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Ascariasis and Its Control Problems in Korea

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INTRODUCTION

Ascaris lumbricoides is one of the most widely distributed and commonest helminths in the world. According to the paper, 'This wormy world' (Stoll, 1947), the number of infected cases among 2,167 million global population was estimated about 644 millions (about 30 percent), and the majority in parts of Asia were found to be infected. Korea, which is a peninsula of Asia continent, seems also one of the nations where temperature, soil nature and other socioenvironmental conditions are favourable for infection cycle of this worm.

In fact, the prevalence had been high in Korea according to many reports until about a decade ago. Recently, however, the condition has been much improved not only due to the elevated socioeconomic status of Korean people but also due to the control activity performed by the Korea Association for Parasite Eradication (KAPE) mainly on primary, middle and high school students for longer than 10 years (KAPE, 1980).

Nevertheless, the present status of *Ascaris* infection in this country is not satisfactory. The prevalence was still 14.6 percent among student groups in spring, 1980 and 41.0 percent among whole age groups in 1976 (KAPE, 1980; Ministry of Health and Social Affairs and KAPE, 1976). However, it is demonstrated that the prevalence has been steadily declining. In this connection the present intention is to strengthen the control activity and also to attempt eradication from this country.

In assessing the desirability of special control programme of ascariasis, the research team of the Institute of Endemic Diseases, College of Medicine, Seoul National University designed a projected programme in 1976 under the ultimate purpose to investigate more effective and efficient mass treatment strategy. The project was carried out for three years from 1977 to 1980 on the inhabitants of a rural area, Hyangnam Myon, Hwasung Gun, Kyunggi Do, through the research grants from Asian Parasite Control Organization, The Ministry of Education, Republic of Korea and others.

The above pilot project was quite successfully pursued in order to make greater progress towards the control of ascariasis in this country. The author would like to present and discuss the obtained results with brief review of literature. The main subjects dealt in this paper were biological and epidemiological parameters related to the control and approaches to the control strategy.

BIOLOGICAL ASPECT

Migration and Prepatent Period

It is well known that infection occurs when embryonated eggs are ingested through contaminated food and drink. They hatch in the duodenum where they penetrate mucosa, submucosa and enter lymphatics or venules. After passing through the right heart, they take the

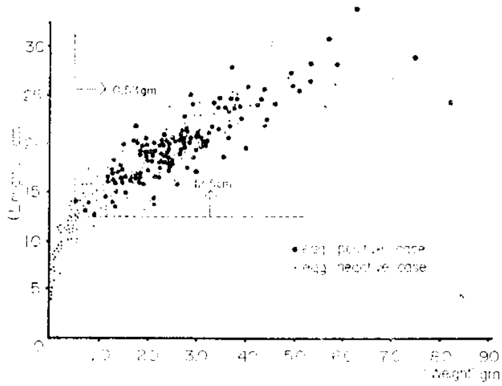

Fig. 1. Positivity of egg according to the length and weight of the infected female worm.

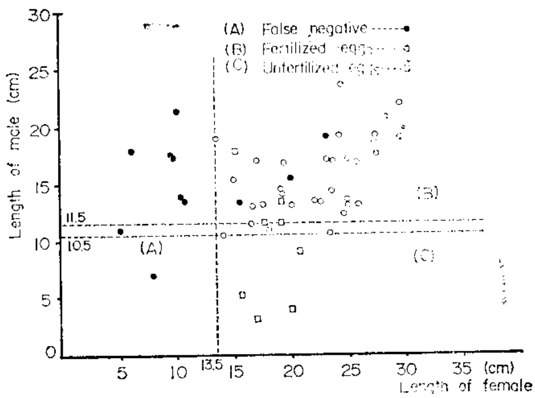

Fig. 2. Egg laying pattern of *A. lumbricoides* according to the length of infected male and female worms.

socalled 'lung migration' process and reach small intestine where they mature.

However, as for the period of lung migration process, few reports are available in case of human *Ascaris*. But in pig strain, *Ascaris suum*, the period was about 14-21 days(Soulsby, 1965), and this may not be far different from that of human strain, considering Koino(1924)'s report that he suffered from severe *Ascaris* pneumonia due to migrating larvae through lungs until 17th day after self ingestion of 2,000 infective eggs.

In assessment of therapeutic efficacy of commonly used anthelmintics such as pyrantel pamoate and mebendazole, it is important to consider the migration period, because the larval worms in migration stage could not be removed by one time treatment, but by repeated chemotherapy after the completion of migration. Based on this concept, Seo et Chai (1980a) added 2 weeks as migration period in calculation of the age of maximum sized worms collected after repeated mass chemotherapy at regular intervals.

After the migration, *Ascaris* worms grow rapidly in the small intestine until they are able to reproduce eggs. The period from infection to oviposition, i.e., the prepatent period, was reported about 61-76 days according to some papers (WHO, 1967; Galvin, 1968).

Then, Seo et al.(1980a) calculated this period again in different way from the above reports. They analyzed the relationship between length of worms of each sex and result of egg examination in 289 cases, 241 with only one female and 48 with a pair of worms.

As shown in Fig. 1 and Fig. 2, the lowest limitation of length of females which produced eggs was 12.5 cm in Fig. 1 and 13.5 cm in Fig. 2, and that of males was 10.5-11.5 cm in Fig. 2, which values were not so different from those reported by Masuda (1959). The time needed for worms to grow to such extent was calculated with the equations of growth curves in length (Seo et Chai, 1980a) and the result was 1.8-2.1 months in female and 2.1-2.5 months in male, which was nearly the same value as ever reported.

The prepatent stage of *Ascaris* worms is epidemiologically important because newly fertilized eggs would be produced after the stage passed, and thus, reinfection chance would increase accordingly. Therefore, in order to prevent new egg production from a community, mass treatment interval should not exceed the prepatent period of this worm. In practice, Seo et Chai (1980a) applied this concept in eradication model at Hwasung Gun project programme.

Time-related Growth Pattern in Length and Weight

On the time-related growth of *A. lumbricoides* worms in human host, there have been few reports even though it was sometimes needed to estimate the age of worms recovered from intestine. Moreover, Masuda (1963) was of opinion that later than one month after beginning of fertility it was impossible to determine the age of worms with their length and/or weight because weights of females of some age were variable according to depletion status of ovary.

However, Seo et Chai (1980a) did not agree to Masuda's opinion, because length can hardly be dependent upon the status of reproductive organs and because Cho (1977) proved that weight of worms was highly correlated with length under the equation, '$\ln Y=3.032 \ln X -8.2903$ (X: length in cm, Y: weight in gm)'. So, Seo et Chai (1980a) tried to establish time-related growth curves of *Ascaris* by length and weight of the worms collected after chemotherapy in the project area of Hwasung Gun.

