Estimates of the control strategies of schistosomiasis japonica in the Mindoro Island, the Philippines: An analysis using the agent-based simulation model

フィリピン・ミンドロ島における日本住血吸虫症対策の推計：エージェントベースのシミュレーションモデルによる分析

指導教官：大塚柳太郎 教授
人類生態学教室

竹内昌平

INTRODUCTION

Background (1)

Schistosomiasis

- Health problem in developing countries
- 200 million people infected all over the world

In the Philippines:

1. Dominant type: Schistosomiasis japonica
2. 6.7 million people at risk
3. Praziquantel reduced the prevalence rate
4. Objective: Eradication

→ still few areas succeeded

Background (2)

Schistosomiasis japonica

Impossible to know
the real prevalence rate

Complicated
transmission cycle

Simulation study is effective

generating

an artificial perfect data set

But few studies for schistosomiasis japonica

Purposes

To create a simulation model
suitable for a local area,
considering population dynamics

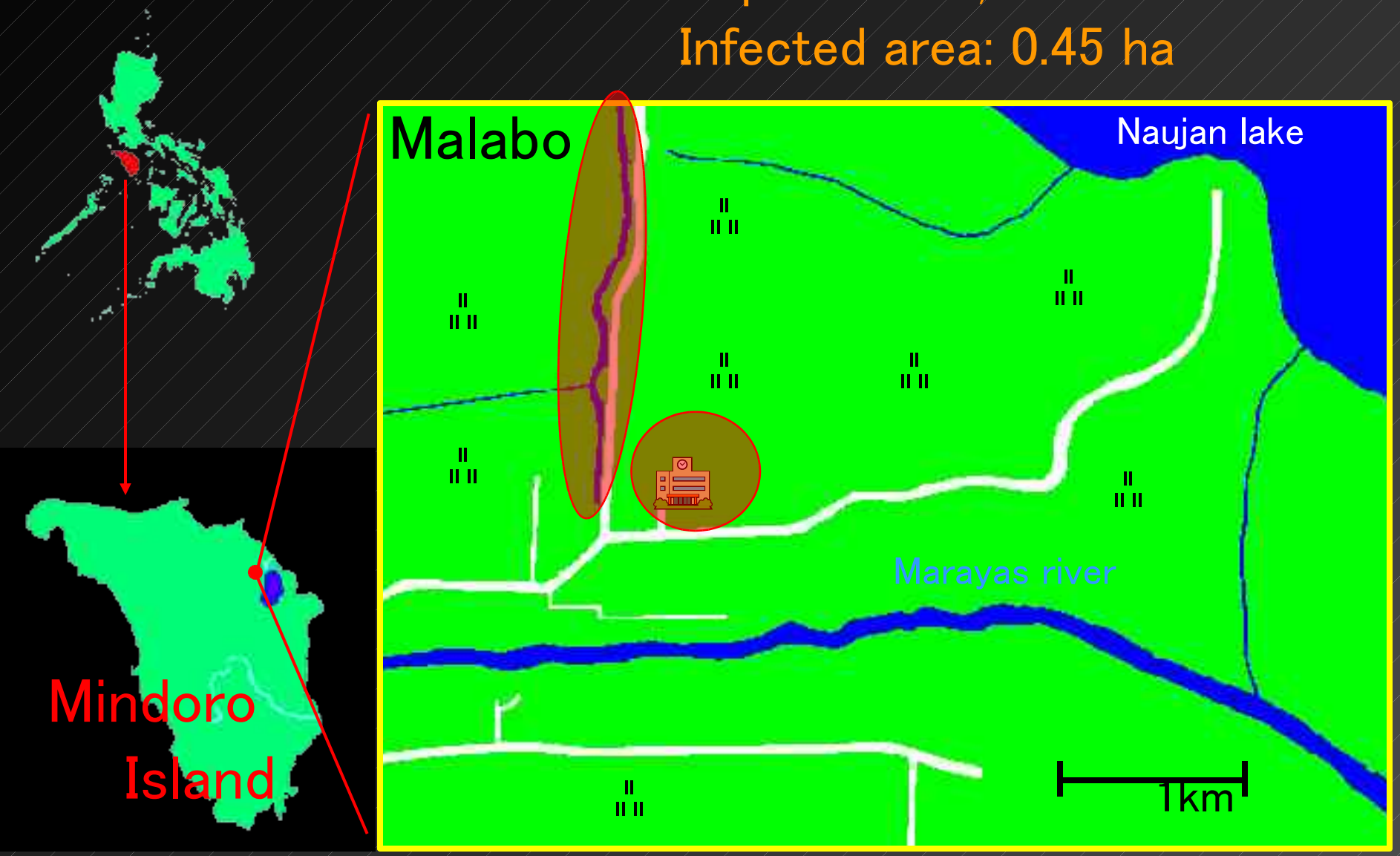
To seek effective control strategies
for schistosomiasis japonica
by comparing among various strategies

SUBJECTS AND METHODS

- Study area
- Fieldwork
- Modeling
  - ✓ Characteristics of hosts
  - ✓ Parameters
  - ✓ Structure of the model
- Simulation
  - ✓ Individual based
  - ✓ 12 strategies
    including the base strategy

