

Intensity of *Metagonimus yokogawai* Infection among Inhabitants in Tamjin River Basin with Reference to Its Egg Laying Capacity in Human Host

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= Abstract = The intensity of *Metagonimus yokogawai* infection in 221 inhabitants residing in the Tamjin river basin, Jeonranam-do, was investigated through quantitative stool examination for eggs and collection of expelled worms after treatment with praziquantel. Comparing the numbers of collected worms with their EPG (eggs per gram of feces) values, the egg laying capacity of *M. yokogawai* in human host was estimated.

Eggs of *M. yokogawai* were positive in 89 inhabitants (40.3%) and their total EPG 151,400 (average; 1,707). Among them 57 cases (64.0%) revealed EPG lower than 900 and remaining 32 cases revealed EPG in range of 1,000-20,800. From fourteen treated cases whose EPG ranged 1,000-6,800, as many as 2,886-63,587 worms were collected from each case.

In these 14 cases EPGs/worm were in the range from 0.11 to 0.35, suggesting the 'density-dependent constraint on worm fecundity'. The relation between worm burden (X) and EPG/worm (Y) was expressed as an exponential equation, $Y = 13.5 \times X^{-0.47}$ ($r = -0.85$). By this equation, the theoretical value of EPG/worm was in the range from 0.07 to 0.32, and an estimate of EPD (eggs per day)/worm was 14-64, provided that the daily stool weight is estimated at 200 g.

The results showed that the intensity of infection (in terms of worm burden) of *M. yokogawai* in the surveyed area was remarkably high and its egg laying capacity revealed so-called 'density-dependent constraint'.

Key Words: *Metagonimus yokogawai*, Egg laying capacity, Density-dependent constraint, *Metagonimus* worm burden

INTRODUCTION

Metagonimus yokogawai is one of the important trematodes from the public health point of view in Korea. Human infection is contracted by eating the raw flesh of the sweetfish, *Plecoglossus altivelis*. For this reason, human metagonimiasis is mainly distributed along riverside areas of southern and eastern coasts where the sweetfish are available (Yeo and Seo 1971; Soh *et al.* 1976; Chai *et al.* 1977; Soh and Ahn 1978; Seo *et al.* 1981).

According to the reports, its prevalence among local inhabitants has sometimes been over 40%.

So far as the intensity of infection in terms of number of worms is concerned, there has been few report in Korea, except for two cases from whom 154 and 17,560 worms respectively were recovered after the treatment with tetrachlorethylene or niclosamide (Seo *et al.* 1971). Many epidemiological reports have described the intensity of infection by EPG (eggs per gram of feces) value as an alternative estimate. However, only by EPG, it has been difficult to calculate their real worm burdens because the egg laying capacity of

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this fluke is not clearly known, especially in human host.

This study was performed to observe the intensity of infection in worm number of *M. yokogawai* among inhabitants along the Tamjin river basin, by treatment with praziquantel and purgation of infected cases. The egg laying capacity of this fluke (EPG/worm or EPD: eggs per day/worm) in human host was also estimated by comparing individual worm burdens with their EPG values.

MATERIALS AND METHODS

1. Stool Examination and Count of Worm Burdens

Stool specimens of a total of 221 inhabitants, all age classes and both sexes, residing in two small villages (Sukyo-ri and Dukcheon-ri) of Goondongmyon, Kangjin-gun, Jeonranam-do, located at the lower reach of the Tamjin river, were examined during the period from January to February, 1984. The qualitative examination was done both by cellophane thick smear and formalin-ether sedimentation techniques. Stoll's egg counting technique was applied for the quantitative examination of *M. yokogawai* egg positive cases. Only one smear was examined in each case.

Cases with EPG values higher than 1,000 were treated with 10 mg/kg single dose of praziquantel (Distocide[®]), followed by purgation with 30-40 g magnesium sulfate, and expelled worms in diarrheal stools were collected and counted under stereomicroscopy. Out of 26 cases treated 14 were cooperative for collection of their diarrheal stools passed more than 5 consecutive times during 6-7 hours following the treatment. The data from these 14 cases were used in the estimation of the egg laying capacity of this fluke in human host.

