Estimates of the control strategies of schistosomiasis japonica in the Mindoro Island, 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

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INTRODUCTION

Schistosomiasis is one of the major infectious diseases of public health concerns in developing countries. This parasitic disease is sometimes fatal unless any treatment is made after the liver or kidney is severely damaged, even though there are few cases of leading to death. The treatment using praziquantel is highly effective. Despite large amounts of control efforts using this medicine, however, WHO (2002) estimates that 200 million people in the world are infected, with 120 millions in symptomatic state and 20 millions in severe state. There are 4 *Schistosoma* species, i.e. *S. japonicum*, *S. mekongi*, *S. mansoni* and *S. haematobium*, which distribute differently in the continents of the world.

Philippines is one of the countries with schistosomiasis prevalence due to *S. japonicum* (schistosomiasis japonica), the intermediate host of which is a snail, i.e. *Oncomelania quadrasi*. It is reported that there are 3,391 snail colonies in the area of 11,250 ha and 6.7 million people in 1,212 barangays (an administrative unit, corresponding to a village) are at risk of this disease (Leonardo et al, 2002). Historically, the schistosomiasis control teams have been organized by the Department of Health, the government of

Philippines. Before the discovery of praziquantel, their efforts were devoted to the control of snails, which was costly and difficult in success. Since the 1980's, the treatment of people with praziquantel has decreased prevalence rate of schistosomiasis (Leonardo et al, 2002), but the eradicated areas have still been very limited.

Due to complicated transmission pathways of schistosomiasis japonica, detailed understanding of the mechanisms of prevalence is difficult. Thus, simulation modeling is judged as one of the effective approaches; even if the phenomenon cannot be essentially observed, it is possible to generate and to obtain a perfect data set from a simulation in the short time (Dyke, 1981). The modeling studies have been conducted mostly for schistosomiasis mansoni, which is prevalent in Africa and Latin America. In contrast, schistosomiasis japonica has seldom been targeted in the modeling analysis mostly because there are more variety of hosts, compared to schistosomiasis mansoni. According to a recent simulation study for schistosomiasis japonica in China, buffalo plays the most important role in the transmission among the host animals other than humans (Williams et al, 2002). In Philippines, buffalo (called carabao in this country) does not transmit this parasite, but rats and dogs are considered to play more important roles (Leonardo et al, 2002).

Based on the data collected in the author's fieldwork, which included census of the villagers and parasitological examination of their stool samples, a simulation model was constructed. Then, different parameter sets were given to this model to estimate what kinds of prevention and treatment are effective for mitigation of schistosomiasis and what extents. This study, thus, aims to contribute to public health approaches for mitigation or eradication of this parasitic disease in the local human-environment relations.

SUBJECTS AND METHODS

Study area

The study community, called Malabo, is located in the eastern part of Mindoro Island, Philippines (Figure 1). This community is one of the 48 schistosomiasis endemic areas around the Naujan lake in Mindoro. The land area of Malabo is 170 ha, of which 4,500 m^2 is considered to accommodate snail colonies. Population of Malabo is about 1,600 in the study period and the major occupations of the residents are farming and fishing, to which the males are engaged, while the bulk of females are housewives. There is an elementary school in Malabo, which is located in the schistosomiasis infected area, which is defined in terms of the existence of the infected snails. High schools, to which the boys and the girls of this village commute by bus, are located in the nearby barangays, which are free from schistosomiasis infection. Domestic water sources of Malabo village are canals, rivers, lake and artificial piped wells, of which the canals and rivers are infected. In the rainy season from July to September, the lake is sometimes flooded and about half of the land in Malabo is under water.

The office of the local schistosomiasis control team (called SCT for short) is located near Malabo, from which it takes 5 minutes by car. The SCT is a regional office of the Department of Health and undertakes the schistosomiasis control of all endemic areas around the Naujan lake.

Fieldwork

Fieldwork was conducted twice: the preliminary survey between March and April 2002 and the main survey between July and September 2002. Aside from general observation for the settlements and 2 snail habitats (Figure 1) and for the villagers' daily activity patterns, 2 kinds of systematic data were obtained by means of interview and collection of stool samples, which was associated with the laboratory examination.

Interviews were carried out by the author, with assistants who were members of the SCT, to all residents aged 2 years or more, numbering 1,507 in total. The language used was Tagalog, which was translated by the assistants, and the interview about the small children was made to his/her mother. The interview items included (1) age, (2) sex, (3) occupation, (4) type of latrine, i.e. inside the own house, outside the own house, neighbor's house, public one or none, (5) frequencies of visits to paddy fields, lake, canals and rivers, the elementary school, and the high schools as well as the infected places and (6) the last time when he/she was treated with praziquantel; however, the results of the 3 items (numbers 4, 5 and 6) were not directly used in the parameters of the present modeling analysis. The interview was done for about 5 minutes for each person.

For stool samples, the collection box was delivered to each villager and it was collected by barangay health workers in the following morning and then transported to the laboratory in the SCT. The samples collected numbered 407. In the SCT laboratory, well-trained medical technicians identified the samples positive or negative by the Kato-Katz thick smear method (Katz et al, 1972). The infection rates used in simulations were estimated from the results of this investigation (Table 1), as described later.

Modeling

The hosts of schistosomiasis japonica are categorized into 4 types, i.e. humans, snails, wild animals and domestic animals. The wild and domestic animals concerned in Malabo are rats for the former and dogs and buffaloes for the latter. However, buffaloes are not infected to schistosomiasis japonica in the Mindoro Island; the reasons why this animal is infected in some areas, like China, and is not in other areas, including the Mindoro, have not been clarified (Anonymous, 1998).

As shown in Figure 2, the model constructed in this study treated humans, snails, rats and dogs, which are expressed as, respectively, H, S, R and D for short. Humans were defined by age, sex, occupation and infectious status: there were 6 age/occupation groups, i.e. pre-school children, elementary school children, high school students, farmers (adults), fishermen (adults) and others (adults), taking into account difference in the infection rate based on the smear testing for the stool samples and different possibilities of treatments of schistosomiasis. On the other hand, snails, rats and dogs were defined only by age and infectious status. The infectious status was assumed into 4 periods, i.e. susceptible, exposed, infected and recovered, for humans but into only 2 periods, i.e. susceptible and infected, for snails, rats and dogs: the susceptible, exposed, infected and recovered periods in humans are expressed as, respectively, H-sus, H-exp, H-inf and H-rec, and similarly, the susceptible and infected periods for other hosts are expressed as S-sus and S-inf, R-sus and R-inf, and D-sus and D-inf.

