Rice Planthoppers in Vietnam and Their Migration

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Abstract

Migration source for immigrants of *Nilaparvata lugens* and *Sogatella furcifera* in southern China from April to May was estimated by using a three-dimensional backward trajectory method and light trap data in China. Sources in most cases were estimated to be in Red River delta in northern Vietnam and in middle Vietnam. Population density of macropterous adults of the two species in Red River delta was high in May, which supported the analytical result in this study. Forward migration simulations of the brown planthopper from Mekong Delta in southern Vietnam indicated that brown planthoppers in some cases could migrate from the south to middle Vietnam, depending on weather condition. Although outbreak of virus diseases such as rice grassy stunt virus disease and rice ragged stunt virus disease has not occurred in northern regions so far, it is important to keep careful monitoring of migration of brown planthoppers.

Key Words. *Nilaparvata lugens*, *Sogatella furcifera*, long-distance migration

Introduction

The East Asian population of rice planthoppers, the brown planthopper *Nilaparvata lugens* (BPH) and white-backed planthopper *Sogatella furcifera*, overwinters on rice plants of winter-spring crop in Red River delta in Vietnam and emigrates to southern China in early summer (Sogawa, 1993). This migration is called as the first step migration. The planthoppers produce a few generations on rice plants of the early crop in southern China, and migrate to the Yangtze delta, Korean peninsula and Japan in *Bai-u* rainy season (Kisimoto, 1976, Sogawa, 1993). This migration is called as the second step migration. Although many pieces of analysis have been reported on the second step migration (Kisimoto, 1976; Rosenberg and Magor, 1983; Sogawa, 1995; Otuka et al, 2005a, b; Furuno et al 2005; Otuka et al 2006), there has been little analytical report on the first step migration, except some descriptive reports (Sogawa, 1992; Sogawa, 1993; Suzuki and Wada, 1994; Otuka et al, 2007). This was mainly because trap data available for foreign scientists had been limited until recently. If trap data in southern China was available, a backward migration simulation (Otuka et al, 2005a) could be conducted and show possible source and destination regions of the first step migration, presenting new ecological knowledge on the first step migration.

After the outbreak of BPH in East Asia in 2005, more information on their occurrence has been available at Internet sites of plant protection institutes in Chinese provinces, including a part of their light trap data. Therefore this study reports migration analyses conducted using those light trap data and presents a concrete picture of the first step migration.

In addition, the brown planthopper is a major insect pest of rice in Mekong Delta, southern Vietnam. In 2006, the outbreak of BPHs occurred and two virus diseases transmitted by BPHs, Rice Ragged Stunt Virus disease (RRSV) and Rice Grassy Stunt Virus (RGSV) disease, spread over in the delta, resulting in big loss of rice production. Furthermore, Matsumura et al. (2008) have shown that insecticide-resistance of BPH in the delta has risen recently. Therefore, it is very much necessary to properly control the highly-virulent BPHs. If such BPHs in Mekong Delta could migrate to northern part of Vietnam, it would be a huge risk to the East Asian population. Therefore, this study investigates the possibility of long-distance migration of BPHs from Mekong Delta to northern or middle Vietnam by using a migration simulation model (Furuno et al, 2005; Otuka et al, 2006).

Materials and Methods

Catch data in southern China

Catch data of light traps were cited from rice disease and pest section at following three provincial Internet sites; *http://www.gxzb.com* of Guangxi Plant Protection General Station in Guangxi Zhuang Autonomous Region, *http://gdzbz.com* of Guangdong Plant Protection General Station in Guangdong province and *http://zhibao.jxagri.gov.cn* of Jiangxi Plant Protection and Quarantine Station in Jiangxi province. These stations released planthopper occurrence information for several times during rice cultivation season in 2006 and 07, which included catch number of their light traps, or sum of the catches during a period, which showed clear migration peaks. The catch data in April and May were used for backward trajectory analysis.

