Seasonal variations in the incidence of pine wilt and infestation by its vector near the northern limit of the disease in Japan

Kazuhiko Hoshizaki

Akita Prefectural University, Japan

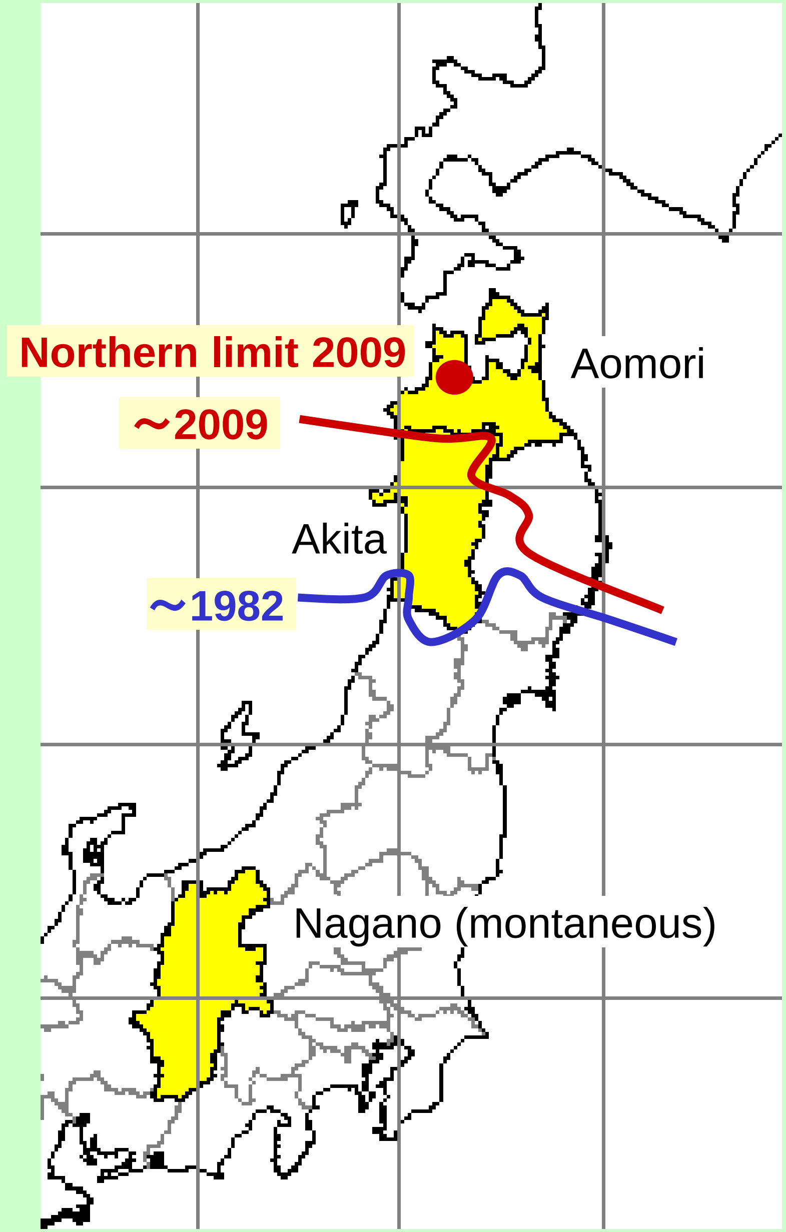
Recent spread of pine wilt disease damages

Spread to northern Japan (after 1970's)

- up north to Akita (1982-)
  to Aomori (2009)
- <u>Annual damages in cool climate regions</u>
  (i.e. northern and montaeous areas)
  occupy 25% of national totals.

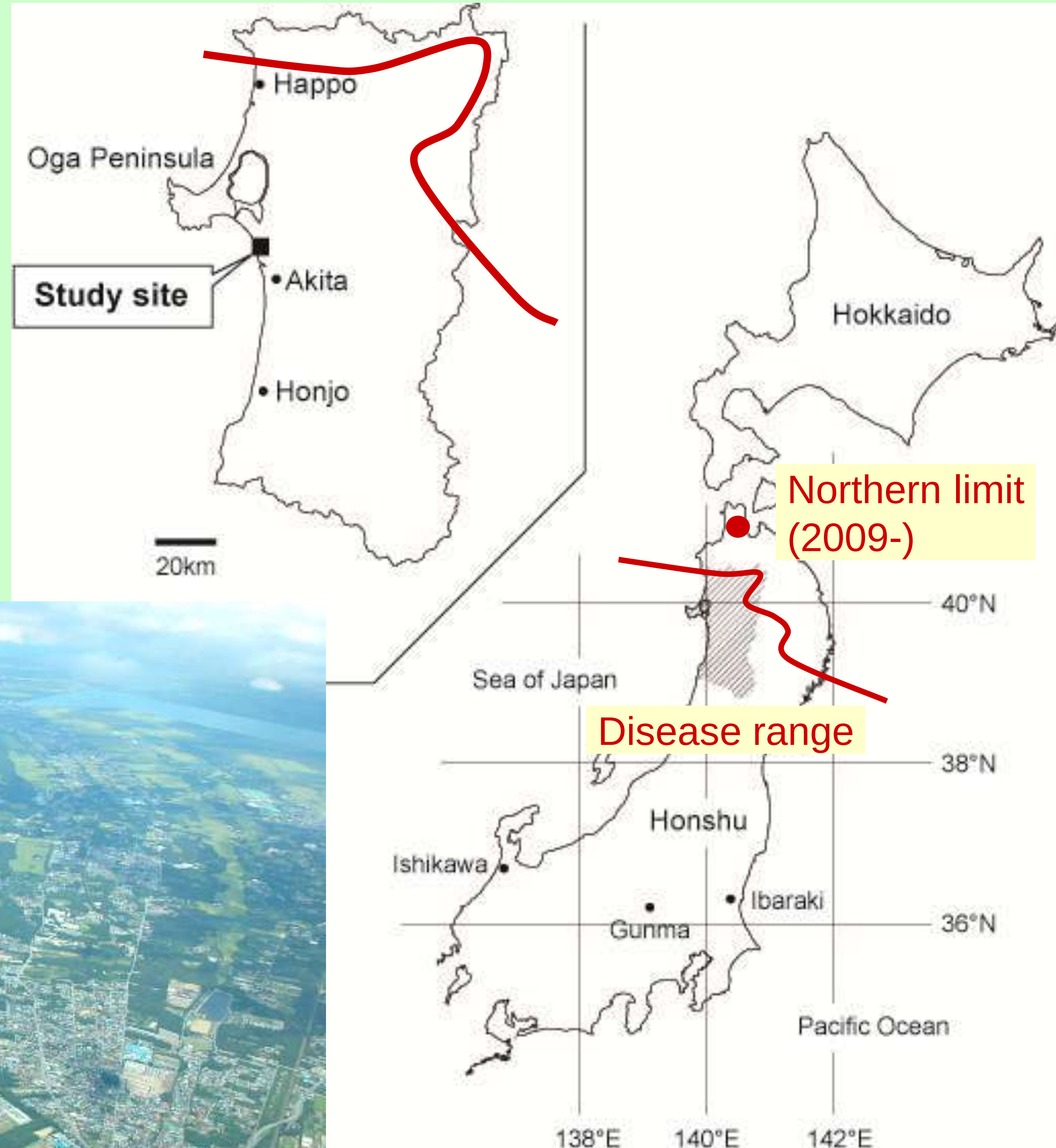
→ Korea, China, Taiwan (1980's)

