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ADAPTATIONS OF BROWN PLANTHOPPER (*NILAPARVATA LUGENS*) POPULATIONS TO RICE VARIETIES IN SRI LANKA

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Field populations of *N. lugens* were collected from 5 different cultivated rices and from wild rice, *Oryza rufipogon*, in Sri Lanka. Each population was tested in the laboratory for virulence by measuring weight gain and honeydew production on its own field host variety and on the other local varieties, as well as on the standards, TN1, Mudgo and ASD7. In local populations close adaptation with particular host varieties was demonstrated.

KEY WORDS: Brown Planthopper — *Nilaparvata lugens* — Resistant plant varieties — Rice — Sri Lanka — Virulence.

Field control of the Brown Planthopper, *Nilaparvata lugens* (Stål), in Asia relies heavily on the use of resistant rice cultivars (Pathak & Khush, 1979). Resistance sources have been identified by screening large numbers of rice varieties against populations of the insect (Seshu & Kauffman, 1980; Seung Yoon Choi, 1979). In this way several varieties which show resistance to feeding and development of *N. lugens* have been found (Pathak & Khush, 1979). All such varieties derive from southern India and Sri Lanka and genetic analysis has revealed 4 or 5 different genes which control resistance (Khush, 1979).

Insect populations which may overcome the effects of these genes were originally established in the laboratory. Similar populations also occur widely in the field. Such virulent populations have been termed biotypes and allocated numbers according to the resistance gene, the effects of which they are able to overcome. This system was first introduced and subsequently developed at the International Rice Research Institute (IRRI), Philippines (Pathak & Khush, 1979; Khush, 1979). Mass screening of populations in Asia has shown complicated but distinct patterns of virulence in different geographical regions (Seshu & Kauffman, 1980).

Our previous work demonstrated that the Philippine biotype populations show great individual variation in virulence (Claridge & Den Hollander, 1980) and suggested that virulence is inherited by a system of polygenes (Den Hollander & Pathak, 1981). Indeed biotype characteristics may be totally changed in as few as 10 generations of laboratory selection (Claridge & Den Hollander, 1982), so that the use of the term biotype for this species may be misleading.

From our observations we should expect field populations of *N. lugens* to adapt quickly to the rice varieties on which they occur. Thus long-term planting of one variety may lead to the development of populations of the planthoppers increasingly adapted to that variety and thus greatly increase the possibility of serious outbreaks and hopperburn.

The history of domestication of cultivated rice from the wild rices, *Oryza rufipogon* and *O. nivara*, involved selection for such characteristics as grain size, non-shattering heads, *etc.* (Chang, 1976), rather than specifically for insect resistance. Thus we might expect cultivated varieties to be more susceptible to planthopper attack than indigenous wild rices. The latter should show resistance, but cannot be totally resistant because the insect has survived and evolved on them. Populations of wild *O. rufipogon* are widely distributed in southern and south-east Asia, but most plants found now have hybridised extensively with cultivated varieties (Chang, 1976).

In order to investigate the adaptations of *N. lugens* to wild and cultivated rice varieties we have studied the feeding performance of populations collected from the field in Sri Lanka on the varieties from which they were collected and on 3 other test varieties.

MATERIALS AND METHODS

Samples of *N. lugens* were collected from 5 different rice varieties grown in farmers' fields and from wild rice in Sri Lanka (Fig. 1) during

