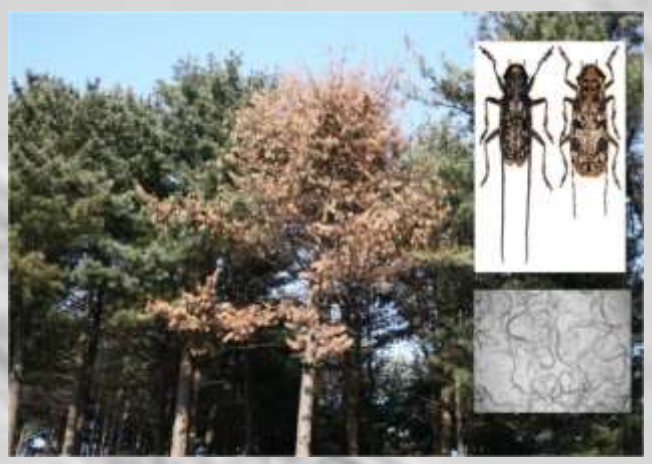
Dispersal patterns of exotic forest pests in Korea



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June 12, 2012

Major forest pests in Korea

- 8 species for long term monitoring
- Among them, 4 or 5 species are invasive species

Invasive species

Domestic species

Pine wood nematode

Thecodiplosis japonensis

Matsucoccus thunbergianae

Dendrolimus spectabilis

Hyphantria cunea

Corythucha ciliata

Agelastica coerulea

Acantholyda parki

Biology and invasive history

- **Introduction for Four exotic forest pests with basic biology and invasive history in Korea**
  - **Pine needle gall midge**
  - **Black pine bast scale**
  - **Fall webworm**
  - **Pine wood nematode**

Pine needle gall midge
(*Thecodiplosis japonensis*)

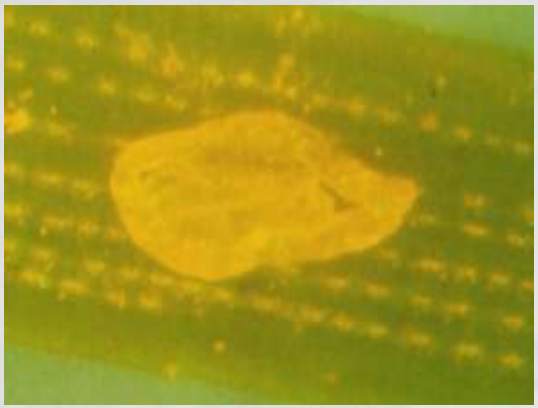
- **Distribution : Japan, Korea**
- **Hosts : *Pinus densiflora, P. thunbergii***
- **First Occurrence : 1929. Seoul and Mokpo**
- **Spread all over South Korea in 1998**

⇨ **One of the most important pest in Korea From 1980’ to1990’**

Life cycle

Adult(female)

- Emergence: late May ~early July
- Lifetime: 1~2 days
- Body length: 2.0~2.5mm

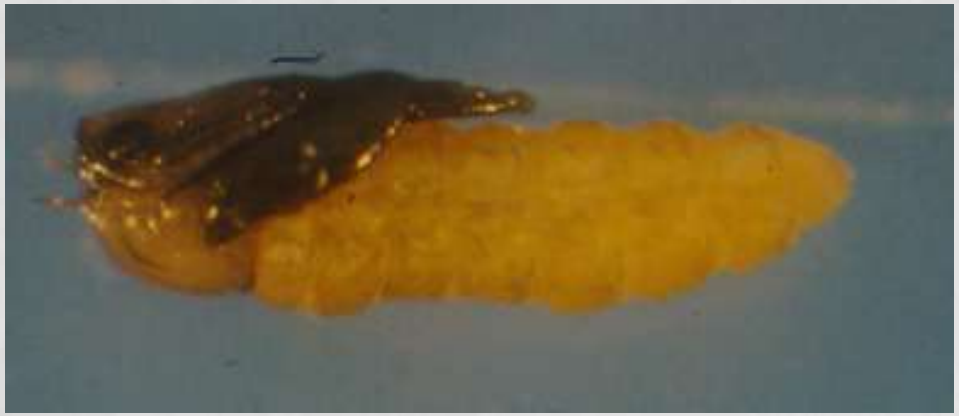


Egg

- No. of egg/ leaf : 7~8 eggs
- Egg period: 5~7 days

Larvae

- Body length: ~2mm
- Feeding period: June ~ November
- Insect gall formation
- Falling: November~December
- Wintering: November~next May
- 5~7 larva/ single gall