As the first step, worms of the maximum growth were collected among those recovered from the inhabitants after repeated mass chemotherapy at regular intervals, 2-month, 4-month, 6-month and 12-month, and as the next step their age as calculated by adding 0.75 month to each interval. This calculation took into consideration both the drug resistance of larval worms during a period of about 2 weeks for the migration and the delay of about one week between successive treatments.

The growth curves obtained were as drawn in Fig. 3 and 4. And according to Seo et Chai (1980a), the relation between length and age of worms could be expressed as follows: $Y=9.213 \ln (X+1)+0.025$ in male and $Y=11.953 \ln (X+1)+0.025$ in female (X: age in month, Y: length in cm). From the figures, it was indicated that the growth of females was more rapid and remarkable than that of males, and the weight increase was more marked than the length one, especially after sexual maturity in both sexes.

Although the growth pattern is fairly well

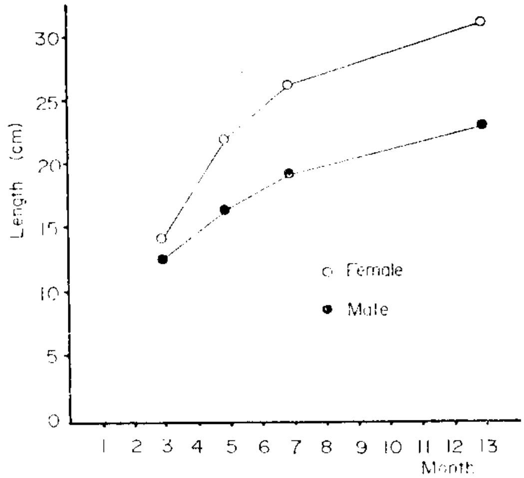

Fig. 3. The growth curve of *A. lumbricoides* revealed by length of worms(from Seo et Chai, 1980a).

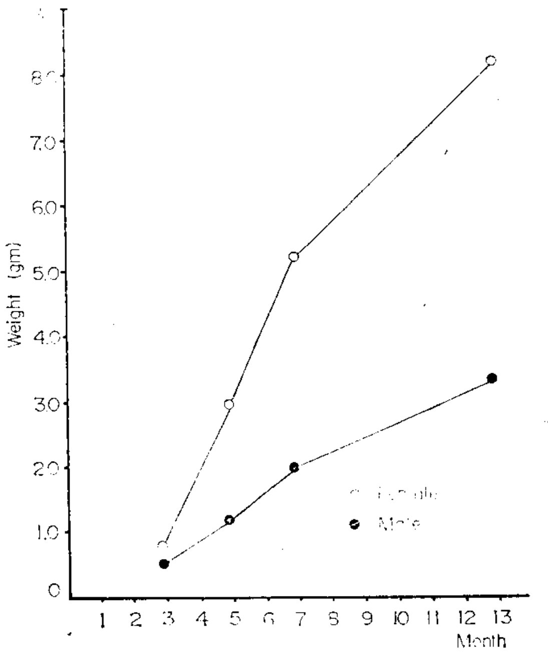

Fig. 4. The growth curve of *A. lumbricoides* revealed by weight of worms(from Seo et Chai, 1980a).

understood, there are regretfully few informations either on life span or on natural turnover pattern of *Ascaris* worms within human host. Detailed study should be performed on this matter so as to understand better the epidemiological relation between host and parasite.

EPIDEMIOLOGICAL CHARACTERISTICS

Prevalence in Korea

For the better understanding of the present status of *Ascaris* infection, it seems necessary to review the chronological rates of prevalence which have been reported in Korea since 1910s. As summarized in Table 1, egg positive rate in some Korean people has been higher than 80 percent until Korean War, 1950～53. After then, the prevalence must have increased as a sequelae of the war, although there are few available data to verify it.

An apparent decreasing tendency of *Ascaris* prevalence was recognizable after 1960s, when the civilian parasite control organization such as Korean Association for Parasite Eradication (KAPE) was founded in 1964. Thus, according to Seo et al. (1969), who firstly performed nationwide and full-scale prevalence survey in Korea, egg positive rate was lower than before 1960 and 58.2 percent among 40,581 randomly selected persons from all over the country. Afterwards, the nationwide prevalence of *Ascaris* was estimated by the Ministry of Health and Social Affairs and KAPE (1971 and 1976) to be 54.9 percent in 1971 and 41.0 percent in 1976 among urban and rural inhabitants. From the above nationwide surveys with regular interval, annual rate of decrease in prevalence was calculated 2.78 percent in average.

However, more recently, there are few reports on the nationwide prevalence of general parasitic helminths in Korea. Seo et al. (1980c) detected 23.7 percent of *Ascaris* egg rate during the status survey on fluke infection in the inhabitants residing at riverside villages (unpublished data), however, this data may not be appropriate to represent nationwide status of *Ascaris* infection.

Therefore, it is strongly postulated that the nationwide surveys on general human parasites should be performed in the near future.

On the other hand, there are much reliable data on the prevalence in student group. Resulted from the biannual mass chemotherapy performed about fifteen years by KAPE, egg rate of *Ascaris* had much decreased from 55.4 percent in 1960 to 15.1 percent in 1979, as pre-

Table 1. Decreasing pattern of *Ascaris* prevalence in Korea

Author(Year)	No. exam.	Egg posit. rate (%)	Subject	Area
Stryker(1914)	206	85.0	Hospital patients	Hwanghae Do
Hara et Himeno(1924)	1,141	81.3	Students	South Kyongsang Do
Sekiguchi et al.(1937)	601 4,594	95.6 95.7	Students Inhabitants	South Kyongsang Do
Keijo Imperial Univ.(1940)	717	79.9	Inhabitants	Suburban Seoul
Hunter et al.(1949)	919	82.4	Inhabitants	All over the country
Brook et al.(1956)	1,726	81.3	Prisoners of war	North Korea
Seo et al.(1969)	40,581	58.2	Inhabitants	All over the country
*MHSA & KAPE(1971)	24,887	54.9	Inhabitants	All over the country
*MHSA & KAPE(1976)	27,178	41.0	Inhabitants	All over the country
Seo et al.(1980c)	13,375	23.7	Inhabitants	Riverside villages

*Ministry of Health and Social Affairs, Republic of Korea & The Korea Association for Parasite Eradication

Table 2. Annual prevalence of *Ascaris* in student group (KAPE's report, 1980)

Year	No. exam.	No. egg positive	(%)
1969	6,551,926	3,631,699	55.4
1970	10,871,280	6,042,588	55.6
1971	11,813,868	6,100,187	51.6
1972	11,243,033	5,148,951	45.8
1973	12,116,892	5,830,227	48.1
1974	11,901,236	4,545,509	38.2
1975	12,480,942	4,835,409	38.7
1976	13,423,636	4,519,433	33.7
1977	14,160,212	4,211,724	29.7
1978	15,030,061	2,914,865	19.4
1979	15,592,977	2,347,664	15.1

sented in Table 2 (KAPE, 1980). Annual rate of decrease was 3.44 percent during 1969-74 and 4.62 percent during 1974-79.