The parameters used in this model were as follows. There were 9 kinds of constant parameters: (1) infection rate for each host, (2) hatch ability except snails (Pesigan et al, 1958), (3) the mean daily egg output except snails (Pesigan et al, 1958), (4) death rate except dogs, (5) birth rate, (6) exposed period, (7) recovered period, (8) recovery rate and (9) the voluntary participation rate to SCT-organized mass-treatment with praziquantel; the latter 5 items were applied only to humans. The infection rate implied the probability of successful transmission when one host individual contacted with one cercaria unit in a week for humans, rats and dogs, and with one egg unit in a week for snails. The cercaria unit was equal to the number of infected snails and the egg unit was calculated from the hatch abilities and the sum of the daily egg outputs of humans, rats and dogs (Table 2). The infection rate of humans differed by the age/occupation groups, as mentioned previously. On the other hand, the 3 variable parameters, all of which were changeable by the judgment of the individuals and communities, were (1) the participation frequency to SCT-organized mass-treatment by the age/occupation groups, (2) frequency of snail control and (3) frequency of rat control.

This model is constituted by the 2 parts. In the first part, the infected statuses of any hosts are considered. The probabilities of change from H-sus to H-exp, from R-sus to R-inf,

inf, and from D-sus to D-inf are equal to the products of the infection rates and the number of cercaria units. Similarly, the probability of change from S-sus to S-inf is equal to the infection rate of snails multiplied by the egg units. The velocity, which changes from H-exp to H-inf, is the reciprocal number of the exposed period, which depends on the normal distribution around 2 months. The recovered period of humans is determined, based on the distribution around 2 months, during which the effect of praziquantel is continued.

The second part considered population dynamics of the hosts. For humans, the stable population model was applied. Survival curve of humans for either sex was based on the age-specific survival rates of the whole Filipinos (SEAMIC Health Statistics, 1999) and fit to Denny's model (Denny, 1997); the function is presented in Table 3 and the survival curve is shown in Figure 3. The age-specific fertility rates followed those of the whole Filipinos, as shown in Table 4. For rats and snails, the stationary population model was applied, because there were few available data for their population dynamics. Population of rats was estimated as 10 times as that of humans (Pesigan et al, 1958) and the survival curve was formulated, using the Weibull function, while population of snails was estimated at 45,000, based on the estimated snail density in Malabo, i.e. 10 per m^2, and the area of snail habitat in it, i.e. 4,500

m^2. The age-specific death rates for snails followed the Pesigan's (1958) data.

The infection rates are fixed to reflect the current conditions; the results of field investigation (Table 1) were applied to humans using logistic regression analysis and pre-simulation; in recent time in Malabo, the prevalence rate of schistosomiasis is about 10%; the SCT-organized mass-treatment is conducted once a year with 30% of participation rate; and 0.5% of infected residents voluntarily go to the SCT office to be treated; and snail control is carried out once a year. The parameters of the initial population and infection rate were fixed for the simulations, as shown in Table 5.

Simulation

The basic characteristics of the simulation model developed in this study were as follows. First, this model was programmed by C language. Second, the unit time of simulation was set at 1 week; from the beginning point, at which the egg unit and the cercaria unit were set, the infection statuses were simulated week by week, using the changing egg units and cercaria units of any agents. Third, the simulation continued for 10 years (520 weeks), with 100 runs for each case. Fourth, the pseudo-random numbers were generated by the Mersenne Twister algorithm (Matsumoto, 1998) for applying to the parameters, which depended on the probability, and the velocity to change from infected period to susceptible period of humans while the pseudo-random number, which depended on normal distribution, was also generated for applying to the variable parameters, for which the changing velocity was decided by the set periods except the recovery rate.

In this study, 12 strategies (scenarios) were prepared for the simulation. Among them, one strategy, called the base strategy, reflected the actual situations in Malabo. On the other hand, the remaining 11 strategies were designed to change the 4 parameters, i.e. (1) participation rate to, and frequency of, mass-treatment, (2) frequency of snail control, (3) frequency of rat control, and (4) frequency of treatment for school children or high-risk groups, i.e. high school students, farmers and fishermen, as shown in Table 6. Treatment for humans, snail control and rat control were set to occur in the intervals of 52 weeks (1/year) or 26 weeks (2/year); any of them was conducted at the end of the 52 or 26 weeks. It is noted that the infection rate differed among the age/occupation groups, based on the examination of stool samples.

Statistical analysis

Logistic regression model was used to examine the ratio of infection rate among the age/occupation groups and pairwise t-test adjusted by Holm method performed to examine the differences between the prevalence rates. All analyses were carried out with R software (Version 1.6.1).

RESULTS

Table 1 shows the distribution of the subjects, whose stool samples were examined, by the age/occupation group and sex. The prevalence rate was the highest in fishermen, followed by farmers and high school students. Concerning the sex difference, the prevalence rate was significantly higher in males than in females.

In this simulation, total population of Malabo increased from 1,600 to 1,994.3 (SD = 23.5) after 10 years run. Overviewing the changing patterns of prevalence rates of all human groups pooled in the 12 strategies (Figures 4-9, Table 7), there were 3 characteristics. First, all strategies but strategy 1 showed intermittent declines in the end of every year or half a year (or 52 or 26 weeks). Second, year-by-year (or half-year by half-year) changes differed between the earlier several years and the remaining years, represented by decreases in the former and increases in the latter. Third, the changing patterns were basically consistent in the later several years, and thus the prevalence rates at the endpoint of simulation, i.e. 10 years or 520 weeks later, were of meaning for comparisons of different strategies.

The prevalence rates in the base strategy (strategy 0) and strategy 1, in which any treatment nor preventive means were not conducted, are shown in Figure 4. Compared to the base strategy, with the prevalence rate of 11.8% (SD = 0. 8%) at the endpoint, strategy 1 was characterized by rapid increase of this rate from the early stage to reach 29.6% (SD = 1.1%) at the endpoint.

The comparisons of strategies 2, 3 and 4, in which the frequency of mass-treatment or that of snail control or the both were increased, demonstrated that the prevalence rate was lower than that of the base strategy (Figure 5). The prevalence rate at the endpoint did not differ between 7.2% (SD = 0.7%) in strategy 2, and 7.3% (SD = 0.7%) in strategy3, while 4.3% (SD = 0.5%) in strategy 4 was significantly lower, compared to the rates in strategies 0, 2 and 3.

As shown in Figure 6, the prevalence rate in strategy 5, which involved rat control, was 11.9% (SD = 0.9%), without significant difference from that in the base strategy.

Figure 7 shows comparisons of strategies 6 and 7, in which all school children or high-risk groups (high school students, farmers and fishermen) were always treated but no other residents were treated, and snail control was not done. Compared with the base strategy, the prevalence rate in strategy 6 was significantly higher, i.e. 22.9% (SD = 1.0%), while that in strategy 7 was significantly lower, 10.3% (SD = 0.8%). It is also noted that the prevalence rates of elementary school children and high school students were significantly lower in strategy 6 than in the base strategy and that the prevalence rates of high school students, farmers and fishermen were also significantly lower in strategy 7 than in the base strategy.