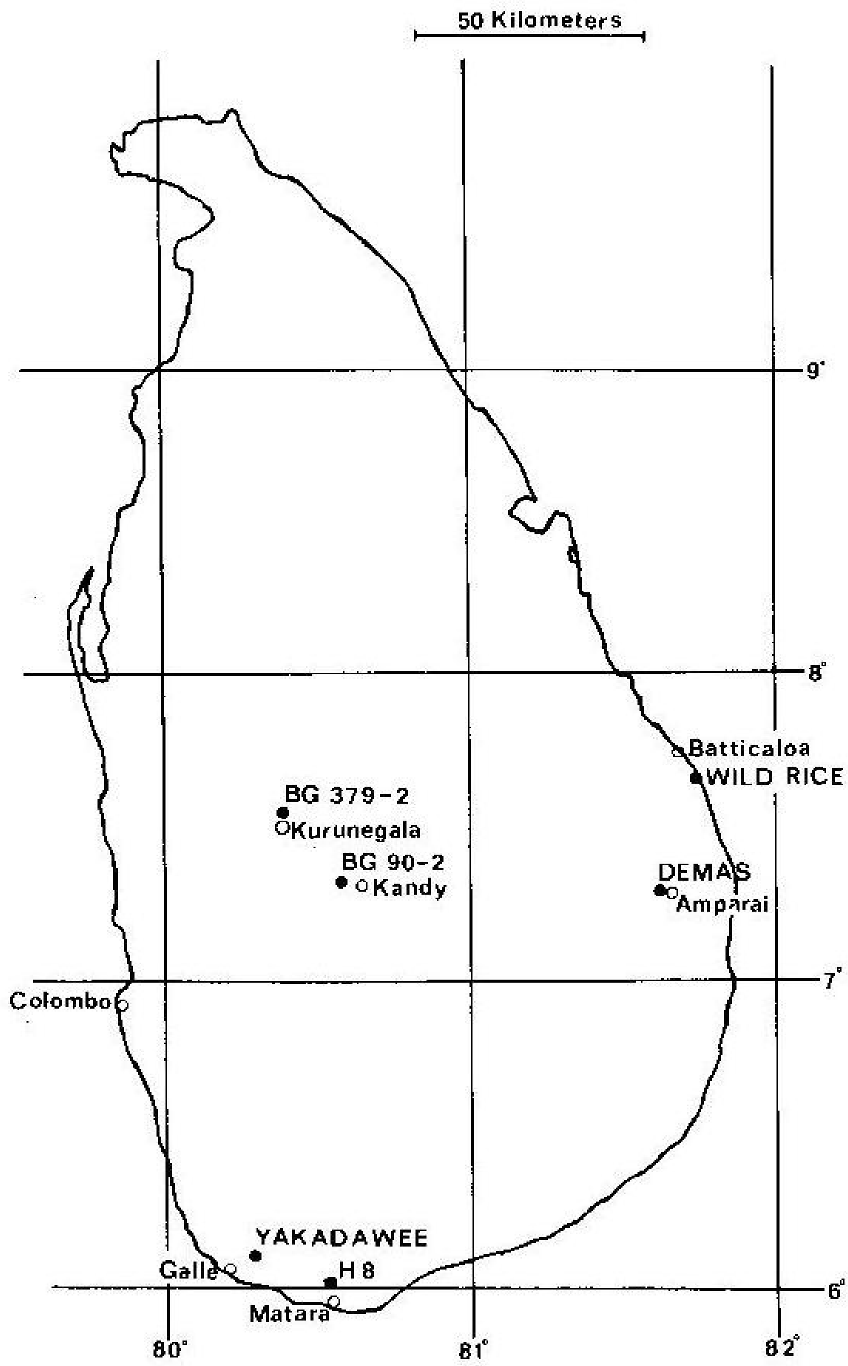

Fig. 1. Sketch map of Sri Lanka to show relative positions of field sites from which *N. lugens* populations were collected.

July 1980 by one of us (J.D.H.). Collections were made towards the end of the crop cycle and nymphs and brachypterous adults only were then used to establish laboratory cultures. The cultures were brought back to Cardiff where they were maintained in temperature-controlled glasshouses on the varieties from which they had been collected. The rice varieties were chosen according to their field availability in Sri Lanka; without any regard to their susceptibility or resistance to Brown Planthopper. They were as follows:

Yakadawee (collected at Galle)	— traditional variety, tall, lodges readily, 4 months to maturity, supposed to be resistant to insect damage (Fernando *et al.*, 1979).
Demas (collected at Amparai)	— traditional variety, short, about 3 months to maturity.
H8 (collected at Matara)	— early improved variety developed in Sri Lanka, semi-tall, lodges readily, Brown Planthopper susceptible.
BG 90-2 (collected at Kandy)	— improved variety, short stature, 4.5 months to maturity. Brown Planthopper susceptible.
BG 379-2 (collected at Batalogoda)	— improved variety, short stature, 4.5 months to maturity, recently developed as resistant variety. Not yet widely released to farmers, resistance based on PTB 33.
Wild Rice (collected at Batticaloa)	— *O. rufipogon*, Brown Planthopper susceptible (C. Kudagamage, pers. comm.).

Each population was tested for its virulence on the variety from which it was collected as well as also on all other varieties after no more than 2 generations in the laboratory. In addition, each population was tested on the standard varieties TN1 (no known gene for resistance), Mudgo (Bph 1) and ASD7 (bph 2).