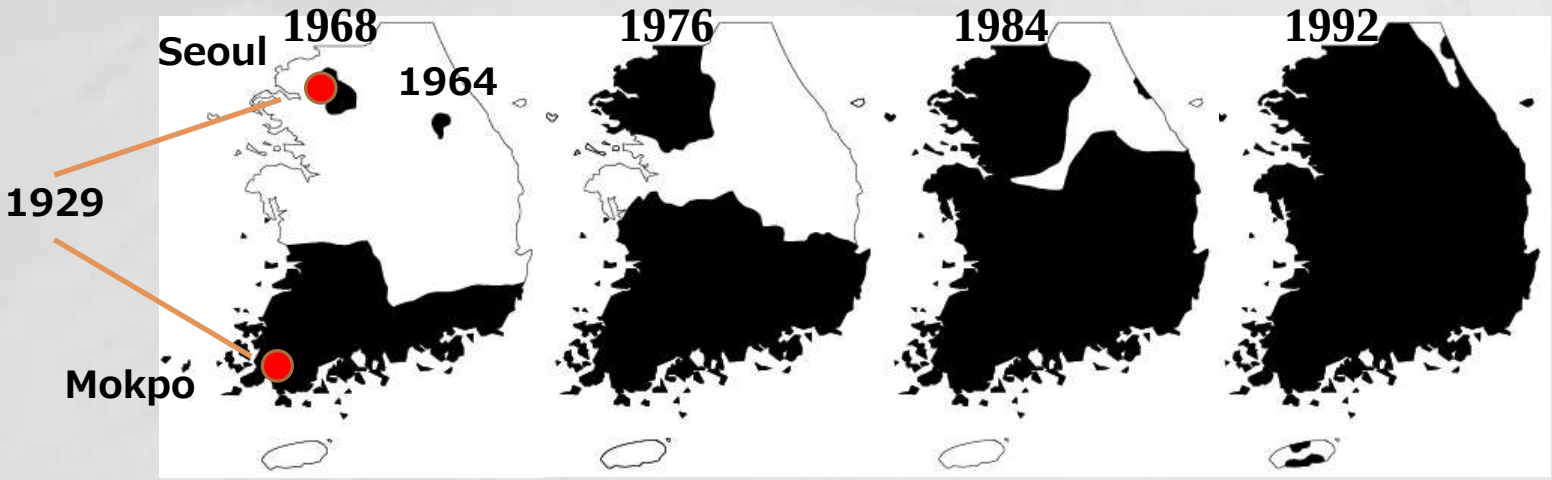


Larvae

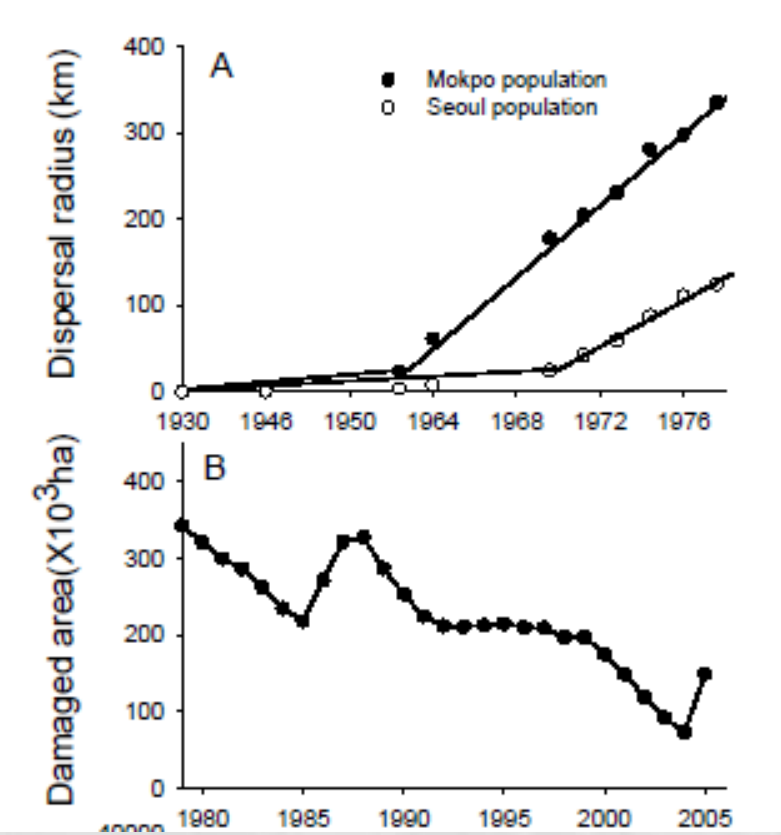
Insect gall

Invasive history of Pine Needle Gall Midge

Annual spreading distance : 1~8km in average



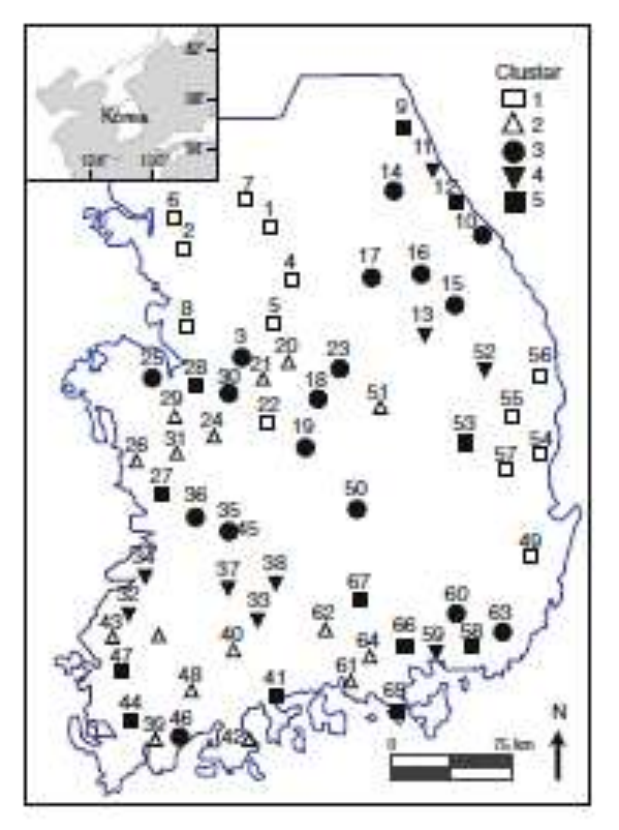
Dispersal pattern

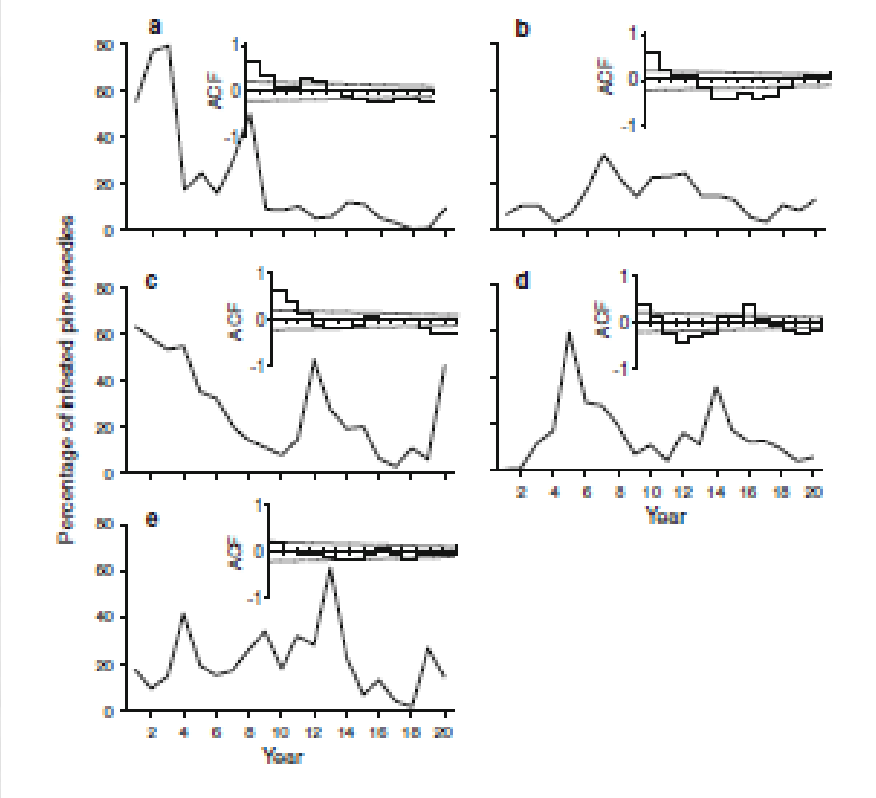


-The dispersal pattern :
Type 2 based on Shigesada *et al*. (1995)
-Dispersal speed at early invasion phase :
1.2 - 2.2 km/year
-Dispersal speed after break point :
8.2 km/year for the Mokpo population
5.2 km/year for the Seoul population
- Dispersal capacity of PNGM adults was estimated to be up to 400 m