Finally, Figures 8-11 were compared, respectively, among the base strategy and strategies 8 and 10, and among strategies 4, 9 and 11; the participation rates differed but the frequencies of mass-treatment and snail control were same (once a year in the former and twice a year in the latter). The most important finding was that the prevalence rate in strategy 9, i.e. 2.0% (SD = 0.3%), was significantly lower than that in strategy 10, i.e. 3.5% (SD = 0.4%).

DISCUSSION

In the simulations for any strategies except strategy 1, the prevalence rate was characterized by the similar changing patterns. During the earlier several years, the prevalence rate decreased gradually and increased little by little in the later several years. The former was derived from the lack of consideration of the incubation period in the initial settings. The latter was likely to be caused by human population increase; after the 10 years run, human population reached about 2,000 and consequently the number of infected persons also increased. Due to the structure of this model, the increase of infected persons was related to the following actions: (1) the number of egg unit was increased, (2) the increase in the number of the egg unit led to the increase of infected snails, (3) the increase of the infected snails pulled the number of cercaria unit, and (4) the increase in the number of cercaria unit caused the increase of the infected hosts except snails. It is, therefore, reasonable to suppose that the increase of one host (e.g. humans) in the schistosomiasis endemic area would lead to the rises of the prevalence rate of all hosts.

Under the same participation rate to the mass-treatment, the effects of the frequencies of treatment of humans and snail control were compared among strategies 0, 2, 3 and 4. From strategies 2 and 3, which resulted in almost same prevalence rate the treatment of humans and the snail control were similarly effective for the prevalence rate of humans. In contrast, the rat control which was included in strategy 5 did not significantly decrease the prevalence rate from the base strategy. It is thus summarized that mass-treatment for humans and snail control were effective but rat control was not.

The results of strategies 6 and 7 demonstrated importance of treating humans who belonged to the high-risk groups. In both strategies, the prevalence rates of the targeted age/ occupational groups were decreased from the base strategy. However, the prevalence rates of any other human groups, snails and rats were increased. In strategy 6, in which the school children were treated, the prevalence rate of humans was higher than that of the base strategy. This result was derived from low prevalence rates of the school children, though McGarvey et al (1992) reported high prevalence rates of children in other Filipino population. On the other hand, the prevalence rate of humans in strategy 7, in which the high-risk groups were treated, was significantly lower than that of the base strategy and the prevalence rate of snails did not change from the base strategy, despite no snail control.

Compared between strategies 9 and 10, the prevalence rate was lower in the former than in the latter, implying that the combined effort for treatment of 70% of humans and snail control every half year is more effective than that for treatment of 100% of humans and snail control every year. The former pattern seems highly possible by the efforts of the residents of Malabo and staff of the SCT.

There was one reported program, which reached the verge of elimination in the northeastern part of the Island of Bohol, Philippines (Yasuraoka et al, 1996), by means of twice snail controls a year and once treatment for humans a year. In this study, however, eradication did not occur even in strategy 11, in which 100% of humans were treated twice a year and the snail control were carried out twice a year. This difference may attribute to much more water suitable for habitation of snails in Malabo than in Bohol. This fact suggests importance of understanding local environment for the control of schistosomiasis.

One previous study reported that the control programs with vaccine of buffaloes and treatment of targeted humans eliminated schistosomiasis japonica in China (Williams, 2002). In the area of that study, the hosts of schistosomiasis japonica are only humans, snails and buffaloes. In Malabo, however, there are 4 hosts, i.e. humans, snails, rats and dogs, and rat control is quite difficult. Even when the prevalence rate of humans is 0% for a while owing to owing to treatment with praziquantel, *S. japonicum* can survive in other hosts, such as rats.

These results of this study suggest that eradication of schistosomiasis is difficult in Malabo, though these are possibilities that some strategies, including treatments of the high-risk groups of humans and frequent (twice a year or more) efforts for control of other hosts, decrease the prevalence rate.

SUMMARY AND CONCLUSION

There were many deterministic modeling studies for schistosomiasis infection, but no study has developed individual-based stochastic simulation model. The model analyses in this study, in which population dynamics of humans was treated, have indicated the results as follows.

(1) The population of Malabo increased to about 2000 persons after 10 years run and the prevalence rate was increased by the impact of population increase.

(2) Increases of both frequencies of treatment for humans and snail control effectively decreased the prevalence rate.

(3) The treatment for the high-risk age/occupation groups was effective even if the snail control was not carried out.

(4) The strategy of treatment for 70% of humans and snail control twice a year was more effective than the strategy of treatment for 100% of humans and snail control once a year.

(5) Even the strategy, in which 100% of humans were treated twice a year and snail control was done twice a year, failed to eradicate schistosomiasis in Malabo.

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Table 1. The number of participants whose stool samples were analyzed, and the infected rate

Age (years)	Age/occupation											
	Pre-school		Elementary school		High school		Farmer		Fisherman		Others	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
0 - 6	26	15	3	0	0	0	0	0	0	0	0	0
7 - 12	3	1	62	44	1	0	0	0	0	0	0	0
13 - 16	0	0	5	7	9	7	0	0	0	0	4	3
17 -	0	0	0	0	3	1	65	5	35	0	19	89
Total	29	16	70	51	13	8	65	5	35	0	23	92
The number of infected (%)	0 (0.0%)	0 (0.0%)	3 (4.2%)	1 (2.0%)	3 (23.1%)	0 (0.0%)	11 (16.9%)	0 (0.0%)	8 (22.9%)	0 (-)	3 (13.0%)	5 (5.4%)

Table 2. Hatch ability of eggs and the mean daily egg output

Host	Hatch ability (%)	Mean daily egg output
Humans		
Age group (years)		
0 - 9	40.0	370
10 - 14	48.4	4318
15 - 19	37.1	1156
20 - 29	36.2	547
30 - 39	34.4	533
40 - 49	47.2	733
50 - 59	34.7	304
60 -	37.2	1105
Rats	10.6	2
Dogs	17.8	2333

After Pesigan (1958).

Table 3. The estimated weights in Denny's function[*1] for the Filipinos

	a	b	c	RMSE[*2]
Male	0.071614	0.166778	0.025322	< 0.01
Female	0.038103	0.092627	0.046952	< 0.01

*1 Denny's function (1997): $l(x) = 1/(1+a(x/(105-x))^3+b((e^x/(105-x))-1)^{1/2}+c(1-e^{-2x}))$.

*2 Root mean square error.

