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Polymorphism of the Southern Green Stink Bug *Nezara viridula* Linnaeus, 1758 (Hemiptera: Pentatomidae) In Vietnam

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ABSTRACT: In Vietnam, field surveys of *N. viridula* (Hemiptera: Pentatomidae) on host plants (rice, corn, sesame) was collected 10 color morphs including G, O, F, R, OR, GY, OG, Y, B and C. Among them G and O types were common. The rare phenotype included B, C, Y, OR, OG and GY. Type G is the best adapted to colonize different environments. The emergence of the phenotype depends on the temperature and food (host plants). Type F and R are better adapted to higher temperatures in summer crop on sesame. Low temperatures are the good conditions for the emergence of O type. The 4th and 5th instars belong to both in GxG and GxO, had two colors: green and black; among colors, green was the most common. GxO pair created 4 phenotypes: G, O, F, R. The GxG pairs created 3 phenotypes: G, O, F.

Key words: *Nezara viridula*, polymorphism, host plant, distribution

INTRODUCTION

The southern green stink bug, *Nezara viridula* (L.) is known to be polymorphic, including 12 different color morphs (Kiritani & Yukawa 1963, Yukawa & Kiritani 1965, Kiritani 1970, Vivan & Panizzi 2002).

Although the color polymorphisms are manifested in both nymphal and adult stages, previous studies have focused only on the more obvious adult traits. The four main color forms were distinguished and given names based on the color pattern on the dorsum (Kiritani and Yukawa 1963, Yukawa and Kiriani 1965). *N. viridula* f. *smaragdula* F. (G type) is the common green form, *N. viridula* f. *torquata* F. (O type) has median and lateral lobes and the anterior margin of the pronotum yellow or orange, f. *viridula* L. (R type) has green spots on a background of yellow or orange over the entire body, and an unnamed morph (F type) is like f. *torquata* except it also has yellow or orange along the margins of the convexium. Other morphs with combinations of these orange and green color traits exist, including an entirely orange morph called f. *aurantiaca* (Y type). The ventral and dorsal coloring of *N. viridula* f. aurantiaca is uniformly orange.

The mix of *N. viridula* color polymorphisms varies with region. The greatest diversity of color polymorphisms occurs in Japan, whereas *N. viridula* populations in many parts of the world (Australia, Pacific Islands, United States, Central America, and the West Indies) seem to be only or primarily green (Yukawa and Kiritani 1965). *N. viridula* is widespread in Brazil and that type G (smaragdula) is the best adapted to colonize different environments. Type O (torquata) is favored by the conditions in the South Region, which allow the gene(s) responsible for the polymorphism to be expressed (Vivan and Panizzi 2006). The f. *aurantiaca* (Y type) morph is very rare in Japan, occurring in 5,000 individuals (Yukawa and Kiritani 1965). In Brazil, the frequency of f. *aurantiaca* is higher at 0.7% (Vivan and Panizzi 2002).

The different color polymorphisms are under genetic control. Crossing studies using the main color morphs (O, G, and R types) suggested the body color polymorphisms are controlled by two sets of genes on two independent loci (Ohno and Alam 1992). *N. viridula* f. *aurantiaca* was not included in the study. McLain (1981) showed that an orange color polymorphism discovered in an *N. viridula* population in Florida was sex linked and recessive.

Some types of *N. viridula* are known to be better adapted to unfavorable abiotic conditions due to their variable genetic composition, and this is an important factor that contributes to the abundance of the populations (Kiritani 1971).

The polymorphisms of *N. viridula* has been studied worldwide. However, few data on the color of nymphs and adult of different types, related to the different parents, are available. Therefore, studies were conducted to evaluate the effect of different host plants and seasonal crops on the distribution of the color morphs of *N. viridula* in Vietnam.

MATERIAL AND METHODS

Field surveys: *N. viridula* adults were surveyed, each week, in 2010 and 2011, different host plants including corn (*Zea mays*), rice (*Oryza sativa*) and sesame (*Sesamum indicum*). From each host plant, 50 samples were taken at random per week, using either a sweep net or a beat cloth, depending on the type of plants available. Usually on corn and sesame, the beat cloth was used. The samples consisted of beating plants over the beat cloth 20 times. On the rice the sweep net was used, sweeping the plants 20 times. Adults of *N. viridula* captured were killed, using killing jars, and were pinned and stored in the Insect Collection of Vinh university.

