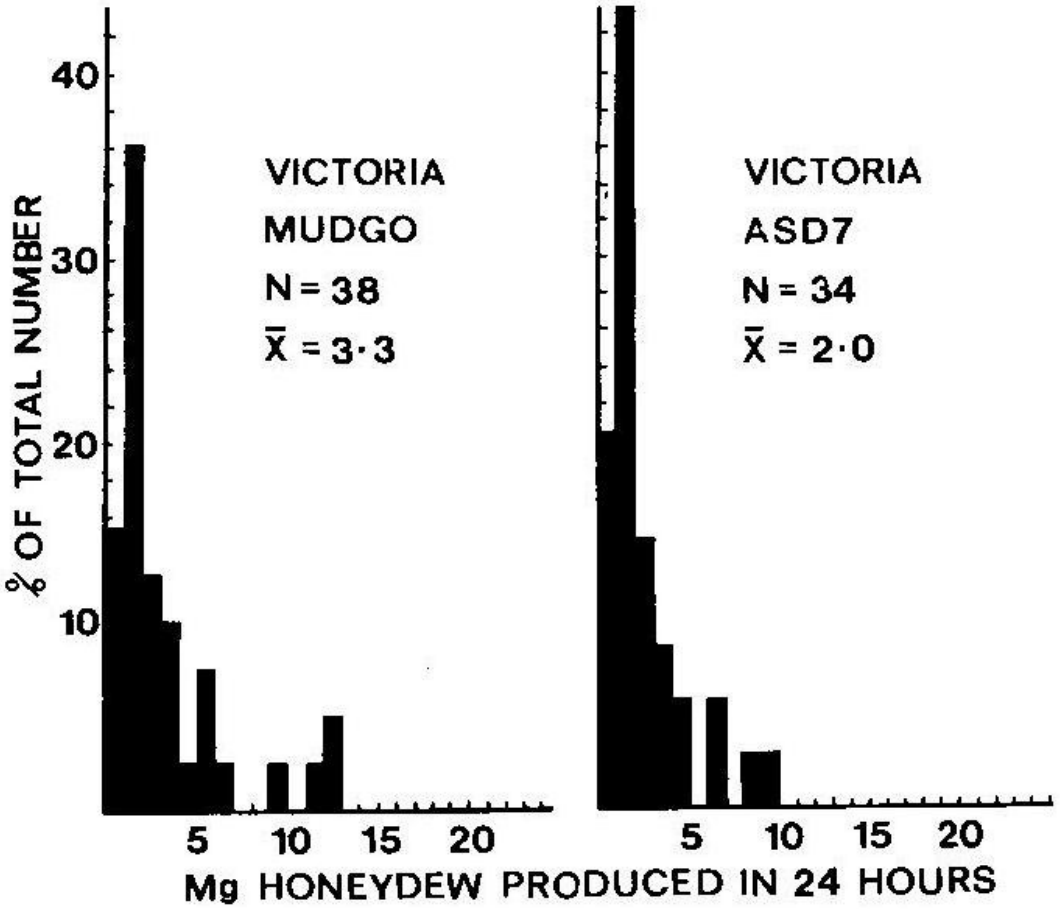

Fig. 2. Honeydew produced by individuals from field sample of *N. lugens* from Victoria (Laguna, Luzon, Philippines) collected from IR22 and tested on Mudgo and ASD7.

It seems likely that field populations of *N. lugens* are normally variable for virulence and will evolve in response to the particular rice varieties planted in any area. Thus, it is dangerous to speak of the same biotypes as occurring in widely different geographical areas. Naming or otherwise labelling such biotypes may make the situation worse. We should expect that local populations of *N. lugens* will adjust by means of natural selection to the dominant rice varieties being grown in an area. However, though populations subjected to the same cultivar in widely different geographical regions may come to resemble each other in patterns of virulence, it is likely that they will differ considerably in their genetic constitution. It is thus important that studies should be undertaken on such geographically separated populations and on the genetics of them.

It may be concluded that the sympatric biotypes of *N. lugens* in the Philippines represent fairly simple genetic variants with no breeding barriers between them. The relative status of the so-called "biotypes" from widely different geographical areas remains to be established. We suggest that the practice of identifying and numbering "biotypes" of *N. lugens* should not be extended and that no nomenclatural or taxonomic status should be attributed to them. To do so gives a false impression of the biological status of the insects referred to, thus masking the inherent variability of the planthopper populations.

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RÉSUMÉ

LES "BIOTYPES" DE NILAPARVATA LUGENS *(STÅL)*

La nature biologique de ce qui a été appelé des biotypes de *Nilaparvata lugens*, paraît obscure si l'on se réfère aux études antérieures. Des expériences sur les biotypes 1, 2 et 3 des Philippines révèlent qu'ils ne présentent pas de barrières sexuelles significatives. Les élevages consanguins de biotypes présentent une variabilité considérable, et les virulances des biotypes se chevauchent les unes les autres. De même une population récoltée dans les champs aux Philippines était hétérogène et comprenait des individus qui auraient pu être rattachés à différents biotypes. On peut en conclure que le terme de biotype est, pour cette espèce, inapproprié et indésirable.

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