Table 4. Age-specific fertility rates of Filipinos

Age (years)	Age-specific fertility rates (per 1000 females)
15 - 19	46
20 - 24	177
25 - 29	21
30 - 34	156
35 - 39	111
40 - 44	40
45 - 49	7

Based on the government's statistic records (1998).

Table 5. Infection rate by the age/occupation group and initial population

Host	Age/occupation group	Infection rate	Initial population
Humans			1,600
Male	Pre-school children	0.0000000375	
	Elementary school children	0.0000000375	
	High school students	0.000000251	
	Farmers	0.000000171	
	Fishermen	0.000000248	
	Others	0.0000000375	
Female	Pre-school children	0.0000000375	
	Elementary school children	0.0000000375	
	High school students	0.0000000375	
	Farmers	0.0000000375	
	Fishermen	0.0000000375	
	Others	0.0000000375	
Snails		0.00000002	45,000
Rats		0.000028	16,000
Dogs		0.000000003	100

Table 6. The settings for 11 strategies

Strategy	For humans			For snails	For rats
	Voluntary treatment	Mass-treatment			
	Participation rate (%)	Participation rate (%)	Frequency (per year)	Frequency (per year)	Frequency (per year)
0	0.5	30	1	1	0
1	0.5	0	0	0	0
2	0.5	30	1	2	0
3	0.5	30	2	1	0
4	0.5	30	2	2	0
5	0.5	30	1	1	1
6	0.5	All school children	1	0	0
7	0.5	All high-risk groups*	1	0	0
8	0.5	70	1	1	0
9	0.5	70	2	2	0
10	0.5	100	1	1	0
11	0.5	100	2	2	0

* High-risk groups involved high school students, farmers and fishermen.

Table. 7. Prevalence rate at the endpoi

Strategy	Humans														Snails		Rats	
	Pre-school		Elementary school		High school		Farmers		Fishermen		Others		Total					
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
0	0.043	0.012	0.060	0.013	0.154	0.031	0.209	0.022	0.298	0.033	0.062	0.010	0.118	0.008	0.044	0.002	0.317	0.009
1	0.123	0.020	0.189	0.030	0.348	0.038	0.506	0.026	0.616	0.038	0.198	0.016	0.296	0.011	0.091	0.005	0.475	0.004
2	0.024	0.010	0.033	0.013	0.094	0.025	0.132	0.019	0.191	0.032	0.036	0.007	0.072	0.007	0.037	0.002	0.192	0.008
3	0.026	0.009	0.035	0.009	0.103	0.027	0.133	0.018	0.188	0.029	0.035	0.006	0.073	0.007	0.034	0.002	0.282	0.008
4	0.016	0.008	0.019	0.009	0.060	0.019	0.079	0.014	0.115	0.025	0.020	0.005	0.043	0.005	0.030	0.002	0.169	0.006
5	0.043	0.012	0.058	0.016	0.154	0.027	0.214	0.023	0.292	0.031	0.061	0.008	0.119	0.009	0.044	0.003	0.316	0.009
6	0.102	0.015	0.039	0.012	0.129	0.026	0.455	0.025	0.571	0.030	0.159	0.014	0.229	0.010	0.061	0.003	0.475	0.003
7	0.056	0.015	0.099	0.018	0.145	0.031	0.102	0.017	0.145	0.024	0.104	0.013	0.103	0.008	0.044	0.003	0.320	0.011
8	0.026	0.009	0.031	0.012	0.094	0.020	0.123	0.018	0.180	0.026	0.032	0.007	0.068	0.006	0.032	0.002	0.267	0.007
9	0.008	0.006	0.008	0.006	0.030	0.014	0.038	0.011	0.054	0.018	0.009	0.003	0.020	0.003	0.025	0.001	0.146	0.004
10	0.025	0.008	0.015	0.008	0.048	0.017	0.059	0.012	0.091	0.021	0.015	0.004	0.035	0.004	0.025	0.002	0.229	0.005
11	0.012	0.006	0.002	0.002	0.007	0.006	0.009	0.004	0.013	0.007	0.002	0.001	0.006	0.002	0.022	0.001	0.133	0.005

Figure 1. Sketchmap of Malabo and its location in Mindoro Island.

