REPLACEMENT PATTERNS OF *ASCARIS LUMBRICOIDES* POPULATIONS IN FILIPINO CHILDREN

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Abstract. The replacement patterns of *Ascaris lumbricoides* worm populations were investigated by complete deworming of 150 Filipino children (0-14 years old) from both urban and rural barangays and analyzing the age distribution of the 2,072 adult worms (939 males and 1,133 females) obtained, based on Seo's (1983) regression equation relating length to age. It was observed that most worm populations followed a periodic pattern of replenishment. This supports the general practice of periodic anthelminthic campaigns. However, there seems to be a tendency for moderate and heavy cases to follow a continuous replacement pattern as evidenced by shorter time intervals between generations and wider age ranges. The data suggest that periodic deworming schedules may not be appropriate in areas where cases are predominantly of higher intensity. In such situations, control and/or eradication can probably be achieved only if chemotherapy is applied more frequently and supplementary health education and environmental modification measures are provided.

INTRODUCTION

In the Philippines, the extent of local research on *A. lumbricoides* has been wide and varied. From 1907 to 1977 alone, 155 local studies on this species had been published and were concentrated on the following aspects : a) prevalence surveys from different regions and among different ethnic groups in the country, b) clinical features, symptomatology and pathology of ascariasis, c) diagnostic procedures, d) treatment and e) epidemiological studies in connection with prevention and control (Revatoris-Rosal, 1978).

With the exception of a few studies on the physiology (Africa, 1932; Africa and Garcia, 1936; Arambulo, 1966) and immunology (Latonio, 1974) of ascarids, local work on the basic biology of this helminth is incomplete (PCHRD, 1984).

The control of ascariasis and other soil-transmitted helminthiases is one of the more important concerns of public health workers because of the morbidity associated with them. However, effective measures can only be formulated based on the existing knowledge about the parasite's life cycle, physiology and other unique characteristics. Thus, research on basic biological information becomes necessary and relevant even when practical application of that knowledge is not immediate.

It has also been noted that the findings of foreign authors are not always applicable to the local situation. The possibility that geographical strain differences exist within a species further strengthens the need for local research even on a much studied subject.

One particular aspect of *A. lumbricoides* that deserves further investigation concerns infection or worm replacement patterns. Experts disagree as to the general pattern of worm replacement and two opposing views exist concerning the turnover of *Ascaris* populations in the intestines. Some are of the opinion that worms are generally of a single brood (all about the same age and maturity) while others believe that worms are lost and acquired more or less continuously. The elucidation of this problem could assist in the planning and interpretation of the effects of periodic mass anthelminthic campaigns (WHO, 1967).

It is the purpose of this paper to characterize the age distribution of *A. lumbricoides* populations from selected Filipino children in order to determine the general pattern of worm replacement, whether periodic or continuous.

MATERIALS AND METHODS

A. lumbricoides worm populations were derived from the same 150 Filipino children (0-14 years of age) dewormed with Combantrin (pyrantel pamoate) and Quantrel (oxantel-pyrantel pamoate) in an earlier study by Monzon *et al* (1990). The subjects were residents of two urban barangays (Daang Bakal, Mandaluyong, Metro Manila and Pook Amorsolo, UP Diliman Campus, Quezon City) and one rural barangay (Soyung, Echague, Isabela) which had been surveyed earlier and found to have a high prevalence of soil-transmitted helminthiases. The expulsion of the entire worm population from each subject was assumed since 3 complete consecutive stool movements following purgation were ascertained.

Expelled worms were cleaned by repeated washings in sedimentation flasks and each worm population was put in a separate jar containing 10% formalin solution. The worms were counted, sexed and dissected to determine sexual maturity. Intensity of infection or worm burden was classified according to the scheme proposed by Keller and Leathers (1936).

All worms were straightened out on paraffin boards and measured by means of a transparent ruler to the nearest 0.1 cm. The age of each worm was estimated based on its length, using Seo's (1983) regression equations relating length to age, namely: for females, $y = 11.953 \ln(x + 1) + 0.025$ and for males, $y = 9.213 \ln(x + 1) + 0.025$ where y is length in cm and x is age in months. Both equations were transposed to the following alternative forms to simplify computations : $y = \exp(x - 0.025/9.213) - 1$ for males and $y = \exp(x - 0.025/11.953) - 1$ for females, where y is age in months and x is length in cm.

After the ages of all worms in each population were determined, each case was classified as to whether the worm population present arose from a periodic or continuous pattern of infection. The following working definitions and assumptions were applied:

A worm population was classified as *periodically* generated if the age distribution of the worms indicated that they could be separated into 2 or more broods (generations) while a *continuously* generated worm population consisted of a single brood which, until the period just prior to deworming, was theoretically still growing in number. However, populations consisting of only one brood were considered periodic if no sexually immature adult individuals were present since this implied that the continuous growth had already terminated prior to deworming.