2. Analysis of Egg Laying Capacity of *M. yokogawai*

In the calculation of EPG/worm values, EPG of each case was divided with the number of worms recovered after treatment, irrespective of various possible variables such as chronological fluctuation in the egg laying capacity. The EPG/worm was calculated with the average weight of the daily stool output of 200 g.

The obtained EPG/worm values varied greatly as the cases (Table 3), seemingly dependent upon the degree of their worm burdens. Then, it was taken into consideration that there should be a density-dependent constraint in worm fecundity of *M.*

yokogawai, which was chiefly reported in infections with nematodes such as *Ancylostoma caninum* (Krupp 1962), *Ascaris lumbricoides* (Croll *et al.* 1982) and trematodes such as *Schistosoma mansoni* (Cheever 1968). For analysis of this phenomenon Anderson and May (1982) introduced equations applicable to express the relations between worm burden (X) and worm fecundity (Y); $Y = a \cdot X^b$ or $Y = a \cdot e^{-bx}$, where 'a' and 'b' are constants determining the degree of constraints. Using the former equation, a regression curve best fitted to the observed values was drawn and thereby theoretical values of EPG/worm (and EPD/worm) were calculated in 14 heavily infected human host.

RESULTS

1. Results of Stool Examination

In qualitative stool examination, various kinds of helminth egg and/or protozoan cyst positive cases were detected (Table 1). The egg positive rate of helminths was highest for *M. yokogawai* (40.3%), next *Trichuris trichiura* (38.5%) followed by *Clonorchis sinensis* (14.0%) and *Ascaris lumbricoides* (11.8%). The egg positive rate of *M. yokogawai* was approximately the same in two surveyed villages.

The total sum of *M. yokogawai* EPG was 151,400 among 89 egg positive cases, with an average value of 1,707 and the standard deviation of 3,528 (Table 2). The number of cases with EPG values lower than 1,000 were 57 (64.0% of all positive cases) and those with 1,000-1,900 and with over 2,000 EPG were 13 (14.6%) and 19 (21.4%) respectively. There were 4 cases whose EPGs were extremely high; 13,600, 13,800, 16,000 and 20,800 respectively.

2. Individual Worm Burden and Egg Laying Capacity of *M. yokogawai*

The cases treated and checked their worm burdens consisted of 9 men and 5 women from 30 to 63 years old, and whose EPG ranged 1,000-6,800 (Table 3). The lowest worm burden was 2,886, in which case the EPG was 1,000. Ten cases expelled more than 10,000 worms, and 6 among them, all males, expelled more than 20,000 worms. As many as 33,825, 52,030 and 63,587 worms were recovered from each of three cases (Table 3), but individual values showed a variation from 0.07 to 0.35 (Table 4). The EPD/worm was calculated to be from 14 to 70 with an average of 32.

The egg laying capacity in terms of EPG/worm seems to vary with the intensity of infection in

Table 1. Results of stool examination on the inhabitants of Kangjin-gun (January, 1984)

Parasite	No. egg or cyst positive cases (%)		
	Sukyo-ri	Dukcheon-ri	Total
No. examined	115	106	221
<i>Ascaris lumbricoides</i>	7 (6.1)	19 (17.9)	26 (11.8)
<i>Trichuris trichiura</i>	39 (33.9)	46 (43.4)	85 (38.5)
<i>Clonorchis sinensis</i>	18 (15.7)	13 (12.3)	31 (14.0)
<i>Metagonimus yokogawai</i>	47 (40.9)	42 (39.6)	89 (40.3)
<i>Taenia</i> sp.	0 (0.0)	5 (4.7)	5 (2.3)
<i>Enterobius vermicularis</i>	7 (6.1)	2 (1.9)	9 (4.1)
<i>Hymenolepis nana</i>	1 (0.9)	1 (0.9)	2 (0.9)
<i>Entamoeba histolytica</i>	0 (0.0)	1 (0.9)	1 (0.5)
<i>Entamoeba coli</i>	3 (2.6)	6 (5.7)	9 (4.1)
<i>Giardia lamblia</i>	1 (0.9)	3 (2.8)	4 (1.8)