Study area

Land area: 170 ha
Population: 1,600
Infected area: 0.45 ha



Images of Malabo

Infected areas

Fieldwork March – April and July – September, 2002

Interviews

- No. of subjects: 1,507 (≧2 years old)
- Language: Tagalog with assistant
- Items used for analysis: age, sex, occupation

Collection of stool samples

- No. of samples: 407
- Collected by barangay health workers
- Kato-Katz thick smear method in laboratory by the schistosomiasis control team

Characteristics of the hosts in the model

✓ Humans

1. Age
2. Sex
3. Age/occupation groups

   pre-school children, elementary school children, high-school children, farmers, fishermen and others

✓ Infectious status

   susceptible, exposed, infected and recovered

2. Snails, Rats and Dogs

✓ Age (except for dogs)

✓ Infectious status

   susceptible and infected

Parameters

Constant parameters

- ✓ Transmission rate

  transmission probability per week

- ✓ Mean daily egg output
- ✓ Hatch ability of eggs
- ✓ Death rate
- ✓ Birth rate
- ✓ Exposed period: 8 weeks
- ✓ Recovered period: 8 weeks
- ✓ Recovery rate: 1/260 per week (5 years)
- ✓ Voluntary participation rate: 0.5%

Transmission rates – constant parameter

Observed prevalence rates and estimated transmission rates

	Prevalence rate (%)		Transmission rate (10^{-9})	
	M	F	M	F
Pre-school	0.0	0.0	37.5	37.5
Elementary school	4.2	2.0	37.5	37.5
High school	23.1	0.0	251.0	37.5
Farmers	16.9	0.0	171.0	37.5
Fishermen	22.9	–	241.0	–
Others	13.0	5.4	37.5	37.5

Parameters

Variable parameters

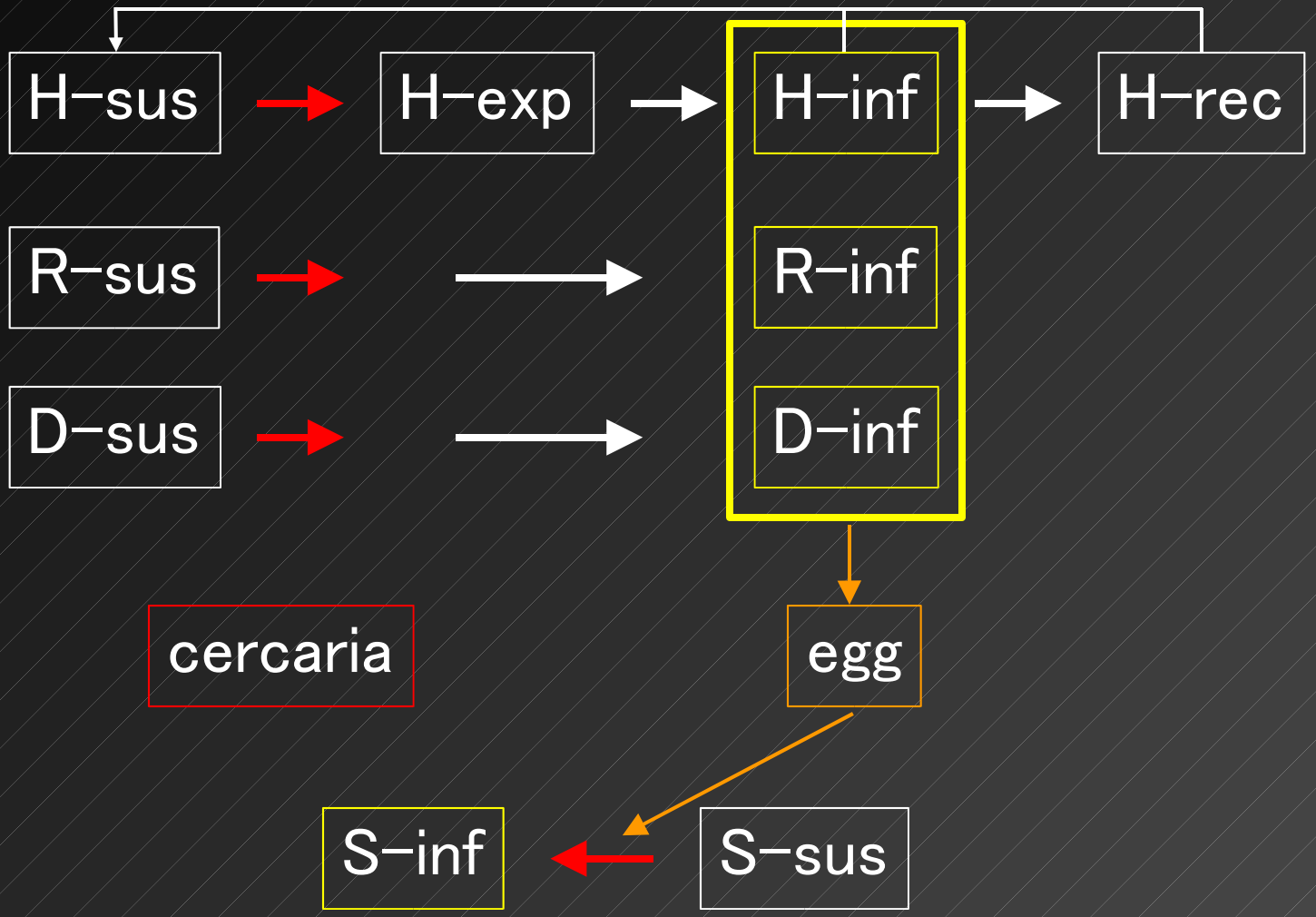
1. Treatment for humans
   - Frequency of treatment with praziquantel
     1/year or 2/year
2. Target age/occupation groups
   All or specific age/occupation groups
3. Participation rate
   ([participants]÷[infected residents])
   30%, 70% or 100%

