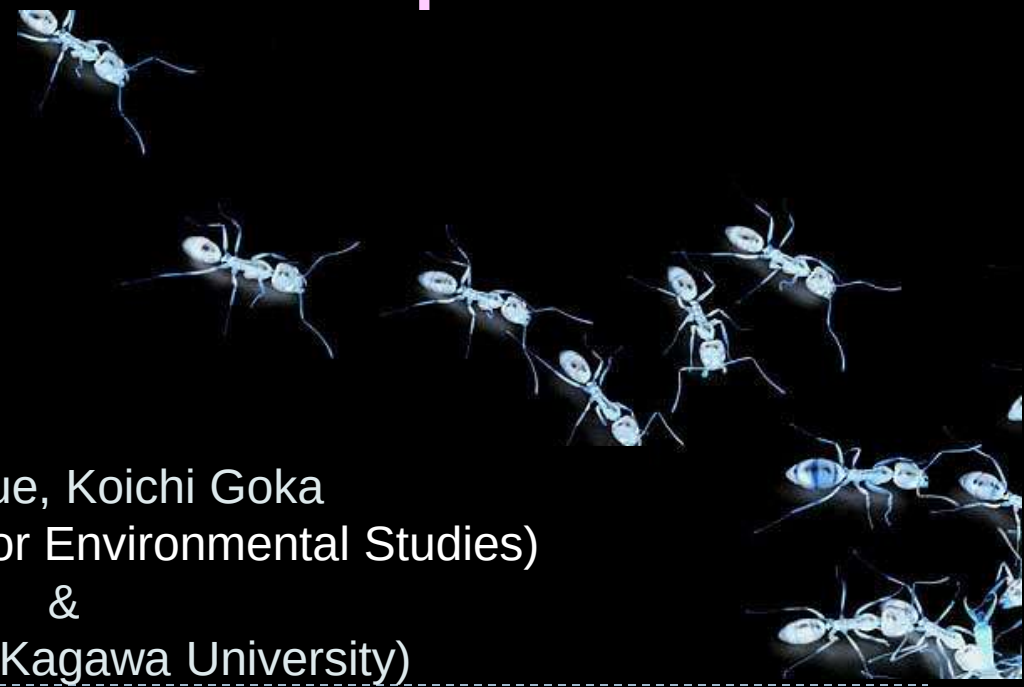
IUFRO meeting (2012.06.12)

Understanding invasion history: the recent range expansion and population genetics of the Argentine ant in Japan



Maki Inoue, Koichi Goka
(National Institute for Environmental Studies)
&
Fuminori Ito (Kagawa University)

Alien ant species

- Alien ant species are considered to be more damaging invasive insects
- Five ant species are ranked among the '**100 World's Worst invasive species**' by IUCN

Solenopsis invicta *Wasmannia auropunctata*

Lenepithema humile *Pheidole megacephala* *Anoplolepis gracilipes*




The Argentine Ant *Linepithema humile*

- **Native to South America**
- **The impacts of the Argentine ant**
  - Competitively displace or disrupt native ants and the arthropod communities
  - Imperil other species in the ecosystems such as native plants or lizards
  - Cause agricultural damage by protecting plant pests from predators and parasitoids
  - Invades human houses

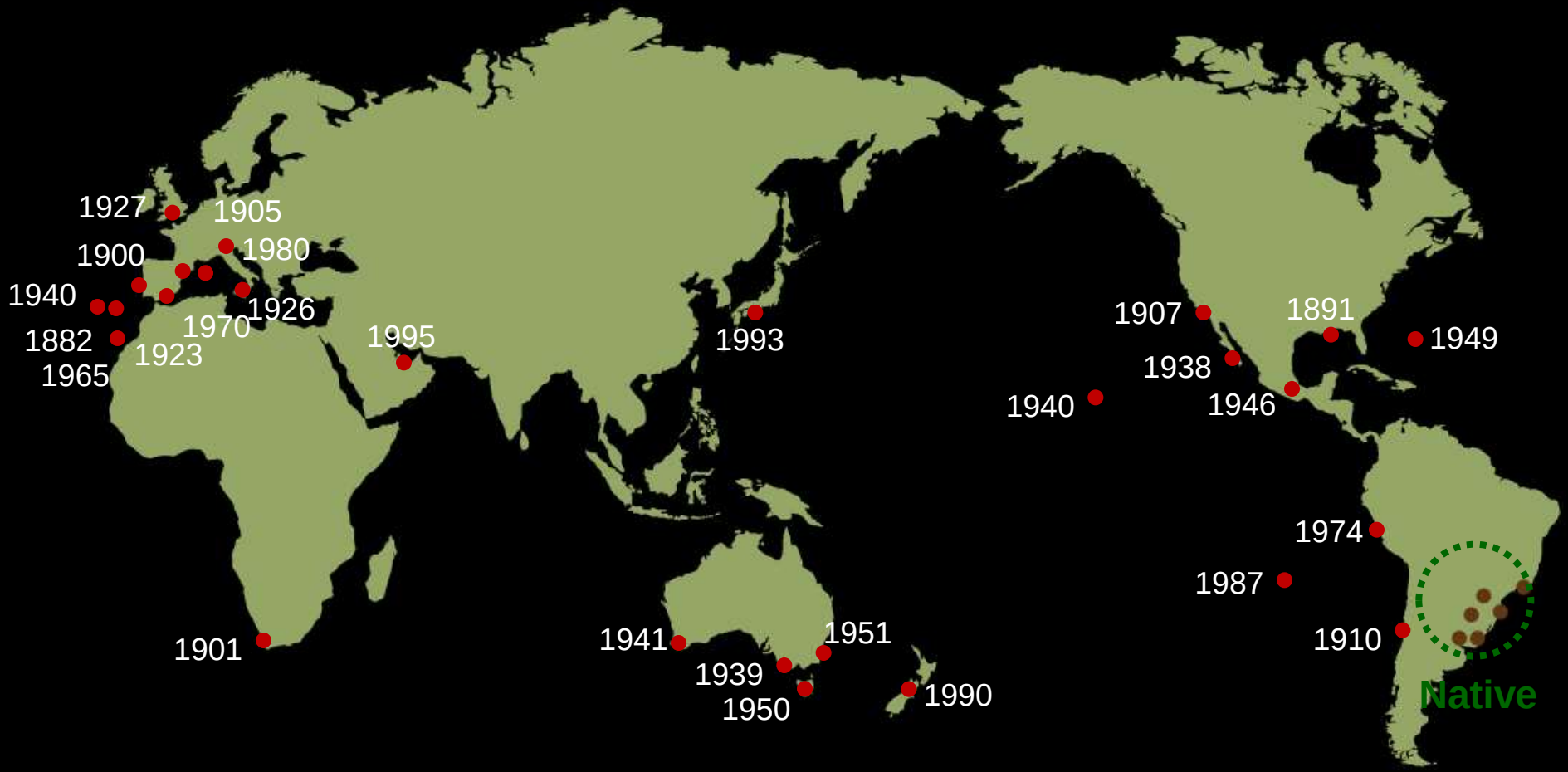
Photos © Hideaki Mori

The Argentine Ant *Linepithema humile*

- **Ecological traits:**
  - Polygyne, polydomy, and supercolony formation
  - Low-cost and frequently-changed nest construction

highly invasiveness and difficulty of eradication

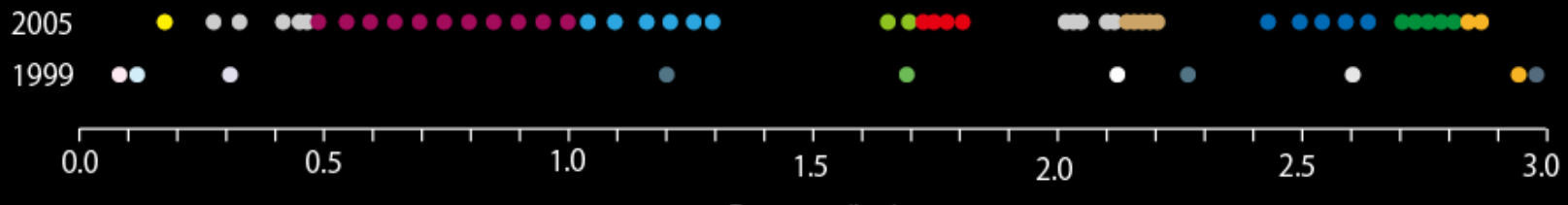
Distribution of the Argentine ant worldwide