Nevertheless, it is assumed that the present status of *Ascaris* infection is far from satisfactory as already mentioned because the ultimate goal is to achieve the control and eventually the eradication from this country. Now mass treatment programmes have demonstrated that it is amenable to control and, in certain circumstances, to eradicate. And it is highly desirable that a more effective measure of mass chemotherapy be determined.

In the project area of this study, the overall pre-treatment egg rate was 41.7 percent among 937 inhabitants in April, 1977. After 3 years' progress of the control programme, the rate was reduced to 9.1 percent among 695 examined in May, 1980.

Intensity of Infection

There have been used three kinds of methods to measure the intensity of *Ascaris* infection in a community(WHO, 1967). Those are worm counting at autopsy table, worm counting after chemotherapy with excellent drugs, and egg counting in each unit of stool specimens.

In Korea, few studies have been performed on worm burden of *Ascaris* in autopsy cases because there have been few cases of autopsy itself. Although measurement of worm burden by chemotherapy was attempted in earlier days, the available records had not been made on the results. Quite recently, Cho(1977) estimated the intensity of infection in some rural populations using pyrantel pamoate. He reported that average worm burden of *Ascaris* in primary school children at Eujungbu City and inhabitants of Hoengsung and Jinyang Guns were 2.0, 3.4 and 10.2 percent among infected cases, where egg rates were 28.5, 53.8 and 72.3 percent respectively. In the project area of Hwasung Gun, where egg rate was 23.9 percent at pre-treatment, average worm burden was 2.7 among infected cases and 1.1 among whole inhabitants(Seo et al., 1979a).

Many reports have been made on the intensity of infection revealed by average value of egg counts(E.P.G.: number of eggs per gram of feces) in various groups of population in Korea. It was reported by KAPE (1980) that average E.P.G. was reduced from about 3,000 to 1,800 during 1973-78 in student goup. In whole age group, average E.P.G. was 9,723 in 1969 (Seo et al., 1969) but reduced to 2,658 in 1976 (Ministry of Health and Social Affairs and KAPE, 1976).

On the other hand, the distribution pattern of E.P.G. grade rather than average value itself was often compared (Ministry of Health and Social Affairs and KAPE, 1976). Then, it was observed that as the prevalence decreased the proportion of cases with low E.P.G. grade under 1,000 increased while those over 10,000 decreased relatively.

Distribution Pattern of Worm Burdens accordng to Endemicity

As is also the case with egg counts, average value of worm burden may vary greatly depending on a few number of heavy burden cases.

Table 3. Frequency distribution pattern of *Ascaris* in host population according to surveyed areas (from Seo et al., 1979a)

No. worms per case	Observed frequency of cases in areas*						Total
	A	B	C	D	E	F	
0	329	57	13	18	8	17	442
1	108	21	5	7	3	6	150
2	39	15	3	4	1	7	69
3	22	7	3	6	5	5	48
4	12	8	3	6	2	3	34
5	9	11	2	1	0	3	26
6	4	2	0	1	4	3	14
7	4	1	1	2	2	2	12
8	5	2	0	0	1	2	10
9	0	1	0	0	1	0	2
10	1	1	0	0	3	1	6
11	0	1	1	0	1	2	5
12 & over	7	9	1	2	8	8	353
Total	540	136	32	47	39	59	853
Egg rate (%)	23.9	40.4	46.9	46.8	66.7	59.3	

*A: Hwasung Gun, B: Machun Dong, Seoul, C: Hoengsung Gun, Kangwon Do, D: Jangheung Gun, South Cholla Do, E: Jinyang Gun, South Kyongsang Do, F: Kangjin Gun, South Cholla Do

Therefore the distribution pattern of number of cases with certain expelled worm burdens of *Ascaris* in a group of population is also more important so as to understand better the severity of infection.

In Japan, Fushimi (1959) observed that the pattern was not regular distribution but overdispersed and skewed one with an apparent tendency that the lower the burden the more the number of cases were and the heavier the burden the less the cases. He fitted his data to the theoretical model of Polya-Eggenberger distribution and obtained low grade statistical fitness. Similar finding was observed by Seo et al. (1979a) as shown in Table 3, however, statistical test revealed better fitness to negative binomial pattern than Polya-Eggenberger one. And yet, in highly endemic groups such as Groups E and F, both kinds of distribution patterns were equally fitted to observed data.

Table 4. Relatively constant proportion of cases with worm burden 1~4 regardless of endemicity (from Seo et al., 1979a)

Endemicity (Area)	Low(A)	Moderate (B,C & D)	High(E&F)
Worm burden	No. cases (%)	No. cases (%)	No. cases (%)
0	329(60.9)	88(40.9)	25(25.5)
1~4	181(33.5)	88(40.9)	32(32.6)
5~9	22(4.1)	24(11.2)	18(18.4)
10 & over	8(1.5)	15(7.0)	23(23.5)
Total	540	215	98

*Statistical test for identity of above three patterns; $p<0.001$

The difference in the epidemiological meaning of two kinds of patterns is not so clear-cut, although negative binomial pattern was more properly applicable in helminthic infections while Polya-Eggenberger pattern was applicable in case of protozoal infections in which parasite population geometrically increase within or without host(Crofton, 1971).

Anyway, an interesting finding was observed by Seo et al.(1979a) that as shown in Table 4, when the prevalence in 6 surveyed areas (Table 3) was divided into three different endemicity groups, the proportion of heavy burden cases was much lower in less endemic areas, while that of light burden cases with 1~4 worms was quite consistent. This observation is thought to suggest that as endemicity was lowered by chemotherapy or other measures, the heavy burden cases shift to light burden cases and the light burden cases to non-infected group. Another observation supporting this suggestion was dealt in next section(Fig. 6).

Egg Discharging Pattern according to Worm Burdens

It is certain that even in actual infection cases with *Ascaris* worms, there can be three kinds of manifestation in stool examination. Those may be one of the followings; false negative, positive for unfertilized eggs, and positive for fertilized eggs with/without unfertilized ones.

Seo et al.' (1979b) analyzed the concrete relationship between the number (and sex combination) of worms and egg findings. As shown in Fig. 5, it was apparent that the higher the worm burden the possibility to produce fertilized eggs increased remarkably, on the other hand, the possibility to be false negative or positive only for unfertilized eggs increased as the worm burden became lower. In practice, nearly all of the false negative and unfertilized egg cases harboured less than 5 worms of any sex.