2. Frequency of snail control
   1/year or 2/year
3. Frequency of rat control
   none or 1/year

Model – infectious status

H: Humans, R: Rats, D: Dogs, S: Snails

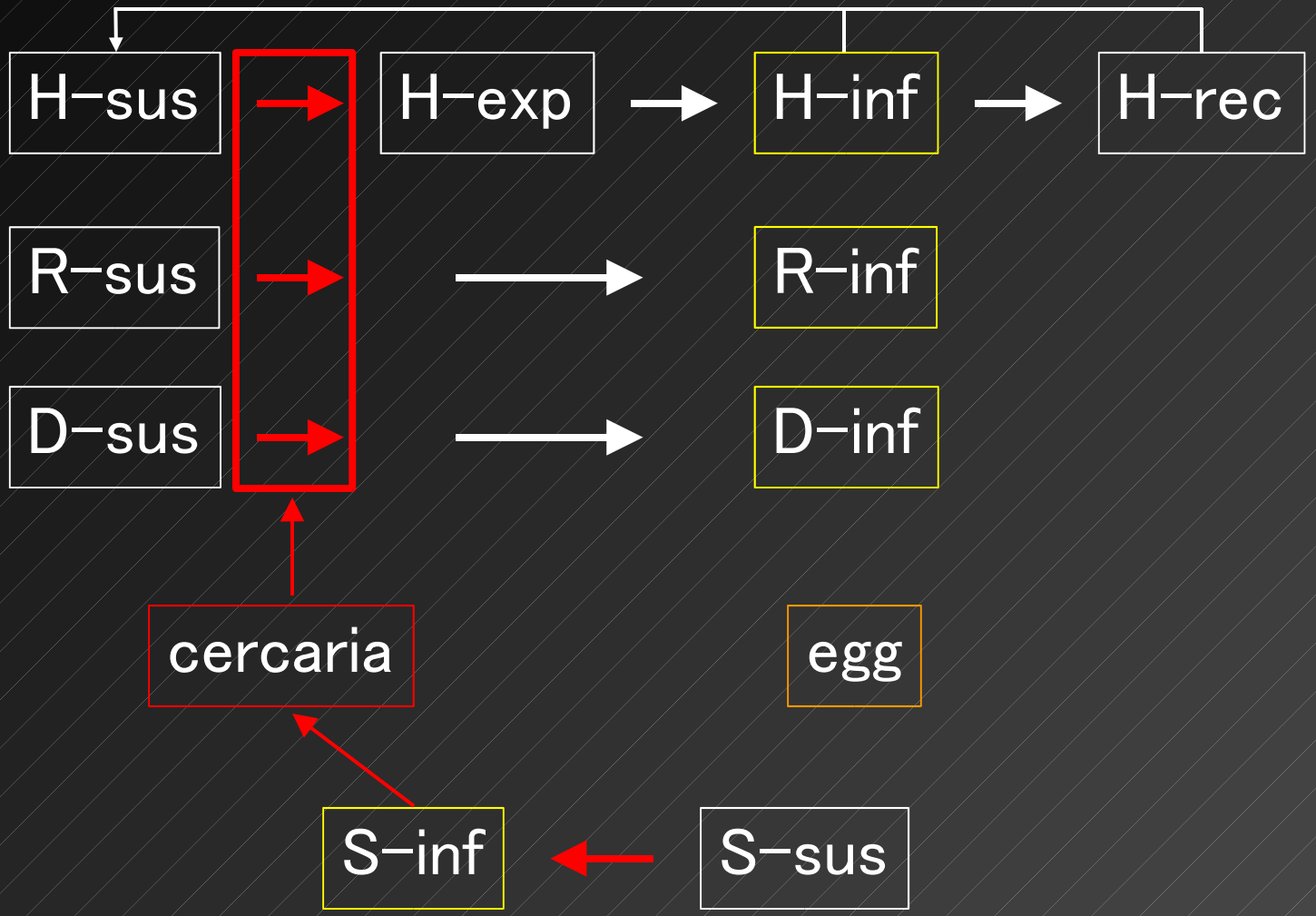
sus: susceptible, exp: exposed, inf: infected, rec: recovered



