ARTICLE

Determination of soil-transmitted helminth infection and its association with hemoglobin levels among Aeta schoolchildren of Katutubo Village in Planas, Porac, Pampanga

Janice V. Ng[1*], Vicente Y. Belizario, Jr.[2], and Florencia G. Claveria[3]

[1]Department of Biology, College of Arts and Sciences, University of the Philippines Manila, Padre Faura St., Ermita, Manila 1000 Philippines
[2]National Institutes of Health and College of Public Health, University of the Philippines Manila, 623 Pedro Gil St., Taft Avenue, Ermita, Manila 1000 Philippines
[3]Biology Department, College of Science, De La Salle University Manila, 2401 Taft Avenue, Manila 1004 Philippines

Documented reports about the health status of Aetas, one of the oldest indigenous groups in the Philippines, are limited. In view of their cultural practices, Aetas are considered at great risk of exposure to soil-transmitted helminth (STH) infections. This study investigated STH infection and its possible association with hemoglobin levels among Aeta schoolchildren from Katutubo Village in Planas, Porac, Pampanga. Parasitologic assessment was performed using fecalysis by the Kato-Katz quantitative technique, while blood samples were collected for hemoglobin-level analysis using a portable HemoCue machine. Out of 195 children who submitted their stool samples, 97.4% of them had at least one STH infection, with *Trichuris trichiura* being the most prevalent (94.4%), followed by *Ascaris lumbricoides* (84.1%), and hookworm (21.5%). Schoolchildren with moderate- to heavy-intensity infections were found in 152 (82.6%) out of 184 Kato-Katz processed stool. Co-infection rate with *A. lumbricoides* and *T. trichiura* was high at 81%. Of the 213 schoolchildren analyzed for hemoglobin levels, 18.3% were anemic (<11.0g/dl). Hemoglobin level was found to be significantly associated with the children's age ($p<0.01$) and intensity of hookworm infection ($p=0.013$). The present findings suggest the need for sustainable deworming programs including biannual treatment of helminths combined with improvements in water, sanitation, and hygiene. The high STH infection rates found among Aeta schoolchildren put them at greater risk of morbidity. Accessible and high-quality health services must be provided and ensured. Further studies on the hosts' nutritional status may prove useful in identifying other anemia-producing factors.

*Corresponding author
Email Address: jah.velasco@gmail.com
Submitted: October 10, 2013
Revised: January 7, 2014
Accepted: February 7, 2014
Published: March 1, 2014
Editor-in-charge: Eduardo A. Padlan
Reviewers: Mary Grace Dacuma and Marilen M. Parungao-Balolong

INTRODUCTION

Soil-transmitted helminthiasis, one of the most neglected tropical diseases (NTDs), is of major public health importance worldwide. The disease has continued to afflict humans living in areas of poverty and has greatly affected the health and socio-

KEYWORDS
soil-transmitted helminths, anemia, Aetas, *Ascaris lumbricoides*, hemoglobin level, hookworm, *Trichuris trichiura*

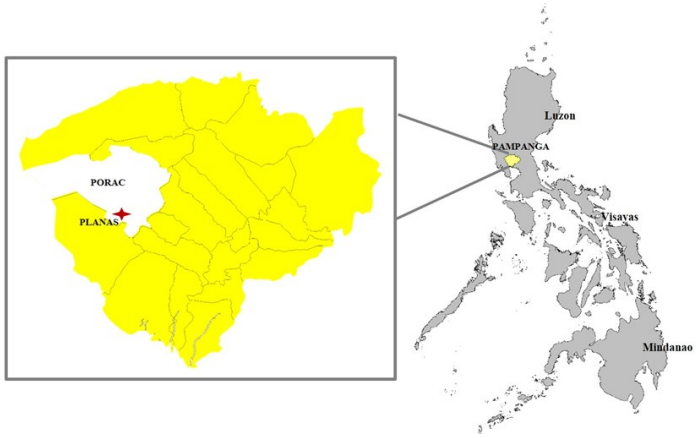

Figure 1. An outline map of the Philippines showing the approximate location of the main study site in Barangay Planas, Porac, Pampanga. Map generated through DIVA-GIS software.