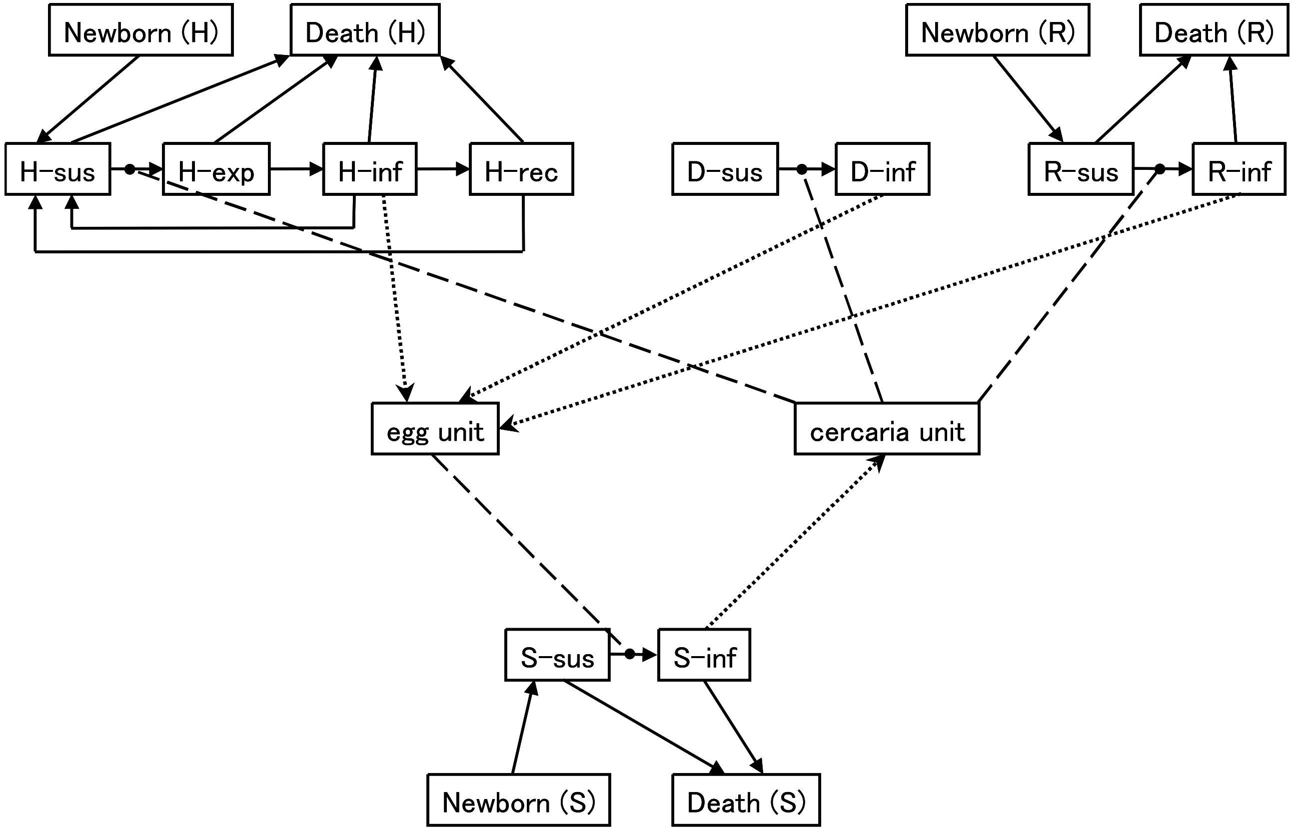

Figure 2. Pictorial model of schistosomiasis japonica transmission.
H: humans, D: dogs, R: rats, S: snails.
Sus: susceptible, exp: exposed, inf: infected, rec: recovered.

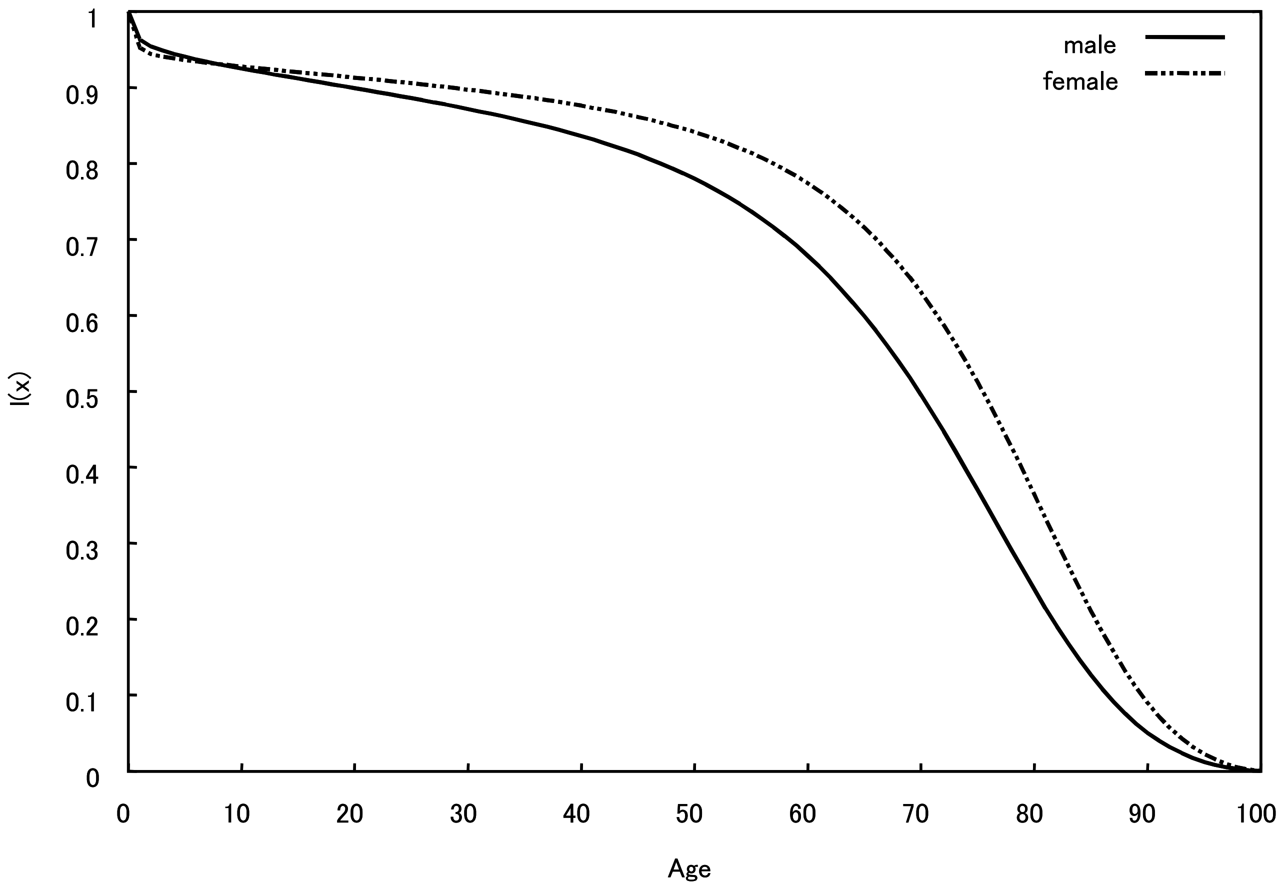

Figure 3. Survival curve of humans applied to the simulation model.