Model – infectious status

H: Humans, R: Rats, D: Dogs, S: Snails

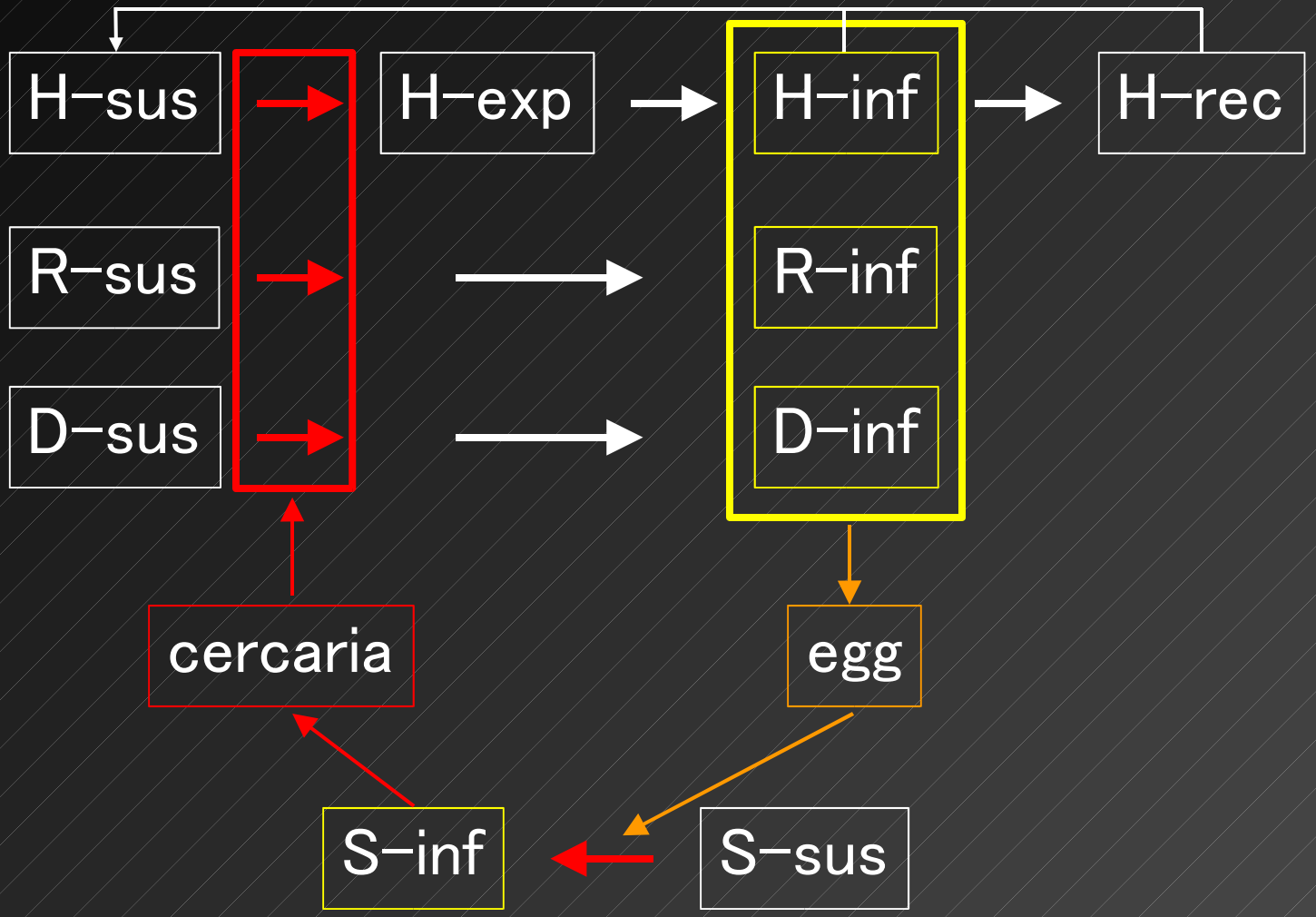
sus: susceptible, exp: exposed, inf: infected, rec: recovered