→ Portugal (1999) → midwest Europe ?



Akita, the disease frontier

- Now the northern most part of the continuous range of the disease
- Large body of coastal pine forest (planted stands)
- Disease has increased in the 2000's.
- Southern coast severely damaged



Common eradication practices in Japan

1. Cut-and-treat

Target: larvae of wood-boring insects

- Fumigating insecticide
- Chipping
- Least costly, but depends on detection

2. Insecticide spraying

Target: adults of *M. alternatus*

- Aerial and ground application
- Requires expensive devices (e.g. helicopter)

3. Trunk injection

Target: pine wood nematode

- Most effective
- But also most costly
- Few stand-level application

4? Charcoal burning: a public-participating practice ("Sumi-yaki")

(Hoshizaki et al. 2005)

<u>A kind of cut-and-treat eradication</u>

- No insecticide, very costless
- Damaged trees re-usable as various resources
- Collaboration with the public
  (>110 burning events since 2002)
- Detection of damaged trees also feasible

Distinct disease features in cool climate regions

(Zinno et al. 1987, Nakamura-Matori 2008)

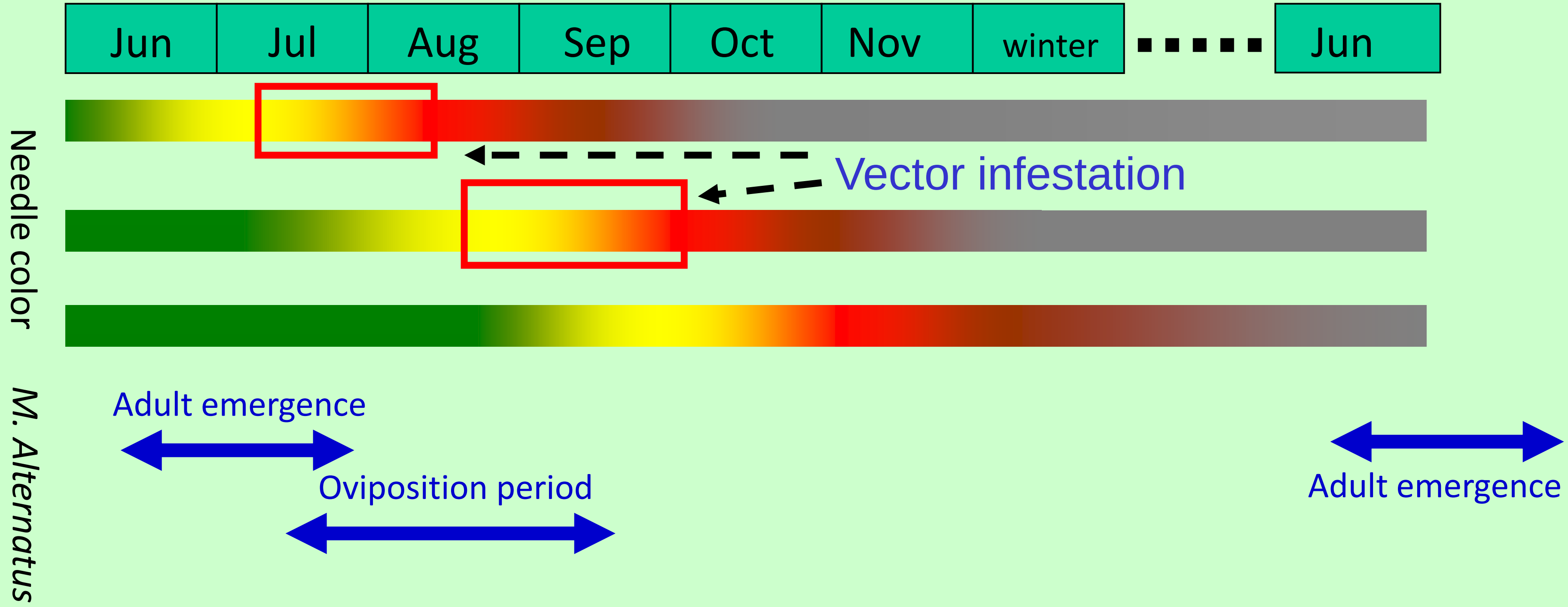
Low temp. suppresses activities of *B. xylophilus* and *M. alternatus*.

1. Delay of disease development → Discolored tree occurs year round.

   ←→ peaked in summer in central Japan (e.g. Kishi 1995)

2. Shorter flight season → Infestation by *M. alternatus* should be limited to trees in which weakening time falls within oviposition period.

   ←→ Damaged trees were mostly infested in warmer regions.



To what extent these features are examined?

If true, we might adopt a selective eradication strategy, in which only necessary infectees are served for eradication, in cool climate regions.

(“Akita system”; Kobayashi 2004, Hoshizaki et al. 2005)

However, findings remains collective and thus the supposed patterns have not been evidenced convincingly.

1. Investigation requires data for both seasonal damage occurrence and disease vector infestation.
2. Insufficient sample size, statistical power of analyses (e.g. data for not-throughout the year

Aims and questions of this study:

1) Need to confirm the pattern of year-round occurrence of pine wilt, based on a big dataset

2) What fraction of damaged trees is infested by *M. alternatus*?