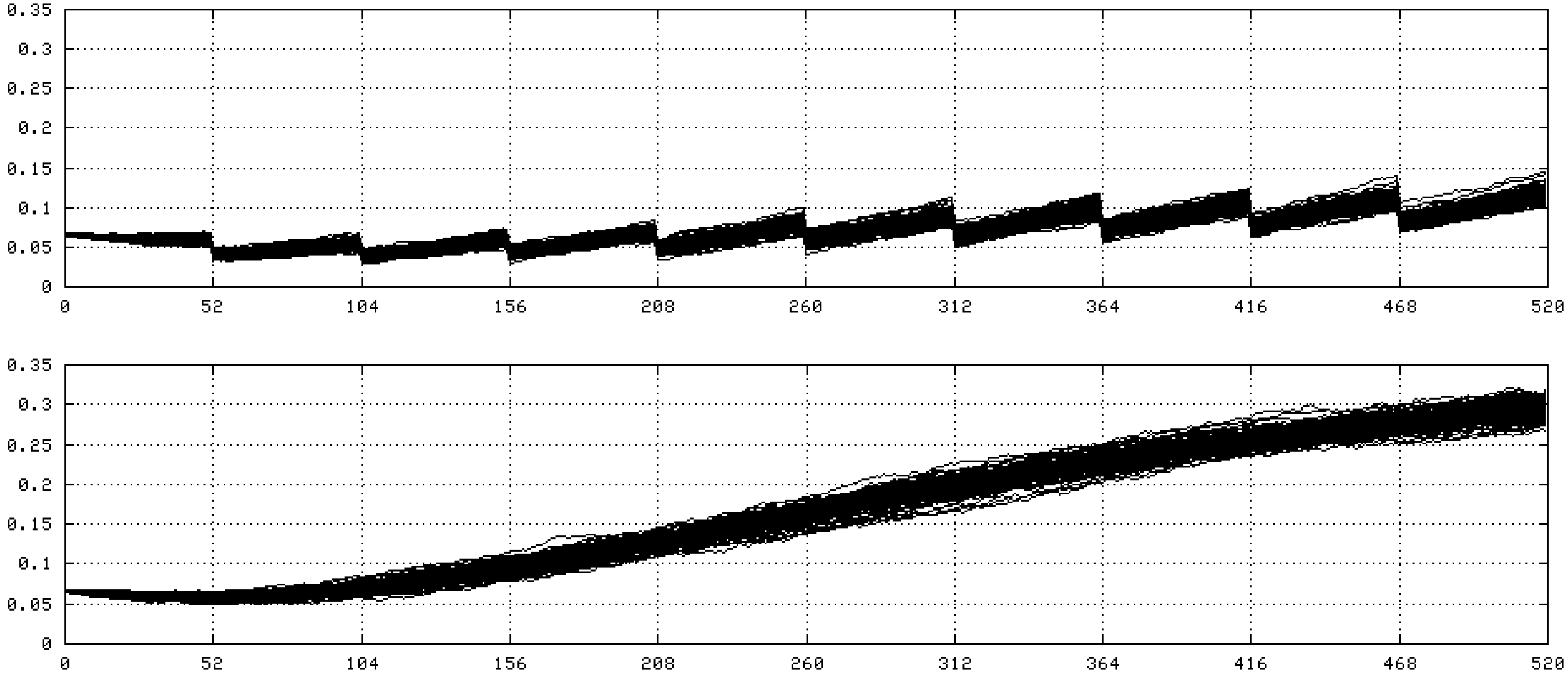

Figure 4. Prevalence rate of humans (all age/occupation groups) in strategies 0 (above) and 1 (below).

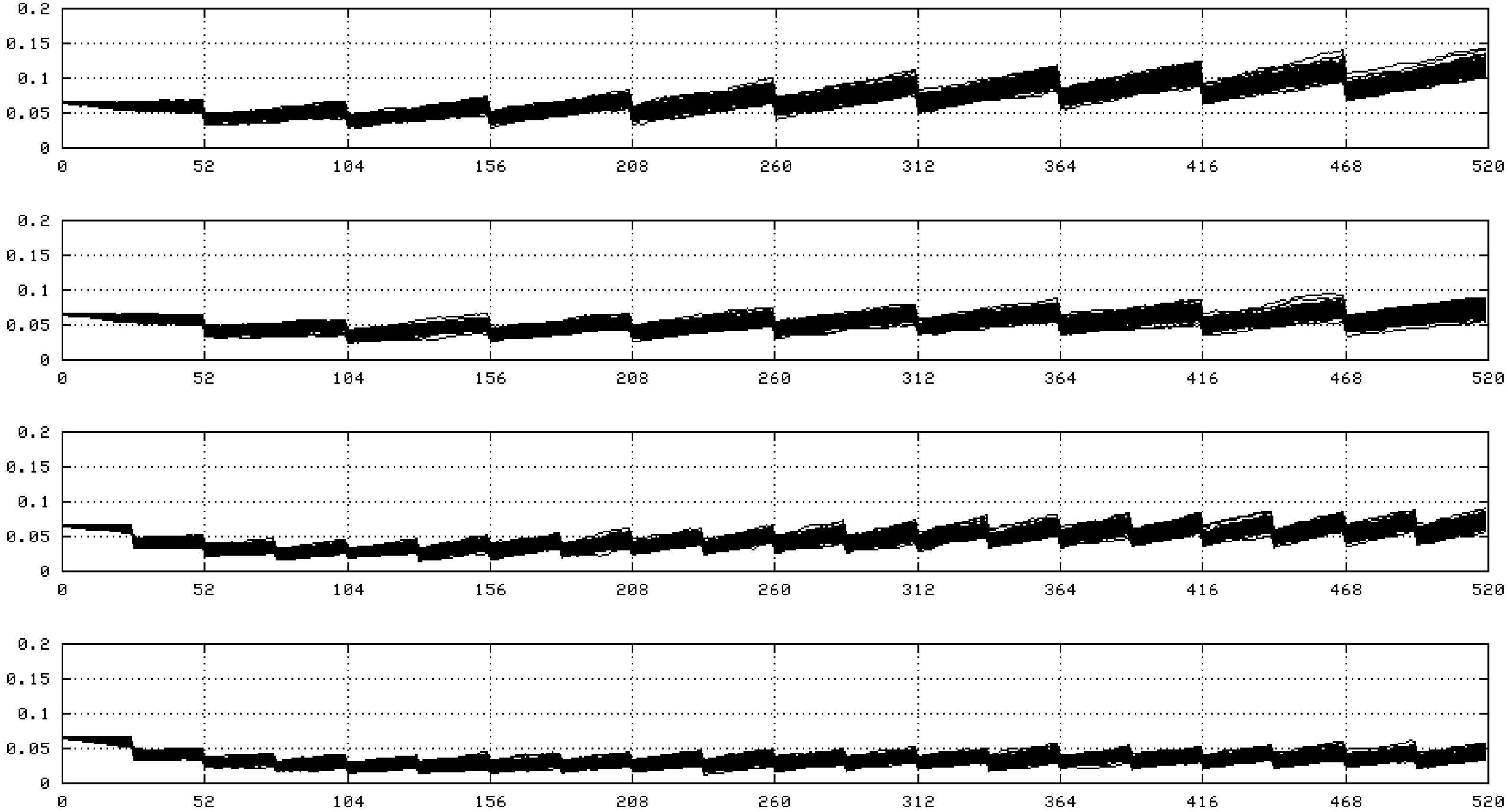

Figure 5. Prevalence rate of humans (all age/occupation groups) in strategies 0, 2, 3 and 4 (from the top to the bottom).