The relationship between the different parents with colors of nymphs and adults: Pairs of *N. viridula* were selected at the adult emergence date and placed each in plastic boxes (15cm diameter × 20cm high) covered with a lid as beat cloth. Bugs were fed by fresh bean. The boxes were then placed in conditions rom (28,48^{o}C-61,75% RH). The number of pairs used at the different parents was, respectively, 20 GxG pairs and 20 GxO pairs. Bugs were observed daily, and the food was replaced every two days. The deverlopmen of bugs were recorded, and the mean (± SEM) rate color nymph and adult were calculated.

Statistics: Data of this study were submitted to analysis of variance (ANOVA). Analyses were performed using the Statistix 9.0.

RESULTS AND DISCUSSION

The color morphs of *Nezara viridula* in Vietnam

During two yaers (2010 and 2011), field surveys of *N. viridula* on host plants (rice, corn, sesame) in Vietnam was collected 5671 speciments, including 10 color morphs (G, O, F, R, OR, GY, OG, Y, B, C) (Table 1).

Table 1: Morphs of *Nezara viridula* in Vietnam.

No.	Type	Name	Color pattern
1.	G	f. *smaragdula* F.	Entirely green (Fig. 1a)
2.	O	f. *torquata* F.	Green with anterior margin of the pronotum and head yellow (Fig. 1g)
3.	F		In additions to the characteristic of O type, connexivum (Fig. 1c)
4.	Y	f. *aurantica* Costa	Entirely yellow (Fig. 1b)
5.	R	f. *viridula* L.	Green spots on yellow ground color (Fig. 1h)
6.	OR		Combination of O and R types (Fig. 1l)
7.	GY		Green-yellowish (Combination of G and Y types) (Fig. 1e)
8.	GO		Anterior margins of the pronotum and head yellow, with the rest of the body green-yellowish (Fig. 1f)
9.	B	f. *vicaria* Walker f. *chlorocephala* Westwood	Brown green with thorax and head yellow; Wings, abdomen and legs with brown red (Fig. 1k).
10.	C		Entirely yellow red (Fig. 1d).

The southern green stink bug, *Nezara viridula* (L.) is known to be polymorphic, including 12 different color morphs which are derived from four basic types (Yukawa & Kiritani 1965, Kiritani 1970, Kazuno & Zinnatul 1992, Vivan & Panizz 2002). In Vietnam, *Nezara viridula* was diversity of phynoltype with 10 types among 12 type were recorded around the world. OY and FR-types have not been recorded in Vietnam.

Distribution of the color morphs of *Nezara viridula* on host plants

Distribution of the color morphs of *Nezara viridula* on host plants: rice, corn, sesame showed by Table 2.

During 2010 and 2011, 5671 adults of *N. viridula* were collected, 72.40% of the specimens belonging to type G (*smaragdula*). The second most abundant type O (*torquata*) was 16.51% (936 individuals). The rate type F was 4.94% with 280 individuals. Type B and C were rare only occurring on rice with a individual (0.02%). There were 15 individuals belonging to type Y (0.26%). The rate of type OR, R, GY and OG were from 1.10 to 1.94% (57-110 individuals) (Table 2). Among three hots plants, collected 10 color morphs on rice, 8 morphs on corn (B, C type not recorded) and 7 morphs on sesame (no bug of B, C and OR type).