Population dynamics based on long-term observation

1. Population dynamics at different region





Popul Ecol
DOI 10.1007/s10144-011-0263-8

ORIGINAL ARTICLE

Geographical variation in the population dynamics of *Thecodiplosis japonensis*: causes and effects on spatial synchrony

Won Il Choi · Mun Il Ryoo · Yeong-Jin Chung · Young-Seuk Park

Received: 12 May 2010 / Accepted: 10 January 2011

Abstract Geographical variation in population dynamics of a species offers an opportunity to understand the factors determining observed patterns of spatial dynamics. We evaluated the spatial variation in the population dynamics of the pine needle gall midge (PNGM), *Thecodiplosis japonensis*, which is a severe insect pest in pine forests in Korea, and studied the influences of weather factors that could affect its population dynamics. Results revealed that PNGM population dynamics were classified into five clusters based on the analysis of autocorrelation function and self-organizing map, which is an artificial neural network. We also quantified spatial synchrony in the population dynamics of PNGM using the nonparametric covariance function. Variation in spatial synchrony was strongly related to differences in maximum temperature and precipitation in Random Forest analysis, suggesting that the synchrony in PNGM population dynamics is largely the result of the Moran effect. In addition, spatial differences in population dynamics could be influenced by transient process of synchronization following invasion. Finally, the present results indicate that differences in population dynamics can be induced by interactions among several factors such as maximum temperature, precipitation, and invasion history of species.

Keywords Autocorrelation function · Invasive species · Nonparametric spatial covariance functions · Pine needle gall midge · Self-organizing map · Spatial synchrony

Introduction

Geographical variation in population dynamics is an important issue in population ecology because it can provide insight into factors determining population behavior as well as providing guidelines for population management. Spatial synchrony in the population dynamics of forest insect pests is important because the resulting regionalized outbreaks dilute the regulating effects of natural enemies, reduce the landscape's ability to buffer the disturbance, exacerbate the economic burden on individual stakeholders, and overwhelm the logistical abilities of

(Population Ecology, Choi et al., 2011)

Black Pine Bast Scale

Matsucoccus thunbergianae

- **Distribution : Japan, Korea**
- **Hosts : *P. thunbergii, Pinus densiflora***
- **First Occurrence : south area of Korea in 1963**

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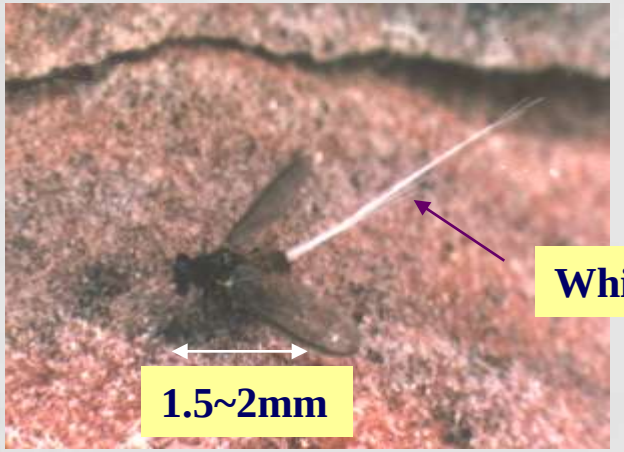

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Characteristics of damage

- Damage occurs in winter time because nymph has long summer diapause(夏眠):June ~ September
- Emerged nymph or egg mass are dispersed by natural factor (ex. wind)
- Insect has narrow host range