(Suarez et al. 2001)

Social structure : Supercolony(SC)

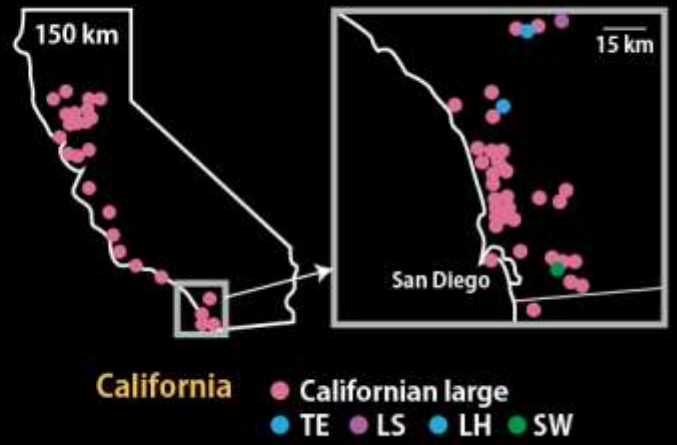
- Many small SCs are in the native ranges, while a few large SCs are distributed in the introduced range



The Natural Reserve of Otamendi, Argentina.

(Vogel et al. 2009)

(Giraud et al. 2002)



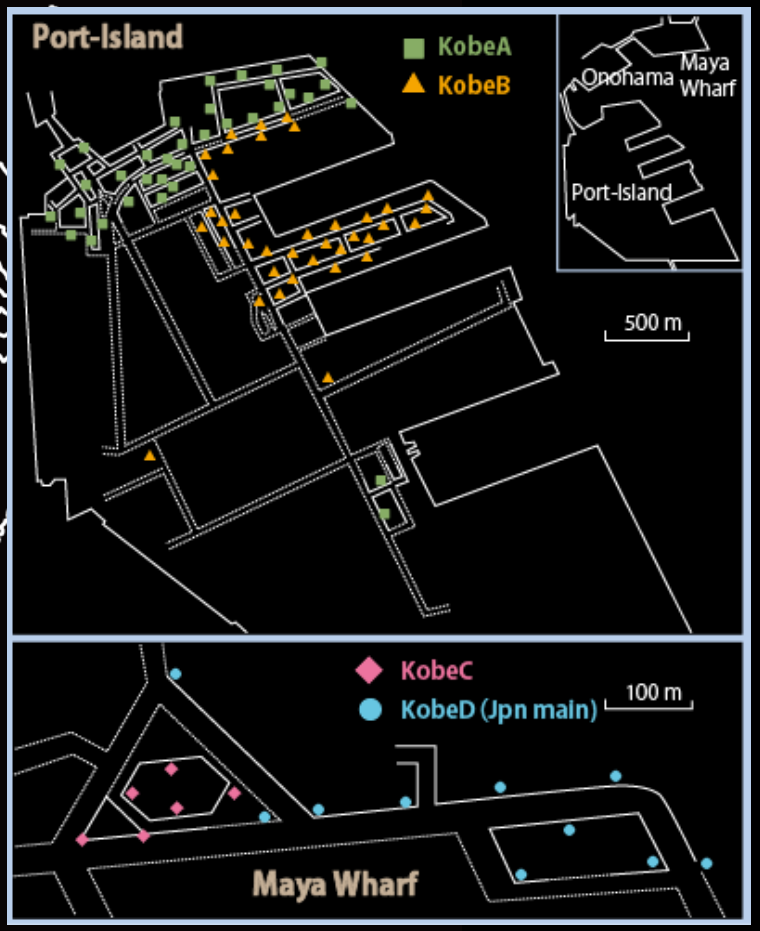
(Tsutsui et al. 2003)

Distribution of the Argentine ant in Japan

Distribution and type of SC in Japan

Aggression test

(Sunamura et al. 2007)



Photos © Queller 2000

Objectives:

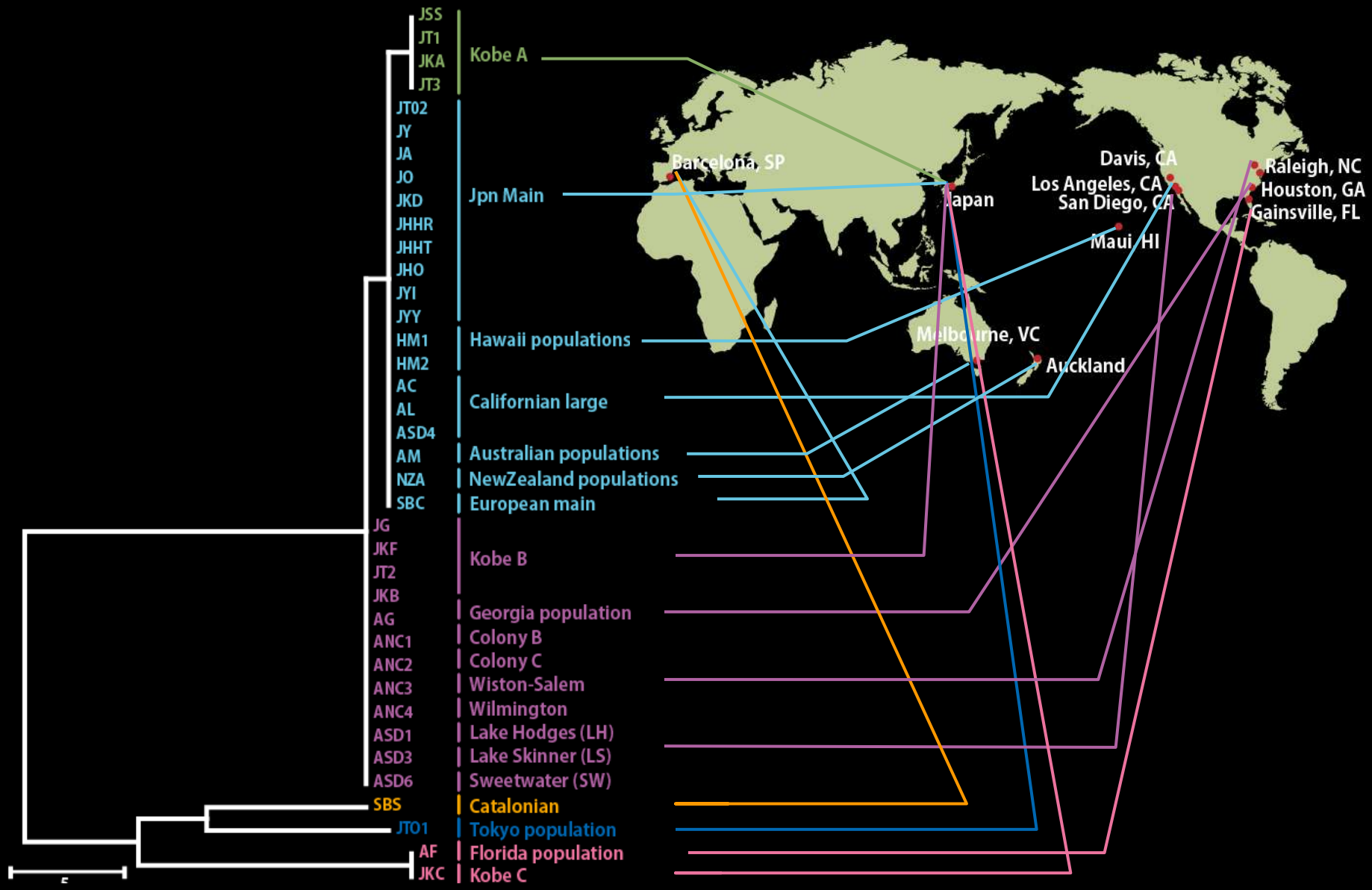
How does the Argentine ant come to Japan?