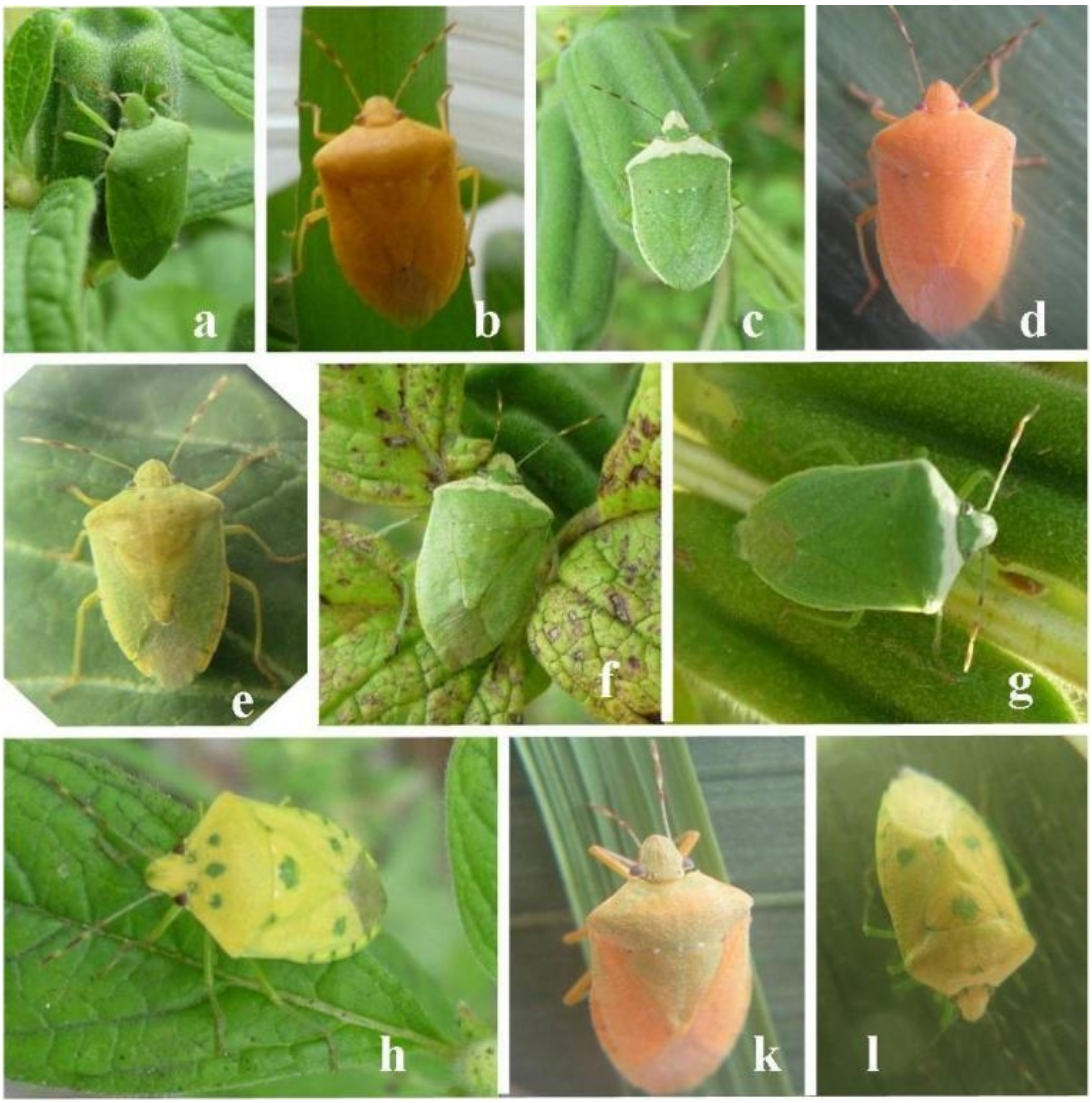

Fig. 1. Different morphological type of *Nezara viridula* occurring in Vietnam. (1a) G type; (1b) Y type; (1c) F type; (1d) C type; (1e) GY type; (1f) OG type; (1g) O type; (1h) R type; (1k) B type; (1l) OR type).

Table 2: Comparision of the frequencies of colour type of adults on hot plants.

Type	**Frequencies of colour type (%) on hots plants**			**No. of speciments**	**Avarage (%)**
	Rice	**Corn**	**Sesame**		
G	74.25	73.23	65.01	4106	72.40
O	16.67	18.43	12.29	936	16.51
F	2.78	5.21	10.52	280	4.94
R	1.27	1.61	4.65	110	1.94
GY	1.23	0.55	5.32	93	1.64
OG	1.31	0.18	1.99	57	1.01
Y	0.40	0.14	0.22	15	0.26
OR	2.02	0.65	-	72	1.27
B	0.04	-	-	1	0.02
C	0.04	-	-	1	0.02

Types G and O are the two most common in all 3 host plants were investigated, respectively, 74.25% and 16.67% on rice; 73.23% and 18.43% on corn and on sesame (64.90% and 12.30%).

With 2598 adults were colected on rice, there are 2 types very rare (B- and C-types) accounted 0.04% (1 individual), followed by Y type was 0.4% (10 individuals).

On corn, collected 2170 individuals (including 8 phenotype). Y and OG were less common at 0.14-0.18% (3-4 individuals). GY and OR phenotype were also relatively less with 0.55-0.65% (12-14 individuals).

Among 905 adults were collected on sesame (including 7 phenotype), only 2 individuals belong to Y-type accounted 0.2%. However, F-type was common with 10.50% (111 individuals) after G and O types.

