FORECASTING THE MIGRATIONS OF BROWN PLANTHOPPER (*Nilaparvata lugens* (Stål)) IN CHINA

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ABSTRACT

The results are reviewed of investigations in China, aimed at developing a system for forecasting the migrations of *Nilaparvata lugens* Stål, an important pest of rice. The results of an overwintering survey are presented, evidence for long-distance migration is given, and rice-growing regions of China are classified according to the migration of the planthopper. The forecasting system that has been developed is described.

INTRODUCTION

The brown planthopper (BPH) is only one of several pests in the central and southern rice-growing regions of China, but it has been prevalent since the end of the 1960s and has become a serious pest of the main rice-growing regions of China in recent years.

A co-operative BPH research project was established in 1977 by the Ministry of Agriculture, involving 134 research units from twenty provinces. Several aspects of the life-cycle and migration of BPH were investigated, including an overwintering survey of BPH throughout the main rice-growing areas from Hai-Nan Island to the northern rice-growing regions of the Yangtze River, aeroplane trap catches at various altitudes, catches at sea, alpine net traps, release and recapture of marked adults, surveys using light traps, population dynamics in different localities and the analysis of meteorological data in relation to insect flight. The general conclusions are summarised as follows:-

Overwintering Survey of BPH

Although BPH has been bred on *Leersia hexandra* Swartz and *Zizania caduciflora* (Turcy) Hand-Mazz under artificial conditions, it has not been found on these host plants under field conditions. BPH has only been found to survive the winter under field conditions on volunteer seedlings germinating in the rice stubble after harvest or on wild rice plants (*Oryza sativa* F. Spontanca) if the temperature is favourable to the activities of BPH.

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Overwintering eggs of BPH in the rice stem fail to survive when the water content of the stem drops below 62.5%. The supercooling points of different development stages of BPH are from -7°C to -9°C, although 100% mortality occurs when different stages of BPH are treated at 0°C for various lengths of time: e.g. for eggs, 5-6 days; nymphs, 3 days; adults, 3-4 days. After an intensive survey of overwintering BPH in various localities, it is concluded that BPH can survive in winter in the area south of 21°N latitude where the average temperature in January exceeds 16°C. No living BPH can be found on any host plant in the area north of 25°N latitude where the average temperature in January is below 10°C. Some overwintering BPH may be found in the area between 21 and 25°N latitude according to the fluctuation of winter temperature but it is usually rare to build up an infestation. Infestations of BPH in this area, as well as in the area north of 25°N latitude, are caused directly by the mass migration of BPH from the south or by their offspring.

EVIDENCE FOR LONG-DISTANCE MIGRATION OF BPH

1. The simultaneous sudden appearance throughout a broad area.

Data obtained from field surveys, light-traps and alpine net traps showed that the number of BPH increased suddenly within a short period over a broad area. For example, it was reported by more than a hundred insect monitoring stations that BPH increased suddenly in the area between 25° and 34°N latitude across eleven provinces from June 26 to July 4 in 1977, although the rice culture systems and the weather conditions were quite different within the area and no local populations were observed at that time. This migration consisted of macropterous adults, and it may be deduced from this that the population of BPH was a mass migration of hoppers from other places. The same phenomenon has been observed in other years.

2. Data from the alpine net traps.

More than forty alpine net traps have been established in different localities since 1977, fourteen of which were situated at an elevation of more than 1,000m. The nets were of two types (a) a fixed net with openings in eight directions and (b) a single-opening net which turned into the direction of the air current. Data of BPH collected from the alpine net traps suggested that the adults were migrating from south-western or almost southern China in spring and summer but north-eastern or almost northern China in autumn. The northward or southward migration coincided with the seasonal changes of the prevailing winds in the upper air layers, which probably acted as the transporters of BPH.

3. Aeroplane catches.

A C-5 type aircraft installed with a net trap of 27 x 130cm or 27 x 100cm was used to catch BPH. The catch tests were conducted in Guang zhou, Wn-Han and Nanjing respectively in spring, summer and autumn from 1977 to 1979. The flight area extended over seven

provinces. The aircraft flew at various altitudes from 100 to 3,000m; total flying hours were 279 and the distance exceeded 35,000km. 3,273 hoppers were caught, 1,190 of which were BPH and 1,777 were Sogatella furcifera (Horvath). The maximum catch was at the altitude of 1,500-2,000m in spring and summer, as compared with 500-1,000m in autumn. The presence of BPH adults in the air 2,000m up strongly suggested that BPH was carried by the air currents in the upper atmosphere from remote distances.

4. Catches at sea.

South Sea, East and Yellow Sea net traps were installed on fishing ships, cargo ships and transporting ships which sailed in the South, East and Yellow Seas during 1977-1980; 430 working days and nights were spent and the total distance travelled was 110,000km. The nearest land was at 12.5km and the farthest 200km; 2,131 BPH were caught and those still alive reproduced normally.