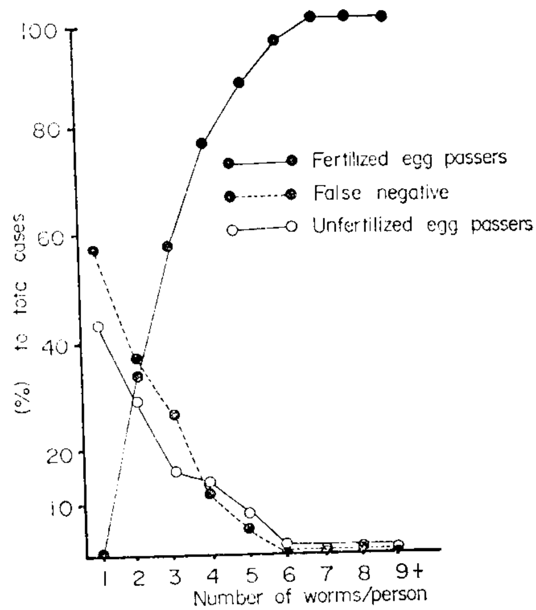

Fig. 5. The probability to be positive for unfertilized or fertilized eggs and false negative result according to worm burdens per case(from Seo et al., 1979b).

Furthermore, they analyzed the biological reason for the false negative result in 125 cases with a few number of worms(Table 5). The most frequent reason was uni-sex infection with male(s) in 52 percent of all cases, the next was infection with immature young worms (females) with/without male(s) in 25 percent.

Table 5. Analysis of the biological reasons for false negative results in stool examination (from Seo et al., 1979b)

Feature of worms	No. cases in each area						Total	
	A	B	C	D	E	F	No.	%
Male worms only	50	7	1	2	3	2	65	52.0
Young female(s) with or without male(s)	13	15	1	0	2	0	31	24.8
Old female(s) with or without male(s)	8	2	0	1	0	0	11	8.8
Females with no distinct character	7	1	2	3	0	5	18	14.4
Total	78	25	4	6	5	7	125	100.0

Remaining 25 percent of cases had mature female(s), but exact cause of infertility was hardly explainable putting aside the fact that some of them were old worms longer than 30cm and heavier than 8.0gm.

Epidemiological Significance of Unfertilized Eggs

As Morishita (1972) stated, observation on the status of unfertilized egg passers in a community is important to estimate the degree of infection and to assess the efficacy of control measures carried out. And according to him, it was indicated that the ratio of unfertilized egg-passers-to-all positive egg-passers (U-rate) was inversely related with the prevalence rate i.e., higher prevalence was accompanied by lower U-rate and lower prevalence by higher U-rate.

Seo et al. (1979a) observed again this phenomenon. As shown in Fig. 6, the ratio of unfertilized egg-passers to total egg positive cases apparently decreased according to elevation of prevalence. The regression equation of U-rate (Y) on prevalence (X) was $Y=69.2-0.90X$ (regression coeff. $r=-0.93$) in the range, $23.9<X<66.7$.

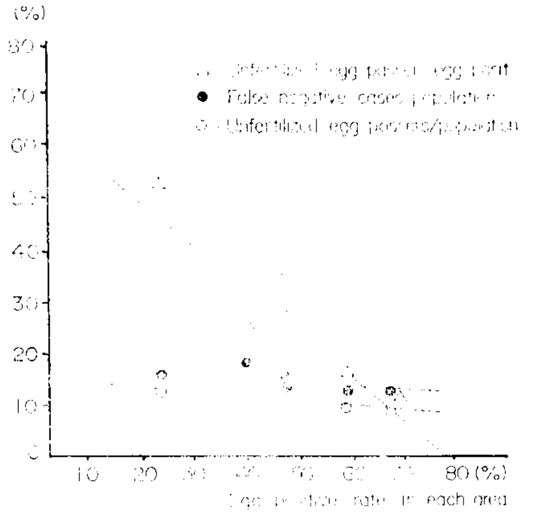

Fig. 6. Regression lines of some indices according to endemicity of each area (from Seo et al., 1979a).

On the other hand, the proportion of unfertilized egg-passers among whole population was nearly not affected by change of prevalence. It appeared to be quite consistent regardless of egg rates, which could support the suggestion, as already described, that heavy burden cases should become light burden cases and light burden cases become non-infected individuals when mass chemotherapy is repeated on the population. The regression equations were '$Y=16.0-0.10X$ ($r=-0.51$)' of unfertilized egg-passers/population(Y) on prevalence(X) and '$Y=18.4-0.09X$($r=-0.63$)' of false negative cases/population(Y) on prevalence(X).

Seasonal Fluctuation Pattern of Reinfection Incidences

It has been suggested in Korea that there would be a tendency of seasonal fluctuation in reinfection incidences according to KAPE's 10 year data on *Ascaris* prevalence in spring and autumn among student group (KAPE, 1980), as presented in Fig. 7. The prevalence in spring has been always higher than that in autumn season of previous and same year, which means higher reinfection rate during winter season.

In the project area, an apparent tendency of seasonal fluctuation in *Ascaris* reinfection was observed (Seo et al., 1979c). The reinfection rates were checked monthly throughout a year in six villages, each of which was treated 6 months previously. Reinfection was expressed in terms of egg and worm positive rates, which meant accumulated reinfection rates during preceding 6 months, and of immature young worm rate, which meant recent reinfection during 1~2 months before (Cho, 1977; Seo et al., 1980a).

Seasonal fluctuation was remarkable, as drawn in Fig. 8, and there were roughly two peaks both in egg and worm positive rates throughout a year. The larger peak was observed from

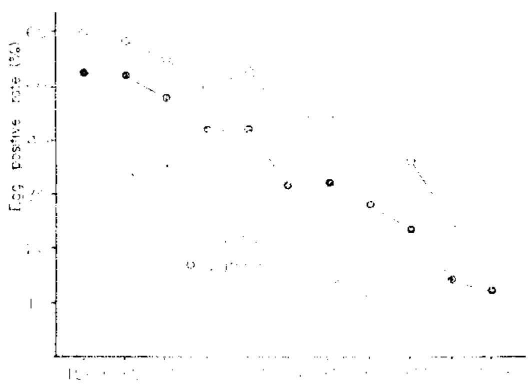

Fig. 7. Higher prevalence of *Ascaris* in spring season than in autumn in student group(KAPE's report, 1980).