Backward trajectory analysis

A three-dimensional backward trajectory analysis (BTA) (Otuka et al, 2005a) was conducted to estimate possible migration source for catch peaks in southern China. The starting times of the trajectories were set every 1 h within 24 h of the catch date. For each starting time at each site, 20 backward trajectories were calculated with different initial heights ranging from 100 to 2000 m at an interval of 100 m above the trap site. The backward trajectories were terminated at dusk, 11 Coordinated Universal Time (UTC) or at dawn, 23 UTC on one or two days before the catch, when planthoppers was assumed to fly out of the source areas. The terminal points were plotted on a map to determine the possible source areas.

In Vietnam, which lies north to south for a long distance along the eastern Indochina Peninsula, populations in the northern part, or Red River delta, and the southern part, or Mekong delta, are thought to be ecologically isolated without known genetic interaction, and with only the northern population thought to comprise the East Asian population (Sogawa, 1992; Sogawa, 1993). There are two crops in the northern delta: a winter-spring crop and a summer crop. Planthoppers overwinter, multiplying on the winter-spring crop, for which rice is transplanted in January to early March and harvested in June (Sogawa, 1993; Suzuki and Wada, 1994; Otuka et al, 2007). Red River delta forms a triangle-shaped region with Red River running through the center, which is a major rice cultivating region and located above latitude 20 degrees north. Below the latitude, paddy fields are distributed along the coast. In this paper, the former triangle region and the latter one are referred to as northern Vietnam and middle Vietnam, respectively (Fig. 1).

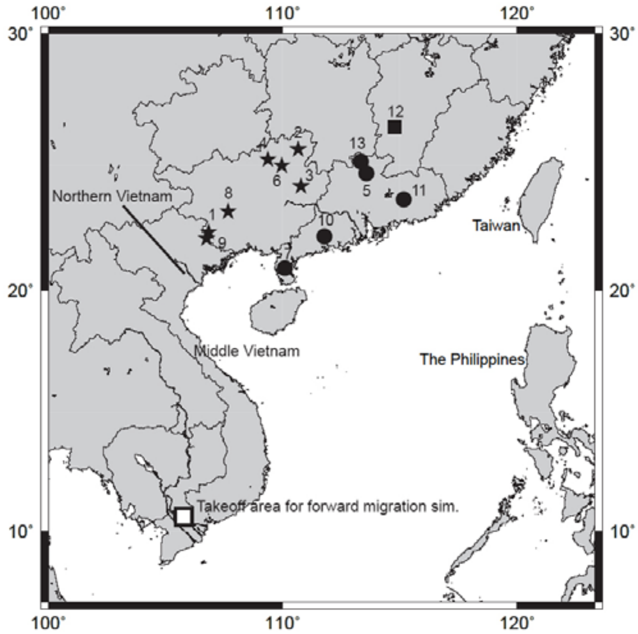

Fig. 1. Location of light traps in southern China, and a takeoff area in Mekong Delta

Forward migration simulation

A migration simulation model developed by Otuka et al (2006) was utilized to estimate destination regions of migrations from Mekong Delta. In the model, as many as 34,000 planthoppers took off from a takeoff area in the delta (a white square in Fig. 1) at dusk, 11 UTC (Coordinated Universal Time), every day from July to August 2007 and in April 2008. These months were selected because they corresponded to rice harvesting season in the delta, expecting emigrations from paddy fields. The positions of migrating planthoppers were calculated using meteorological data simulated by a weather prediction model, and the planthoppers were assumed to move mainly by wind vectors in the time step, taking vertical diffusion into account (Otuka et al, 2006). The planthoppers in flight were also kept from entering cooler upper air at less than a temperature of 16.5 °C. Simulation duration was 48 h. Relative aerial density of the insects was hourly calculated based upon their number in a simulation grid cell stretching 33 km horizontally and 100 m vertically above the ground. An area of non-zero value of the relative aerial density was used. The relative aerial density drawn on a map, which looks like a cloud, is referred to as a migration cloud hereafter. Movement of the migration cloud during the survey period was investigated to know possible destination of migrations from the south.