Materials & Methods

- About 2,200 base pair fragments of mitochondrial DNA from COI to COII, and Cty b regions were amplified from 233 workers

(Inoue et al. in press)

Genetic distribution in the worldwide Argentine ant populations



(Inoue et al., Diversity and Distribution, in press)

Genetic distribution in the worldwide Argentine ant populations

- In Japan, five haplotypes are fixed for five SCs
- Multiple SCs are found within an area

- One haplotype is shared by the dominant SCs worldwide
- Two haplotypes are fixed for each two SC in Europe, three for five SCs in USA

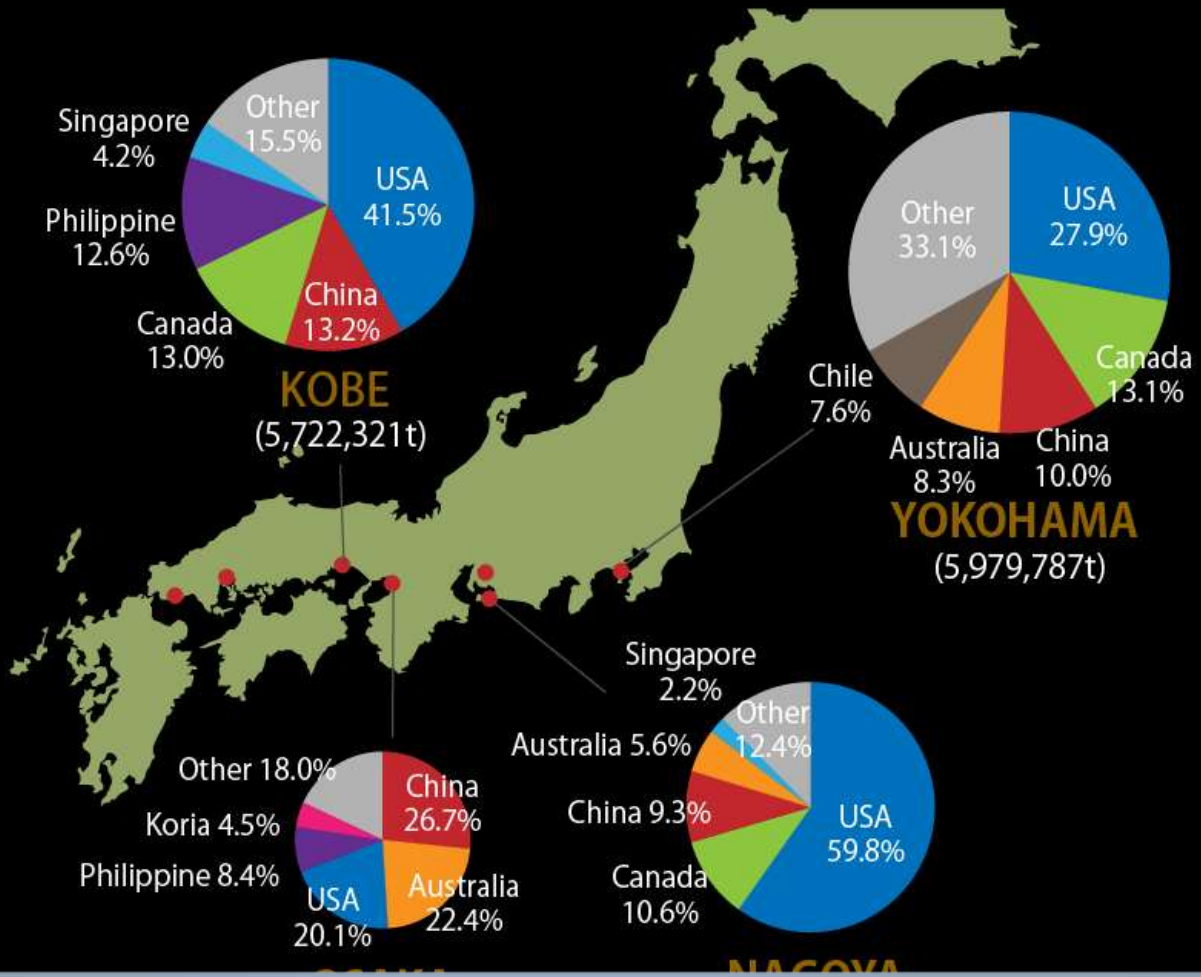
(Inoue et al., Diversity and Distribution, in press)

Invasion history and geneticc diversity

- **The huge dominant SC sharing the same haplotype is distributed worldwide, while several small SCs are locally distributed**
- **Japanese populations have the highest genetic diversity**
  - Japan is one of the top five countries for international trade and thus there are numerous opportunities for species' introductions
  - The short invasion history of 20 to 30 years can explain the maintenance of genetic diversity of each introduction
  - Samplings in the study occur at major international shipping ports that are primary sites of introduction

Invasion pathway into Japan

Ant invasions
with fresh products
(Ward et al. 2006)



The Argentine ant has invaded from native ranges and/or USA?

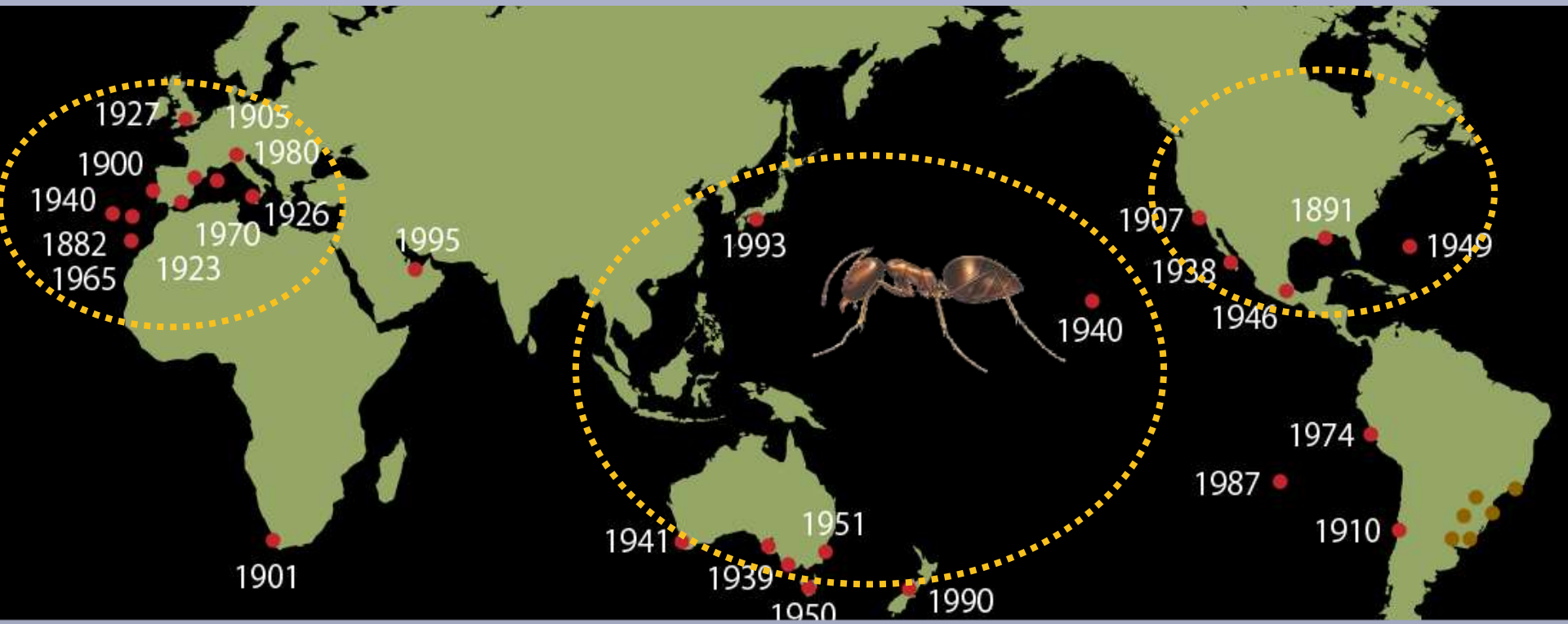
Photos © Alex Wild

(Trade data of imports of agricultural products in 2007)

Scenario of worldwide expansion

How has the Argentine ant been expanding worldwide?