economic status of individuals and communities (Hotez et al. 2006). The burden brought by soil-transmitted helminth (STH) infections on school-age children of developing countries has been estimated to be greater than that caused by any other communicable or non-communicable diseases (Thomas et al. 2005). About 4.5 billion people suffer from STH infections and more than one billion individuals are thought to be infected globally, with the greatest number of infections found in America, China, East Asia, and Sub-Saharan Africa. In Southeast Asia, about 500 million people are infected, with school-age children and women of childbearing age at the highest risk from these infections (Vercruysse et al. 2011).

In the Philippines, the three major causes of intestinal parasitism are infections due to *Ascaris lumbricoides* (intestinal roundworm), *Trichuris trichuria* (whipworm), and species of hookworms such as *Necator americanus* and *Ancylostoma duodenale* (Department of Health Philippines 2010), more commonly known as the soil-transmitted helminths. STH infections are mostly associated with significant morbidity (Hotez et al. 2003), especially among school-age children due to their lower immune response compared to adults, poor hygiene, poor sanitary and environmental conditions (Osazuwa et al. 2011), and frequent outdoor exposures. Filipinos are very much at risk of STH infection mainly because of the environmental conditions that are conducive for helminth egg survival and parasite growth and transmission (Bethony et al. 2006). However, STH infections can be prevented even in high-prevalence communities by treating only school-age children (World Health Organization 2002).

Several studies by Belizario and coworkers (Belizario et al. 2007, 2009, 2011) documented STH infections among Filipino schoolchildren. They reported cumulative prevalence, which is the positivity for at least one type of STH infection, ranging from 13.2% - 54% among children from selected private schools in Metro Manila and from representative public schools in Luzon, Visayas and Mindanao. In a 2011 survey in Davao del Norte (Belizario et al. 2011) involving non-indigenous and indigenous schoolchildren, 34.1% of those examined had at least one STH infection with heavy-intensity infection in about 5.9% of them. Prevalence was higher in indigenous schoolchildren at 39% against 30% in non-indigenous schoolchildren. The Department of Health recognizes indigenous people being at risk and could be gravely exposed to helminth infections due to their nature of work and situation. However, data on STH infections on indigenous groups in the country are scanty, if not altogether undocumented, except for the report of Belizario et al. (2011). The Aetas, a marginalized group, represents 1% of the total population of indigenous people (IP) in the country. The Aetas of Pinatubo constitute a resettled community after the Mt. Pinatubo eruption in 1991. Blum et al. (1997) reported health problems, such as malnutrition, diarrhea, measles, respiratory infections and malaria, common among the Aetas. To date, there are no reports on STH infections, or on the anemia status, among Aetas in the country.

This study aimed to determine the prevalence and intensity of STH infections, as well as the status of anemia among Aeta schoolchildren of Katutubo Village, Planas, Porac, Pampanga, where a worm-control program has been implemented for almost four years. Furthermore, the study aimed to establish the possible association of the schoolchildren's hemoglobin level with the intensity of STH infection.

MATERIALS AND METHODS

Study Site and Population

Pampanga is located in the Central Luzon region of the Philippines (National Statistics Coordination Board 2013). It is bounded by the provinces of Tarlac and Nueva Ecija on the north, Bataan on the south, Bulacan on the east, and Zambales on the west. Katutubo Village, located in Barangay Planas, Porac, Pampanga (Fig. 1), is home to 1,021 Aetas, which is considered a more or less stable population. Established in 1992, the community is comprised of 209 families, with each family consisting of five to eight children. Most residents are engaged in farming. The services of a Health Center are available for ailing

Table 1. Cumulative prevalence and prevalence of moderate-to heavy-intensity infections by age groups of schoolchildren in Katutubo Village.