The distribution of phenotypes of *Nezara viridula* was correlated with hots plants. G-type was most common followed by O type and F type. Additionally, type G is the best adapted to colonize different environments. This result is similar to the investigation of Vivan & Panizzi (2006).

Type O appeared on rice (16.67%) and maize (18.43%) was higher than on sesame (12.29%). This appearance is related to temperature. Rice and corn are grown at lower temperature (in spring crop) than sesame (in summer-autumn crop). The result is similar to Vivan & Panizzi (2005, 2006). Vivan & Panizzi (2006) showed that type O less abundant than the former, was more frequent at latitudes > 23°18' S and mean annual temperatures < 20.8°C (Southern Region) in Brazil, indicates that this type is better adapted to cooler temperatures. Data on nymph biology and adult reproduction of type O in the laboratory, comparing different temperatures, demonstrate its better adaptability to lower temperatures than the most common type G (Vivan & Panizzi, 2005).

The fact that type F is common after G and O types on sesame (10.52%). Additionally, on corn and rice, type F was rather rare (2.78-5.21%).

In Vietnam, the type F is better adapted to higher temperatures in summer crop, which allow the gene(s) responsible for the polymorphism to be expressed.

On sesame, ratios of type R was 4.65% and higher than on corn and rice. There is a significant difference. This phenotype was rare and less adapted, however, its occurrence is related to temperature. High temperatures in summer are the good conditions for the emergence of R type.

The proportions among the types found in Vietnam, the type B, C, Y, OR, GY, OG were being rare, are in accordance with data in the literature for other regions of the world. For example, in a survey conducted in Macau (China), 85% of the specimens were of type G, 13% of type O, and less than 0.2% of type Y (Easton & Pun 1997). Hokkanen (1986) reported one specimen of type Y of 203 individuals (0.5%) in the United States. Because this last type was rare, no relationship of its occurrence with the food or temperatures can be done.

The relationship between the different parents with colors of nymphs and adults

Reseaching of the relationship between the different parents (GxG và GxO) with colors of nymphs and adults showed that, 1st, 2nd and 3rd instars have only one color. 4th and 5th instars have two colors: green and black.

Green was the most common both 4th and 5th instars. For 4th instar, the color ratio of GxG and GxO are similar. GxG pair had 73.3% green 4th instar and 26.7% black 4th instar. There were 74.8% green and 25.2% black of 4th instar belong to GxO pair (Table 3). The results of Table 4 showed that, the colors percentage of 5th instar moult from green 4th instar in different parents pairs (GxG and GxO) were not significant difference. Green 5th instar was the most common. Percentage rate of green 5th instar reached 89.6% and 87.8% respectively GxG and GxO pairs. Black 5th instar rate was lower, respectively, 10.4% and 12.2% in GxO and GXG pairs.

Table 3: The color ratio of 4th and 5th instars.

Nymph		**The color ratio (%)**	
		GxG	**GxO**
4th instar	Green	73.3	74.8
	Black	26.7	25.2
5th instar	Green	86.8	82.2
	Black	13.2	17.8

For 5th instar, green was 86.8% with GxG pair and 82.2% with GxO. Black color of 5th instar was 17.8 % with GxO and higher than GxG pair (13.2%) (Table 3).

Table 4: The color ratio of of 5th instars molting from 4th instar.

Pairs	**The color ratio (%)**			
	Molting from green 4th instar		**Molting from black 4th instar**	
	Green 5th instar	**Black 5th instar**	**Green 5th instar**	**Black 5th instar**
GxG	89.6	10.4	48.1	51.9
GxO	87.8	12.2	25.9	74.1

The color rate of 5th instar molting from black 4th instar is related to the different parents pairs. For GxG pair, the colors rate of green and black 5th instar were similar, reached respectively 48.1% and 51.9%. For GxO pair, black 5th instar was common, with 74.1%, compared to green 5th instar was only 25.9% (Table 4).

The color of 4 th and 5 th instars was controlled by genotypes of parents pairs. This result is similar to Kiritani (1970), showed that, the Southern green stink bug, *Nezara viridula*, is polymorphic both in nymph and adult. The variation in body colour observed among nymph of 4 th and 5th instars.

