Appl. Ent. Zool. **26** (4) 457–462 (1991)

Correlation between the Immigration Area of Rice Planthoppers and the Low-Level Jet Stream in Japan

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(Received December 12, 1990; Accepted June 13, 1991)

A database for light-trap catches at 69 sites and density maps for the immigration of long-distance migratory planthoppers into Japan were developed on a personal computer. Geographical distribution and density gradient of immigrants during Baiu season in 1980 to 1985 were analyzed. There were 32 immigration waves of white-backed planthoppers detected, 24 cases showed a close correlation between the developmental scale and localization of low-level jet stream (LLJET) and the immigration areas. These immigration areas shifted from the Pacific Ocean to Japan Sea coastal areas in response to the localization of LLJET.
Key words: rice planthoppers, overseas immigration, low-level jet stream, computer mapping

INTRODUCTION

The brown planthopper (BPH), *Nilaparvata lugens* (STÅL), and the white-backed planthopper (WBPH), *Sogatella furcifera* (HORVÁTH) (Homoptera: Delphacidae), are long-distance migratory insect pests of rice in Asia. In recent years, it has been pointed out that the low-level jet streams (LLJET) are closely linked to the immigration of these insects into Japan (SEINO et al., 1987). The LLJET is the strong southwesterly air current that often appears at 1,000–3,000 m heights along the frontal system during the Baiu (rainy) season in the June to July period (NINOMIYA, 1979). SEINO et al. (1987) described a procedure to predict the immigration time of the planthoppers into northern Kyushu.

WATANABE et al. (1991) explained that the main immigrations of planthoppers into Kyushu area were based on localization of the LLJETs. The migration of planthoppers and the LLJET are meso-scale phenomena between China and Japan. In this paper, the relationships between the immigration areas and localization of LLJETs over the whole area of Japan were investigated by using the light-trap database.

METHODS

The database of daily catches of the planthoppers, using the light traps in 38 prefectures from May to October, was generated on a personal computer with a 40-megabyte hard disk. Computer programs that could display the density map during migration periods were developed. The light-trap data during migratory periods from 1980 to 1985 at 69 locations (1 to 3 sites in each prefecture) were analyzed with the computer programs (Fig. 1). These programs were written in N88BASIC under MSDOS.

The developmental scale and localization of LLJETs were analyzed on computer programs (WATANABE et al., 1988) which used data on wind direction and speed from the 850 mb weather charts published by Japan Meteorological Agency. When the wind trajectory was traced back to rice cultivated areas in southeastern China, at wind speeds along that trajectory in excess of 10 m/s (20 knots), we defined this area as a LLJET connected with the rice planthopper immigration into Japan (SEINO et al., 1987).

The relationship between the immigration area and the LLJET was analyzed as follows: The immigration waves were first extracted from the database of WBPH from 1980 to 1985 at several points. Then, the geographical distribution of the immigrants for each immigration wave was collated with the localization of the LLJETs.

RESULTS

Thirty two waves of WBPH were detected during 1980 to 1985. The distribution of immigration areas of WBPH changed in response to the localization of LLJETs.

Figure 2A-2 shows that the immigration areas were restricted to the southwestern coastal area. The LLJET developed covering an area from southern East China Sea to ocean coastal areas of western Japan (Fig. 2A-1). There were three occurrences of this type observed during the early Baiu season, early to mid June.

Figures 2B-2 and 2B-1 show the most common immigration pattern of the planthoppers and the localization of the LLJET. The LLJET stretched from the Yangtze river delta to the greater part of southwestern Japan. The immigrants were concentrated particularly in the western coastal regions of Kyushu, decreasing from there toward northeastern Japan. When the immigration scale was small, the immigration area was limited to Kyushu and southwestern Japan. This pattern was observed during the entire Baiu season, primarily from late June to mid July. About one half of the immigrations belonged to this type.

When the LLJET developed over the Japan Sea (Fig. 2C-1), main immigration areas were located along the Japan Sea coastal area, with immigrants reaching northeastern areas of Japan (Fig. 2C-2). This pattern appeared seven times during the late Baiu season, in mid- to late July.