Age Groups	No. Examined	Cumulative Prevalence, n (%)	Prevalence of Moderate-Heavy Intensity, n (%)
3 to 5	33	33 (100.0)	24 (85.7)
6 to 9	94	92 (97.9)	76 (85.4)
10 to 15	68	65 (95.6)	52 (77.6)
Total	195	190 (97.4)	*152 (82.6)

*Stools processed by Kato-Katz (n=184)

Table 2. *Trichuris trichiura* infection rate, geometric mean egg count, and intensity by age groups of schoolchildren in Katutubo Village.

Age Groups	No. Examined	No. Infected, n (%)	Geometric Mean Egg Count (epg)	Light Intensity n (%)	Moderate Intensity n (%)	Heavy Intensity n (%)
3 to 5	33	32 (97.0)	538.0	13 (48.1)	12 (44.4)	2 (7.4)
6 to 9	94	88 (93.6)	704.8	39 (46.4)	40 (47.6)	5 (6.0)
10 to 15	68	64 (94.1)	787.9	27 (42.9)	32 (50.8)	4 (6.3)
Total	195	184 (94.4)	704.5	*79 (45.4)	*84 (48.3)	*11 (6.3)

*For intensity, positive for *T. trichiura* through Kato-Katz = 174

residents. Katutubo Village has an Early Childhood Care and Development Learning Center (ECCD) for preschool children at age three and the Katutubo Village Elementary School (KVES) for children aged four to fifteen, both exclusively for Aeta residents. ECCD, which started only in June 2011, has 27 enrollees. KVES has been in operation since 1994 and has 226 enrollees (kindergarten: 29, grade 1: 55, grade 2: 60, grade 3: 29, grade 4: 24, grade 5: 17, grade 6: 12). As part of the worm-control program implemented by the Department of Health (DOH) and in collaboration with Department of Education (DepEd), KVES pupils, preschool excluded, are given antihelminthics (albendazole) as part of the annual mass drug administration (MDA) during the month of July, according to the school supervisor. Class lists were obtained from the advisers to gather basic information such as birthdate, gender, and grade level. The study involved schoolchildren of both ECCD and KVES, with a total of 253 schoolchildren targeted as respondents.

Study Design

A cross sectional study design was used to determine the prevalence and intensity of STH and the status of anemia from among the schoolchildren surveyed. All schoolchildren enrolled in ECCD and KVES for the current school year were targeted as respondents for stool and blood examinations. Since these are the only existing schools for school-age children in the village and considering the relatively small population, all the children were recruited. Schoolchildren aged three to 15 were included in the study.

Parasitologic Assessment

The parasitologic assessment was conducted in June 2011 before the scheduled annual school deworming that is administered every July. Properly labeled stool containers were provided to the schoolchildren. Instructions on proper stool collection were provided. Each respondent was asked to provide a single stool sample to be submitted within 12 hours after passage to the field laboratory for processing and examination.

Stool samples were examined for evidence of STH infections by the Kato-Katz quantitative technique (using approximately 41.7mg of feces) (World Health Organization 1998). An aliquot of sample was prepared from each stool. Within two hours after processing, microscopic reading of the slides for helminth eggs was done to avoid missing evidence of hookworm eggs. The entire microscopic field was examined for each smear. To determine the number of eggs per gram (epg) of feces per species, raw egg counts were multiplied by 24, a constant value. Depending on the computed eggs per gram of feces, the intensity of STH infection of each child was categorized as light, moderate, and heavy (World Health Organization 2002). In accordance with the World Health Organization (WHO) guidelines issued in 1998 (World Health Organization 1998) and following the study of Belizario et al. (2011), both moderate- and heavy-intensity infections were considered heavy-intensity infections in this study. In addition, the average egg count was obtained by computing the geometric mean egg count (gmec) for each STH. For inadequate fecal samples, only qualitative parasitologic assessment was performed through the Kato thick smear, which follows almost the same procedure as the Kato-Katz technique except for wire-sieving the stool and the use of a template. Categories of light to heavy infections are not applicable for Kato thick-processed stools. Other intestinal helminths were noted when present.