3) Among damaged trees of various onset time of discoloration, which are more likely be infested?

Study site & methods

60 km from the former northern limit

600-m inland from the shoreline

85 ha (forested in 60 ha), 60-90 yr old

Living trees: *Pinus thunbergii* + *P. densiflora*

800-1200 trees/ha

Climate

Annual temperature 11.4 °C

Precipitation 1700 mm/yr

July: rainy season

Damage incidence: initial invasion in 1988, but remains approx. 0.1-2.4 %/yr

Seasonal incidence of diseased trees

(Ohta et al. in press)

June 2007–May 2009, once-a-month survey

- Mapped all damaged trees (>5 cm diameter) in the 85-ha area
- Keyed by:
  - sign of early-stage foliage discoloration & cessation of oreoresin flow

Disease vector infestation

Presence/absence of oviposition scars

climbing & cutting for all damaged trees

Oviposition scar densities

counts at 1-2 m and 4.5-5.5 m high

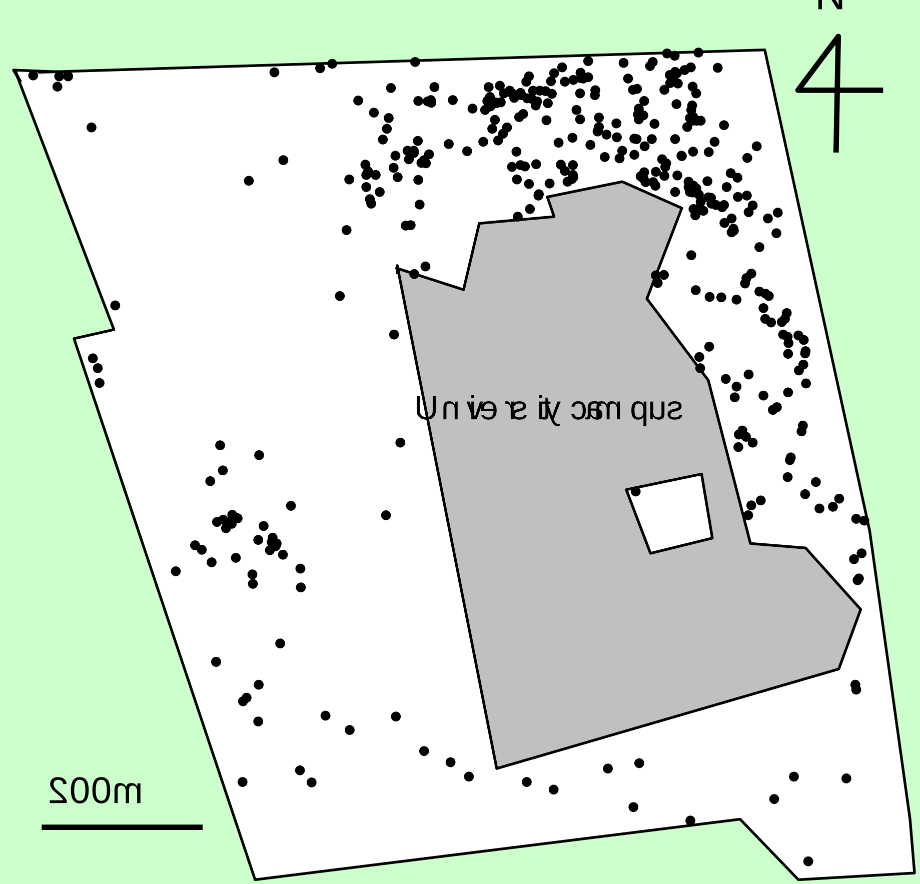
with trunk surface area

Oviposition scar
by *M. alternatus*

Results

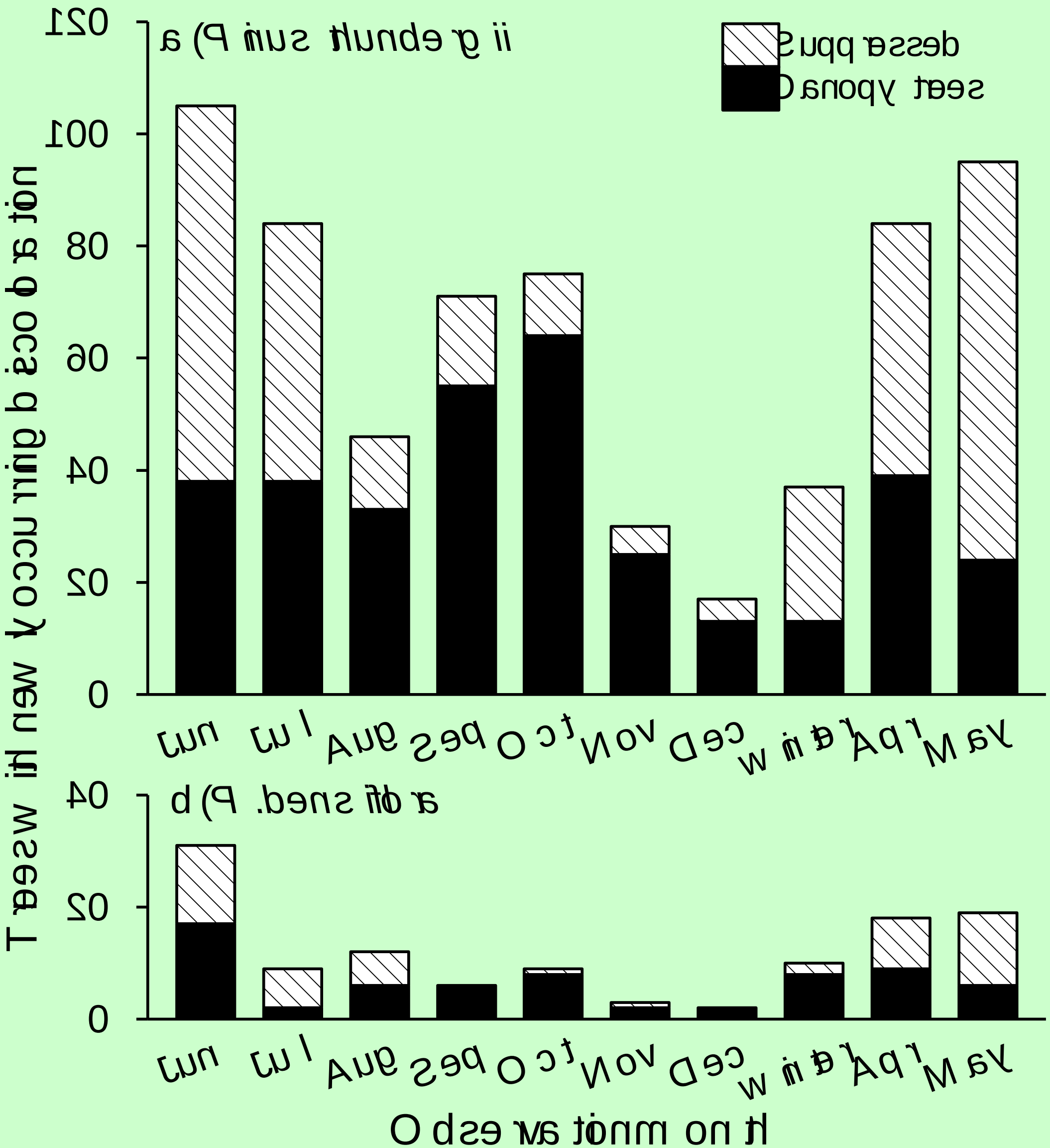
2007-08 (n = 379)