During 19C, invasion mainly into Europe and North America



Since 20C, invasion along the Pan pacific countries

(Suarez et al. 2001)

Scenario of worldwide expansion

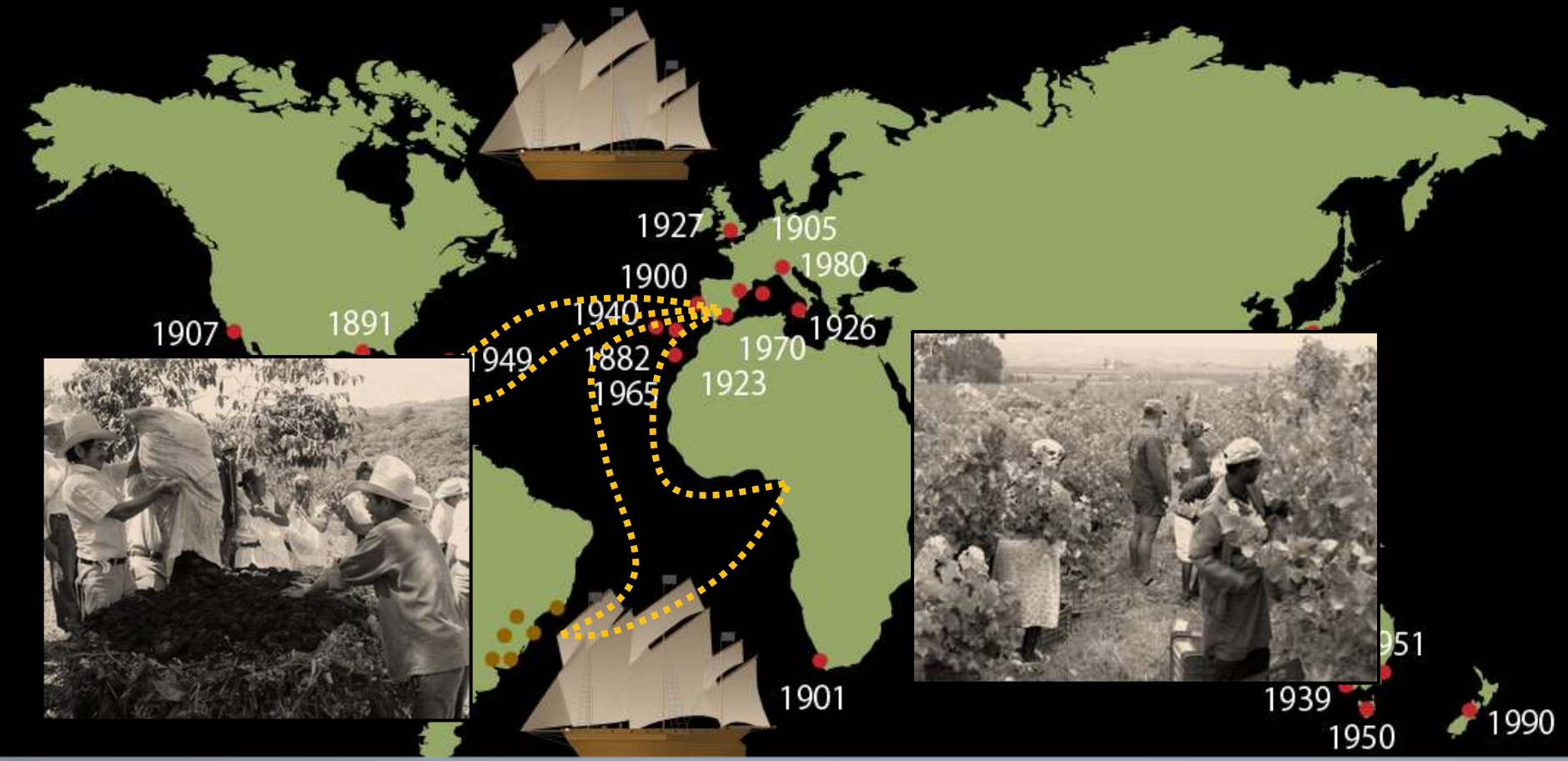
Madeira

: First record in 1858

: The hub for commerce between Portugal and south America (Wetterer & Wetterer 2006)



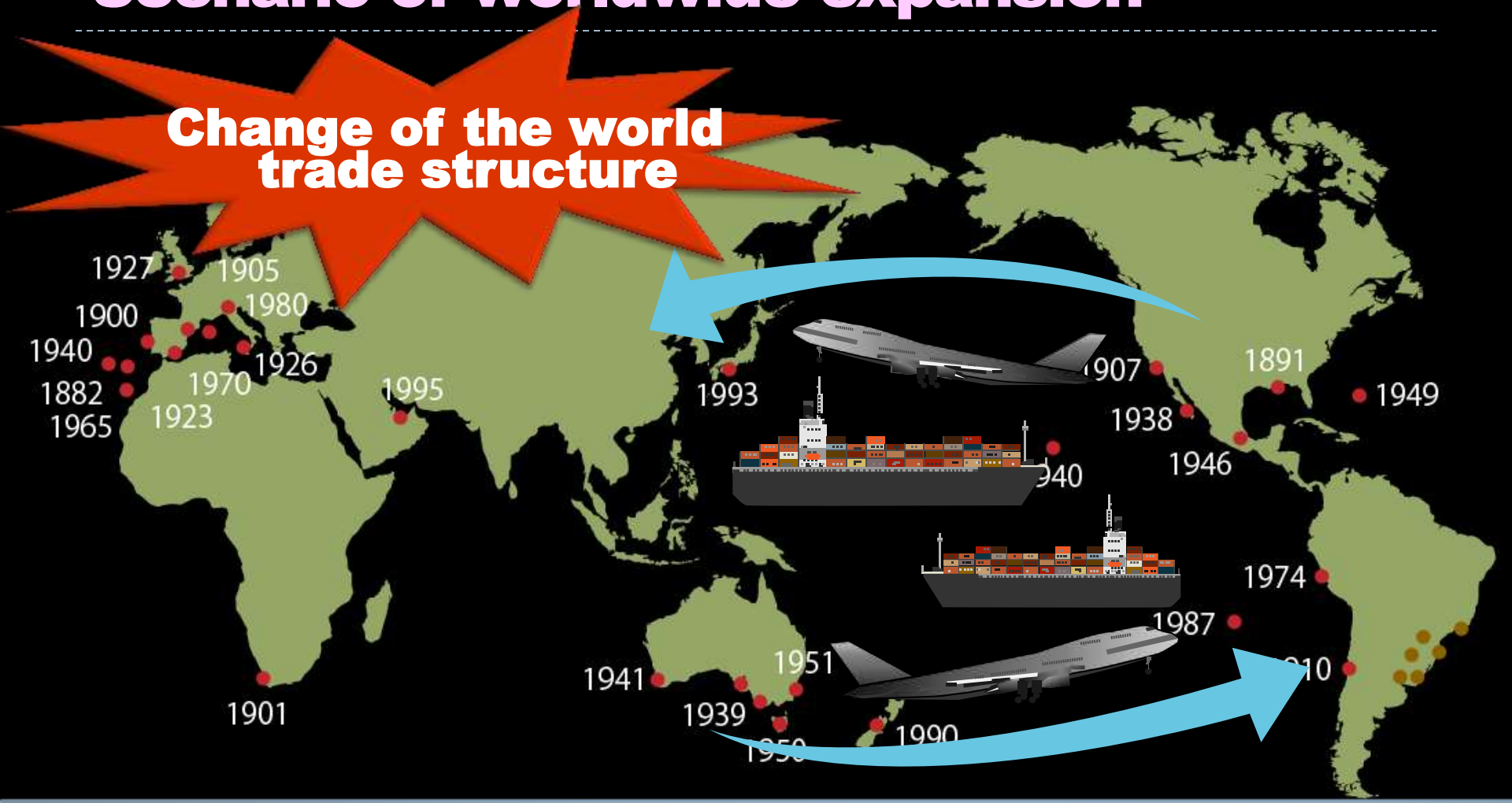

Scenario of worldwide expansion



From 18C to 19C, trades and immigrations across the Atlantic

(Inoue & Goka 2009)