Results and Discussion

BTA

Based upon light trap information from the provincial plant protection stations, 24 clear catch peaks recorded at 13 trap sites in 2006 and 07 were used for BTA (Table 1). The number in Map column shows location number in Fig. 1. These catch peaks were named as migration a to x in the first column. Table 1 indicates two major tendencies. The first one is that large catch peaks appeared in late April (migration l, m, n, q, r, s) to early May (a, b, c, g, h, t) and in late May (d, e, i, j, k, u, v, w, x). Among catches during the period, the second point is that a site closer to Vietnam showed larger catch. For example, the catch at Zhaoping on 22 April 2007 (q) was larger than that at Lechang (m). In other words, the catch in Guangxi, which is adjacent to Vietnam, was larger than in Guangdong or Jiangxi.

Migration source regions estimated by BTA are shown in Table 2. Examples of terminal point distribution are shown in Fig. 2. Source regions in most cases were found to be northern Vietnam and middle Vietnam, and in some cases Hainan province. Since no information on population density in Hainan province in the period is available, it is suspended for now to judge whether Hainan is possible source or not. Source region for the sites in Guangxi were mainly in Red River delta, which is located to the southwest of

Table 1 Catch of light traps in Jiangxi, Guangdong and Guangxi

Migration	Date	Province	Catch	City	Map	Latitude	Longitude
a	7 May 2006	Jiangxi	512	Wanan	12	26.47	114.78
b	06 May 2006	Guangdong	6858	Leizhou	7	20.91	110.10
c	1-10 May 2006	Guangdong	1641	Qujiangqu	5	24.68	113.58
d	21-30 May 2006	Guangdong	642	Leizhou	7	20.91	110.10
e	21-30 May 2006	Guangdong	21658	Qujiangqu	5	24.68	113.58
f	11 Apr 2006	Guangxi	4032	Yongfu	6	24.98	109.97
g	6-10 May 2006	Guangxi	20864	Zhaoping	3	24.17	110.79
h	6-8 May 2006	Guangxi	CP*	Xingan	2	25.61	110.66
i	21-25 May 2006	Guangxi	32200	Longzhou	1	22.35	106.85
j	21-25 May 2006	Guangxi	4689	Pingxiang	9	22.10	106.75
k	21-25 May 2006	Guangxi	5114	Longan	8	23.17	107.68
l	21-25 Apr 2007	Guangdong	337	Zijin	11	23.65	115.17
m	21-25 Apr 2007	Guangdong	340	Lechang	13	25.13	113.34
n	27 Apr-8 May 2007	Guangdong	2358	Yangchun	10	22.18	111.78
o	6-10 May 2007	Guangdong	1402	Zijin	11	23.65	115.17
p	1-10 May 2007	Guangdong	7293	Leizhou	7	20.91	110.10
q	22 Apr 2007	Guangxi	24288	Zhaoping	3	24.17	110.79
r	22 Apr 2007	Guangxi	10240	Yongfu	6	24.98	109.97
s	22-25 Apr 2007	Guangxi	HH*	Longzhou	1	22.35	106.85
t	3-5 May 2007	Guangxi	31100	Longzhou	1	22.35	106.85
u	19-20 May 2007	Guangxi	85000	Longzhou	1	22.35	106.85
v	22-25 May 2007	Guangxi	38021	Xingan	2	25.61	110.66
w	22-25 May 2007	Guangxi	30921	Zhaoping	3	24.17	110.79
x	22-25 May 2007	Guangxi	26079	Rongan	4	25.22	109.38