2008-09 (n = 384)



Overall incidence of damage: 6.3 trees ha^{-1} yr^{-1}

Seasonal incidence of damages (June 2007-May 2009)



For both species …

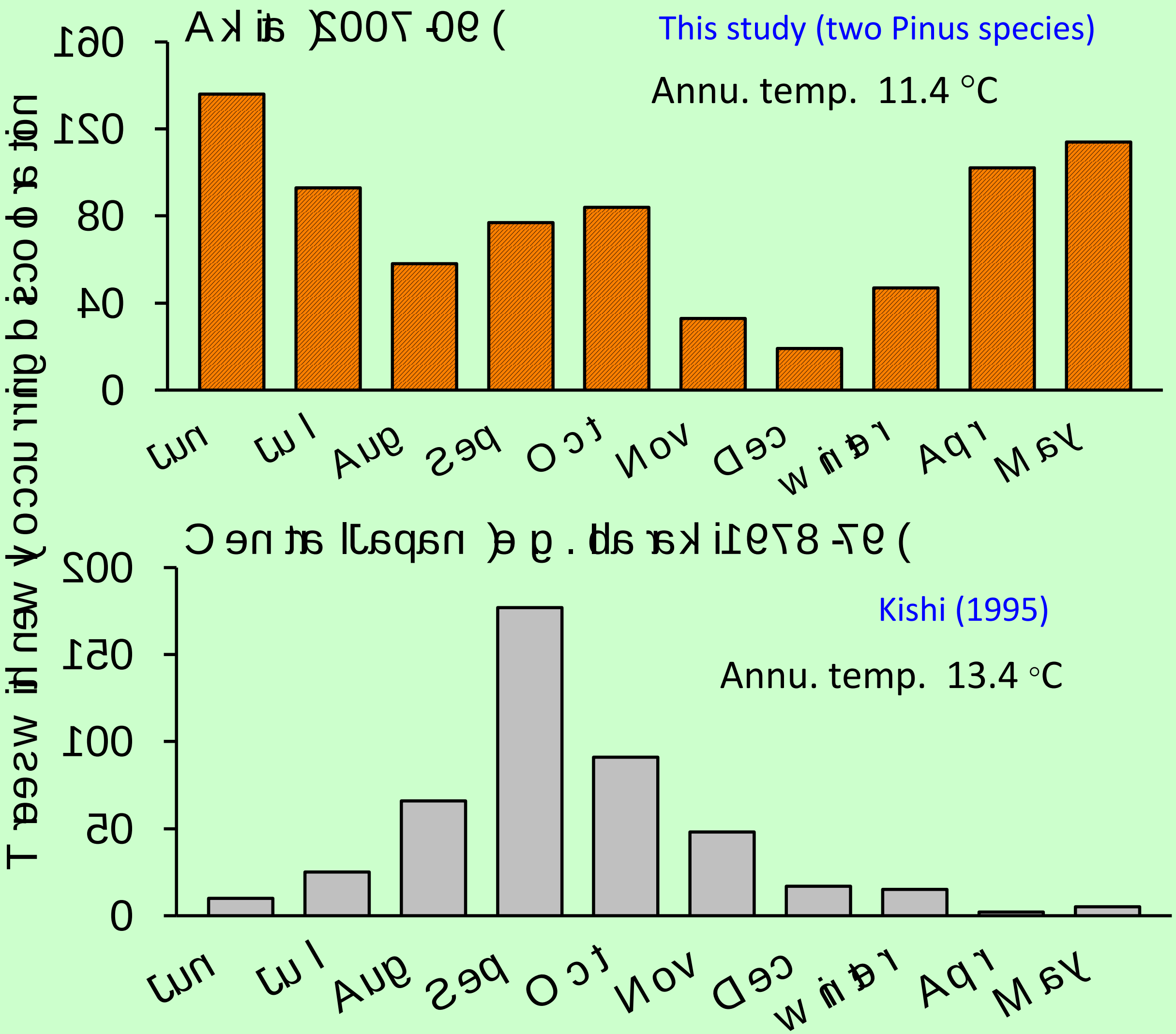
Discoloration

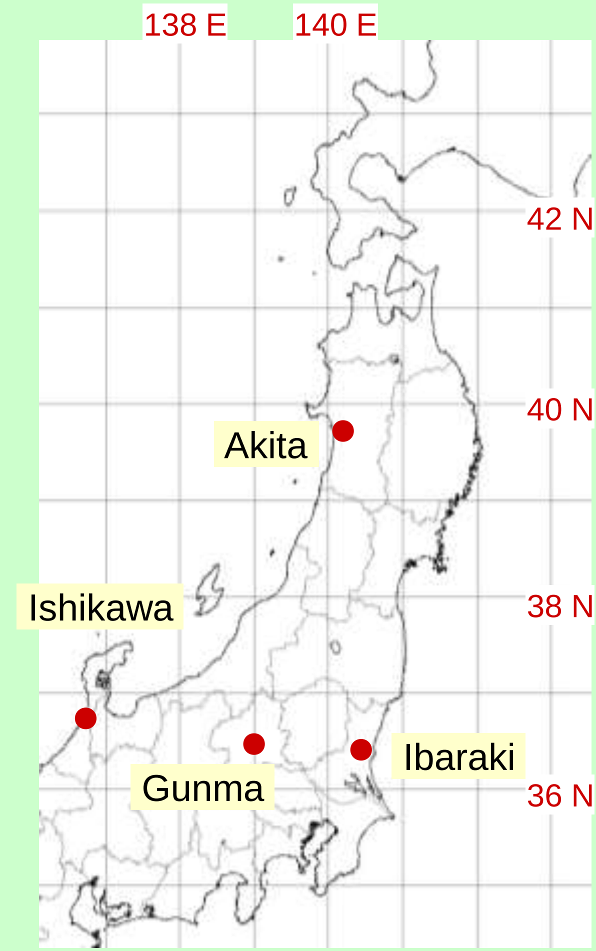
-Occurs year-round

-Most frequently in June

Different patterns for autumn between the species

vs. warmer-climate regions