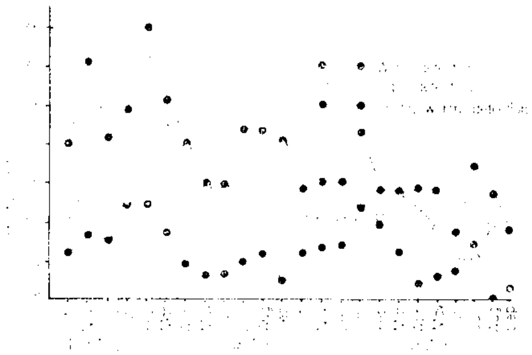

Fig. 8. Seasonal fluctuation pattern of *Ascaris* reinfection incidences(from Seo et al., 1979c).

February to March and the smaller one from August to September in case of egg and total worm rates, however, immature worms were more frequently detected one month earlier. Therefore, actual time for occurrence of reinfection was considered during November to December for the larger peak and May to June for the smaller one, deducting 2 months of the prepatent period. This result explained well the data of KAPE(1980) in Fig. 7.

Seo et al.(1979c) stated that pickled vegetables for the wintering were suggested as the most probable source of reinfection during winter season as is also the case in Japan (Morishita, 1972), but the reason for the peak in early summer could not be explained easily. Morishita (1972) explained that another peak in Spring may be due to *Ascaris* eggs transfered by wind in Japan, however, it seems not so readily admittable in Korea until present.

CONTROL ACTIVITIES IN KOREA

Methods of Ascariasis Control

It is needless to say that the condition of *Ascaris* infection in a community could be reformed not only due to socioeconomic improvement of inhabitants but also by means of control activity of various kinds. The measures for control activity may be one or more of followings: health education, environmental sanitation and mass chemotherapy(WHO, 1967).

Then, among the above measures, mass chemotherapy is considered most active and efficient one because it directly blocks the life cycle of *Ascaris* by removing worms before a vast amount of eggs are liberated at environment. However, even when mass chemotherapy method was adopted as the main control measure, public health education and various kinds of environmental sanitation measures should be concomitantly applied so as to make the result better.

Control Activity by Civilian Organization

There are several civilian health organizations in Korea under the supervision of the Ministry of Health and Social Affairs, Republic of Korea. Among them, the Korea Association for Parasite Eradication (KAPE) was established in 1964 with the ultimate purpose to control parasitic infections in this country. This organization now consists of one central office in Seoul and 11 regional branches in 9 provinces and 2 cities, so as to extend the control activity nationwidely.

The parasite control activity in Korea has been guaranteed under the legal basis (Prevention Law of Parasitic Diseases) since 1966 and all of the important parasites in this country such as roundworm, hookworm, pinworm, liverfluke, lungfluke and tapeworm have been included in KAPE's activity. However, major attention has been given to ascariasis up to present.

As mentioned already, KAPE's control activity has been directed mainly to student group under the principle of biannual mass chemotherapy on egg positive cases since about fifteen years ago. But, persons of certain social groups such as employees, industrial workers, inhibitants of remote islands, etc. have been also favored with periodic examination and treatment in free of charge. Still, there remains many people, especially in highly endemic areas, to be absolutely included in mass chemotherapy in the future.

Other than mass chemotherapy, educational movement for prevention and treatment of parasitic infections has been done through various mass media such as radio, TV, 16mm film, transparency slide, poster, pamphlet, leaflet and periodical journal. Another important activity of KAPE is the nationwide monitoring of intestinal helminthic infection status on all age groups every 5 years. The results in 1971 and 1976 were already reported and the survey in 1981 is now being undertaken.

Chemotherapeutic Agents and Dosage

In treatment of *Ascaris* infection, many kinds of suitable drugs had been used such as santonin, kainic acid, santoninkainic acid complex, piperazine and bephenium salts, etc. But about a decade ago, new excellent drugs such as pyrantel pamoate,, mebendazole and levamisole were introduced and have been widely used in Korea.

The efficacy of one time treatment with those drugs(pyrantel; 10 mg/kg in single dose, mebendazole; 200 mg b.i.d. for 3 days, levamisole; 5 mg/kg in single dose) was satisfactory and over 93 percent in negative conversion(=cure) rate and over 95 percent in egg reduction rate (Rim et Lim, 1972; Seo et al., 1972; Soh et al., 1974; Kim, 1975; Seo et al., 1977; Seo, 1979).

Moreover, pyrantel and mebendazole were proved also highly effective even with reduced doses, 2.5 or 5.0 mg/kg and 100 mg respectively in single dose and over 85 and over 93 percent in cure and egg reduction rates respectively (Seo et al., 1973; Seo et al., 1978). Therefore, these drugs had better been used in reduced dose in mass chemotherapy, considering cost-efficiency of control programmes. Furthermore, Seo et Chai (1980b) proved that the efficacy of quarter dose (2.5 mg/kg) of pyrantel pamoate was nearly equal to higher ones when used repeatedly every other month for one or more years.

All of the above drugs were reported quite safe to human. Although a few cases complained mild gastrointestinal troubles such as nausea, abdominal pain and diarrhea after pyrantel or mebendazole treatment, such symptoms were transient and required no specific treatment.

Subjected Population in Mass Chemotherapy

As well as in other parasitic infections, there may be two kinds of subjected people in mass chemotherapy against *Ascaris* infection. Chemotherapy can be done either on egg positive cases or on whole population. But, the more generally applied method is, of course, treatment only on egg positive cases and it is highly convenient and efficient method in certain circumstances.

However, theoretically, it will be more effective to include whole population residing in the community in each mass chemotherapy trial. With this method, there will be no drop-outs who are actually infected but egg negative cases in stool examination due to any one of the biological reasons (Seo et al., 1979a). Although false negative cases do not take part in spreading infective eggs, they may have possibility to produce fertilized eggs in the near future than uninfected cases.

The latter method was applied in the project programme of ascariasis control (Seo et al., 1980b; Seo et Chai, 1980b) and it was indicated that the better results obtained than those obtained by treatment on egg positives only.

In biannual mass chemotherapy scheme, KAPE's activity by the treatment on egg positives only resulted in 2.3 percent decrease in prevalence rate per treatment during 1974-79, while present study by the blanket mass treatment on whole population (Seo et al., 1980b) allowed 8.5 percent decrease per treatment during 1977-79. Nevertheless, considering the present prevalence on whole population, the blanket mass treatment hardly recommendable for the nationwide control programme. It is assumed that vast amount of budget and manpower is needed but the efficacy may not be better as much as that.

Irrespective of the cost-benefit between the above two methods, it is emphasized that special attention be paid to fertilized egg passers as the important control target, who actually participate into the transmission of the infection (Seo et al., 1979b).

Reinfection after Chemotherapy

In ascariasis as well as other parasitic infections, it is needless to say that reinfection is the most important phenomenon for the successful maintenance of the vicious cycle. Then, the incidence of reinfection is said to be largely affected by prevalence and worm burden in the population, environment, seasonal change and control activity performed (Morishita, 1972). The chemotherapeutic control of ascariasis is encouraged due to the gradual reduction of reinfection.