Virulence was measured by determining the % weight change of individual insects and the amount of honeydew excreted over 24 hr on 35- to 40-day-old plants of each variety (Claridge & Den Hollander, 1980, 1982; Den Hollander & Pathak, 1981). The method used involved enclosing an individual newly emerged ♀ in a parafilm envelope attached to a rice plant for 24 hr. The insect was weighed both before and after the experiment as was also the honeydew accumulated in the parafilm envelope.

Throughout this paper "wild rice" refers only to *O. rufipogon* collected from Batticaloa.

RESULTS

The virulence of each population on the different rice varieties is given in Table I. Each figure represents the mean of up to 25 individuals. Some of the samples were smaller but none was of less than 17 individuals. Weight change and honeydew were analysed separately. For statistical analysis the performance of each population on the different varieties was ranked and the probability of achieving the observed rank or better on its own variety by chance alone calculated. The probabilities

TABLE I

Honeydew (mg) produced and % weight change in 24 hr of newly emerged ♀♀ of N. lugens *populations from 5 rice cultivars and from wild rice collected in Sri Lanka and tested on same varieties and standard varieties TN1, Mudgo and ASD7. Values for each population tested on variety from which collected shown in heavy print*

		Yakadawee		Demas		H—8		BG 379-2		BG 90-2		Wild Rice	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Yakadawee	%	**33.7**	**17.0**	3.6	15.2	12.1	17.8	13.0	15.0	15.9	17.7	24.8	16.3
	mg	**20.3**	**13.7**	13.8	8.2	11.6	7.9	9.7	8.1	19.0	13.4	13.0	10.0
Demas	%	13.1	21.0	**8.6**	**16.4**	−8.8	14.9	−2.1	11.5	7.1	17.1	14.9	17.2
	mg	12.52	13.0	**9.1**	**8.0**	3.7	7.7	5.6	5.6	6.0	4.2	11.4	8.7
H—8	%	19.7	26.0	−5.9	11.2	**13.3**	**16.6**	6.5	15.7	16.1	16.2	15.9	23.3
	mg	16.7	15.1	6.6	8.0	**20.6**	**14.1**	15.3	11.2	20.4	13.1	13.5	9.6
BG-379—2	%	−0.7	15.1	−5.9	11.7	3.2	14.9	**15.2**	**16.7**	8.2	16.2	2.2	12.6
	mg	4.0	3.4	5.3	4.4	9.28	6.2	**16.4**	**12.7**	10.4	10.9	4.9	4.7
BG 90-2	%	16.4	16.9	6.8	17.5	18.6	16.4	4.6	18.3	**23.5**	**14.8**	19.5	17.6
	mg	15.7	8.3	8.5	7.3	18.8	12.9	10.3	8.7	**22.3**	**14.6**	14.0	9.7
Wild Rice	%	23.9	20.0	12.6	21.3	14.2	16.6	10.7	24.3	18.1	19.1	**12.1**	**18.2**
	mg	14.6	8.3	10.0	10.8	9.6	7.7	13.3	10.6	15.9	8.6	**14.2**	**10.0**
TN1	%	41.0	29.3	6.1	14.0	8.2	11.2	12.6	16.70	−3.6	10.8	14.2	13.4
	mg	18.1	13.4	12.0	9.8	13.5	10.1	8.3	5.72	4.9	5.2	17.0	10.5
Mudgo	%	17.8	31.2	3.5	14.0	1.9	15.7	3.8	17.7	6.8	13.0	0.3	10.8
	mg	14.4	13.3	6.5	3.8	7.0	4.8	6.1	5.6	7.2	9.0	9.3	8.3
ASD7	%	17.2	31.0	18.1	25.0	−3.3	12.6	8.2	19.1	11.11	16.0	14.6	17.3
	mg	11.3	8.8	8.04	5.5	5.8	4.3	7.7	6.3	11.08	8.0	14.0	8.8

for all 6 populations were then multiplied together to give the overall probability of achieving the observed result by chance alone. The result obtained was highly significant both for honeydew ($P = 0.002$) and for weight change ($P = 0.0002$).

The experiment showed that most populations fed more and gained most weight on the varieties from which they had been collected in the field. All populations did relatively well on wild rice. At least for Sri Lankan populations, *O. rufipogon* from Sri Lanka behaves as a universally susceptible plant, but the population collected from wild rice also did well on all of the Sri Lankan cultivars, except BG 379-2 (and Mudgo). BG 379-2 is a newly developed resistant variety with resistance derived from PTB 33 from India. The latter may incorporate a novel resistance mechanism to indigenous Brown Planthopper populations from Sri Lanka. Indeed all populations, except that derived from BG 379-2 itself, did poorly on BG 379-2.