Twenty five percent of the slides examined initially were randomly selected and submitted to a reference microscopist for quality control to ensure data accuracy and reliability. Data were carefully encoded and computed using Microsoft Excel. The following parasitologic parameters were obtained: cumulative prevalence rates and specific prevalence rates; intensity of STH infections; and proportions of light-, moderate-, and heavy-intensity STH infections.

Blood Collection and Hemoglobin Level Analysis

Using a portable hemoglobin analyzer (HemoCue® Hb 201^{+}), the hemoglobin levels of the schoolchildren were analyzed on the same day of collection. Briefly, blood was collected by finger prick using a lancing device with disposable lancets. Approximately 10µL of blood were drawn using a microcuvette by capillary action. The microcuvette containing blood was placed inside the HemoCue machine and the hemoglobin level was analyzed automatically within 15-60 seconds. Used lancets and microcuvettes were immediately discarded after each use for hygienic reasons. Hemoglobin levels below the cut-off value of 11.0g/dL were considered anemic following the HemoCue

Table 3. *Ascaris lumbricoides* infection rate, geometric mean egg count, and intensity by age groups of schoolchildren in Katutubo Village.

Age Groups	No. Examined	No. Infected, n (%)	Geometric Mean Egg Count (epg)	Light Intensity n (%)	Moderate Intensity n (%)	Heavy Intensity n (%)
3 to 5	33	26 (78.8)	2588.0	1 (4.5)	15 (68.2)	6 (27.3)
6 to 9	94	83 (88.3)	4767.3	14 (17.7)	45 (57.0)	20 (25.3)
10 to 15	68	55 (80.9)	1924.9	11 (20.4)	36 (66.7)	7 (13.0)
Total	195	164 (84.1)	3122.4	*26 (16.8)	*96 (61.9)	*33 (21.3)

*For intensity, positive for *A. lumbricoides* through Kato-Katz = 155

machine manual (Lewis et al. 2001) and the study of Belizario et al. (2011).

Data Analysis

Chi-square test was performed to determine the association of age groups with prevalence and intensities of infection, gender with different parasitological parameters, and gender-considering age groups with different parasitological parameters. Fisher's test was done where Chi-square test is not appropriate. The association of mean egg counts and age group was tested using the Kruskal-Wallis test. Multiple linear regression was utilized to determine the association of age, gender, and *Ascaris*, *Trichuris*, and hookworm intensity of infection with hemoglobin levels. The level of significance in all cases was set at 0.05. Statistical analyses were performed using Stata Version 11.

Ethical Considerations

Before project implementation, extensive consultations with community health staff and school supervisors were carried out. Consent from the National Commission for Indigenous People (NCIP) was sought. With the NCIP's supervision, the community tribal chieftain was informed and approval was obtained. The project was carefully coordinated with supervisors of ECCD and KVES, local health officers, and parents of the schoolchildren. Parental consent was a prerequisite to a child's participation. In addition, signatures of assent by minors aged 14 to 15 (16 and above were excluded from the study) were also secured. Parents were requested to accompany their children during the actual fieldwork.

The project commenced upon the approval of the Institutional Review Board of the National Institutes of Health, University of the Philippines Manila. A master list of the schoolchildren with codes was prepared for data collection. Only personnel included in the project team were allowed to access the results.

The results of the study were reported to the NCIP, DOH Region 3, Porac's Rural Health Unit, Katutubo Village health staff, and school supervisors. All schoolchildren received albendazole for STH in November 2011. Children with anemia were reported to Porac's Rural Health Unit for appropriate treatment.