However, if mass chemotherapy is done only one time or intermittently, reinfection will be persistently contracted by the eggs already contaminated at environment until they are exhausted out. Therefore, mass chemotherapy should be repeated at regular intervals when satisfactory control is desired.

Arfaa et Ghadirian (1977) reported in central Iran that reinfection was so rapid that the prevalence of *Ascaris* one year after mass chemotherapy with pyrantel pamoate was nearly the same as pre-treatment level, where egg rate and worm burden were 87-95 percent and 16.0-34.8 respectively. Similar finding was observed in the project area in Korea. The egg rate and worm burden were 35.2 percent and 2.1 at pre-treatment and 36.4 percent and 2.4 one year after mass chemotherapy. (Seo et al., 1980b).

These observations indicate that one year interval of mass treatment seems to be sufficient for the prevalence to return to the pre-treatment level and to attain equilibrium status among host population. Consequently the mass chemotherapy should be performed more than twice a year, especially where prevalence is considerably high.

Rapidity of reinfection during shorter period than one year was reported largely variable according to conditions and situations of each area concerned. In Japan, where *Ascaris* was nearly eradicated, the reinfection rate during 6 months was less than 1 percent in 1971-73 (Morishita, 1974). On the other hand, in some areas of the Philippines, where the prevalence rate was in the range, 85-95 percent, there observed much higher reinfection rates up to 68.6 percent during 4.5 months, 85.8 percent during 6.5 months, and 89.5 percent during 8.5 months after one time mass chemotherapy with pyrantel pamoate (Cabrera, 1975). The situation in Korea between the above two countries was that the egg rate which was 33-42 percent at pre-treatment returned to one-third level after 4 months and to about half after 6 months (Seo et al., 1980b).

It was apparent that reinfection incidence decreased as much as control activity progressed. According to Seo et Chai (1980b), monthly new infection rate in the repeatedly treated group with 2-month was about 1 percent at initial stage but decreased to 0.25 percent at later stage. However, in the interruptedly treated groups, the rate was elevated to about 2 percent within one year after the interruption.

Frequency of Mass Chemotherapy

It was already mentioned that, if *Ascaris* control is intended, mass chemotherapy should be by all means repeated. It is not only because repeated mass chemotherapy can reduce continuously fertilized egg production and reinfection rate but because it lessens the worm burdens among population especially of heavily infected cases.

In repetition of mass chemotherapy, there are three important problems to be decided. One is the frequency of treatment in a year (interval between treatments), and the others are the adequate timing (month or season) of each treatment and the total duration of control programme.

On the frequency or interval of mass chemotherapy, Morishita(1972) was of opinion that it should vary according to prevalence rate of the area concerned. But, there have been few studies in Korea to decide it properly. The biannual mass chemotherapy scheme has been conducted by KAPE for more than 10 years although much appreciable result was obtained, with no sufficient background based on any controlled study.

In this respect, Seo et al., (1980b) evaluated the comparative efficacy of 2-month, 4-month, 6-month and 12-month interval schemes in the main project area of the study. They applied blanket mass chemotherapy on whole subjected population using pyrantel pamoate in dose of 10mg/kg throughout the project.

The pre-treatment egg positive rate and worm burden were 33-42 percent and 1.6-4.2 respectively according to each interval group.

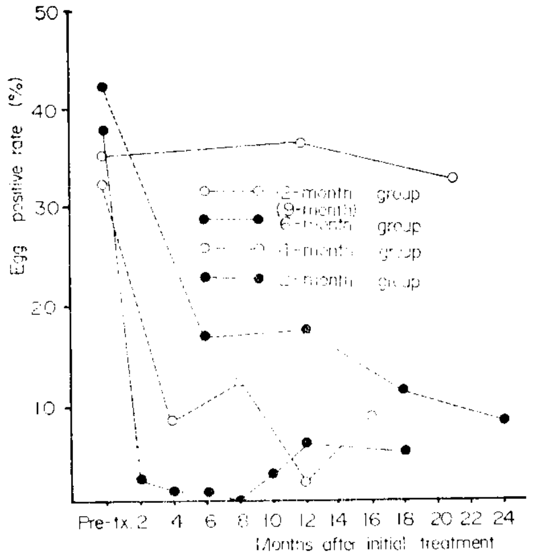

Fig. 9. Comparative efficacy of various interval mass chemotherapy revealed by egg positive rate (from Seo et al., 1980b).

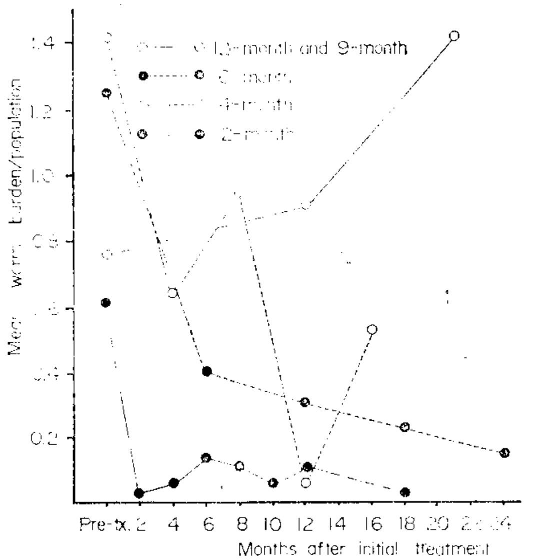

Fig. 10. Decreasing pattern of worm burden per population during the course of various interval mass chemotherapy (from Seo et al., 1980b).

As shown in Fig. 9 and 10, the control efficacy showed the better results when the treatment was repeated more frequently at shorter intervals. And annual treatment scheme was proved by no means effective for *Ascaris* control because the prevalence and worm burden returned to the pre-treatment level.

In all of the other three groups, apparent reduction effect in prevalence was observed. In biannual and triannual schemes, both of the endemicity indices, prevalence and worm burden (Fig. 9 and 10 respectively), were rapidly reduced as the treatment was repeated. And furthermore, in bimonthly schedule, in which reduction of egg rate was more conspicuous, *Ascaris* reinfection was finally stopped after 28 months' trials (Seo et Chai, 1980b).

The efficacy of mass chemotherapy was the better as repeated more frequently at shorter intervals. However, there should be a deep consideration before deciding the interval of treatment. And even though every two or three month scheme has been recommended by some workers (WHO, 1967; Arfaa et Ghadirian, 1977), it may not readily be adopted from the view point of cost-benefit in developing countries as a control measure. In general biannual or triannual scheme seems to be amenable to control. However, the feasibility of a certain control measure should be determined at specific local conditions, namely prevalence rate, intensity of infection, availability of suitable drugs, control organization, amenability of the people to control and other socio-economic factors.