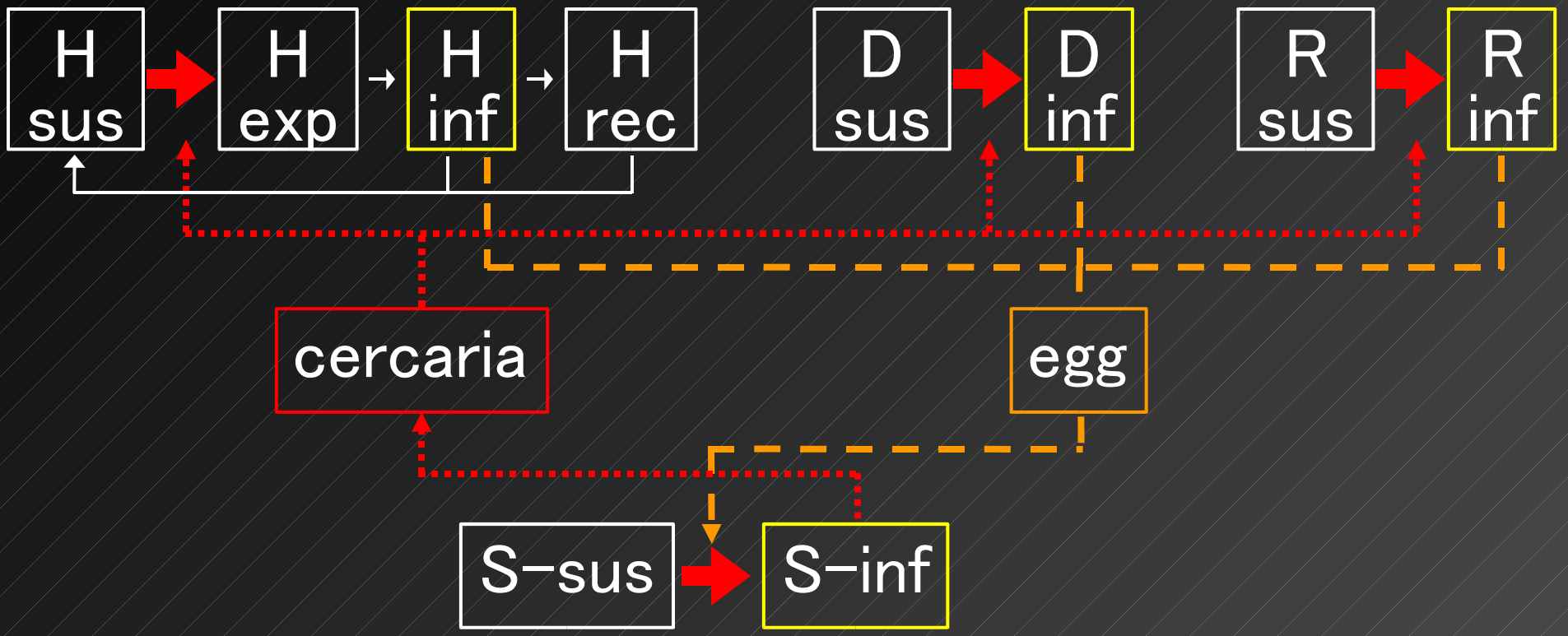
Model – infectious status

H: Humans, R: Rats, D: Dogs, S: Snails

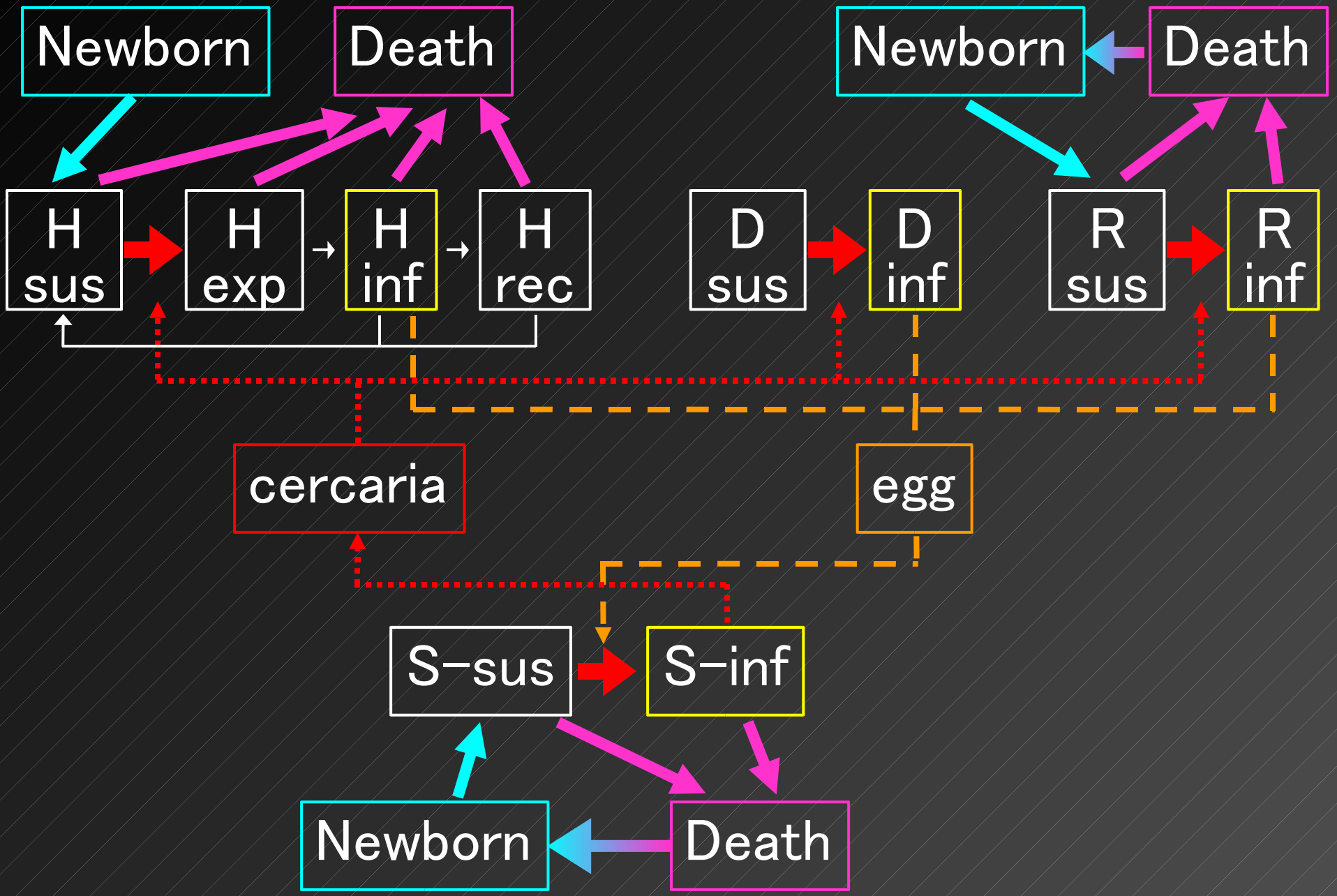
sus: susceptible, exp: exposed, inf: infected, rec: recovered