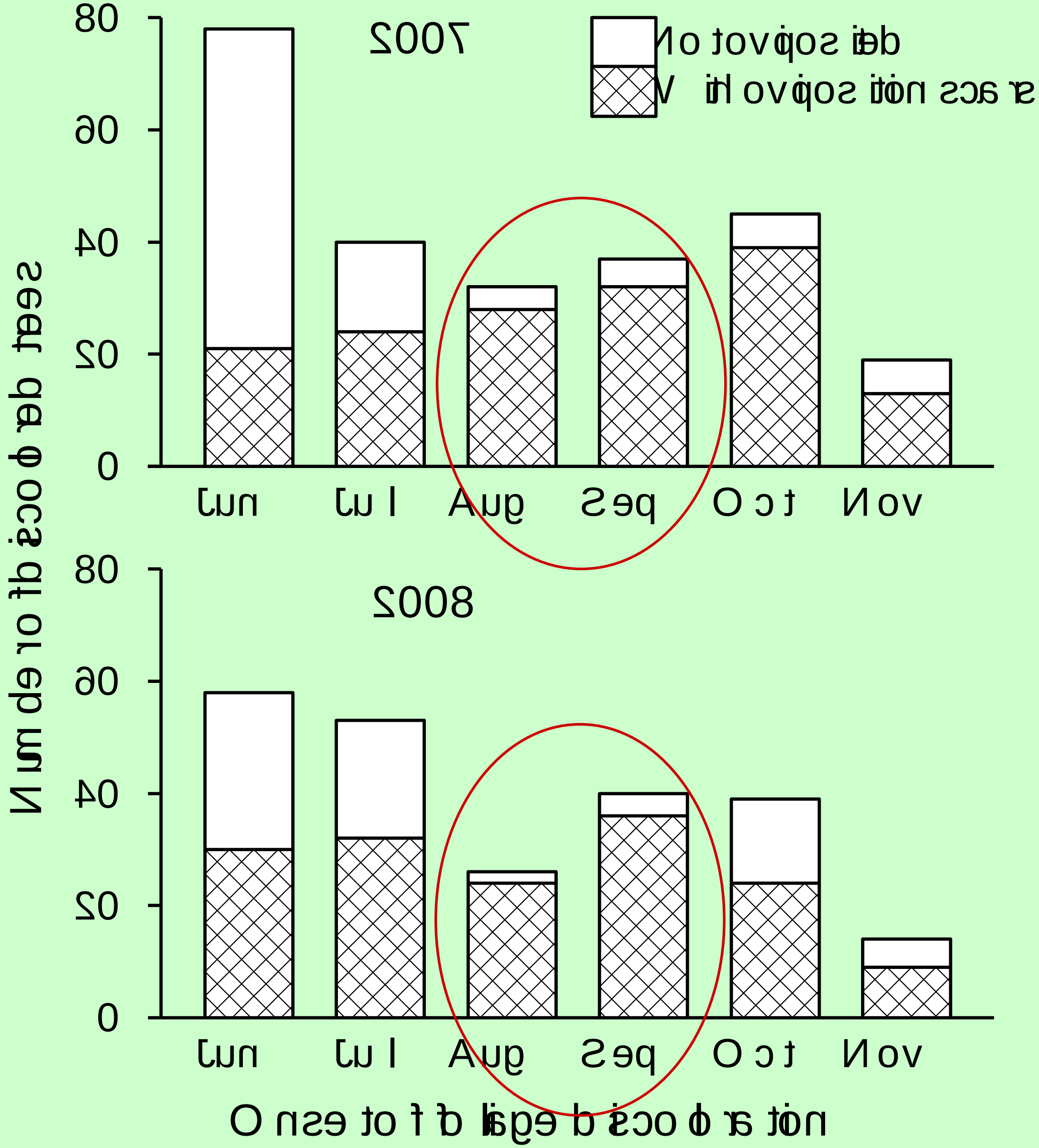


Akita: contrasting with <u>general patterns in warmer regions</u> (annu. temp. 13-15 °C).

e.g. Ibaraki (Kishi 1995) , Ishikawa (Togashi 1989), Gunma (Yamaguchi & Tanaka 1985)

Kolmogorov-Smirnov test, $P < 0.001$

Vector infestation (1): proportion of oviposited trees



% oviposited trees

2007: 44.9% (n = 170 trees)