Scenario of worldwide expansion



Since 20C, with rise of USA and Asia, trade expansion along Pan-pacific

(Inoue & Goka 2009)

Objectives:

Construct the effective control strategy of the Argentine ant

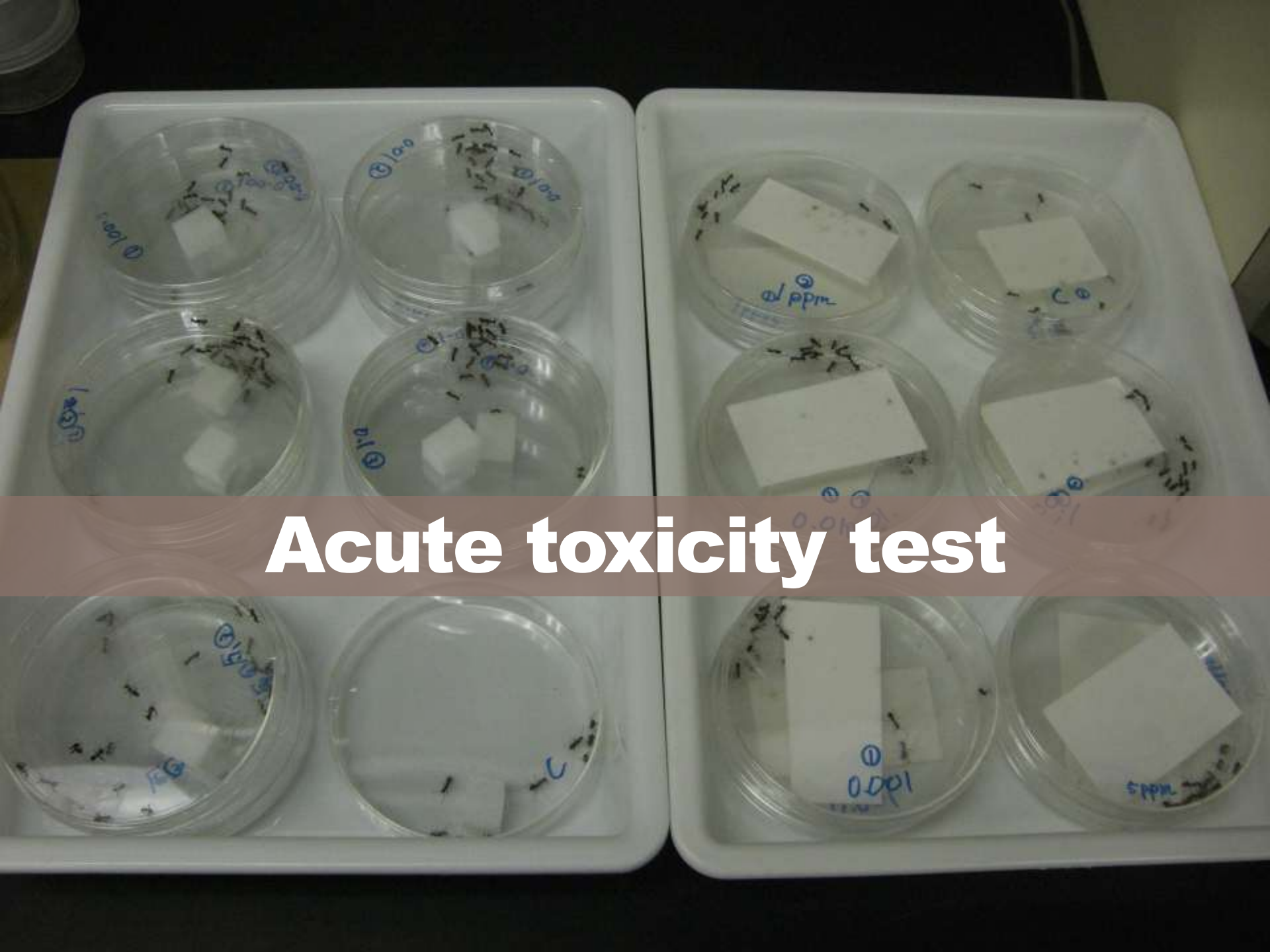
Problems in the Argentine ant control

conducted by the Ministry of the Environment

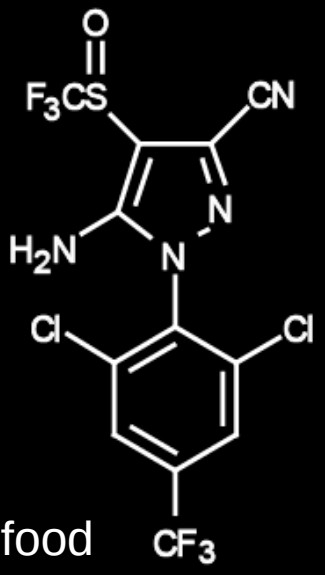
- **Only narrow area and short period due to small budget**
- **Mismatch between eradication schedule and the species' life cycle**
- **No cost calculation**

Construction of effective eradication strategy

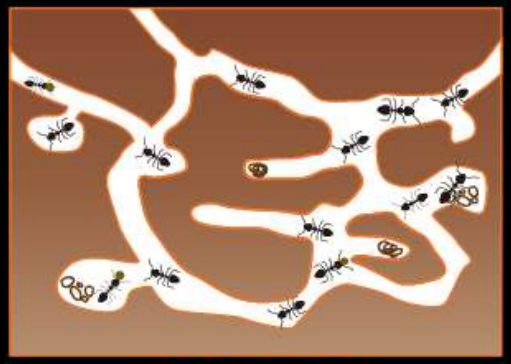
- Risk assessment of pesticide
- Development of integrating pest management based on the species' life cycle, targeting for a whole infected area
- Cost estimation for applying to other infested areas


Acute toxicity test

Slow-acting neutrotoxic Fipronil

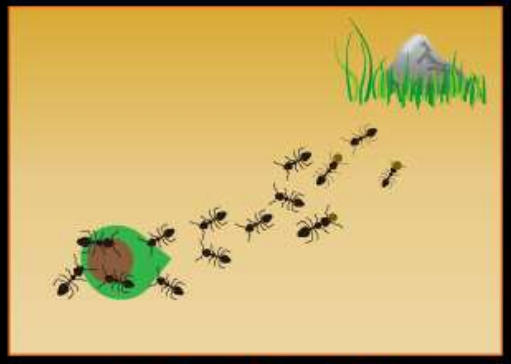


餌を発見！
Find food!



巣仲間に分配

Share food with nestmates



アリの巣へ運搬
Carry food to nest

巣内のアリが死亡
Nest collapsed

Acute Toxicity Test of Fipronil

	Species	96h LC50 (ppm) Oral toxicity (95%CR)	96h LC50 (ppm) Contact toxicity (95%CR)
Native ant species	*Formica japonica*	3.6(2.20<*<5.66)	2.28(0.83<*<5.92)
	Formica lemani	1.22(0.45<*<5.70)	1.33(2.E-17<*<3.63)
	Pristomyrmet punctatus	0.73(0.10<*<5.21)	0.67(0.37<*<2.29)
	Pararechina flaripes	1.41(0.23<*< 4.71)	0.88(0.10<*<1.83)
	Teramonium tsusimae	1.21(0.67<*< 2.73)	0.36(0.13<*<0.52)
Argentine ant	*Linepithema humile*	0.02※(0<*<0.25)	0.1(0.09<*<1.98)

The Argentine ant is highly sensitive against fipronil.