The population on H8 did poorly on BG 379-2, but well on Mudgo and ASD7, confirming that BG 379-2 and thus PTB 33 have different genes for resistance to either of them (Khush, 1979).

The population from Demas did badly on H8 and well on ASD7, whereas that from H8 did poorly on Demas and ASD7, suggesting that Demas may share its resistance mechanism with ASD7.

Apart from the population from Yakadawee, all others did rather poorly on Mudgo. Mudgo has been shown to be susceptible at the seedling stage in Sri Lanka, but developed resistance after 30 days (Fernando *et al.*, 1979). As the plants used by us were 35 to 40 days old, this resistance was confirmed.

As previously shown with a population from Queensland, Australia, TN1 is not necessarily universally susceptible to *N. lugens* (Claridge & Den Hollander, 1982). Here it showed considerable resistance to the population from BG 90-2.

DISCUSSION

Wild rice is naturally a relatively "unapparent" plant (in the sense of Feeny, 1976). It might perhaps then be expected to rely mainly on a variety of specific chemical defences against herbivores. The Brown Planthopper is a specialist, effectively feeding only on rices (*Oryza* species and cultivars) (Mochida & Okada, 1979). It has thus evolved mechanisms which enable it to overcome the plant's specific chemical defences. Also it has a variable genetic system (Den Hollander & Pathak, 1981) by which it is able readily to adapt to different rice varieties.

Modern agricultural practice tends to grow rice as an "apparent" plant — that is in large, often continuously planted areas of genetically uniform individuals. Once specific mechanisms have been overcome in such circumstances pests will readily multiply and may eventually damage crops.

Our results from Sri Lanka, where such large-scale monoculture is still relatively uncommon, show that within a small geographical area (Fig. 1), *N. lugens* populations occur which have adapted closely to different locally grown varieties. This adaptation parallels results obtained by Edmunds & Alstad (1978) who studied populations of the sedentary scale insect, *Nuculaspis californica*, on Ponderosa Pine trees, *Pinus ponderosa*. Individual trees showed great variation in defensive chemistry. The scale population confined to an individual tree became increasingly adapted to it, but at the same time maladapted to other individuals in the same population of trees. Thus fitness on one host individual was developed at the expense of fitness on others. In the much more mobile Brown Planthopper, close adaptation seems to occur at the local population level, but the ability to adapt quickly to new varieties seems always to be present.

The nature of plant resistance to *N. lugens* is little understood. However, considerable information is available on the genetics of such resistance (Khush, 1979). It is thought that the varieties TN1, Mudgo and ASD7 respectively carry no gene for resistance, resistance gene Bph 1 and resistance gene bph 2. Field populations of *N. lugens* from Sri Lanka show that TN1 is not always susceptible. The population from Kandy on BG 90-2 responded to TN1 as a resistant variety (as did also an Australian population, Claridge & Den Hollander, 1982), but to Mudgo and ASD7 as susceptible. The nearby population at Batalogoda, collected from BG 379-2, responded to TN1 as susceptible. As in our previous studies on Philippine and Australian populations (Claridge & Den Hollander, 1982), it is clear that weight change for similar amounts of honeydew produced varies considerably between different varieties (Table I). For example, the population from Demas on Yakadawee gave only 3.8% weight gain for 13.8 mg of honeydew produced, but on ASD7 18.1% weight gain resulted in only 8.0 mg of honeydew. This suggests that different mechanisms of resistance may be involved in different varieties.

Sri Lanka and southern India are the source areas of all rice cultivars so far reported as resistant to *N. lugens* (Seung Yoon Choi, 1979). Our results demonstrate that within Sri Lanka local populations of the insect show wide differences in virulence and adaptation to host varieties. It is certainly not possible to generalize about virulence even in such a small geographical area.

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RÉSUMÉ

Adaptations des populations de Nilaparvata lugens *aux variétés de riz de Sri Lanka*

Les populations de *N. lugens* ont été récoltées dans 5 champs cultivés et sur riz sauvage *Oryza rufipogon*, au Sri Lanka. La virulence de chaque population a été examinée au laboratoire à partir du poids de grain et de la production de miellat, observés tant sur l'hôte qui l'hébergeait que sur les autres variétés locales et sur les variétés standards TN1, Mudgo et ASD7. Des coadaptations étroites avec les variétés hôtes des populations locales ont pu être mises en évidence.

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