RESULTS

Parasitologic Assessment

Out of 253 schoolchildren enrolled in ECCD and KVES, only 195 (77%), comprised of 82 (42.0%) males and 113 (58%) females, submitted stool samples. The age distribution was three to 15 years old. Thirty three children were three to five years old, 94 were six to nine years old, and 68 were ten to 15 years old. The survey revealed that 190 out of the 195 schoolchildren who submitted their stools had at least one STH infection, giving a cumulative prevalence of 97.4%, ranging from 95.6% among children ten to 15 years old to 100.0% among children aged three to five (Table 1). Of the 195 stools examined, 184 were processed by the Kato-Katz technique. Of these, 152 schoolchildren (82.6%) were identified as having moderate to heavy STH infection; the least from the three age groups was 77.6% (Table 1). Cumulative prevalence and prevalence of moderate to heavy infections among the schoolchildren do not significantly vary across the three age groups (p=0.581, p=0.586, respectively).

The most prevalent STH was *T. trichiura* (94.4%), followed by *A. lumbricoides* (84.1%), and hookworm (21.5%). No other helminths were observed. The overall geometric mean egg count (gmec) was 3122.4 eggs per gram (epg) for *A. lumbricoides*, 704.5 epg for *T. trichiura*, and only 2.6 epg for hookworm (Tables 2 to 4). The prevalence rates, gmec, and intensities of *T. trichiura*, *A. lumbricoides*, and hookworm infection among the schoolchildren do not significantly vary across the three age groups (p>0.05).

The occurrence of co-infection was 81.0% for *A. lumbricoides* and *T. trichiura*, 21.5% for *T. trichiura* and hookworm, and 18.5% for *A. lumbricoides* and hookworm. Triple STH infections were found in 18.5 % of the schoolchildren.

Ascaris lumbricoides, T. trichiura, and hookworm infections were common in both genders. Generally, males were more infected, although significant findings were evident only with ascariasis (p=0.017), trichuriasis (p=0.027), and *Ascaris-Trichuris* co-infection (p=0.005). In addition, males were thrice more likely to have *Ascaris* infection (Odds Ratio: 2.89, 95% CI 1.10-7.85) and *Ascaris-Trichuris* co-infection (Odds Ratio: 3.19, 95% CI 1.29-8.13) than females.

Table 4. Hookworm infection rate, geometric mean egg count, and intensity by age groups of schoolchildren in Katutubo Village.

Age Groups	No. Examined	No. Infected, n (%)	Geometric Mean Egg Count (epg)	Light Intensity n (%)	Moderate Intensity n (%)	Heavy Intensity n (%)
3 to 5	33	5 (15.2)	1.5	5 (100.0)	0	0
6 to 9	94	18 (19.1)	1.9	17 (100.0)	0	0
10 to 15	68	19 (27.9)	4.8	15 (78.9)	4 (21.1)	0
Total	195	42 (21.5)	2.6	*37 (90.2)	*4 (9.8)	0

*For intensity, positive for hookworm through Kato-Katz = 41

The highest ascariasis was observed among male children aged six to nine, while male children aged ten to 15 had higher hookworm infections than their female counterparts. Trichuriasis was also more common for both male children aged three to five and ten to 15. However, gender difference for the three age groups was not significant in all parameters examined.

The reliability of the data gathered was validated by submission to an expert microscopist of 25% randomly selected slides initially examined in the field laboratory. The sensitivity of field microscopists for *Ascaris* and *Trichuris* detection was 100%, while specificity was 92.3% and 100%, respectively. Sensitivity for hookworm was low at 40%, while specificity was 88.6%. Overall, the sensitivity of the field microscopists for STH detection excluding hookworm was 100%, while overall specificity was 50%.

Hemoglobin Level Assessment and its Association with age, gender, and STH infection

Hemoglobin levels below normal, suggesting anemia, were observed only in 39 (18.3%) of the 213 schoolchildren who participated. The overall mean hemoglobin level was 12.18 ± 1.26 g/dL, which is above the cut-off value of 11.0 g/dL.

A multiple linear regression model was used to describe the relationship of age, sex, and intensity of infection with hemoglobin levels. Significantly associated with hemoglobin levels were age group ($p<0.01$) and intensity of hookworm infections ($p=0.013$).