Effect on native ants may be small

(Morooka et al. unpublished)

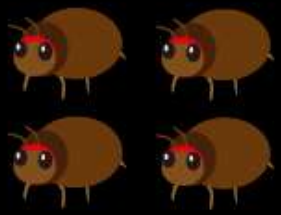

The eradication project has started in Tokyo since 2011


KITA-KU
NERIMA-KU
TOSHIMA-KU
Ikebukuro
ARAKAWA-KU
KATSUSHIKA-KU
NAKANO-KU
BUNKYO-KU
TAITO-KU
Ueno
Asakusa
SUMIDA-KU
Tokyo Dome
Nippon Budokan
SUGINAMI-KU
SHINJUKU-KU
Kabukicho
Shinjuku
Akihabara
EDOGAWA-KU
CHIYODA-KU
Marunouchi
Tokyo Station
Imperial Palace
SHIBUYA-KU
Yoyogi Park
Harajuku
CHUO-KU
Ginza
KOTO-KU
ARA RIVER
Aoyama
Omotesando
Roppongi
Tokyo Tower
Shibuya
Ebisu
MINATO-KU
SETAGAYA-KU
Rainbow Bridge
MEGURO-KU
Tokyo Disneyland
Odaiba
PORT OF TOKYO
SHINAGAWA-KU
TAMA RIVER
TOKYO
TOKAI Area
JOUNAN Area
OTA-KU
N