CP: Clear peak, HH: Historically high

Table 2 Estimated source regions

Migration	Estimated source				
	Northern Vietnam	Middle Vietnam	Hainan	Taiwan	Philippines
a	+		+		
b		+			
c	+	+	+		
d	+	+			
e	+	+	+		
f	+	+			
g	+	+			
h	+	+			
i	+	+			
j	+	+			
k	+	+			
l	+	+	+		
m	+	+	+		
n	+		+	+	
o				+	+
p	+		+	+	+
q	+	+			
r	+				
s	+	+			
t	+				
u	+				
v	+				
w	+				
x	+				

Guangxi (Fig.2g, i, q, t and u). It was natural result since the planthoppers were carried by the southwesterlys. On the other hand, source for Guangdong, which is located to the east of Guangxi, were likely to be in middle Vietnam (Fig. 2b, e). Southern Guangdong is located to the northeast of middle Vietnam. In cases in early May 2006, sources were found to be in the Luzon, the Philippines (Fig. 2o, p). Property of the population in the Philippines is different from that of the East Asian population. Therefore it is necessary to carefully monitor whether the property of the insects was affected by immigrants from outside or not. The result also showed Taiwan could be source. However, because population density there in early May or before is very low, Taiwan may be not likely to be source.

The first step migration of rice planthoppers of the East Asian population was analyzed with the numerical method. Although small migration happened in southern China by early April, major migrations of the first step occurred in late April through late May. During that period, rice plants in eastern provinces in Red River delta were in milky or ripening stage and the population density of macropterous adults of *N. lugens* and *S. furcifera* was high in fields with susceptible rice varieties. It was considered that the planthoppers were carried by the prominent southwesterlys and migrated to a diagonal belt region which includes Guangxi, southern Hunan, northern Guangdong and Jiangxi provinces. Since area of rice field in Red River delta is larger than that in middle Vietnam, this diagonal belt region is likely to be a major invaded region in the first step of migration. For the same reason, southern part of Guangdong, which is outside the diagonal belt, probably had smaller number of immigrants (Matsumura et al, 2006). Within the diagonal migration belt, sites closer to Red River delta got more number of immigrants. The analysis also showed that the migration from the Luzon to southern China could happen, on which a careful attention has to be paid because of different insect’s properties between the populations.