Timing of Mass Chemotherapy

The adequate timing of mass chemotherapy is a very important factor in the control programme from the aspect of its cost-effectiveness. According to WHO(1967), in areas where a large seasonal variation occurs in *Ascaris* transmission, treatment should begin four to six months after transmission starts and it be continued until two months after the end of transmission season.

In this respect, biannual or triannual mass chemotherapy in Korea, seemed to be adequate and recommendable considering the two seasonal peaks in reinfection incidences (Seo et al., 1979c); the larger peak from November and the smaller one from May.

Late December and late June were considered appropriate timings in case of biannual scheme, and late November, late March and late July in case of triannual one. If modification is allowed in triannual scheme emphasizing the transmission control during winter season, late December, late February and late July may be also considerable.

Tctal Duration of Mass Chemotherapeutic Activity

In order to perform satisfactorily the control programme of *Ascaris* infection, mass chemotherapy should be continued until reinfection does not occur. However, it is really hard to check whether reinfection is actually discontinued, unless blanket mass treatment is done and whole-day stool specimens are completely collected and examined for overall worms including immature young worms.

Therefore, it was considered that, theoretically, duration of treatment should be longer than the survival time of already contaminated eggs at surrounding before control activity started, when mass chemotherapy is repeated bimonthly so that there would be no further egg production in the community(Seo et Chai, 1980b). However, it was very difficult to decide the total duration in general because the longevity of infective eggs at environment was reported much variable, 1-10 years according to geographical conditions. In this connection, Seo et Chai(1980b) reported that it took 28 months to eradicate *Ascaris* infection in the project area, a rural Korean village applying blanket bi-

Table 6. Worm collection results by bimonthly mass chemotherapy (from Seo et Chai, 1980b)

Sequential No. treatment	No. exam.	No. worm positive case	No. coll. worms	Worm burden /infected	Worm burden/ population
1	98	45	93	2.1	0.95
2	220	14	34	2.4	0.15
3	183	8	8	1.0	0.04
4	181	21	25	1.2	0.14
5	183	12	16	1.3	0.09
6	168	5	5	1.0	0.03
7	132	10	11	1.1	0.08
8	—	—	—	—	—
9	—	—	—	—	—
10	133	9	16	1.8	0.12
11*	58	2	2	1.0	0.03
12	37	1	1	1.0	0.03
13	50	3	3	1.0	0.06
14	37	1	2	2.0	0.05
15	52	0	0	0.0	0.00
16	41	0	0	0.0	0.00
17	29	0	0	0.0	0.00
18	28	0	0	0.0	0.00

* After 11th treatment, the data were from only Group A in Fig. 11.

monthly scheme.

On the other hand, Hayashi(1977) proposed in Japan a statistical model to estimate not only the effect of control measures but also the possible time when *Ascaris* egg rate would become zero percent, by mass chemotherapy scheme applied. He used several factors as calculating indices such as initial prevalence rate, prepatent period, reinfection rate between treatments, cure rate of the drug used, interval of treatment, etc. The equation of the model was applied in the analysis of KAPE's 10 year biannual prevalence data(KAPE, 1980) and the theoretical data according to Hayashi's model was found well fitted with the observed one.

A Model of Eradication Programme

It is well known that control of reinfection is most important to eradicate *Ascaris* infection from a community. However, it is nearly impossible to block the reinfection cycle completely within a short time, once infective eggs were produced and contaminated at environment. In this respect, Seo et Chai (1980b) attempted to make a village free from further egg production until already contaminated eggs were exhausted out, by means of continuous blanket bimonthly

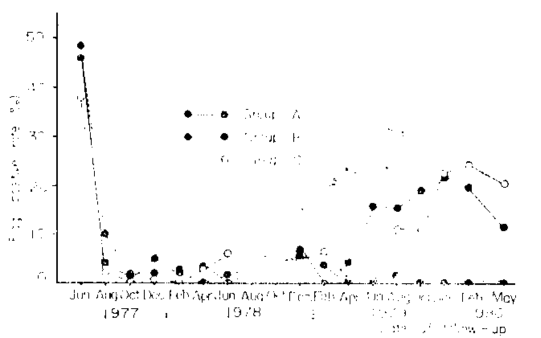

Fig. 11. The results of egg examination in three groups (Group A: bimonthly chemotherapy group until 18th treatment-Table 6, Group B and C: treatment interruption groups on 11th treatment) (from Seo et Chai, 1980b).

mass chemotherapy.

The two months interval mass treatment was adopted in consideration of the prepatent period of this worm lest the larval worms should grow until oviposition, and blanket method was also adopted under the purpose to treat all of the actual infection cases regardless of egg producibility. Discontinuity of reinfection was identified by observing whether immature young worms were found from the stool specimens collected after each treatment.

The result of this study was not different from expected. As shown in Fig. 11 and Table 6, neither egg nor worm positive case was found 2.5 years after the beginning of the programme. Complete negative conversion of adult or immature young worms verified the successful eradication. However, this does not necessarily mean no more reinfection even afterwards because new infective eggs will be introduced again from the outside of the project area due to social communication of inhabitants and foodstuff supply.

Similar *Ascaris* eradication trial was made by Biagi et Rodriguez(1960) by repeated monthly administration of piperazine in a tropical village of Mexico. There, reinfection was stated to have been controlled after 8 months' trial in contrast to this study which took 28 months with a quarter dose of pyrantel pamoate. It may be due to far different situation in reinfection rates between Mexico and Korea where egg rates were 28.3 percent and 48.1 percent respectively. The difference in treatment interval, one month in Mexico and two months in Korea may have been in consideration of the difference in drug efficacy on younger worms residing in intestinal tract of human host.

An important observation by Seo et Chai (1980b) was that when mass chemotherapy was discontinued in Group B and C (Fig. 11) after one and half year's blanket bimonthly trials, the prevalence was found to elevate again. Within one year after interruption, the rate returned to about half of the pre-treatment level. Accordingly, mass chemotherapy should be repeated for sufficiently longer time until ever-contaminated eggs should lose their viability and infectivity.

Future Prospect of Control Activity

On the prospect of *Ascaris* control in this country, a prediction was made by KAPE(1980) that applying Hayashi(1977)'s model in the analysis of 10 years' prevalence data in student group it was revealed that the average value of egg positive rate would be zero percent around 1984-85, if biannual mass chemotherapy is continued.

It must be a delightful prediction to health workers. However, it should not necessarily be interpreted that all of the student group would be free from *Ascaris* infection. There are wide variations in egg rates among students of different schools and areas while in application of the theoretical model the average value was only concerned. So, it is natural to think that it will take longer time than predicted to achieve zero percent status especially where the prevalence is higher than the average value.