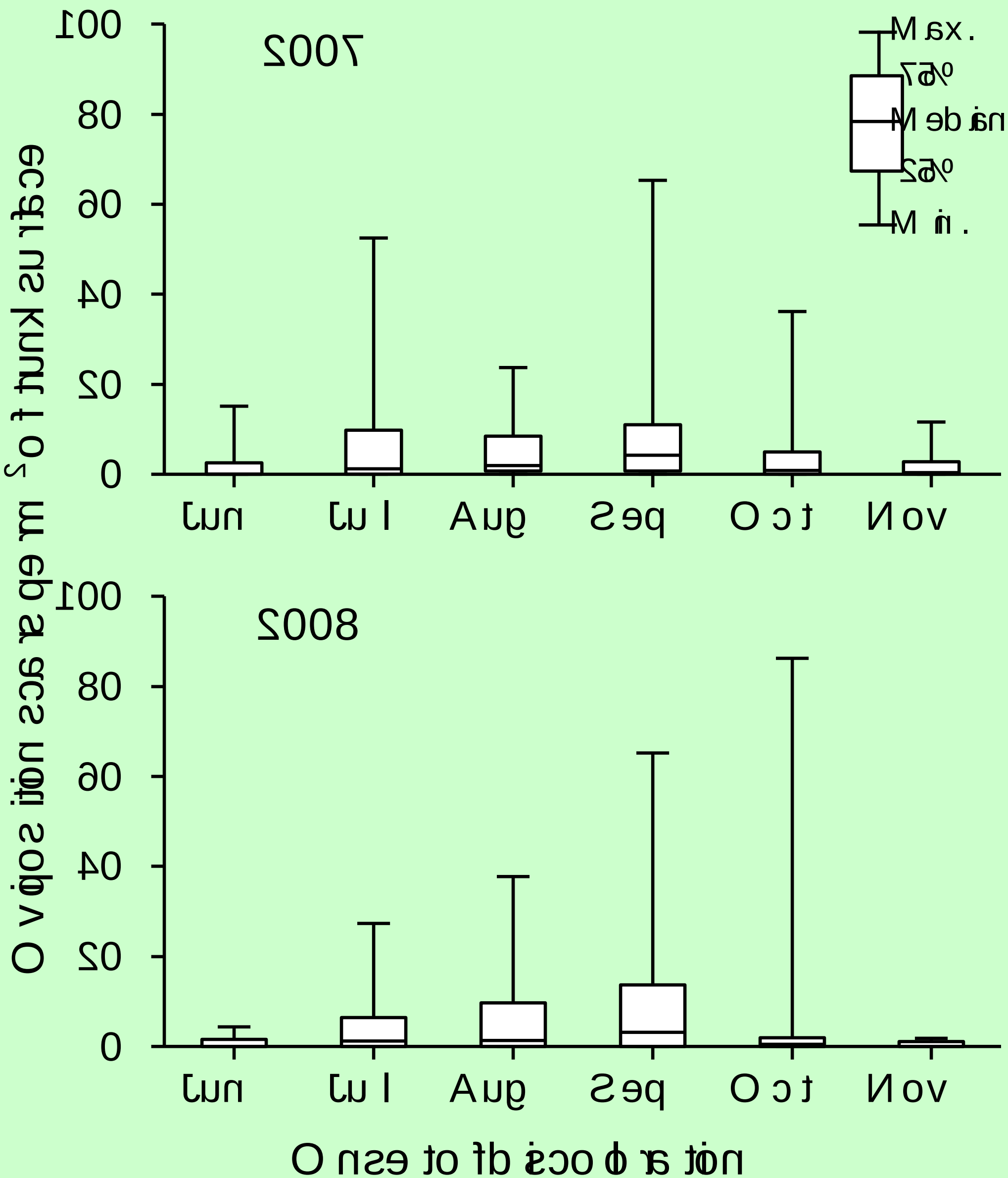
2008: 40.4% (n = 155 trees)

Canopy	58%
Suppressed	25%

(years pooled)

Summer-discolored trees: higher proportion of oviposited trees.

Vector infestation (2): oviposition intensity



Very large variation between samples

Higher density scars

for July- to October-discolored

Lower density

for June and November-discolored

Statistical analysis of oviposition risk

1) Logit generalized linear model

logit ($P_{oviposited}$) = exp (a + b month)

Oviposition (0 or 1) assumed to follow binomial distribution.

→ Relative risk for a given month j

= exp(b_j) , setting a specific month as the baseline.

Relative risk = $P_{oviposited}$ / $P_{no\_oviposition}$

2) Negative binomial GLM

log (*No.Scars*) = exp (a + $b$month)

Number of oviposition scars were assumed to follow negative binomial distribution.

Pairwise relative risks of oviposition

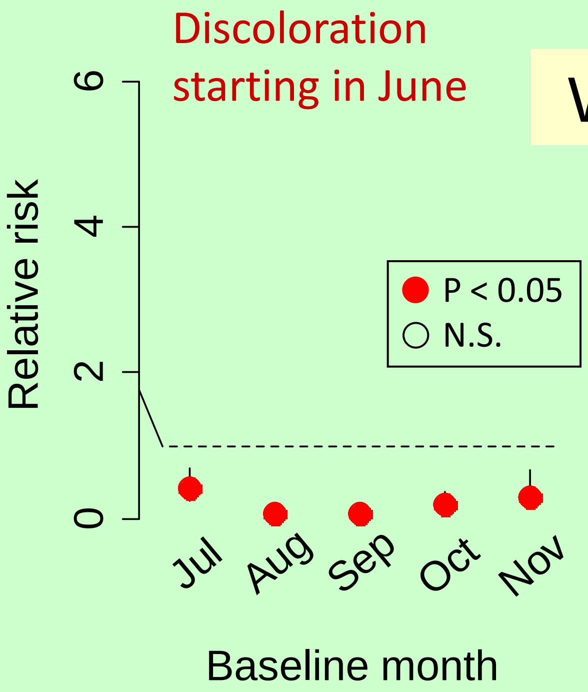
Relative risk = $P_{\text{oviposited}} / P_{\text{no\_oviposition}}$

Baseline month ($P_{\text{oviposited}}$)	Target month: June	July	Aug	Sept	Oct	Nov
June (0.38)	1	2.60**	14.61***	12.74***	5.06***	3.53**
July (0.60)	0.41**	1	5.63***	4.90***	1.95*	1.36
Aug (0.90)	0.07**	0.18***	1	0.87	0.35*	0.24*
Sept (0.88)	0.08***	0.20***	1.15	1	0.40*	0.28*
Oct (0.75)	0.21***	0.51*	2.89**	2.52*	1	0.70
Nov (0.67)	0.30**	0.74	4.14*	3.61*	1.43	1