Table 2. Distribution of EPG grade in 89 egg positive cases of *M. yokogawai*

EPG grade	No. cases (%)
under 900	57 (64.0)
1,000-1,900	13 (14.6)
2,000-2,900	6 (6.7)
3,000-3,900	3 (3.4)
4,000-4,900	1 (1.1)
5,000-5,900	3 (3.4)
6,000-6,900	2 (2.2)
7,000 & over	4* (4.5)
Total	89**

* EPG of these cases were 13,600, 13,800, 16,000 and 20,800 respectively.

** Total EPG of 89 cases were 151,400 with the average of 1,707/case and S.D. of 3,528.

terms of worm burdens. Hence, in order to know the relationship between egg laying capacity and intensity of infection, the concept of 'density-dependent constraint on worm fecundity' (Anderson and May 1982), was applied. By observation and plotting of the values of individual worm burden (X) and worm fecundity (Y) obtained in the present cases, the equation, $Y = a \cdot X^b$, was selected as an appropriate function. The correlation equation was $Y = 13.5 X^{-0.47}$ ($r = -0.85$) (Fig. 1). Based on this equation, the theoretical values of EPG/worm and EPD/worm were calculated and they were in the range, 0.07-0.32 and 14-64, respectively (Table 4). It is presumed that if the worm burden is less

Table 3. The relationship between EPG and worm burden of *M. yokogawai* in 14 inhabitants*

Case No.	Name	Age Sex	EPG	Worm burden
1	Oh, HS	61 M	1,000	2,886
2	Lee, KR	45 F	1,400	4,594
3	Lee, BS	40 F	2,200	7,038
4	Oh, YJ	48 M	1,200	7,047
5	Han, BR	55 F	1,400	10,630
6	Lee, CJ	59 M	2,200	12,685
7	Yun, YJ	34 F	1,600	12,820
8	Hong, HY	57 F	1,600	16,517
9	Kim, YO	63 M	2,200	20,286
10	Oh, SI	50 M	3,000	25,858
11	Oh, WY	30 M	2,800	26,019
12	Park, KS	43 M	2,200	33,825
13	Kim, JH	55 M	4,600	52,030
14	Oh, KS	33 M	6,800	63,587
Total			34,200	295,822

* More than 5 times of diarrheal stools passed were successfully collected in 14 of 24 cases treated.

than 2,800 the EPD/worm would be higher than 64, while more than 60,000, the EPD/worm is lower than 14.

DISCUSSION

There have been few reports which described the worm burdens of *M. yokogawai* in human host, in terms of worm number. According to Ito (1964), a mass treatment of 59 cases from Hiroshima Prefecture, Japan, using 'kamala', revealed the worm

Table 4. Theoretical values for the egg-laying capacity of *M. yokogawai* in human host

Case No	Worm burden	Observed EPG/Worm	Theoretical values	
			EPG/Worm*	EPD/Worm
1	2,866	0.35	0.32	64
2	4,594	0.30	0.26	52
3	7,038	0.31	0.21	42
4	7,047	0.17	0.21	42
5	10,630	0.13	0.17	34
6	12,685	0.17	0.16	32
7	12,820	0.12	0.16	32
8	16,517	0.10	0.14	28
9	20,286	0.11	0.13	26
10	25,858	0.12	0.11	22
11	26,019	0.11	0.11	22
12	33,825	0.07	0.10	20
13	52,030	0.09	0.08	16
14	63,587	0.11	0.07	14

* From equation $Y=13.5 X^{-0.47}$, where X is worm burden and Y is EPG/worm (Observed and theoretical value; $P < 0.005$)