The number of broods (generations) comprising each worm population was determined by first arranging the ages of the worms, regardless of sex, in array. The worms were then grouped into generations starting from the oldest to the youngest.

In order to belong to the same generation, every worm within the same brood must have at least one "sibling" younger or older by not more than 0.5 of a month (2 weeks), which is the estimated lung migration time of juvenile ascarids in man (Koino, 1923; Seo, 1983). It was assumed that any two worms not more than 0.5 of a month apart in age could be considered "of the same brood" since the infective eggs must have been ingested more or less continuously. Thus, as this process was done, the worms in each population could be grouped into separate broods or generations.

Based on these assumptions, a truly continuous replacement pattern should produce populations consisting of old mature, middle-aged mature and immature forms since replenishment of individuals in the population was non-stop. The arbitrary condition that every worm belonging to the same generation have at least one "sibling" younger or older by not more than half a month is set to create a more concrete and feasible distinction between periodic and continuous replacement.

Due to errors encountered in measuring the length of the worms and the variable and unpredictable effects of formalin on tissue shrinkage, a 10% allowance for error was given for age estimation.

RESULTS

A total of 2,072 adult *A. lumbricoides* worms were obtained from the 150 worm populations studied. These consisted of 939 males (900 mature

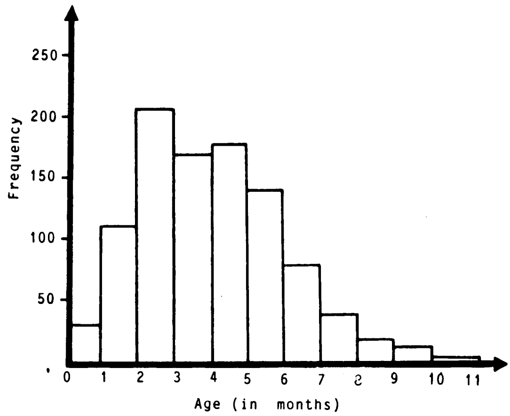

Fig 1—Frequency distribution of ages of 939 male *Ascaris lumbricoides* adults.

Table 1

Descriptive statistics for ages of 939 male and 1,133 female *Ascaris lumbricoides* adults derived from 150 populations.

	Male	Female
Mean	3.96 mo	4.72 mo
Median	3.81 mo	4.55 mo
Mode	4.42 mo	7.08 mo
Range	0.25 - 10.22 mo	0.16 - 14.13 mo
SD	1.86 mo	2.16 mo
CV	47.05%	53.13%

and 39 immature) and 1,133 females 1,030 mature and 103 immature). Figs 1 and 2 present the age distributions of male and female worms, respectively, while Table 1 summarizes the descriptive statistics for both sexes.

Male adult worms were generally younger (mean : 3.96 mo vs. 4.72 mo) and exhibited less variability (coefficient of variation : 47.05% vs. 53.13%) than females. Both age distributions were positively skewed attesting that *A. lumbricoides* adults are generally short-lived, with females outliving males (maximum age : 14.13 mo vs. 10.22 mo). This also suggested a faster turnover rate among the males.

Table 2 summarizes the results obtained regarding the pattern of worm replacement among the 150 cases (populations) classified according to intensity of infection and number of generations. The data indicated that replenishment of worm populations were generally periodic. Out of the

Table 2

Distribution of 150 *Ascaris lumbricoides* populations according to intensity type, pattern of worm replacement and number of generations.

Replacement pattern	Intensity type				Total
	Very light	Light	Moderate	Heavy	
A. Periodic	83	60	3	1	147
a) 1 generation	12	1	0	0	13
b) 2 generations	21	11	0	0	32
c) 3 generations	23	9	0	0	32
d) 4 generations	11	18	3	1	33
e) 5 generations	11	11	0	0	22
f) 6 generations	4	3	0	0	7
g) 7 generations	1	3	0	0	4
h) 8 generations	0	4	0	0	4
B. Continuous	1	0	1	1	3
Total	84	60	4	2	150

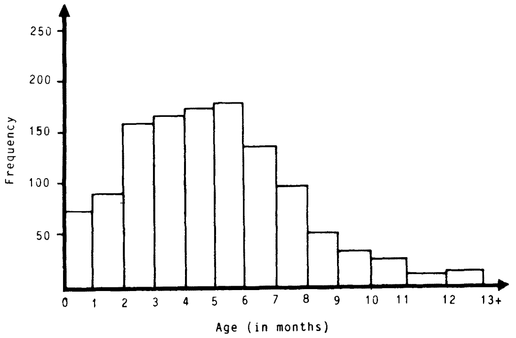

Fig 2—Frequency distribution of ages of 1,133 female *Ascaris lumbricoides* adults.

150 populations examined, only 3 (2.0%) exhibited a continuous growth pattern while the remaining 147 (98.0%) were clearly periodic.