5. Release and recapture of marked adults.

A mixture of alkaline dye, fluorescein and lac was used to mark the macropterous adults of BPH. More than 47 million marked adults were released at various localities in Guangdong, GuangXi, Hunan, Zhejiang, Jiangsu and Anhui provinces during 1978 and 1979. Some marked adults were collected in the light-traps at remote distances. For example, a red-coloured adult released from Dongyuen, Guangdong province was collected at Chenzhou, Hunan province, on June 27, 1978. The linear distance is more than 300km. A green-coloured adult released from Qujing, Guangdong province, was collected at Guangzhou on October 25, 1978, a distance of 200km; two green-coloured adults released from Xinxing, Guangdong province, were collected at Chenzhou, Hunan province, on July 2, 1979; and a green-coloured adult released from Yonfu, Guangxi province, was collected at Nanchang, Jiangxi province, on July 26 in the same year, distances of 500km and 700km respectively. The interval between releasing and collecting was less than one week.

All the above data provide incontrovertible evidence of long-distance migration of BPH.

SOME BIOLOGICAL, ECOLOGICAL AND PHYSIOLOGICAL EVIDENCES FOR MIGRATION OF BPH

The macropterous adults of BPH on maturing rice plants will stop to feed and climb up to the tip of upper leaves from their habitat at the base of rice stems. At a certain light intensity the adults suddenly fly and ascend through the air. Adults usually start flying at dawn before sun-rise, and again in the evening after sun-set, when the temperature is greater than 25°C from summer to early autumn, and in the late autumn flying will start in the afternoon. The peak of flying occurs at 20-30 lux of light intensity.

Some diapause characteristics of migrating adult females of BPH were observed. The end of the first stage or the early part of the second stage of development of the ovary in female BPH ceased while the adult was flying in the air and it continued to develop after landing, which was followed by copulation and reproduction. Flying behaviour and development of the ovary are controlled by juvenile hormone. The flying activity is also influenced by the nutrient content of food and the density of the population.

Mass migration of the macropterous adults is usually synchronised with the approaching maturity of the rice plant in the areas of original infestation. A significant increase of macropterous adults occurs at the yellow maturing stage of rice and is followed soon afterwards by the flight of the adults. The planting dates of rice start early in the south and fall gradually later towards the north. The maturing dates of rice probably follow a similar pattern. Thus the macropterous adults migrate from south to north in spring and summer, and from north to south in autumn to optimise the nutritional benefit they receive from their host plants.

METEOROLOGICAL CONDITIONS AND MIGRATION OF BPH

Since most of the rice growing area is situated in the monsoon zone, the migration of BPH is also much influenced by changes in meteorological conditions and the air currents in the upper atmosphere. When the continental high pressure declines towards the north in spring and summer while the sub-high pressure gradually increases in its intensity, then BPH adults are carried northwards by the warm and moist south western air currents. The weather conditions at the source of BPH emigration often appear to consist of a hot low pressure layer near the ground accompanied by prevailing south western air currents in the upper atmosphere. In the area to which BPH immigrates the weather is controlled by a subtropical wedge and frontal zone which are favourable for the settlement of BPH.

The optimum temperature for long-distance flight of BPH is 17° - 22°C, while the lowest temperature is 12°C and the highest temperature is 30°C.

CLASSIFICATION OF RICE AREAS WITH RESPECT TO THE MIGRATION OF BPH

The occurrence of BPH may be classified into five zones, based on the cultural system of rice growing areas, the overwintering survival of BPH, the emigration and immigration of macropterous adults and the meteorological conditions:

1. Areas south of 21°N latitude
2. Southern parts of Guangdong and Guangxi region (21-23°N)
3. Nanling ridge region (23-28°N)
4. Yangtze River rice-growing region (28-32°N)
5. Huaihe river rice-growing region (north of 34°N)

BPH adults migrate from the south and settle in the southern parts of Guangdong and Guyangxi region from late March to May. When the early rice crop matures in this region the BPH emigrates and settles in the Nanling ridge region in the middle of June. The next migratory movement is the settlement in the Yangtze river and Huaihe river rice-growing region from the middle to the end of July. The pattern of migration may be varied to a certain extent from one year to the next due to variation in the meteorological conditions.

THE METHOD OF FORECASTING

Based on the general rules of the migration of BPH as mentioned above, we have established a united monitoring net system of BPH in several main growing regions since 1977 to forecast the occurrence of BPH throughout the rice-growing regions. Information on the dates of appearance of macropterous adults, rice growth stages, meteorological conditions, light-trap catches and field population surveys of BPH should be collected. The first forecast should be made in the early part of June giving information about the emigration period and density of macropterous adults in the early rice crop in the southern parts of Guangdong and Guangxi region and its major setting areas. The second forecast should be made in the early part of July giving information about the emigration period and the density of macropterous adults in the early rice crop of Nanling ridge region and its major setting areas. The third forecast should be made in the end of August, outlining the trend of BPH infestations on the middle of late rice crops of the mono-rice-planting system and the late rice crop of the double rice planting system in the northern rice growing region. The united monitoring net system has been running successfully for four years. The forecasts were practically coincidental with the occurrence of infestations in various areas. An outbreak of BPH in the northern rice-growing area in 1980 was predicted early in June so that the control of BPH was started as soon as the infestation appeared and the damage was reduced. Referring to the varying climatic conditions, it would be better to collect all local information in detail so that one can check or correct any bias from the forecasting information caused from the variation of some natural conditions.

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