In the above respect, further attention should be specially given to those students whose egg rate is considerably high and who are continuously exposed to the vicious cycle of reinfection. And yet, for more effective control, the subjects of mass chemotherapy should be extended to whole population and inhabitants especially in highly endemic areas as soon as possible.

SUMMARY

The results obtained from the project programme of ascariasis control in Hwasung Gun, Korea during 1977-80 were presented in terms of biological and epidemiological characteristics and control problems with brief review and discussion on the related topics. The important observations and comments on each subject were summarized as follows:

In biological aspects: 1) The range in length and the prepatent period of *Ascaris lumbricoides* to become fertile were 12.5-13.5 cm and 1.8-2.1 months in female and 10.5-11.5 cm and 2.1-2.5 months in male respectively. 2) The time related growth curves revealed by length or weight were established and it was observed that females grew more rapidly and remarkably than males.

In epidemiological aspects: 1) The prevalence among Koreans had been over 80 percent until 1960 but afterwards it has been decreasing remarkably to 41.0 percent among inhabitants in 1976 and to 15.1 percent among student group in 1979. 2) The average value of worm burdens was 2.0-10.2 in 1977 according to surveyed groups. 3) The distribution pattern of worm burdens in host population was better fitted to negative binomial distribution than Polya-Eggenberger one. 4) The higher the worm burden in each case the possibility to produce fertilized eggs increased while that to be false negative or positive only for unfertilized eggs became negligible. 5) The ratio of unfertilized egg-passers/total egg positive cases (U-rate) was closely related with prevalence rate inversely. 6) There observed two seasonal peaks in reinfection incidences in Korea, from November to December for the larger peak and from May to June for the smaller one.

And, the problems related with control activity were: 1) In Korea, the Korea Association for Parasite Eradication has been performing control activity under the principle of biannual mass chemotherapy mainly on school student group. 2) Recently introduced drugs such as pyrantel pamoate and mebendazole were proved highly effective and safe even in reduced doses. 3) There may be two groups of target population in mass chemotherapy, but in both cases, the fertilized egg-passers should be considered as primary and absolute target. 4) Although the rapidity of reinfection depends on some factors such as prevalence and worm burden, one year period seemed sufficient time for the egg rate to return to the pre-treatment level. 5) The efficacy of mass chemotherapy was the better as repeated more frequently, however, the interval of mass treatment should be determined at local conditions and situations. 6) Adequate timing of mass chemotherapy in Korea was proposed considering the seasonal fluctuation pattern of reinfection rates emphasizing the transmission control during winter season. 7) It seems possible to decide the total duration of control activity applying a statistical model to each scheme of mass chemotherapy. 8) Reinfection control was aimed by means of blanket bimonthly mass chemotherapy in a rural village, and it took 28 months to make the whole villagers free from reinfection. 9) A prediction was made that the average prevalence in student group would be zero percent in 1984-85 repeating biannual mass chemotherapy, however, more attention should be given to highly endemic population.

=國文抄錄=

韓國의 蛔蟲症 및 그 管理問題

서울大學校 醫科大學 寄生蟲學敎室 및 風土病硏究所

徐　丙　卨

본 硏究所에서 1977年부터 1980年까지 3년간 實施한 京畿道 華城郡 蛔蟲管理示範事業으로부터 얻은 資料를 蛔蟲의 生物學的, 疫學的 및 管理問題의 側面에서 각각 정리하고 관련주제에 관한 文獻考察을 실시하여 종합한바 다음과 같은 結論을 얻었다.

첫째, 生物學的 側面으로 볼 때

1. 生殖能力을 갖게되는 회충의 성장기간 및 그 때의 길이는 암컷의 경우 각각 1.8—2.1 個月 및 12.5—

13.5 cm이었고 수컷의 경우 각각 2.1—2.5個月 및 10.5—11.5 cm이었다.

2. 길이 및 무게로 본 蛔蟲의 時間別 成長曲線을 作成한 바 암컷이 수컷보다 더 빨리 그리고 더 현저히 성장하는 것으로 나타났다.

둘째, 疫學的 特性으로는

1. 韓國人의 蛔蟲感染率은 1960년이전만 해도 80% 이상이던 것이 그 이후 현저히 감소되어 일반주민의 경우 1976년 41.0%, 學生集團의 경우 1979년 15.1%로 나타났다.

2. 個人別 平均 感染蟲體負荷는 1977년 調査에서 대상 群別로 2.0—10.2마리로 나타났다.

3. 感染蟲體負荷의 分布양상은 Polya-Eggenberger 分布보다는 陰의 二項分布에 더 잘 附合되었다.

4. 個人別 感染蟲體負荷가 많을 수록 受精卵을 排出한 確率이 높았으며 반면에 僞陰性이나 不受精卵양성으로 나타날 確率은 희박하였다.

5. 不受精卵率(U-rate)은 流行度와는 밀접한 逆相關關係에 있었다.

6. 韓國의 蛔蟲再感染 발생빈도는 1年 2回의 peak가 形成되었는데 큰 것은 11—12월경, 작은 것은 5—6월경에 觀察되었다.

셋째, 管理現況과 그간 研究綜合結果를 살펴볼 때

1. 韓國寄生蟲撲滅協會는 주로 學生集團에 대하여 1年 2回의 集團投藥을 실시해오고 있다.

2. 最近에 紹介된 藥劑인 pyrantel pamoate 및 mebendazole등은 減量療法으로도 매우 우수한 藥効로 確認되었다.

3. 集團投藥의 對象者選擇은 2가지 方法이 있을 수 있으나 어느경우이든 受精卵排出者를 1차적이고도 절대적인대상으로 하여야 한다.

4. 集團治療後 再感染의 速度는 그 地域의 流行度및 感染强度에 크게 左右되나, 1年間 방치하면 陽性率이 治療前 수준으로 되돌아가는 것으로 나타났다.

5. 集團投藥의 效果는 投藥回數를 늘일수록 우수한 것으로 나타났으나 지역적 특성 및 상황을 고려하여 결정해야 할 것으로 생각되었다.

6. 集團投藥의 適切한 時期는 우리나라 再感染發生의 特徵中 겨울동안의 集中再感染에 대한 管理問題를 勘案하여 決定해야 하겠다.

7. 각 集團投藥方法에 있어서 총 投藥期間은 統計學的 model에 의하여 計算이 可能할 것으로 생각되었다.

8. 再感染을 完全 管理하고 撲滅을 目的으로 2개월 간격 全住民 集團投藥을 계속한 바 28개월의 기간이 소요되었다.

9. 우리나라 學生集團에 있어서 1984~1985년경에 平均蟲卵陽性率이 0%에 도달할 것이라는 統計的 處理結果가 報告되었으나 平均以上의 특히 고도 流行地의 住民에 대하여는 좀더 積極的인 管理對策이 마련되어야 할 것으로 생각되었다.

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