A Possible Relationship between Outbreaks of Planthoppers, *Nilaparvata lugens* STÅL and *Sogatella furcifera* HORVÁTH (Hemiptera: Delphacidae) in Japan and the El Ninõ Phenomenon[1]

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Outbreaks of the brown planthopper, *Nilaparvata lugens* STÅL, and the whitebacked planthopper, *Sogatella furcifera* HORVÁTH, have been occurring in Japan for a long time. However, the factors causing these outbreaks have not yet been clarified, At present, it is considered that the planthoppers (*N. lugens* and *S. furcifera*) spread from Southeast Asia, where they reproduce throughout the year, to subtropical and temperate zones (KISIMOTO and DYCK, 1976). Recently, the El Ninõ/Southern Oscillation (ENSO) phenomenon has been the focus of attention as a factor in global climatic change. ROPELEWSKI and HALPERT (1987) found that precipitation patterns changed in Southeast Asia during the ENSO phenomenon.

The objective of the present paper was to investigate the statistical relationship between the outbreaks of the planthoppers in Japan and the climate changes associated with the ENSO phenomenon during 1890–1989.

MATERIALS AND METHODS

I followed the identification of ENSO years by RASMUSSON and CARPENTER (1983), except for 1969, because the Japan Meteorological Agency (1989) reported that the ENSO did not begin in 1969, but in 1968. A total of 23 ENSO years were identified for the period 1890–1989.

Since data on areas affected by the planthoppers were not available before 1936 in Japan, I followed the records of the outbreaks by SUENAGA (1954) for 1890–1936. As for the period of 1937–1955, data on the areas affected by the two species of the planthoppers were available (Japanese Ministry of Agriculture and Forestry, 1971), as were data for the period of 1956–1989 (Japanese Ministry of Agriculture, Forestry, and Fisheries, 1971, 1971–1990). Data on rice field areas in Japan were obtained from the Investigation Committee on Agricultural Policy (1977) and the Japanese Ministry of Agriculture, Forestry, and Fisheries (1977–1990).

The percentage of the areas affected by the planthoppers to the total rice field area was used as an occurrence index. When it exceeded 20%, it was designated as an outbreak of the two planthopper species for 1937–1955. As for each species, an outbreak was defined when the percentage exceeded 30% for the period 1956–1989, since the areas infested by the planthoppers had become more extensive after 1955.

RESULTS AND DISCUSSION

Figure 1 shows the outbreaks of the planthoppers and ENSO events during the period of 1890–1936. Large-scale outbreaks of the planthoppers occurred all over Japan in 1897, 1903, 1912, 1924, 1926 and 1929. These outbreaks, except in 1929, occurred in the years immediately following the ENSO events.

Figure 2 shows annual fluctuations in the percentage of areas affected by the two planthopper species out of the total area of rice fields during 1937–1955. Outbreaks, which were defined as infestation of more than 20% of the rice fields by the planthoppers, occurred in 1951 and 1954. Although

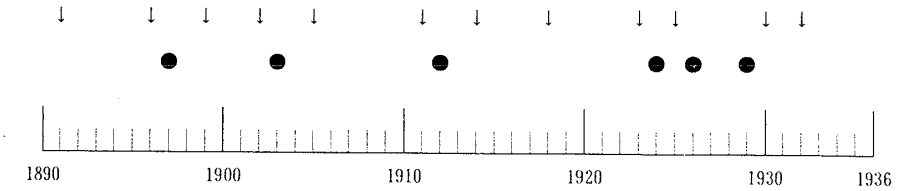

Fig. 1. Outbreaks of planthoppers in Japan (closed circles, derived from SUENAGA, 1954) and ENSO years (El Ninõ/Southern Oscillation years, arrows) during 1890–1936.

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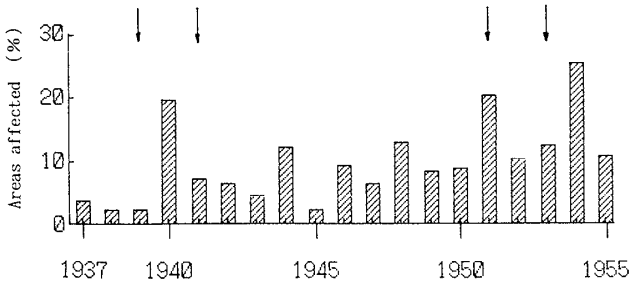

Fig. 2. Areas affected by planthoppers in Japan (percentage of the total rice field area, shaded columns) and ENSO years (arrows) during 1937–1955.