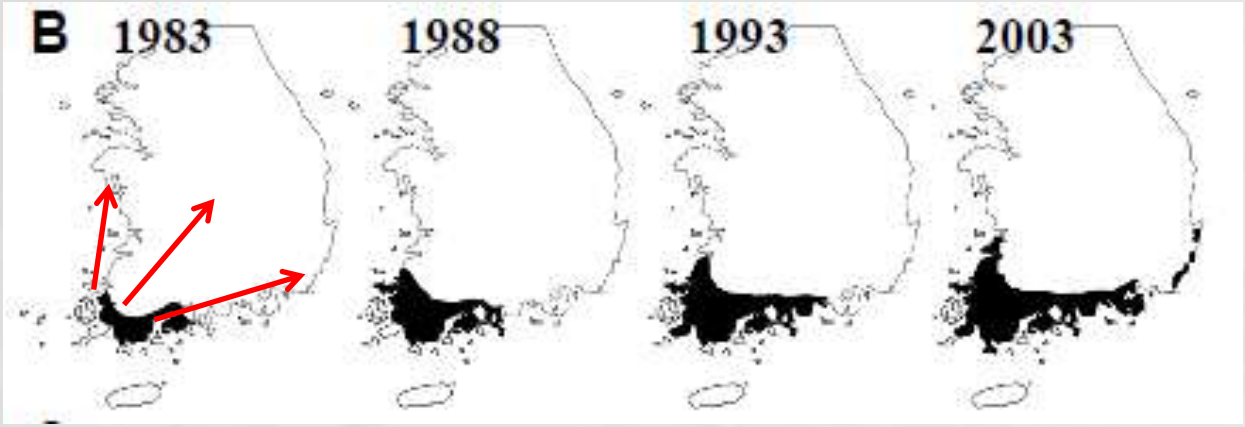
Origin of BPBS

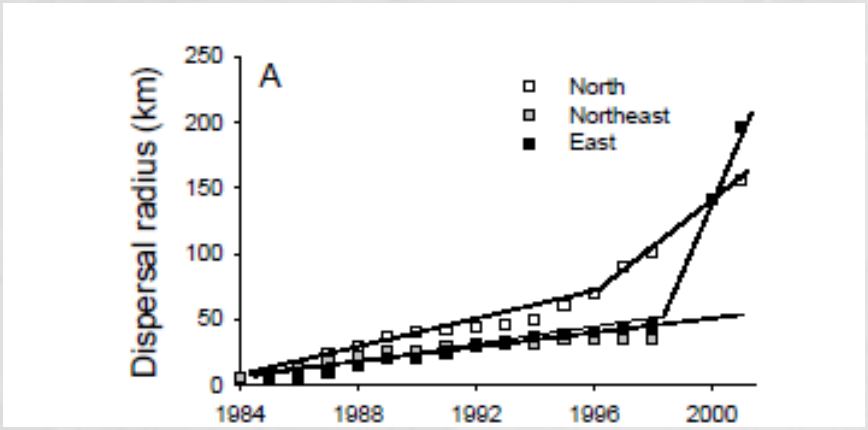
-The first occurrence of BPBS was observed in Goheung, Jeonnam-do, in the southwestern coast of South Korea in 1963 (Miller and Park, 1987).

-First hypothesis : the origin of BPBS in South Korea was from Japan because the species is also found in Kyushu, Japan at a low density.

-Second hypothesis : possibility that BPBS is an endemic species in South Korea, because BPBS was first reported in South Korea.

Spreading of *Matsucoccus thunbergianae*





-Dispersal speed is direction dependent:

5.9km/year to the north
3.3km/year to the east
4.3km/year to the northeast

-Dispersal by wind in egg stage
-Dispersal capacity is unknown

Fall Webworm
(*Hyphantria cunea*)

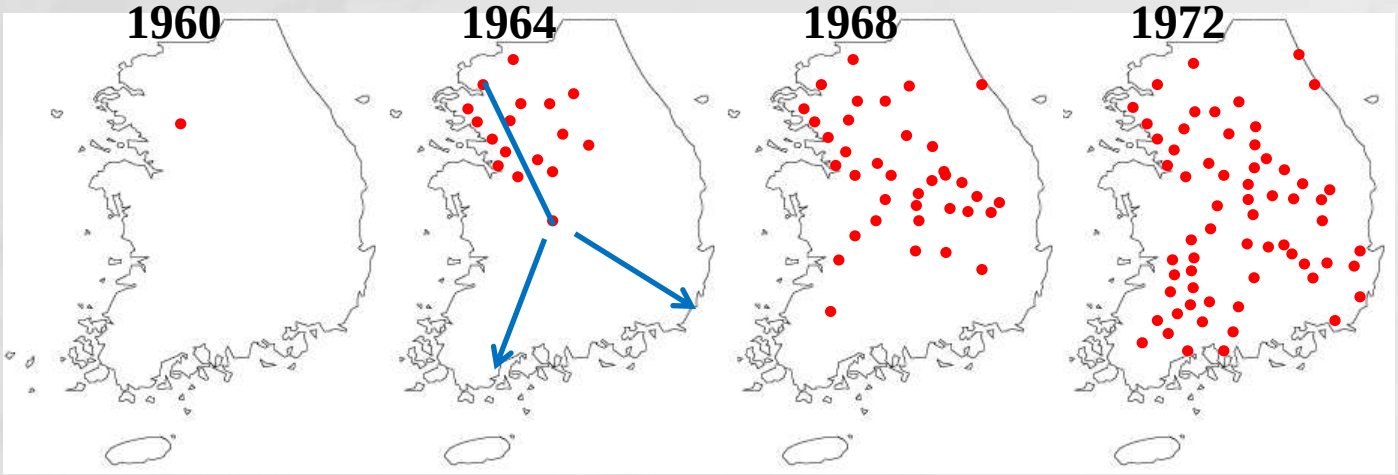
- **Origin : North America**
- **Distribution : China, Japan, Korea, Canada, Europe, Russia**
- **Hosts : Deciduous trees, 160 species (roadside tree)**
- **First Occurrence in Korea: 1958**