Model


H
sus
H
exp
H
inf
H
rec
D
sus
D
inf
R
sus
R
inf
cercaria
egg
S−sus
S−inf

Model


Newborn
Death
Newborn
Death
H sus
H exp
H inf
H rec
D sus
D inf
R sus
R inf
cercaria
egg
S−sus
S−inf
Newborn
Death

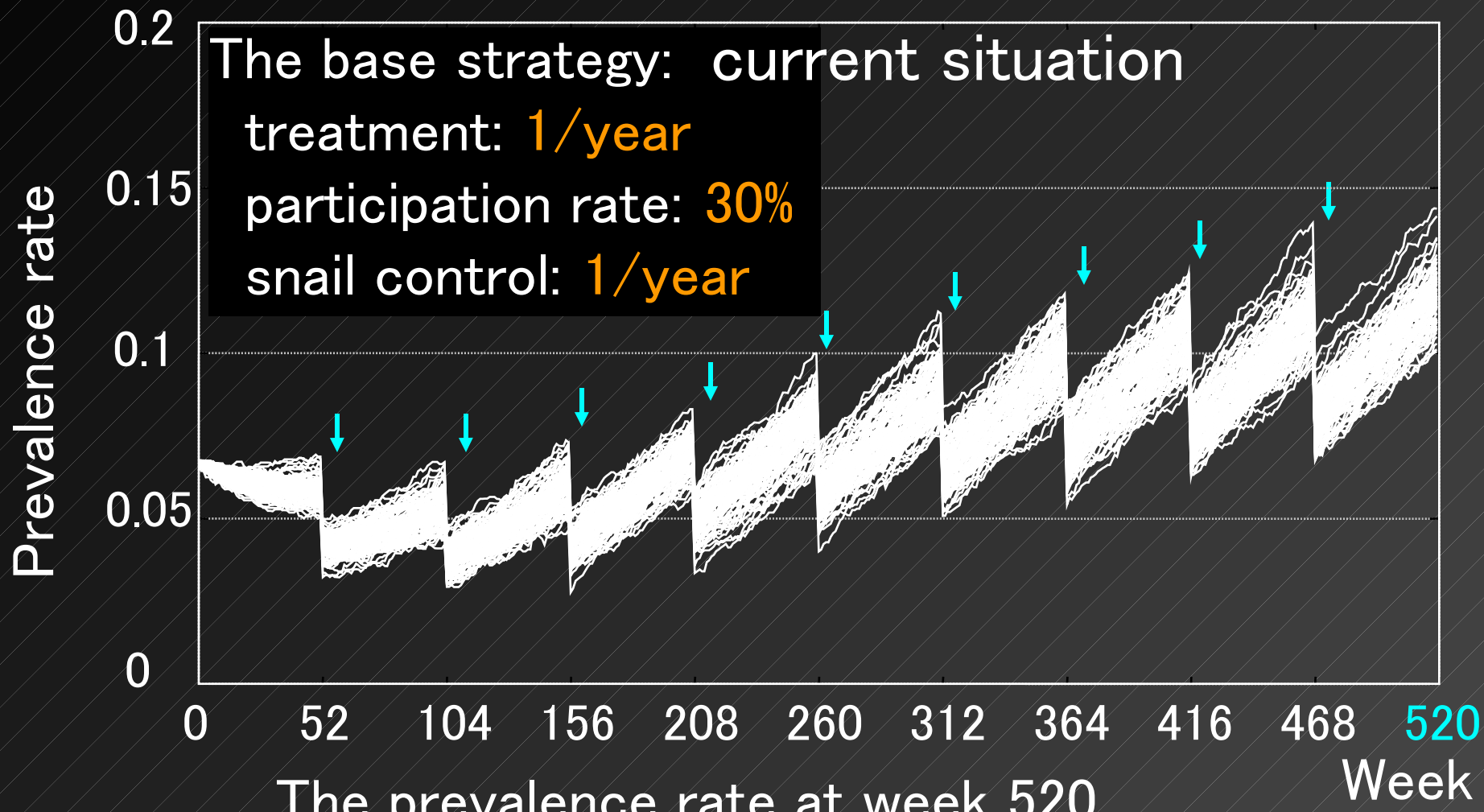
Simulation – individual based

1. Programmed by C language
2. Unit time: 1 week
3. 520 weeks with 100 runs
4. The Mersenne Twister algorithm
   for pseudo-random numbers
5. Initial population
   - Humans: 1,600
   - Snails: 45,000
   - Rats: 16,000
   - Dogs: 100