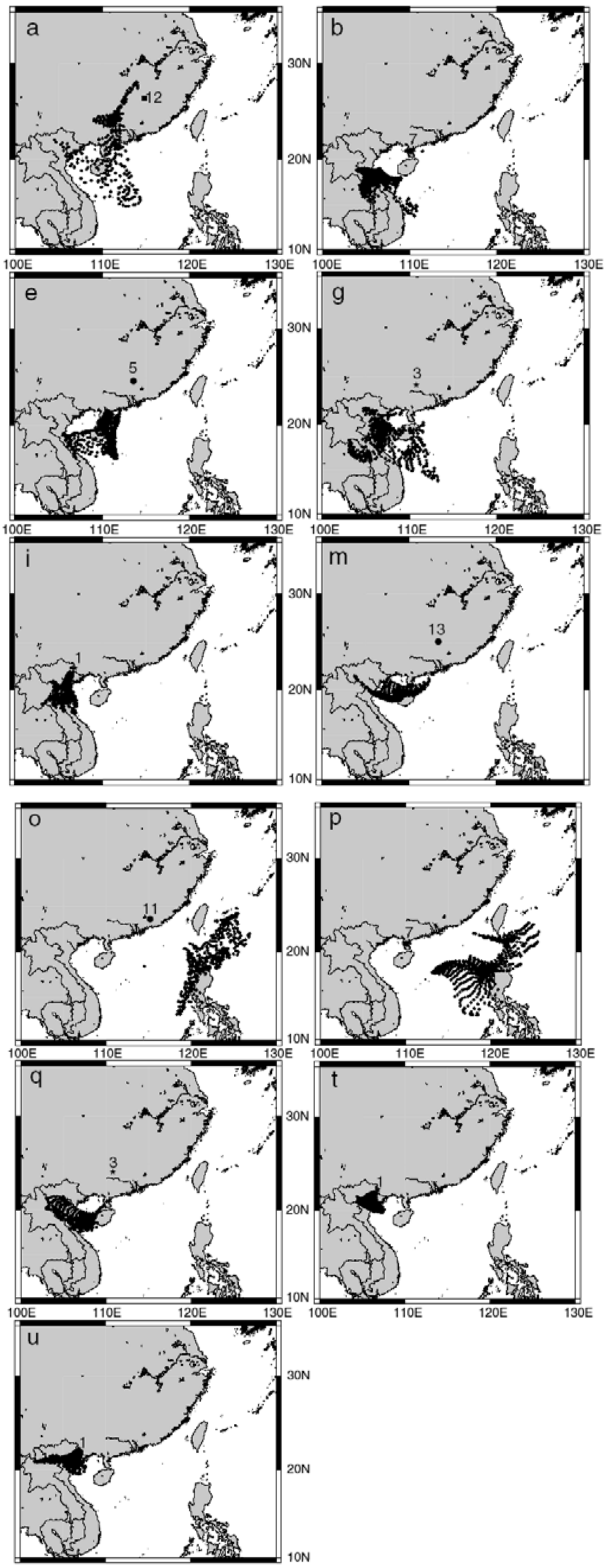

Fig. 2 Terminal point distribution by the backward trajectory analysis

Table 3 Estimated destination of possible migrations from Mekong Delta

Month	Destination				
	PH	MV	TH	SC	SJ
All	**19**	**7**	**21**	**2**	**2**
Jul-07	9	3	3	0	0
Aug-07	10	2	0	2	2
Apr-08	0	2	18	0	0

PH: the Philippines, MV: Middle Vietnam, TH: Thailand, SC: southern China, SJ: southeast Japan

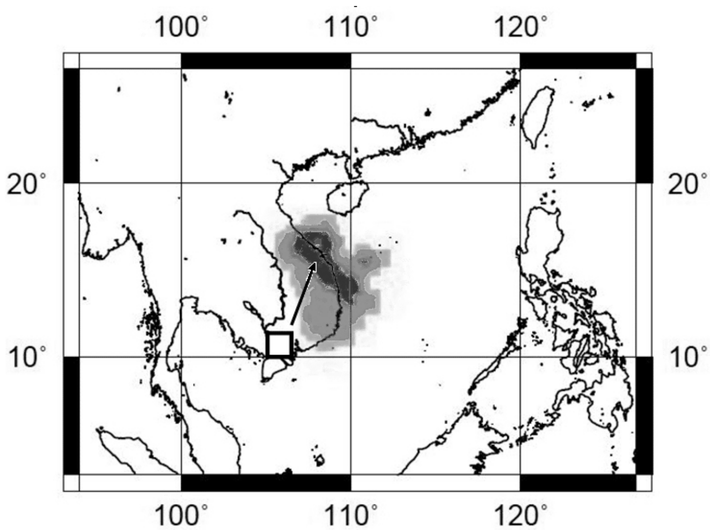

Fig. 3 An example of the migration cloud to move to middle Vietnam. This migration cloud started to take off on 20 August 2007.

Forward migration simulation

Migration clouds moved to various regions around Mekong Delta. Possible destination was summarized in Table 3. The table shows that Thailand (movement in northwest direction) and the Philippines (movement in east direction) were common destinations in many migration cases. However, seven cases were found to move in north direction to middle Vietnam, where is the source for the first step migration of the East Asian population (Fig. 3). The result implies that a migration of BPHs from Mekong Delta could occur in some weather condition. To confirm whether such a migration actually occurs or not, further field surveys are needed. There has been no reported outbreak of the virus diseases (RRSV, RGSV) in middle Vietnam so for. But it is important to keep a careful migration monitoring of the highly-virulent BPHs in the delta.

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