⇨ **Damages are occurred in the road trees located in city area however, population density is stabilized.**

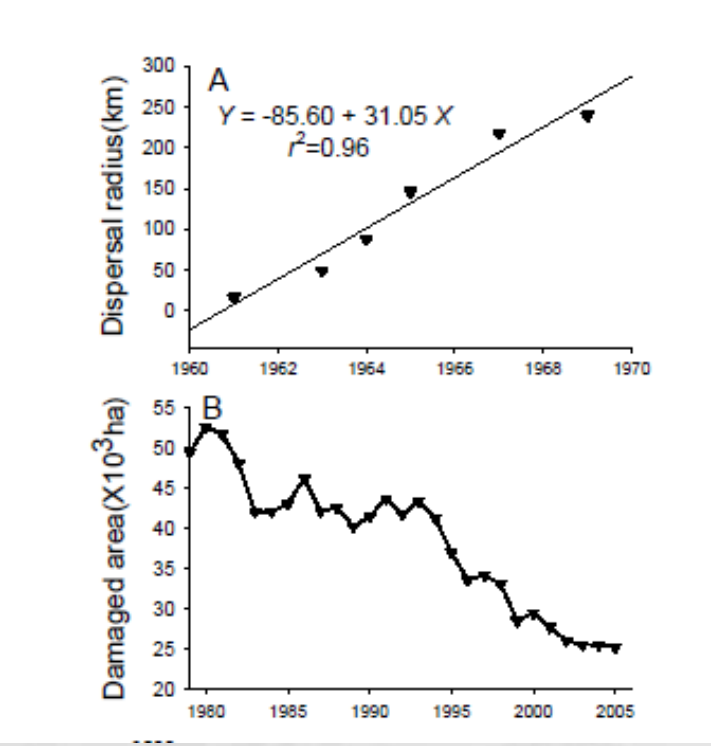
Adult(female)

- Emergence: 2 times/ year
  - First: mid May ~ early June
  - Second: late July ~ mid August
- Life time: 4~5 days
- No. of eggs: 600~700

Dispersal history of FWW in Korea



Dispersal speed of FWW in Korea



-The dispersal speed of the fall webworm: 31.1 km/year,
-Dispersal capacity of FWW: less than 300 m/day (Yamanaka *et al*., 2001)
-Fastest spread than other invasive forest pests in Korea
-The dispersal process of the FWW : Type 1 under the model of Shigesada *et al*. (1995)

Pine wilt disease

Pine Wilt Disease

- Caused by pinewood nematode (PWN),

  Bursaphelenchus xylophilus

  - ✓ native to North America and introduced into Korea in 1988
  - ✓ major host trees : *Pinus densiflora, P. thunbergii, P. koraiensis*
  - ✓ Introduced PWN reproduce rapidly in the sapwood resulting in rapid and extensive tree mortality

- Symptoms
  - ✓ rare of resin secretion and then discoloration and bent down of shoots

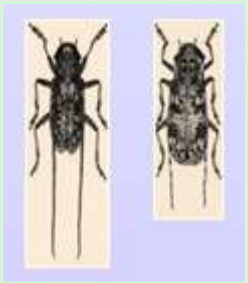
- Development
  - ✓ dead within 3 months after infection (susceptible host) if conditions are favorable to disease development