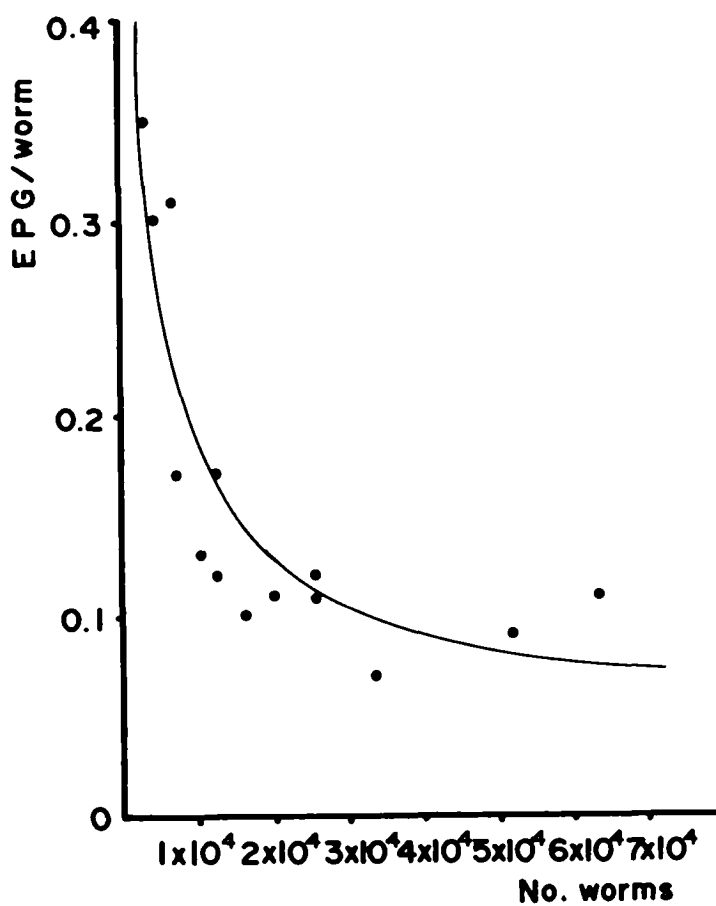


Fig. 1. The density-dependent constraint on worm fecundity of *M. yokogawai* in man ($Y=13.5 X^{-0.47}$, where 'X' is worm burden and 'Y' is EPG/worm). (●: observed values)

number distribution as follows; less than 10 worms in 13 persons, 11-100 worms in 25 persons, 101-1,000 worms in 13 cases and more than 1,000 worms in 8 cases. The largest number recorded was 7,681 in a 31-year old male. A case with exceptionally heavy burden of 30,462 worms was reported in Japan (Nagayoshi 1949). In Korea, two cases who expelled 17,560 and 154 worms after treatment were described (Seo *et al.* 1971). In the present study, the number of *M. yokogawai* collected from a case showing EPG 1,000 was 2,886 and 10 cases with EPG over 1,400 revealed more than 10,000 worms. From three cases in this study 33,825, 52,030 and 63,587 worms were collected, who seemed to be the most heavy infection ever reported.

However, the EPGs of the above three cases were lower than 6,800 per case and there have been many records of high EPG in human metagonimiasis. Seo *et al.* (1971) reported a case with remarkably high EPG of 71,300, however, from whom only 17,560 worms were collected after the treatment with tetrachlorethylene. It seems to have probably been due to a poor efficacy of the drug used. Yeo and Seo (1971) described 5 male inhabitants, over 50 years of age, residing in the Sumjin river basin, who showed an average EPG of 21,360. Seo *et al.* (1981) also reported several eastern and southern coastal areas where the EPG of heavy infection cases was over 10,000 (highest; 67,900) in the Oship stream, Yeongdeok-gun, Gyeongsangbug-do. Soh and Ahn (1978) reported several cases of over 10,000 EPG in the Boseong river basin. In this respect, there should be a considerable number of cases whose worm burden was over 60,000 in highly endemic areas.