Eradication schedule based on life cycle

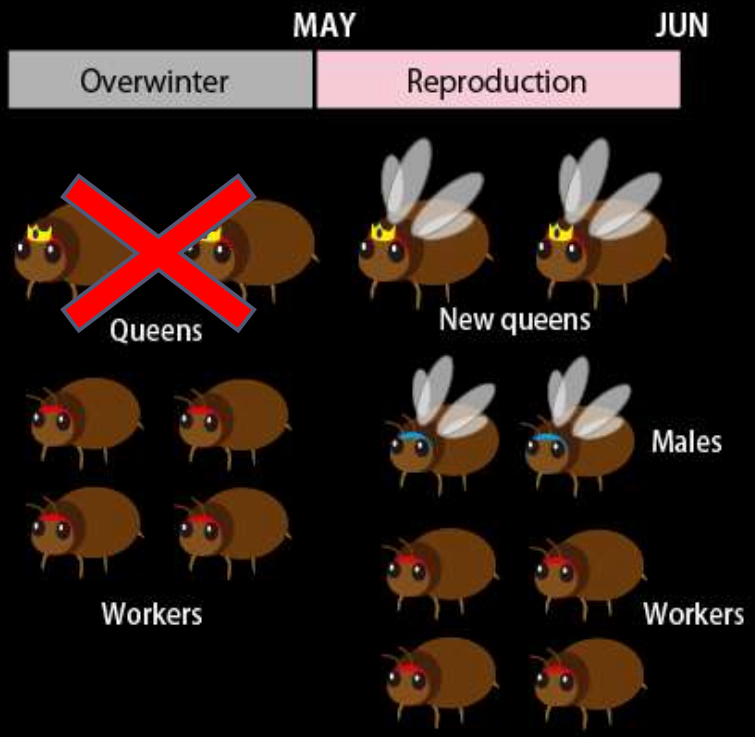
Overwinter

Queens



Workers

Eradication schedule based on life cycle



Eradication schedule based on life cycle

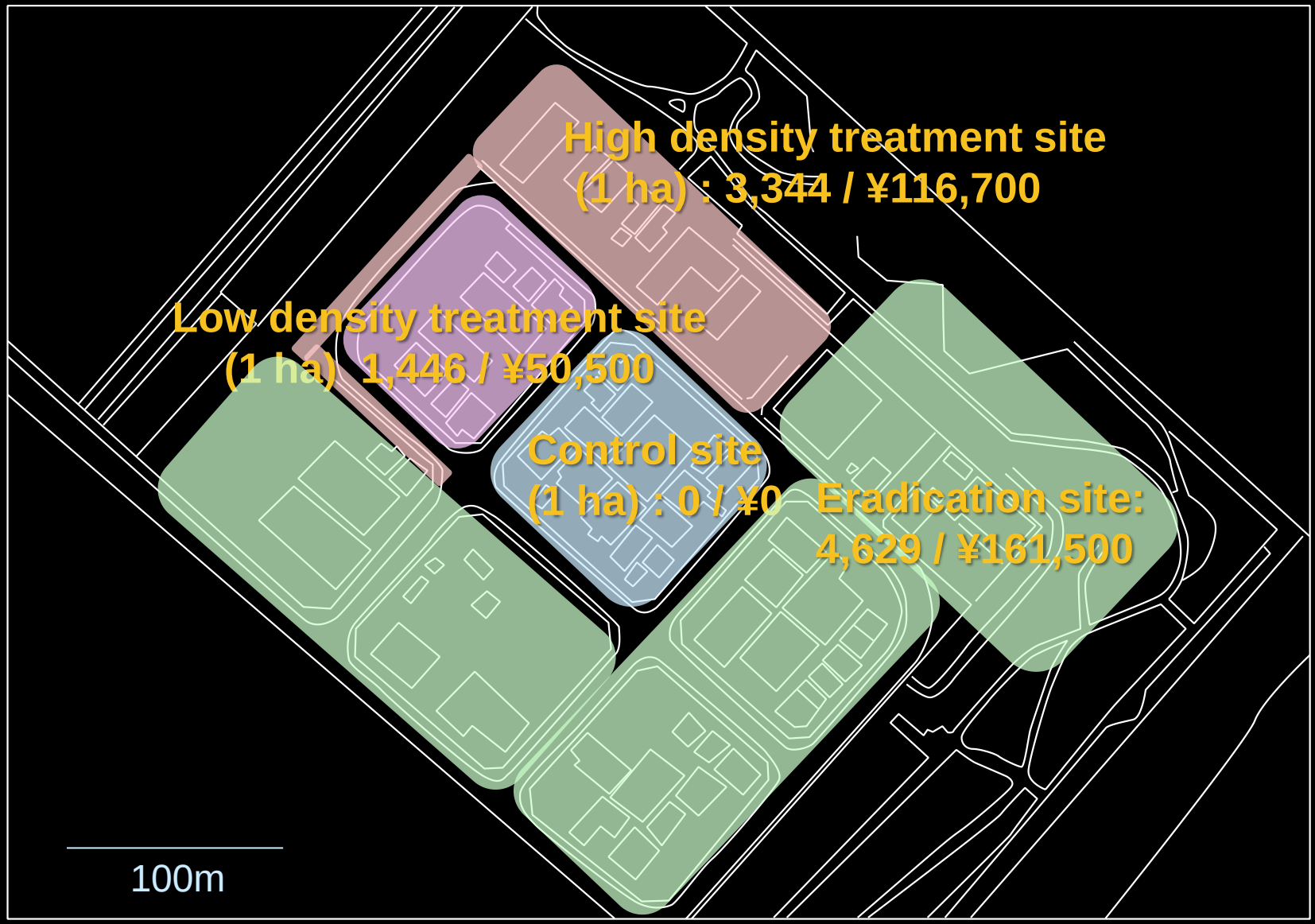
Eradication project in Tokyo

Toxic bait leaf

Monitoring trap

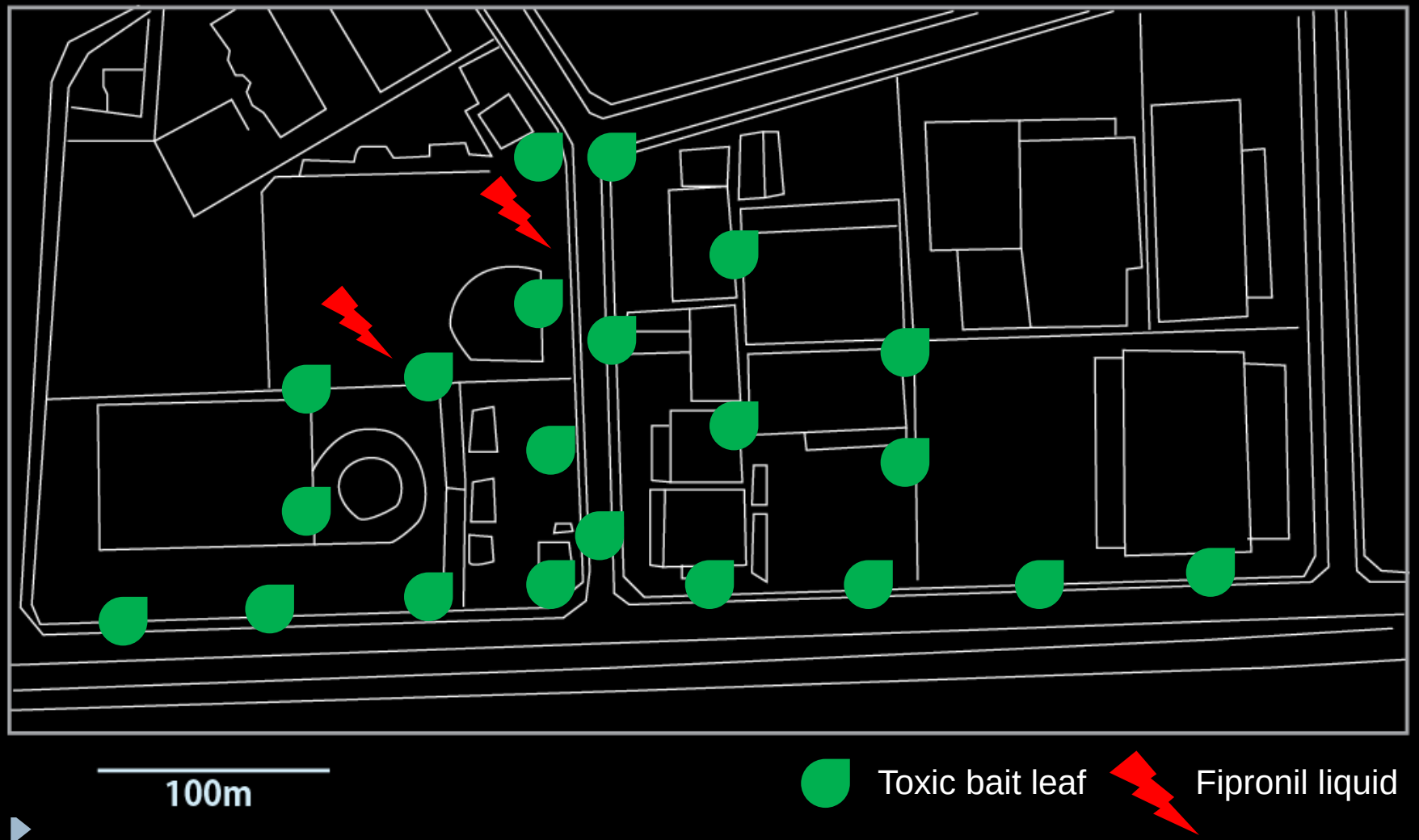
Fipronil liquid spray

JOUNAN area (2011.4-2012.2)

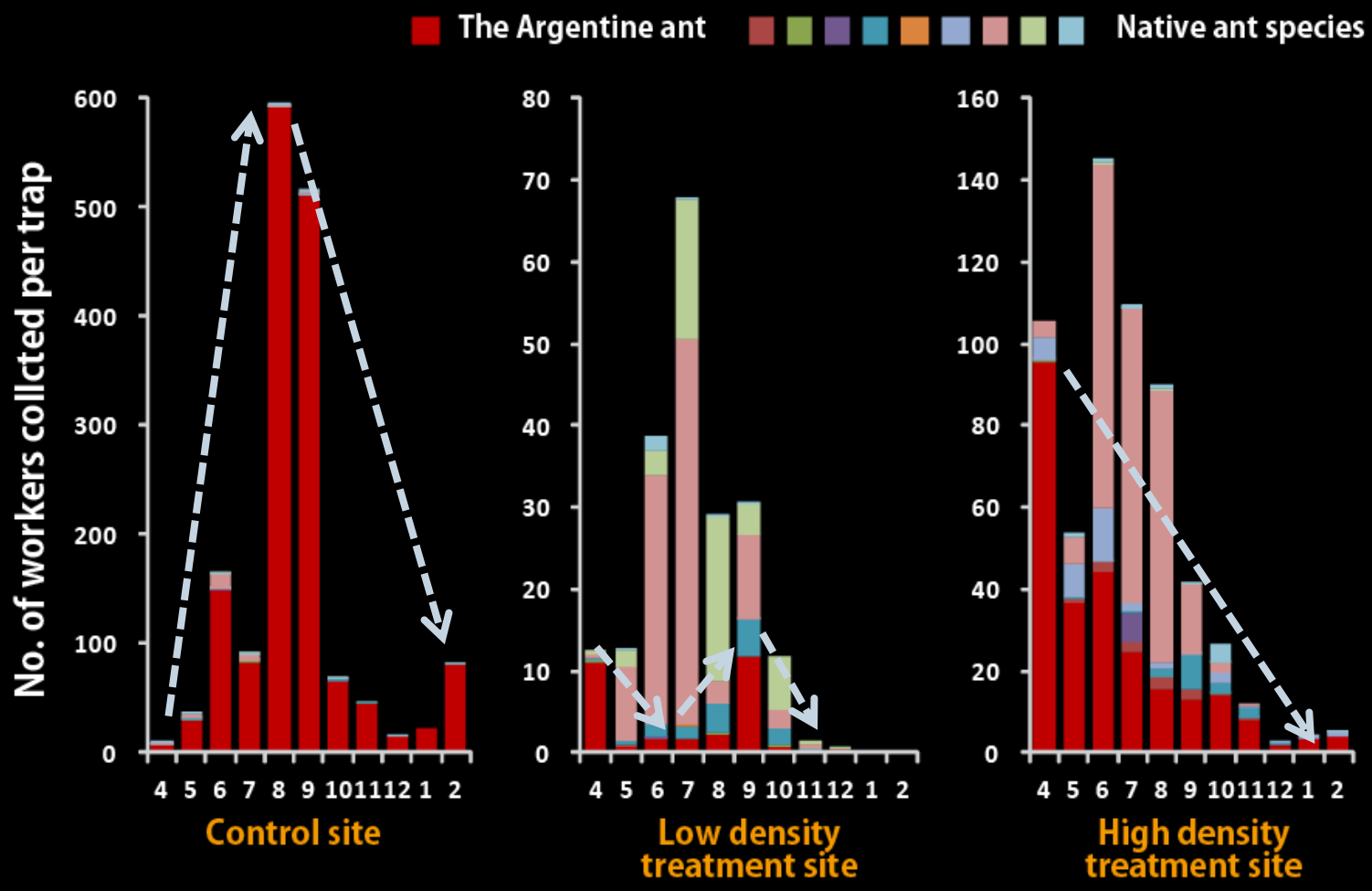


TOKAI area (2011.4-2012.2)