- Base strategy and 11 strategies
  Changing variable parameters

RESULTS AND DISCUSSION

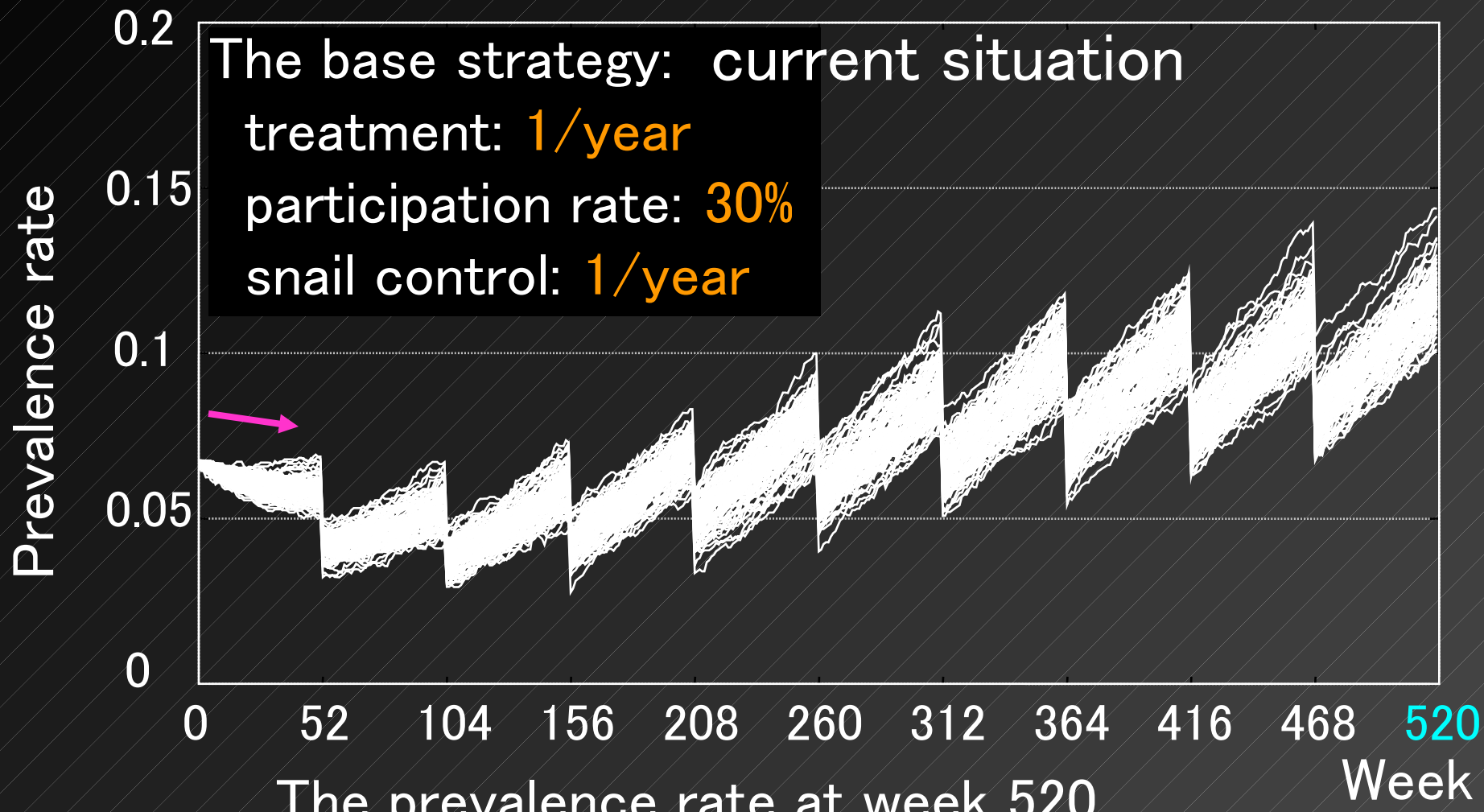
The change of the prevalence rate



The prevalence rate at week 520

Humans	Snails	Rats
11.8%	4.4%	31.7%

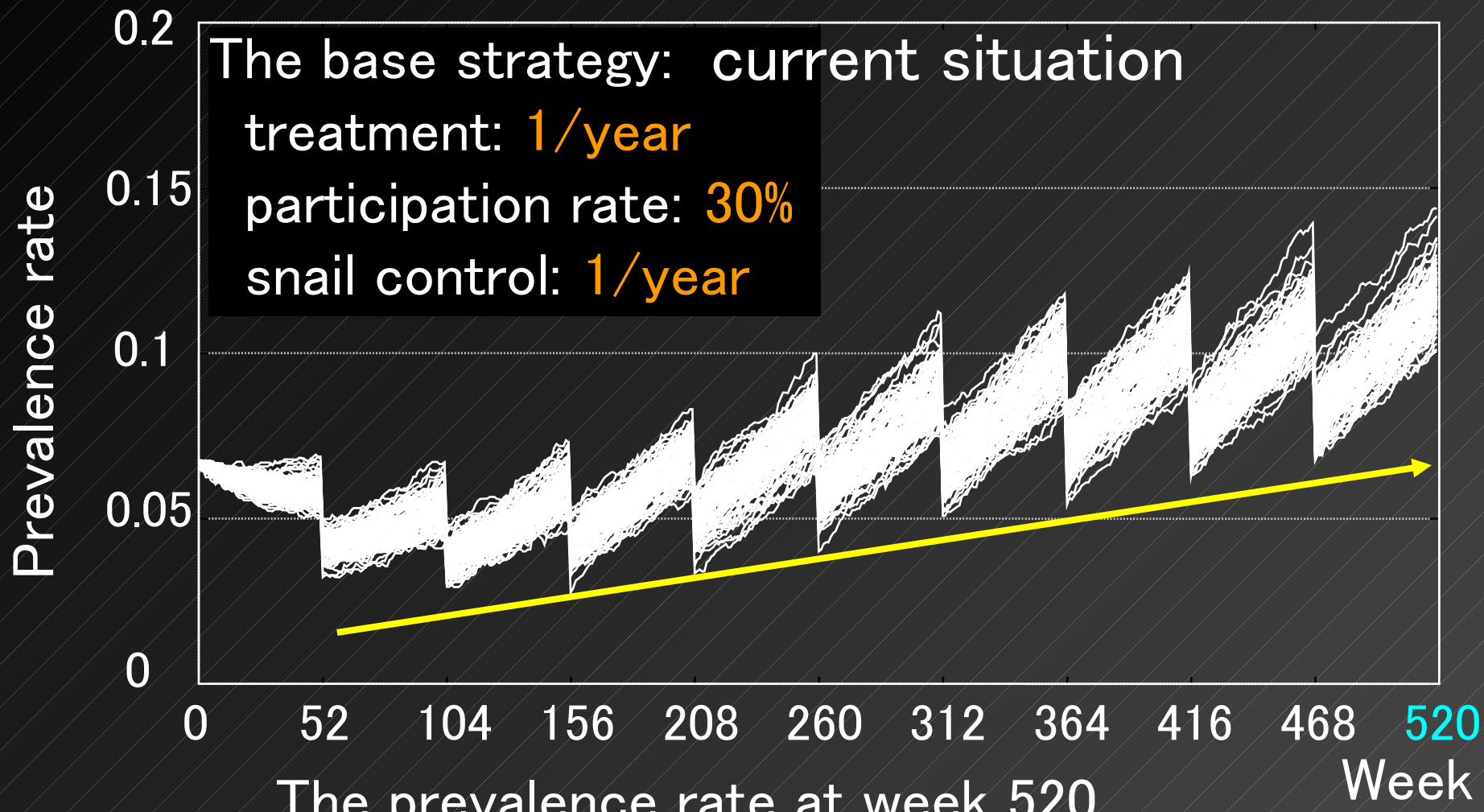
The change of the prevalence rate



The prevalence rate at week 520

Humans	Snails	Rats
11.8%	4.4%	31.7%

The change of the prevalence rate



The prevalence rate at week 520

Humans	Snails	Rats
11.8%	4.4%	31.7%

Effects of frequencies of control strategies on the prevalence rate

The prevalence rates at week 520

Strategies	Humans
(H), (S): 1/year	11.8%
(H): 1/year, (S): 2/year	7.2%
(H): 2/year, (S): 1/year	7.3%
(H), (S): 2/year	4.3%

(H): treatment for humans, (S): snail control.

Effects of treatment for selected groups

The prevalence rates at week 520

Strategy	Pre-school	Element school	High school	Farmers	Fisher-men	Others	Total
Base	4.3%	6.0%	15.4%	20.9%	29.8%	6.2%	11.8%
School	10.2%	3.9%	12.9%	45.5%	57.1%	15.9%	22.9%
High-risk	5.6%	9.9%	14.5%	10.2%	14.5%	10.4%	10.3%

Base: all groups with 30% participation rate and snail control
School: school children with 100% participation rate
High-risk: high school students, farmers, fishermen with 100% participation rate.

Effects of treatment for selected groups

The prevalence rates at week 520

Strategy	Pre-school	Element. school	High school	Farmers	Fisher-men	Others	Total
Base	4.3%	6.0%	15.4%	20.9%	29.8%	6.2%	11.8%
School	10.2%	3.9%	12.9%	45.5%	57.1%	15.9%	22.9%
High-risk	5.6%	9.9%	14.5%	10.2%	14.5%	10.4%	10.3%

Base: all groups with 30% participation rate and snail control