*P＜0.05 **P＜0.01 ***P＜0.001

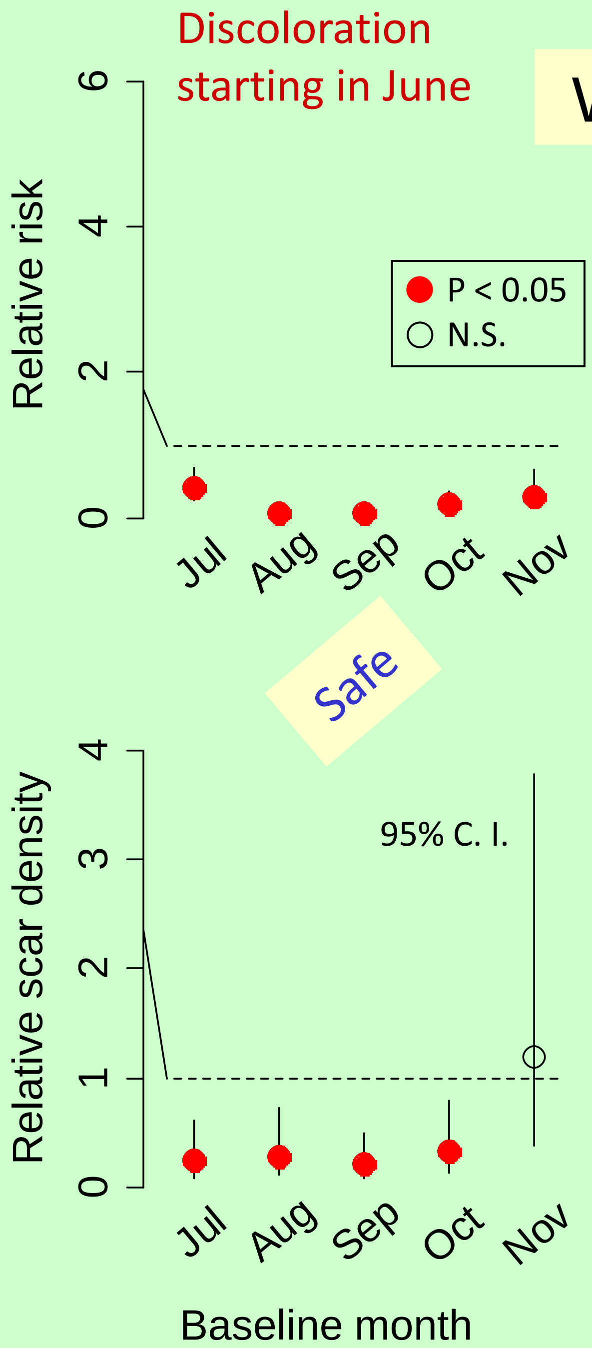
Trees with discoloration starting between August-September had high risk of being oviposited.

Which trees are important in eradication ?



Baseline month	Target month			
($P_{oviposited}$)	June	July	Aug	Sept
June (0.38)	1	2.60**	14.61***	12.74***
July (0.60)	0.41**	1	5.63***	4.90***
Aug (0.90)	0.07**	0.18***	1	0.87
Sept (0.88)	0.08***	0.20***	1.15	1
Oct (0.75)	0.21***	0.51*	2.89**	2.52*
Nov (0.67)	0.30**	0.74	4.14*	3.61*

Which trees are important in eradication ?

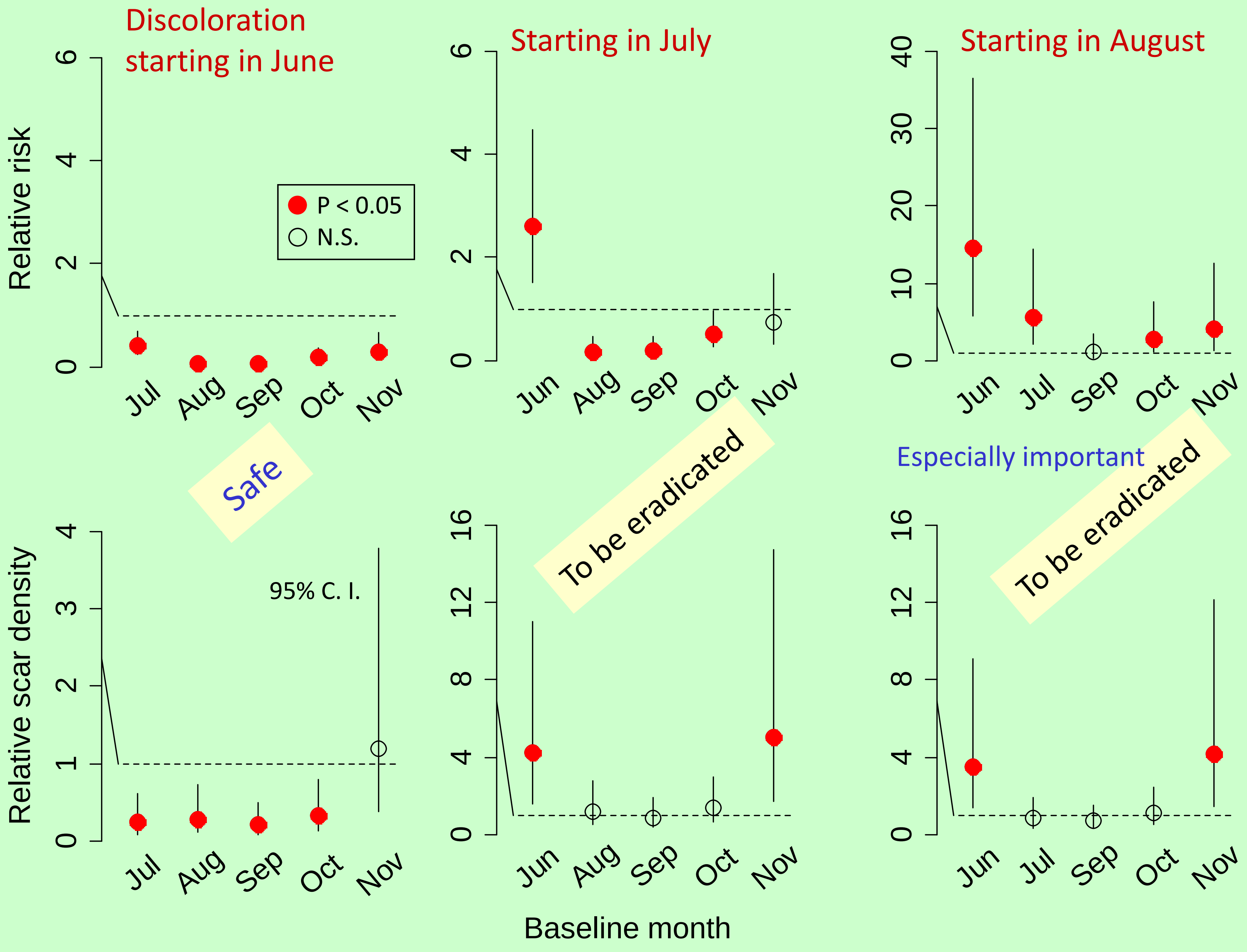


June-discolored trees:

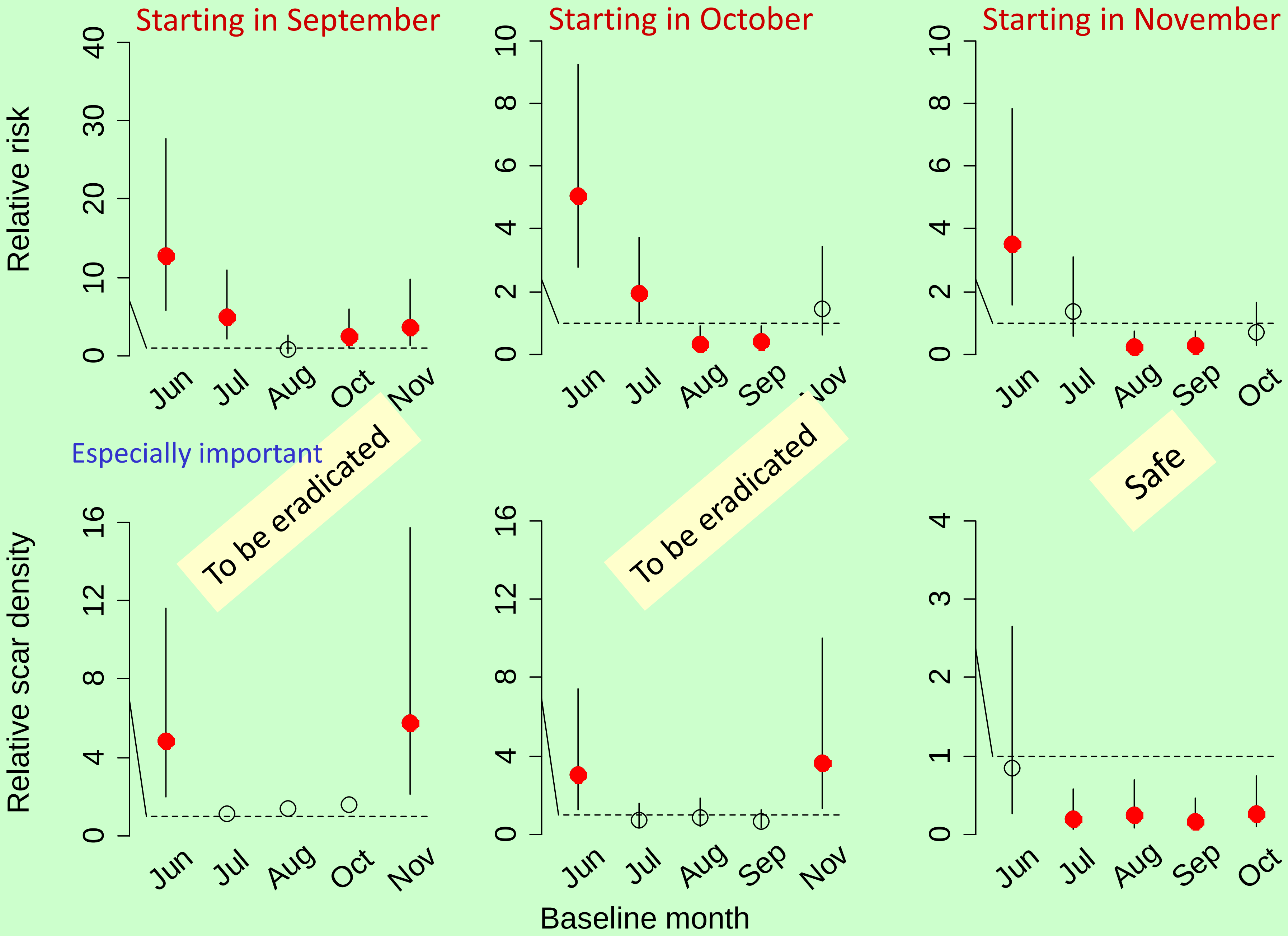
Lower risk, fewer oviposition scars than all other month

↓

"Safe" from the disease vector infestation.



Discoloration starting in June
Starting in July
Starting in August
Relative risk
Relative scar density
P < 0.05
N.S.
95% C. I.
Safe
To be eradicated
Especially important
To be eradicated
Jul
Aug
Sep
Oct
Nov
Jun
Baseline month


Starting in September
Starting in October
Starting in November
Relative risk
Relative scar density
Jun Jul Aug Oct Nov
Jun Jul Aug Sep Nov
Jun Jul Aug Sep Oct
Especially important
To be eradicated
To be eradicated
Safe
Baseline month

Summary & discussion

In Aklita, cool climate region, ・・・

- Damage occurred year-round, ca.40 % of which were infested by the disease vector. (highly contrasting pattern with warmer, central Japan)

- Analyses of relative oviposition risks and scar densities provides a effective tool in deciding eradication priority. (in this study, July-October discolored trees)

- Selective cutting for eradication is feasible as a cost- and labor-effective control, "Akita system". (Kobayashi 2004, Hoshizaki et al. 2005)

  → Investment of resources can be toward a wider area.

Acknowledgements

Kazumasa Ohta, Katsunori Nakamura, Akihiko Nagaki, Yoichi Ozawa, Aoi Nikkeshi, Akifumi Makita, Kazumi Kobayashi, Osamu Nakakita

--- co-workers

Volunteers for eradicating pine wilt trees --- help with tree cutting

Colleagues in Forest Science Lab, Aktia Pref. University

--- field assistance

Ministry of Agriculture, Forestry and Fisheries of Japan

Akita Prefectural University, Akita Prefecture --- funding

Have a look at our publication in *Journal of Forest Research* :

Ohta K, Hoshizaki K, Nakamura K, et al. (*in press, August issue*) Seasonal variations in the incidence of pine wilt and infestation by its vector, *Monochamus alternatus*, near the northern limit of the disease in Japan. J. For. Res.