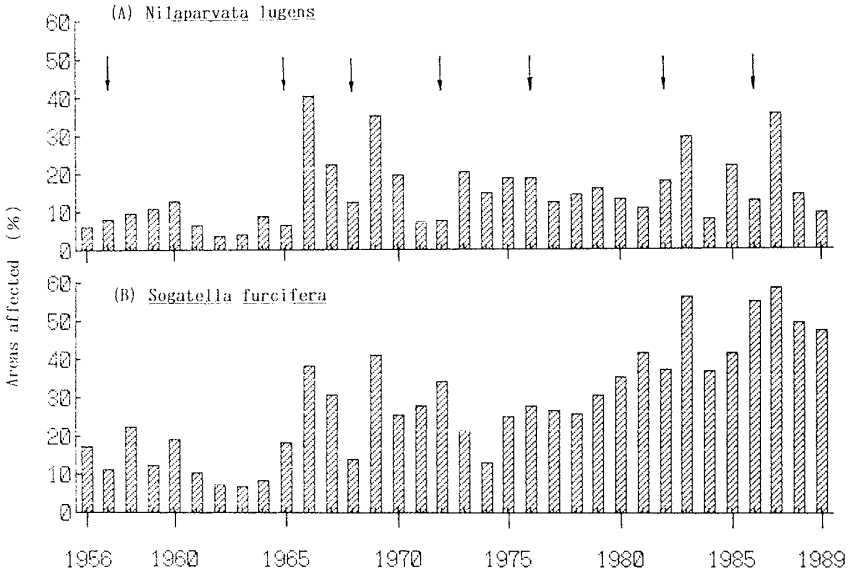

Fig. 3. Areas affected by planthoppers (percentage of the total rice field area, shaded columus), (A) *Nilaparvata lugens* and (B) *Sogatella furcifera* in Japan and ENSO years (arrows) during 1956–1989.

Table 1. Relationship between outbreaks of planthoppers (mainly *Nilaparvata lugens*) in Japan and ENSO events during 1890–1989

	No. of years with outbreaks	No. of years without outbreaks	χ^2
ENSO year	11	12	32.0 ($p<0.001$)
non-ENSO year	2	75	

1940 had less than 20% of rice field infestation (19.6%), I treated it as an outbreak year. SUENAGA (1954), too, reported 1940 as a large outbreak year. All these outbreaks, except the one in 1951, took place in the years following the ENSO events.

Figure 3 shows the percentage of rice field areas affected by *N. lugens* and *S. furcifera* and the ENSO years in the period of 1956–1989. More than 30% of rice fields were affected by *N. lugens* in 1966, 1969, 1983 and 1987. All these years followed the years of ENSO events.

Summarizing Figs. 1–3, 13 outbreaks of the planthoppers or *N. lugens* occurred in Japan during 1890–1989 and 11 of them occurred in the years immediately after the ENSO events. Table 1

shows a chi-square analysis for the independent occurrence of outbreaks of the planthoppers, mainly *N. lugens*, and ENSO events. The outbreaks occurred significantly ($\chi^2=34.2$, $df=2$, $p<0.001$) in the years immediately following the ENSO events. This fact suggests that some climatic changes associated with ENSO events accelerated the population increase of *N. lugens*. In ENSO years, amount of precipitation decreased in Indonesia, Philippines and New Guinea during the dry season (Ropelewski and Halpert, 1987). It is possible, therefore, that changes in precipitation patterns associated with ENSO events affect the population fluctuation of *N. lugens*.

Percentage of rice field areas affected by *S. furcifera* fluctuated in a manner similar to that of *N. lugens* until 1975. More than 30% of rice fields was affected by *S. furcifera* in 1966, 1967, 1969 and 1972, and all these years, except 1967, were preceded by ENSO events. The percentage of areas affected by *S. furcifera* increased and was more than 30% every year since 1979. No significant relationship was, therefore, found between outbreaks of *S. furcifera* in Japan and climatic changes associated with ENSO events.

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