Distribution range shift of plant pests, possibly due to climate change: examples in Japan

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Benefits for studying northward range extensions of plant pests on the Japanese Archipelago

The Japanese Archipelago extends for about 2,000 km from south (24°02’N) to north (45°31’N)

There are 4 distinct seasons in a year

Many armature entomologists have accumulated collection records of various insect species
The number of alien pest species that have established in the Nansei Islands, Japan (including both natural invasion and accidental introduction)

Data indicate an increase of alien pest species from 81 to 106 in recent years.
About 250 butterfly species occur in Japan. At least 40 of them are exhibiting northward range extensions in recent years.

Recently, 15 species newly arrived naturally and established on the Nansei Islands.
Papilio memnon, a pest of citrus trees, has extended its distribution range in western Honshu.

Established record: 1940

1956

1983

In 2000, P. memnon arrived in Tokyo.
A case study: Distribution range shift of *Nezara viridula* and *N. antennata*

Both species are pests of various crops, such as rice, soybean, corn, tomato, eggplant, etc.

*N. antennata* is distributed in Japan, Korea, China, and southeastern Asian countries

*N. viridula* is distributed widely in the tropics, subtropics, and southern temperate zones

In Japan, it was first recorded in 1874 and has been increasing since the 1950s in southwestern parts of Japan in association with the prevalence of early-planted rice
Distribution of *Nezara* bugs in the Kii Peninsula
Distribution map of *N. viridula* and *N. antennata* in the Kii Peninsula in the 1960s

*N. viridula* was distributed along the sea coast and south of Wakayama.
Distribution map of *N. viridula* and *N. antennata* in the Kii Peninsula in 2005

*N. viridula* was found in northern parts of the Kii Peninsula

Northern limit moved 70 km northward
Distribution range shift of *Nezara viridula* in northern Kyushu and Yamaguchi Prefecture
Collecting records of *N. viridula* before and after 2000

*N. viridula* has extended its range northward also in northern Kyushu.
Changes in mean monthly temperature for January in northern Kyushu for 48 years from 1960 to 2007

Since 1986, the temperature has exceeded 5°C that is the lowest thermal limit for *N. viridula* to overwinter successfully.
In red-colored areas, mean temperature for January exceeds 5°C, allowing *N. viridula* to overwinter successfully.

In 2005, temperature is about 1°C higher than in the 1960s. **Red-colored areas** coincide well with the actual range of *N. viridula* in 2005.

*N. viridula* will cover a large area of Kyushu in 2100, if the temperature rises by 1.4°C, which is the minimum prediction by Houghton *et al.* (2001).
Interspecific mating occurs in the field between the two *Nezara* bugs.

*N. viridula* has higher reproductive potential than *N. antennata* in terms of fecundity and the number of generations a year (*3 in viridula, while 2 in antennata*).

Interspecific mating caused a decline of *N. antennata* reducing the chance of intraspecific mating, resulted in the replacement of *N. antennata* by *N. viridula* in many places.
Ratio of *N. viridula* to *N. antennata* increased from 2002 to 2004
Summary of the case study

*N. viridula* has been extending its distribution range northward, possibly due to global warming.

The northern range limit of *N. viridula* is determined by the mean monthly temperature for January.

*N. antennata* has been replaced by *N. viridula* in many places as a result of interspecific competition. This is an indirect effect of climate change on the range shift of a congener.

This study is a good example to indicate that climate change affects biodiversity.
In order to investigate and predict northward extensions of plant pests, we need to gather information about:

- Detailed biological traits of the plant pests
- Distribution records in the past and present
- Factors limiting northward extension, such as
  1. Cold hardiness in relation to winter temperature
  2. Presence or absence of host plants, effective natural enemies, and competitors
  3. Reproductive potential and ability of dispersal
  4. Geographical barriers
Thank you for your kind attention