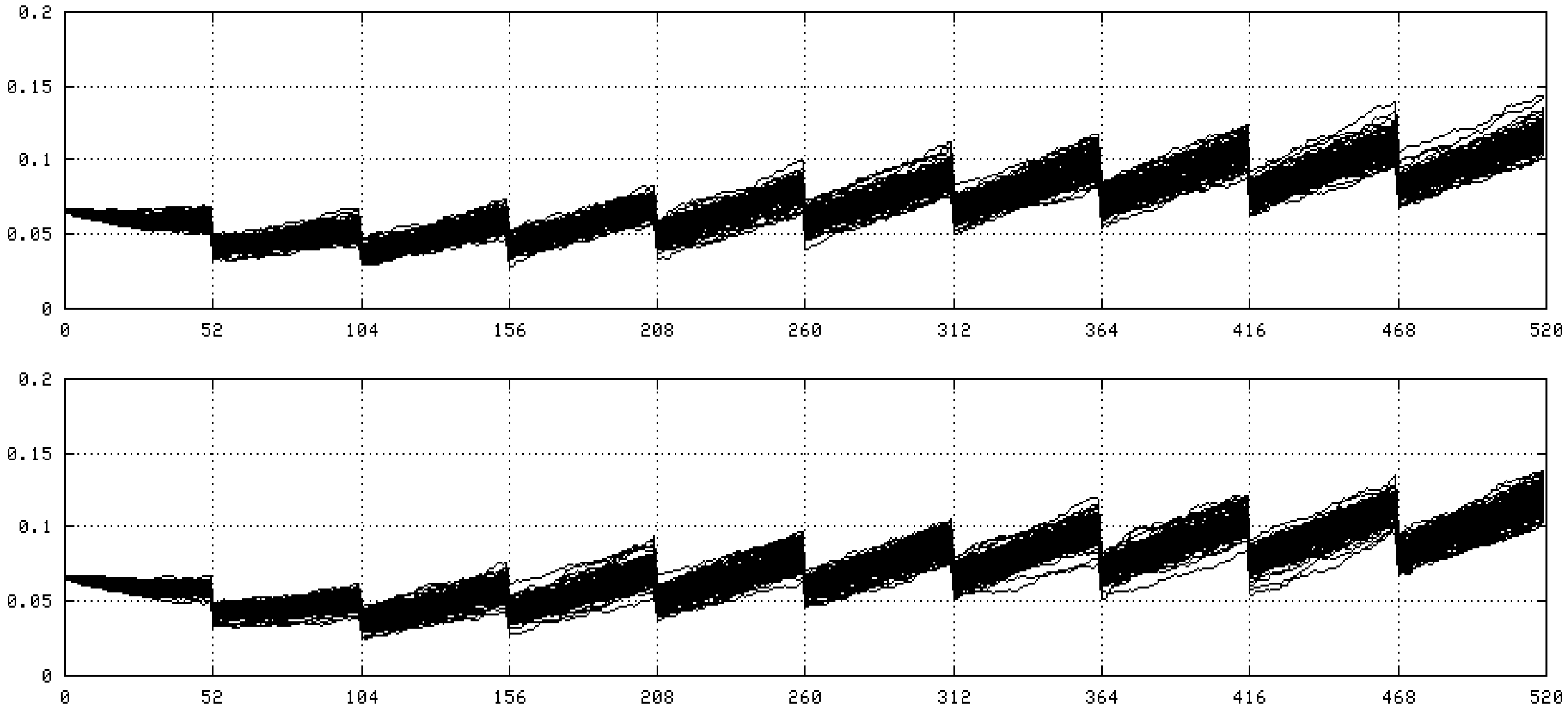

Figure 6. Prevalence rate of humans (all age/occupation groups) in strategies 0 (above) and 5 (below).

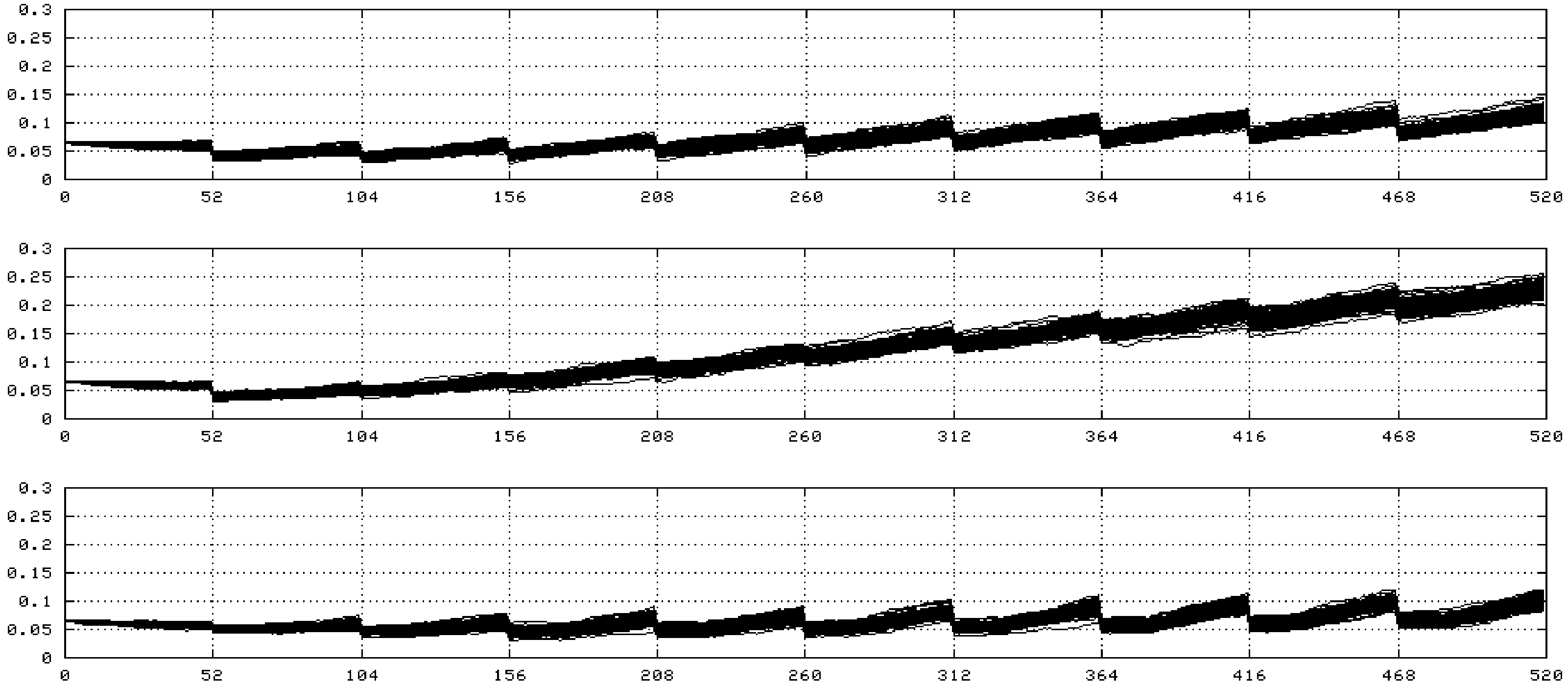

Figure 7. Prevalence rate of humans (all age/occupation groups) in strategies 0, 6 and 7 (from the top to the bottom).