- **Significant economic, aesthetic and cultural loss**

Host trees

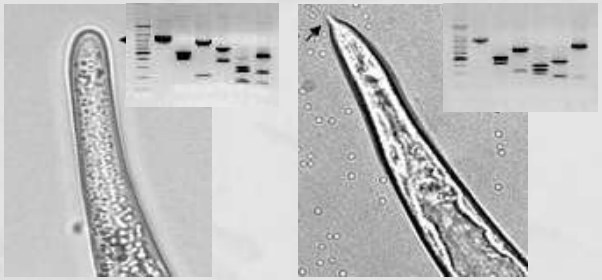
Insect vectors

Monochamus alternatus

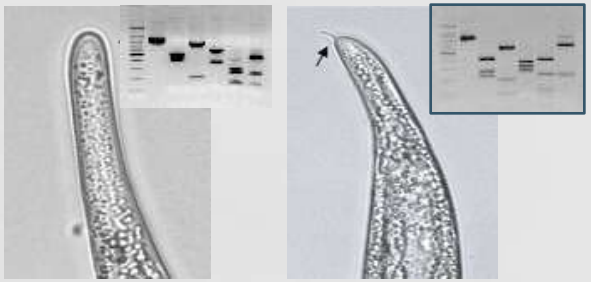


M. saltuarius

Nematodes

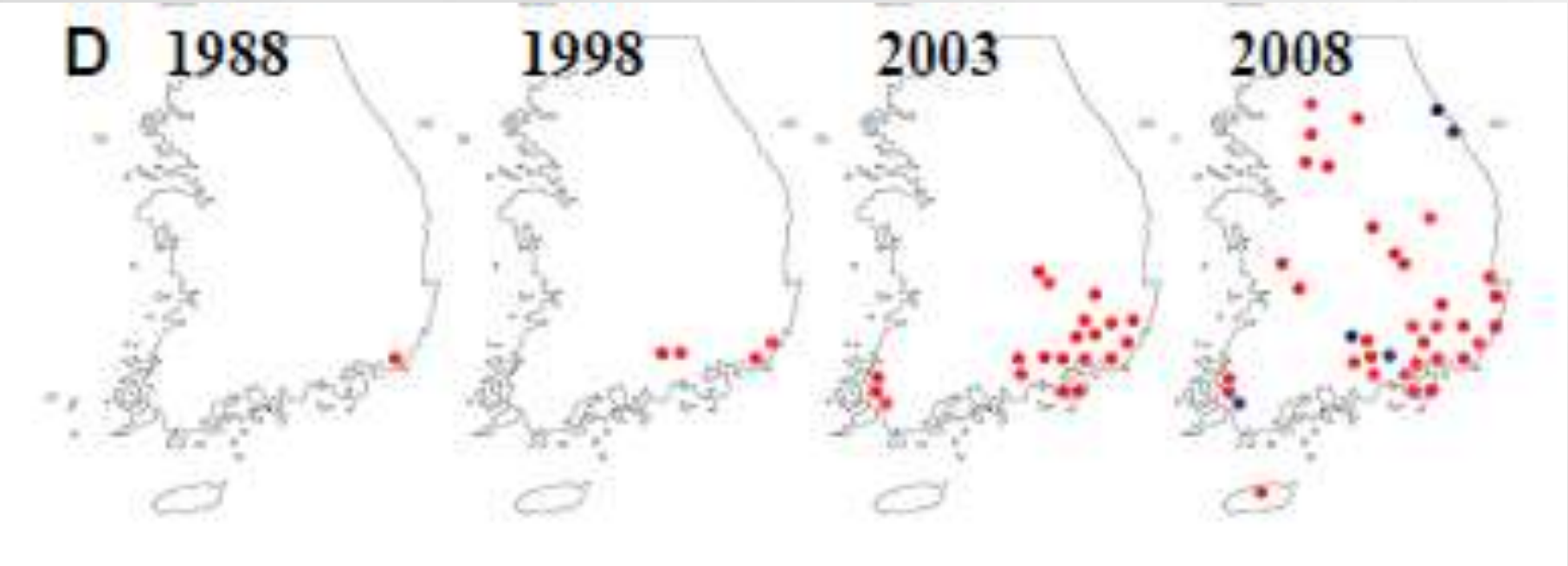


B. xylophilus ***B. mucronatus*** **(East Asian type)**



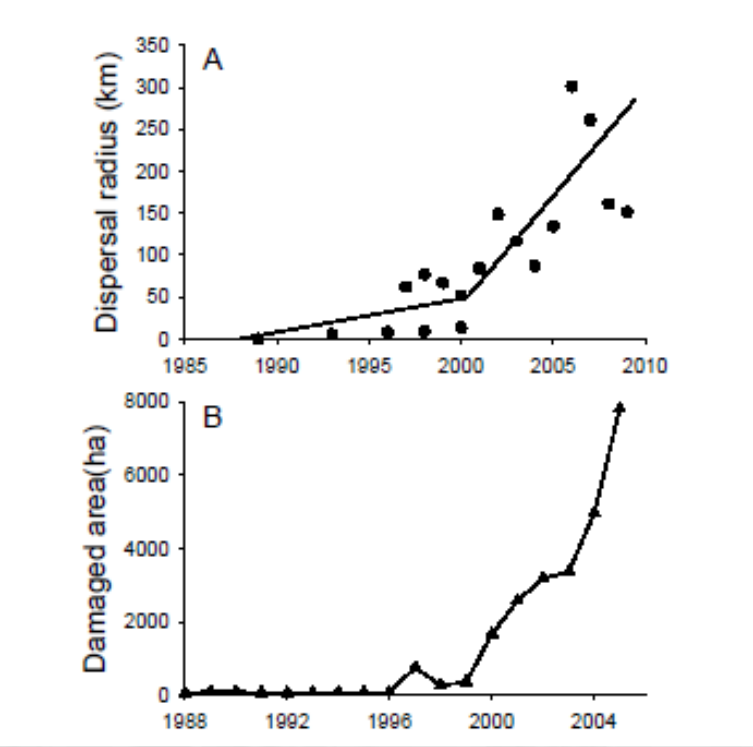
B. xylophilus ***B. mucronatus*** **(European type)**

Dispersal history



(Choi and Park, in press)

Dispersal speed of pine wood nematode



-Dispersal process of the PWN from 1988 to 2000 in the Busan area:
1.1 km/yr without any break points

-Dispersal after 1998:
13.8 km/year

-The patterns of PWN dispersal:
type 2 based on Shigesada *et al*. (1995).

-Dispersal capacity of vector :
average 1.4 km (Shin, 2008)

Conclusion

- The expansion of PNGM, BPBS and PWN follow “type 2” patterns, and FWW follows the “type 1” model of Shigesada and Kawasaki (1997), suggesting that human-mediated movement of exotic species accelerates their expansion.

- The four species reviewed had lag phases of about 10 years before range expansion.

- Although expansion speeds were faster than the moving capacity of the invasive species, expansion speeds were positively correlated with dispersal capacity.

- Japan was the source or route of many invasive species into South Korea, showing that neighboring countries are the potential source for most such species.

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Insect science

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REVIEW

Dispersal patterns of exotic forest pests in South Korea

Won Il Choi[1] and Young-Seuk Park[2]

[1]Division of Forest Disease and Insect Pests, Korea Forest Research Institute, Dongdaemun, Seoul, [2]Department of Biology and The Korea Institute of Ornithology, Kyung Hee University, Dongdaemun, Seoul, Republic of Korea