It is quite possible to have such a high intensity of *M. yokogawai* infection if the number of metacercariae infected in the sweetfish is taken into consideration. For example, in Tamjin river basin, where the present study was conducted, it is known that the number of metacercariae per fish was as much as 15,688 in average (range; 144-49,956) (Chai *et al.* 1977) or 14,887 (range; 532-45,018) (Seo *et al.* 1982). In Sumjin river basin, the metacercarial burden in the sweetfish was 3,851/fish (Hong and seo 1969). Even if the infectivity of metacercariae to man were assumed about 50% and if 10 sweetfish in Tamjin river were presumed to be eaten by a person, the resulting worm burden would be about

70,000–80,000.

On the egg laying capacity of *M. yokogawai* in human host, there has been no useful method to measure it exactly. For this purpose, it is so far a most convenient and feasible method to correlate the EPG value with the number of discharged worms after treatment of infected cases with an effective drug such as praziquantel or, at least, bithionol. But if the drug efficacy is poor the result shows a variation. An estimated EPD/worm to be as much as 1,500, after treatment of two human cases with tetrachlorethylene and niclosamide respectively (Seo *et al.* 1971) seems to have been probably overestimated because of incomplete discharge of worms. In the dog host, the EPG/worm was calculated about 35–45 (Kim and Lee 1965; Ahn *et al.* 1981). In the present study, the value of EPG/worm varied according to the intensity of infection, in the range of 0.07–0.32, which made EPD/worm approximately 14–64.

The density-dependent constraint of parasite fecundity, which was observed in several kinds of helminthic infections (Anderson and May 1982), was also suggested to occur in human *M. yokogawai* infection. Such phenomenon is regarded as one of the major regulating mechanisms to control the growth of the total parasite population in host community (Anderson and May 1982) and the best fit model for metagonimiasis in the present study was $Y=13.5 X^{-0.47}$ in 14 heavily infected human host.

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= 국문초록 =

탐진강 流域 住民의 요꼬가와吸蟲 感染量 및 人體에 있어서의 蟲卵產出能力

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전라남도 탐진강流域에 거주하는 221명의 住民에 대하여 1984年 1월부터 2월까지 요꼬가와吸蟲(*Metagonimus yokogawai*) 感染强度를 조사하였다. 感染强度는 스톨氏 蟲卵計算法을 이용한 EPG值(大便 1 g내의 蟲卵數) 및 praziquantel投藥後 수집된 蟲體數로 표시하였고 이 두가지 資料에서 EPG/worm(蟲體 마리당 EPG)을 구하여 人體內 요꼬가와吸蟲의 蟲卵產出能力을 評價하였다.

결과는 다음과 같다.

1. 住民 221名중 요꼬가와吸蟲卵 陽性者는 89名(40.3%)이었고 이들의 總 EPG는 151,400 (平均 1,707)이었다. 그중 57名(64.0%)은 EPG 900이하하였고 나머지 32名은 EPG 1,000~20,800의 범위에 있었다.

2. 投藥後 排出된 蟲體數를 조사한 14名은 EPG 1,000~6,800의 범위에 있었고 그들로부터 각각 2,886~63,587마리의 蟲體가 수집되었다.

3. 이들 14名에 있어서 EPG/worm은 0.11~0.35로 다양하게 나타났으며 이것은 蟲體의 產卵力에 미치는 感染密度性 抑壓要因 (density-dependent constraint on worm fecundity)에 의한 것으로 생각되었다. 즉, 感染蟲體數(X)와 EPG/worm(Y)의 상관관계는 $Y=13.5 X^{-0.47}$ ($r=-0.85$)의 數式으로 표현되었고 이 式에 의하면 EPG/worm의 理論値는 대략 0.07~0.32의 범위에, EPD/worm(蟲體當 1日 產卵數)은 1日 大便量을 200 g으로 할 때 14~64의 범위를 보일 것으로 추측되었다.

이상의 결과로 볼 때 이 地域 住民의 요꼬가와吸蟲 感染量은 예상했던 것보다 매우 높았으며 이 吸蟲의 產卵能力은 人體內에서 感染量이 많을 수록 感少되는 경향이 있는 것으로 생각되었다.