DISCUSSION

SEINO et al. (1987) analyzed the weather conditions during the Baiu season in 1980 to 1986, and found that the development of LLJETs was closely associated with the immigration periods of the planthoppers in Chikugo, Fukuoka, Japan.

In this paper, a close correlation between the geographical distribution of immigrants and the localization of LLJETs over the whole area of Japan was apparent in 24 out of 32 immigration waves examined. However, there were eight cases that could not be explained by the LLJETs. In two cases in 1984, the LLJET conditions were regarded as suitable for immigrations, yet immigrant densities were very low as

Fig. 1. Map of the light-trap stations from which the data were collected.

Table 1. Number of white-backed planthopper (WBPH) caught during the Baiu season by light-traps in Chikugo, Fukuoka, Japan

Year	June	July	Total
1980	212	1,950	2,162
1981	1,461	319	1,780
1982	15	2,705	2,720
1983	744	1,065	1,809
1984	33	350	383
1985	17	818	835

compared with those in other years (Table 1). When the immigrant density was very low, the relationship between the immigration area and the localization of LLJET became unclear. In another two cases, the immigrations occurred in southwestern Japan without the development of any definite LLJETs. In the remaining four cases, the localization of LLJETs did not coincide with the immigration areas of the planthoppers. We had analyzed the wind conditions at intervals of 24 hr. When a LLJET moves up rapidly from south to north on Japan within one day, we can not establish a correlation between the localization of a LLJET and an immigration area of planthoppers.