Abstract Invasive species have potentially devastating effects on ecological communities and ecosystems. To understand the invasion process of exotic forest pests in South Korea, we reviewed four major species of exotic forest pests: the pine needle gall midge (*Thecodiplosis japonensis*), pine wilt disease caused by the pine wood nematode (*Bursaphelenchus xylophilus*), the fall webworm (*Hyphantria cunea*) and the black pine bast scale (*Matsucoccus thunbergianae*). We consider their biology, ecology, invasion history, dispersal patterns and related traits, and management as exotic species. Among these species, the dispersal process of fall webworm was linear, showing a constant range expansion as a function of time, whereas the other three species showed biphasic patterns, rapidly increasing dispersal speed after slow dispersal at the early invasion stage. Moreover, human activities accelerated their expansion, suggesting that prevention of the artificial movement of damaged trees would be useful to slow expansion of exotic species. We believe that this information would be useful to establish management strategies for invasion species.

Key words *Bursaphelenchus xylophilus*, dispersal pattern, exotic species, fall webworm, forest management, *Hyphantria cunea*, *Matsucoccus thunbergianae*, pine wilt disease, *Thecodiplosis japonensis*

Announcement

International Symposium on Oak Forest Preservation: Understanding and managing important insect pests and disease of oaks.

The symposium will be held in Korea Forest Research Institute (KFRI) Seoul, South Korea, from Monday, August 27 to Wednesday, August 29, 2012

Thank you for attention