School: school children with 100% participation rate
High-risk: high school students, farmers, fishermen
with 100% participation rate.

Effects of participation rate

The prevalence rates at week 520

Participation rate	(H), (S): 1/year	(H), (S): 2/year
30%	11.8%	4.3%
70%	6.8%	2.0%
100%	3.5%	0.6%

Participation rate: ([participants]÷[infected residents]).
(H): treatment for humans and (S): snail control.

Effects of participation rate

The prevalence rates at week 520

Participation rate	(H), (S): 1/year	(H), (S): 2/year
30%	11.8%	4.3%
70%	6.8%	2.0%
100%	3.5%	0.6%

Participation rate: ([participants]÷[infected residents]).
(H): treatment for humans and (S): snail control.

Effects of participation rate

The prevalence rates at week 520

Participation rate	(H), (S): 1/year	(H), (S): 2/year
30%	11.8%	4.3%
70%	6.8%	2.0%
100%	3.5%	0.6%

Participation rate: ([participants]÷[infected residents]).
(H): treatment for humans and (S): snail control.

Comparison with Bohol Island

	Strategy	Result
Bohol Island (Yasuraoka et al,1996)	Treatment for humans: 1/year Participation rate: ca. 70% Snail control: 2/year	Almost eradicated
Malabo (this simulation)	Treatment for humans: 2/year Participation rate: 100% Snail control: 2/year	0.6±0.2%

More water in Mindoro (Malabo) than in Bohol

Suitable for habitation of snails

→ difficult to eradicate schistosomiasis

CONCLUSION

1. Influence of population increase
   on the prevalence rate

2. Marked reduction
   by treatment of high-risk groups
   even without snail control

3. The most feasible strategy in Malabo:
   both treatment with 70% participation rate
   and snail control twice a year