Periodic worm populations consisted of 1 to 8 broods or generations but the usual number was 2 to 4. Among the intensity classes (Keller and Leathers, 1936), 83 out of 84 (98.8%) very light cases (1-9 worms), 60 out of 60 (100%) light cases (10-49 worms), 3 out of 4 (75%) moderate cases (50-99 worms) and 1 out of 2 (50%) heavy cases (100 or more worms) were periodic.

Only 3 continuous cases (one each of very light, moderate and heavy) were recorded. This weakly suggested that moderate (1 out of 4 or 25%) and heavy (1 out of 2 or 50%) cases tend to follow continuous instead of periodic patterns.

In order to investigate this hypothesis further, the time intervals between generations were determined for all periodic cases consisting of more than one brood. This measured how soon the next generation of worms followed the previous one. Theoretically, the shorter the time intervals between generations, the closer the population approaches a continuous pattern of replacement.

The summary of time intervals between generations among periodic cases of more than one brood according to intensity of infection is presented in Table 3. It can be observed that the mean time interval between generations is longest among very light cases (1.61 month); it decreases among light cases (1.19 month) and is lowest among moderate and heavy cases combined (0.85 month).

The age range of each worm population was also considered (Table 4). The mean age range was found to increase from very light (3.86 months) to light (6.30 months) to moderate/heavy combined (7.64 months). The difference between mean age ranges of light and moderate / heavy cases was not statistically significant; however, the mean age ranges of both groups were significantly larger than that of very light cases ($p < 0.01$, Duncan's multiple range test). The relevance of an increased age range, especially among moderate / heavy cases is that it also implies a continuous replenishment of worms in the existing population since larger age ranges are to be expected when both very young and very old worms are simultaneously present.

Table 3

Summary of time intervals between generations (in months) among periodic cases of more than one brood according to intensity of infection.

Intensity	No. of periodic cases	Range	Mean	SD
Very light	71	0.69 - 4.22	1.61	0.77
Light	59	0.56 - 3.27	1.19	0.54
Moderate or heavy	4	0.75 - 0.93	0.85	0.07
Total	134			

Table 4

Mean and standard deviation of age ranges (in months) among worm populations classified according to intensity.

Intensity	Number	Mean	SD
Very light	76	3.80	2.10
Light	60	6.30	2.61
Moderate or heavy	6	7.64	2.82

F-test = 22.73 ($p < 0.01$)

DISCUSSION

Cabrera *et al* (1975) first recommended the use of Combantrin (pyrantel pamoate) at half the recommended dosage every 3 months for 12 months in rural communities of the Philippines and suggested the possibility of eradication, and not just control, of ascariasis based on the periodic deworming schedule. They were able to achieve a reduction in prevalence rate, from 84.4% to 0.5% (a 99.4% reduction), after the fourth consecutive treatment.

Earlier attempts to control ascariasis by treatment alone, given once a year, failed due to high reinfection rates among treated cases. A study among school children in Manila (an urban area) revealed reinfection rates of 68.63% after 4 1/2 months, 85.79% after 6 1/2 months and 89.54% after 8 1/2 months (Garcia *et al,* 1961) while a similar study among school children in Laguna (a rural area) obtained reinfection rates of 4.2% after 2 months, 47.8% after 5 months and 80.9% after 7 months (Jueco and Cabrera, 1971). These high reinfection rates have been attributed to poor environmental sanitation and the lack of personal hygiene (Cabrera *et al,* 1975).

The results obtained in this study confirm the generally periodic nature of *A. lumbricoides* worm replacement patterns, which are more or less synonymous to infection patterns. This characteristic justifies the periodic scheduling of most control programs dealing with ascariasis.

Cabrera (1984) has linked this cyclical pattern of *Ascariasis* infection and reinfection in the Philippines with seasonal variation. He claimed that it was highly correlated with the amount of rainfall throughout the year. Transmission is highest when rainfall is minimal and lowest when rainfall is at its peak. This has been attributed to the flushing action of rainwater and floods which wash away infective eggs from the soil surface.

It should be pointed out however that the earlier studies did not consider the relationship between worm burden (intensity of infection) and reinfection rates. Although there were only 4 moderate and 2 heavy cases obtained, the data suggest that they begin to follow a continuous worm replacement pattern (Table 2), which is further supported by the trend for such cases to have a shorter mean time between generations (Table 3) and longer mean age range (Table 4).

An important corollary to these findings is that periodic deworming schedules alone may be insufficient in ascariasis control programs among communities where the majority of cases are moderate to heavy. In such heavily infected areas, the environment must be so heavily seeded with infective eggs that the infection process, especially among children, becomes a routine occurrence. Additional measures consisting of health education and drastic environmental modification should be implemented together with more frequent chemotherapy.

Since most cases encountered in communities surveyed are of relatively low worm burden, the general practice of periodic anthelminthic treatment is supported.

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