The color morphs of adults molting from 5th instar (Table 5, Fig. 2) showed: There were three phenotypes: G, O, F were moult from both in green and black 5th instars for GxG pairs. G-types are common, whith 79.9% from green 5th instar and 59.4% from black 5th instar. F phenotypic is he lowest rate reached 8.0% and 12.5% respectively, molting from green and black 5th instars.

GxO pair created 4 phenotypes: G, O, F, R molting from green 5th instar, is similar to Kiritani (1970). No bugs belong to R phenotype molting from black 5th instar. G types are dominant and lower than GxG respectively, 67.8% and 37.9% molting from green and black 5th instar. Percentage rate of O and F types of GxG were higher than GXG pair. Rate of R phenotype was very low (0.9%) molting from green 5th instar (Table 5, Fig. 2).

The relationship between different parents pairs to the color of the offspring showed by Fig. 2.

Table 5: The color ratio of adult molting from 5th instar.

Pairs	The color ratio (%)							
	Molting from green 5th instar				Molting from black 5th instar			
	G	O	F	R	G	O	F	R
GxG	79.9	12.1	8.0	0.0	59.4	28.1	12.5	0.0
GxO	67.8	20.9	1.4	0.9	37.9	41.4	20.7	0.0

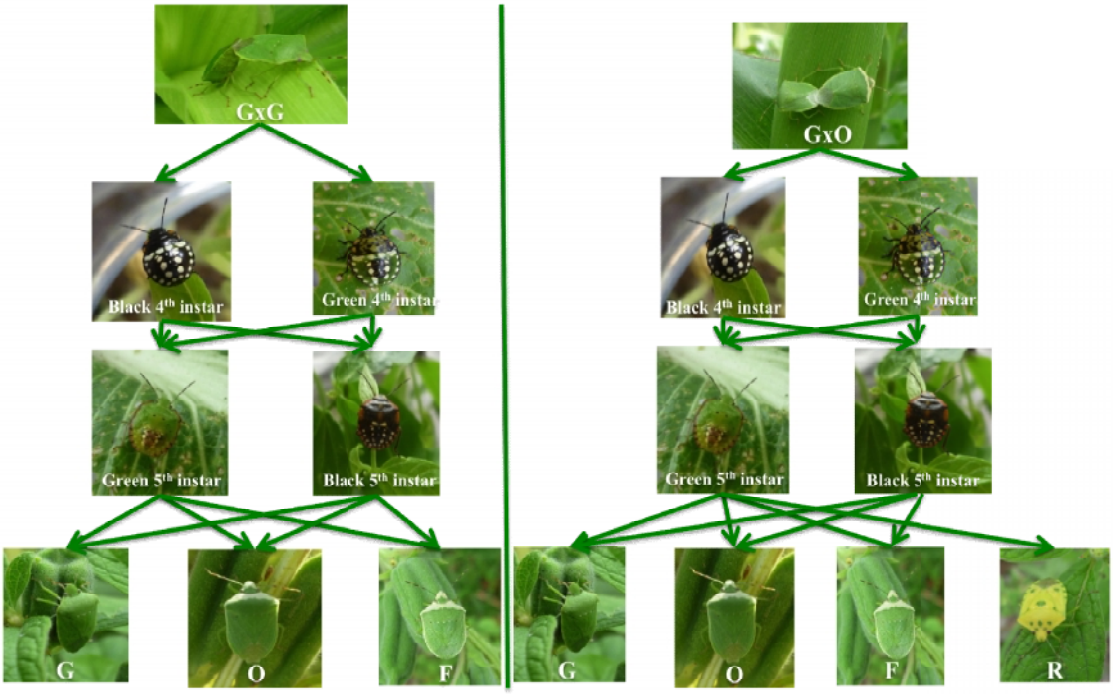

Fig. 2. The relationship between the different parents with colors of nymphs and adults.

CONCLUSION

1. In Vietnam, field surveys of *N. viridula* on host plants (rice, corn, sesame) was collected 10 color morphs including G, O, F, R, OR, GY, OG, Y, B and C. G- and O- types were common. The rare phenotype included B, C, Y, OR, OG and GY.

Type G is the best adapted to colonize different environments. The emergence of the phenotype depends on the temperature and food (host plants). Type F and R are better adapted to higher temperatures in summer crop on sesame. Low temperatures are the good conditions for the emergence of O-type.

2. The 4th and 5th instars belong to both in GxG and GxO, had two colors: green and black; among colors, green was the most common. GxO pair created 4 phenotypes: G, O, F, R. The GxG pairs created 3 phenotypes: G, O, F.

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