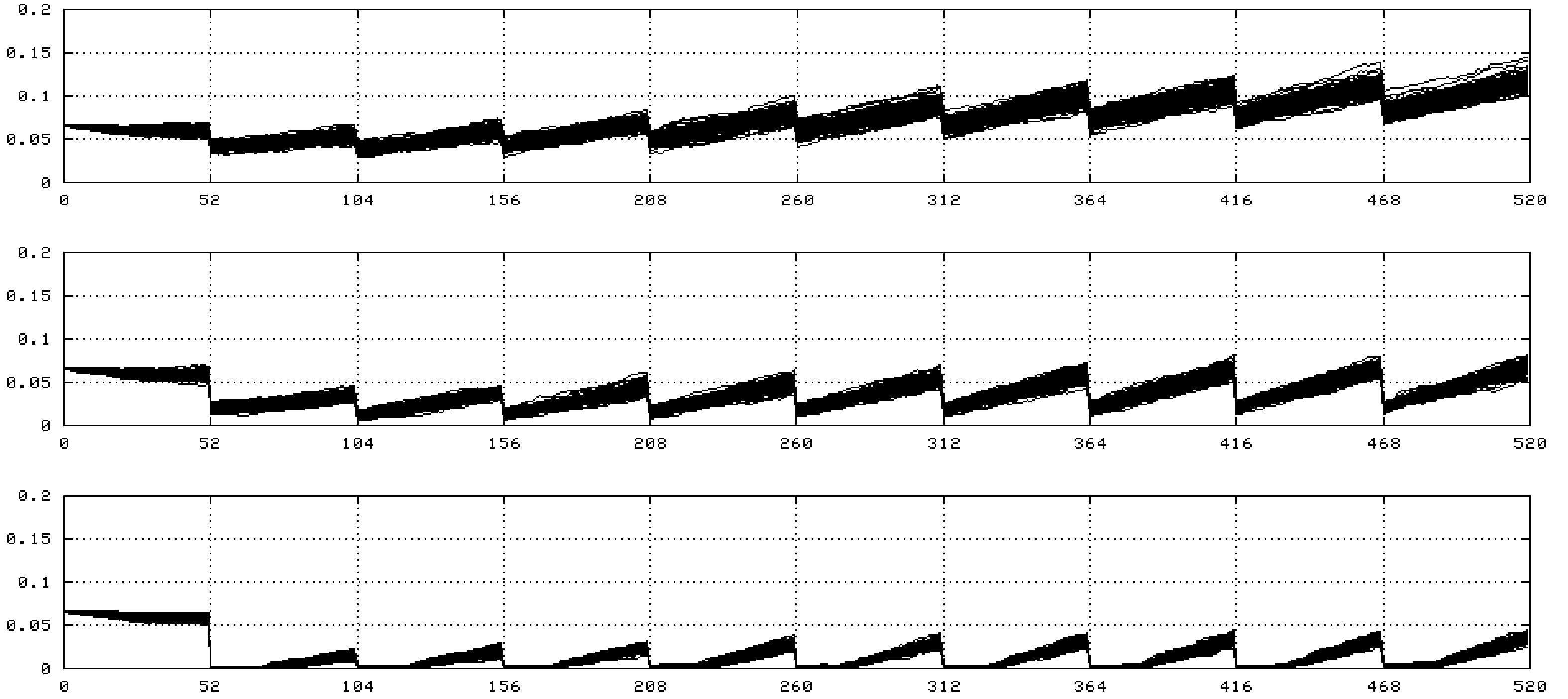

Figure 8. Prevalence rate of humans (all age/occupation groups) in strategies 0, 8 and 10 (from the top to the bottom).

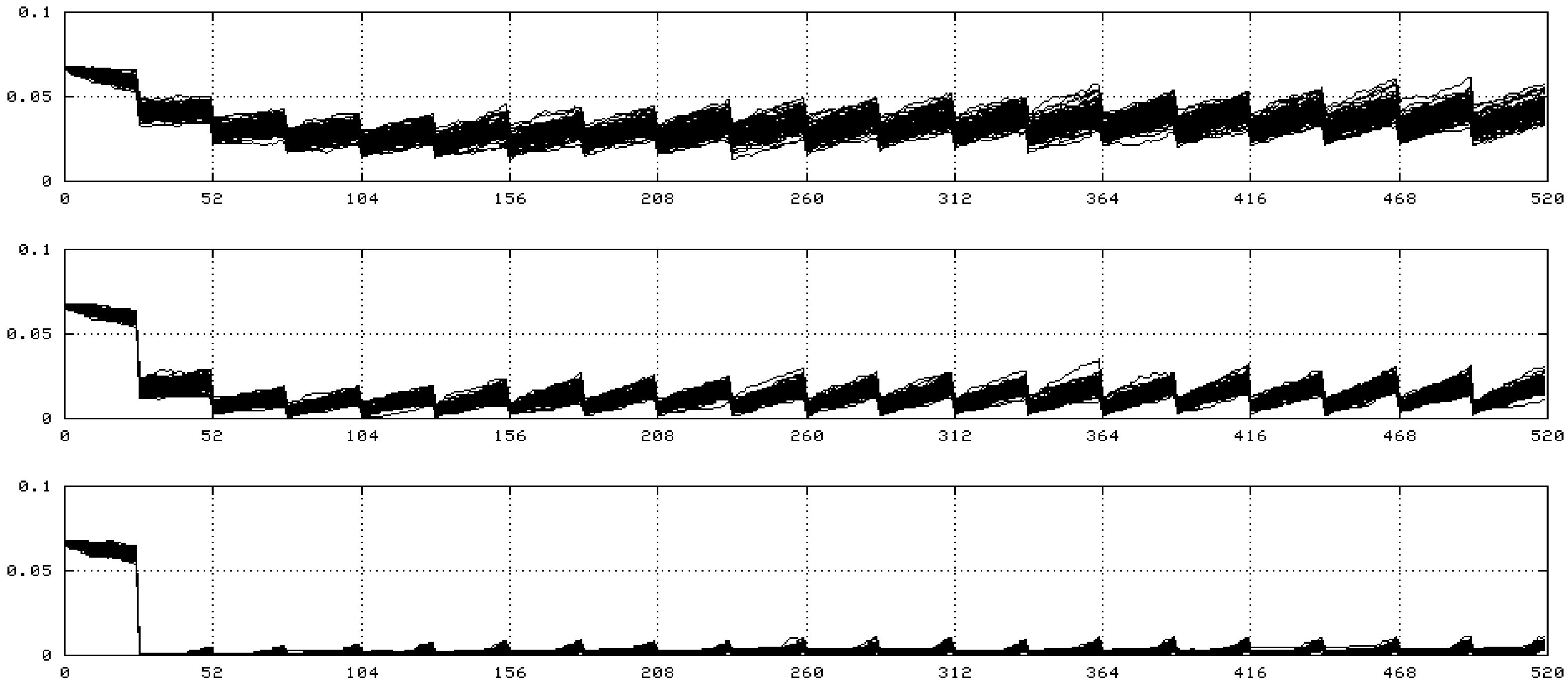

Figure 9. Prevalence rate of humans (all age/occupation groups) in strategies 4, 9 and 11 (from the top to the bottom).