Eradication site (5 ha): 10,400 / ¥362,700



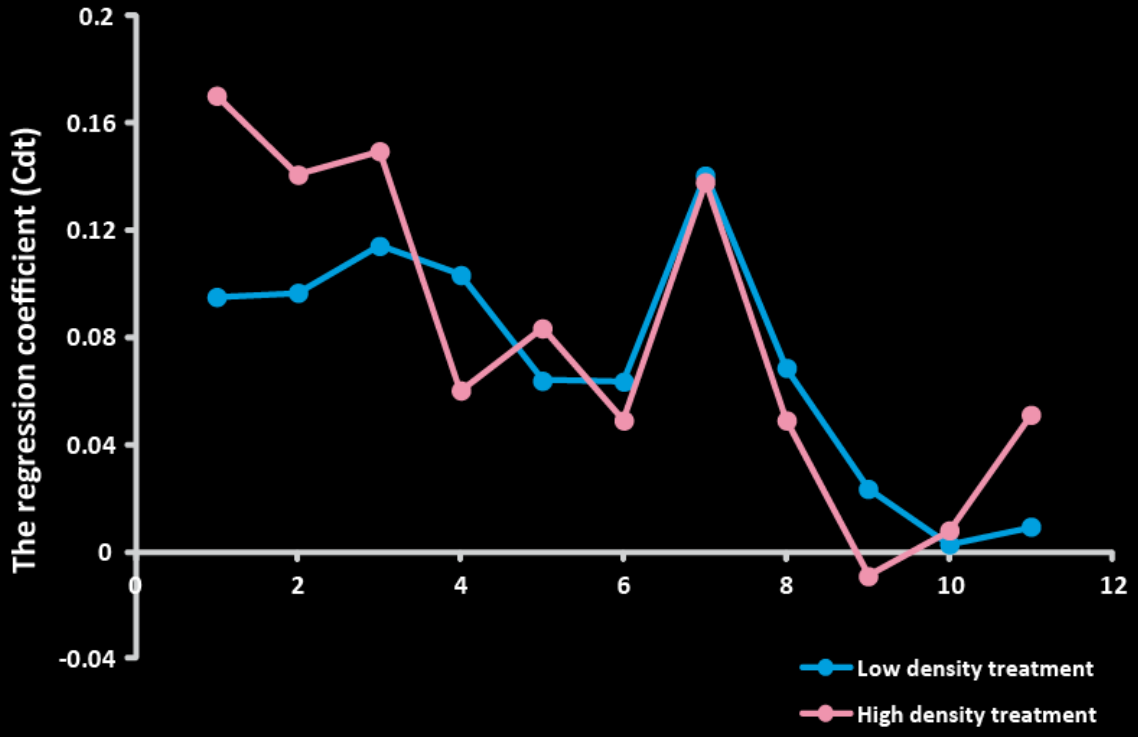
JOUNAN area (2011.4-2012.2)

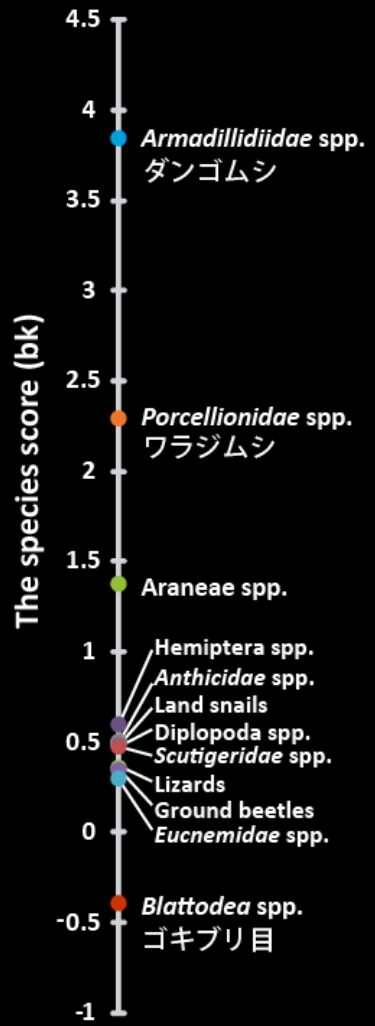


The Argentine ant largely declined and native ants increased in treatment sites

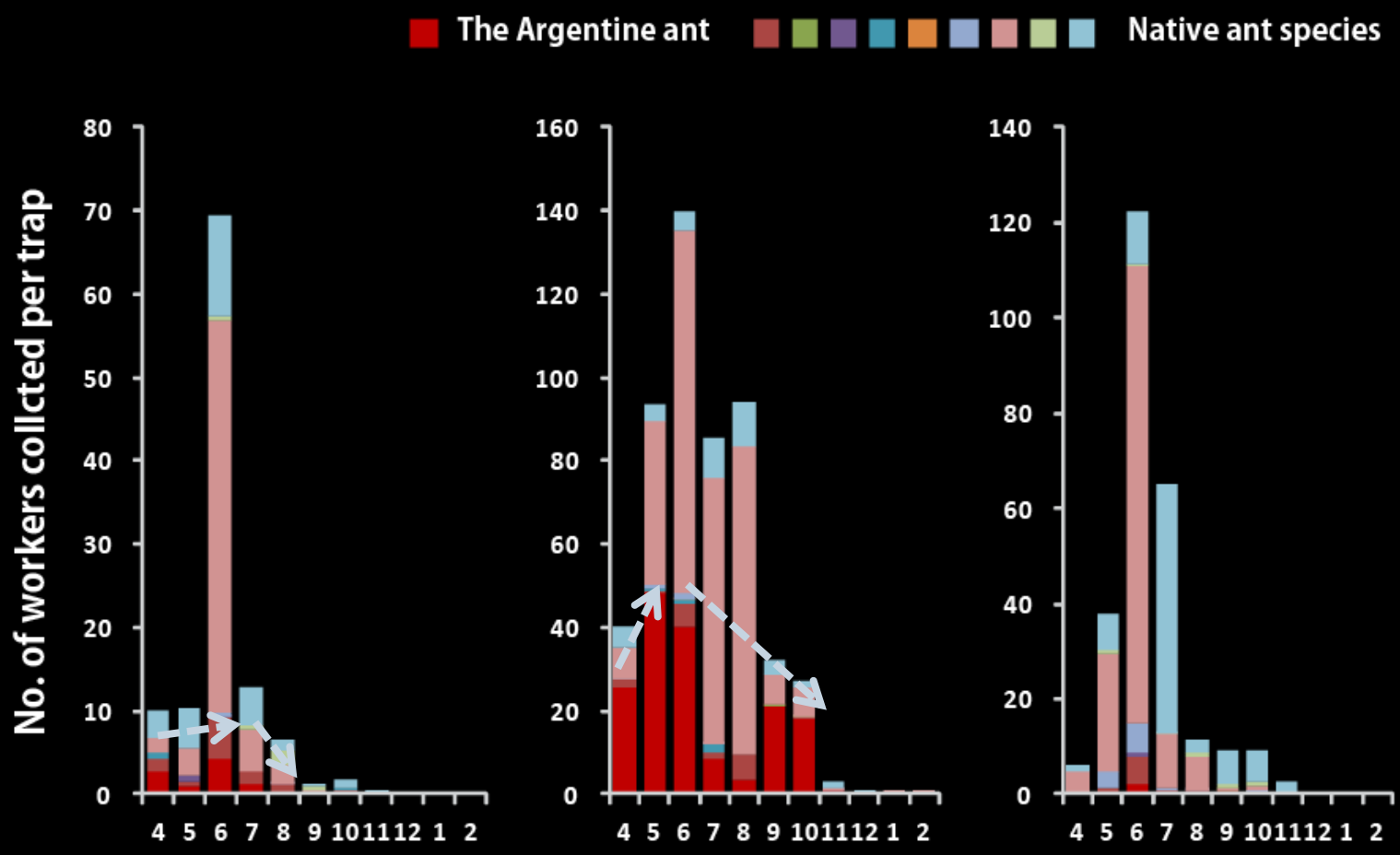
JOUNAN area (2011.4-2012.2)

Principal Response Curve (PRC) indicates no negative effect of fipronil on vertebrate and invertebrate communities, except for cockroach.





TOKAI area (2011.4-2012.2)



The Argentine ant declined, accompanied with the native ants increased

Conclusion

- The Argentine ant largely increased in the control site but decreased in the treatment sites.
- Eradication rates were similar in both treatment sites, but the Argentine ant showed an increase in September in low density treatment site.
- Japanese native ants have largely increased in the treatment sites.
- Total pesticide cost was about ¥820,000: ¥362,700 in TOKAI area and ¥328,700 in JOUNAN area for baits, and ¥130,000 for fiplonil liquid.

- **For the eradication, high density treatment will be more effective**.

Conclusion

- At population level, the Argentine ant largely decreased in TOKAI area but showed an outbreak in and around the control site in JOUNAN area.

- **For the next year, high density treatment will be also applied to JOUNAN area.**
- **We estimate the eradication rate in both areas and develop the eradication method.**

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