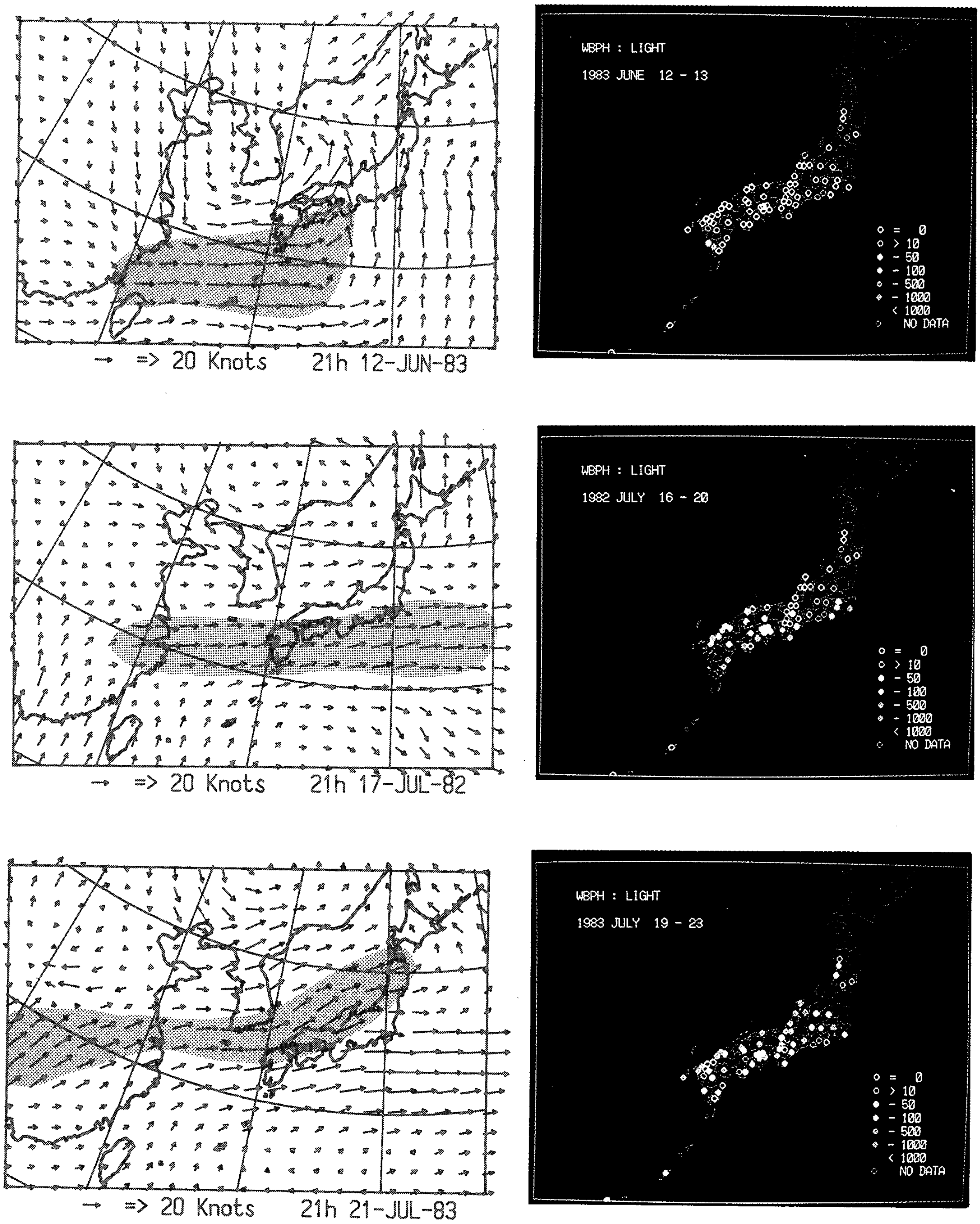

Fig. 2. Left: Mesh map of the wind direction and speed on the 850 mb weather chart. Shaded area indicates the strong wind area of more than 20 knots. Right: Distribution of the immigration density of WBPH. Colored circles indicate the total number of planthoppers caught during the migration waves. A-1: 2100 12 June, 1983. A-2: 12 to 13 June, 1983. B-1: 2100 17 July, 1982. B-2: 16 to 20 July, 1982. C-1: 2100 21 July, 1983. C-2: 19 to 23 July, 1983.

CHENG et al. (1979) reported that the immigrant densities of BPH decreased exponentially with distance from the source of the migrants in China. KISIMOTO (1979) also showed that the density of immigrated planthoppers, on a logarithmic scale, decreased linearly with distance from the western coast line of Kyushu. In the present study, Fig. 2B-2 shows the same pattern that KISIMOTO (1979) reported. Figure 2A-2 and Fig. 2C-2, however, show different distribution patterns of immigrations depending on the localization of the LLJETs. These patterns were generally observed in the early and late Baiu season. AKIYAMA (1973) showed that the area covered by a LLJET shifted northward gradually as the Baiu season progressed. WATANABE et al. (1991) showed a good correlation between the geographical distribution of immigrants and the localization of the LLJETs, supporting the hypothesis of SEINO et al. (1987) to the effect that the LLJET is a main factor in the transportation of planthoppers.

Geographical mapping of the pest density is a powerful technique facilitating the understanding of the wide range of distribution and abundance of pests. This technique is widely adopted in monitoring the population change of aphids in England (e.g. WOIWOD and TATCHELL, 1984). In this paper, simple maps of the distribution of immigration areas of planthoppers were presented. In Japan, the Plant Protection Division of Ministry of Agriculture, Forestry and Fishery, established a monitoring network system for migratory rice planthoppers in which daily trap data at more than 200 sites are collected, compiled, and disseminated by a computer network (YOKOTA, 1987). This monitoring system will become more useful in understanding the immigration density of the planthoppers over Japan when combined with the mapping technique.

ACKNOWLEDGEMENTS

We would like to express our gratitude to Dr. K. SOGAWA, Kyushu National Agricultural Experiment Station, for his critical reading of this manuscript. We would also like to thank the members of the division of plant protection in each prefecture who supplied data for this study and Messrs. K. MIYAHARA, S. OYA and Dr. Y. HIRAI who collected these data. We wish to acknowledge Misses C. BABA and N. NAKAMURA for their gracious assistance in this study.

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