DISCUSSION

The results of this study provide one of the first estimates of soil-transmitted helminth infections and prevalence of anemia among Aeta schoolchildren in Katutubo Village, Planas, Porac, Pampanga. In view of the standard set by the WHO 2002 report (World Health Organization 2002) on community diagnosis of STH for schoolchildren, the present findings of 97.4% cumulative prevalence and 82.6% proportion of moderate- to heavy-intensity STH infection classify the community of schoolchildren in Katutubo Village as Category I. Being Category I, the recommended interventions following the WHO 2002 report (World Health Organization 2002) include twice to thrice a year treatment for one to two years, promotion of activities on health education, and improvement in overall sanitation. As part of the Integrated Helminth Control Program (IHCP), the DOH promotes WASHED or water/washing, sanitation, hygiene and education, and deworming as comprehensive control measures for STH and neglected tropical diseases (NTDs), in general. Considering that deworming alone will not completely eliminate STH as it does not offer lasting impact on STH transmission (World Health Organization 2002), a broader approach for STH control may be achieved with appropriate deworming strategies ensuring high coverage, coupled with improvements in water source, sanitation, hygiene, environmental conditions, as well as proper health education (Belizario et al. 2009, World Health Organization 2002). The current findings are in fact higher than those first documented in the country among indigenous communities in Davao del Norte (Belizario et al. 2011) and are as high as those among STH-infected IP schoolchildren in other countries (Holt et al. 2010, Scolari et al. 2000).

The prevalence rates were higher than 90.0% and the prevalence of heavy-intensity infections were all greater than 70.0% for the three age groups. The heavy parasite burden points to STH as a serious health threat to the schoolchildren of Katutubo Village. The present findings suggest that the existing program for helminth control is insufficient, from administration to monitoring and evaluation of treatment. In addition, the probability of low drug coverage, or of few schoolchildren actually receiving antihelminthics, either due to unavailability of the drugs in the area or to refusal due to personal beliefs, could also account for the high STH prevalence and intensity.

Belizario et al. (2006) reported that the high STH prevalence might also suggest high transmission rates among the children practicing poor personal hygiene and exposure to poor environmental conditions. The implications for children with high intensities of STH infection are high incidence of morbidity and other complications, which could have detrimental effects both on the children's health and school performance (Belizario et al. 2006). The inability to identify the factors that may have contributed to the prevalence of STH in this community is a limitation of the study. However, previous reports have suggested that the risk of transmission and acquisition of parasitic infections are predominantly associated with environmental conditions, socioeconomic status, and poor quality of education. The risk of infection is particularly heightened by poor sanitation and unhygienic practices, including indiscriminate defecation, lack of

footwear, and other health-related factors (Hotez et al. 2008, Lim et al. 2009). Taking into consideration the viability of the STH eggs in soil alone, which could last from months to several years, the likelihood of transmission is not impossible. The limited support of government for basic social services for indigenous families found in remote areas, like the Katutubo Village, also results in limited health-care services and inadequate quality of the education received by the indigenous people, in general, and may therefore contribute to an increased risk of STH transmission and reinfection (Belizario et al. 2011).

Ascaris lumbricoides is normally the most prevalent STH in indigenous communities (Bóia et al. 2009, Scolari et al. 2000, Hurtado et al. 2005, Belizario et al. 2011); however, the current study revealed more children having trichuriasis than ascariasis. The high prevalence of *T. trichiura* may be due to the occurrence of superinfection, a phenomenon where the host harboring the parasite is reinfected with the same parasite species, especially when existing STH measures are insufficient to effect control (Beaver et al. 1984, Belizario et al. 2006). Whipworms tend to infect the lower bowel and are known to exhibit higher tolerance against antihelminthics, so that a single drug dose is generally not effective especially for heavy infections (Horton 2000, Vercruysse et al. 2011), more so if no follow-up treatments are received. Though not the most dominant form, all age groups had high geometric mean egg counts for *A. lumbricoides*, ranging from 1924.9 epg to 4767.3 epg. The high infection rate in virtually all age groups can be attributed to poor hygienic practices considering their economic status, an observation that is corroborated by the earlier studies of Ozasuwa et al. (2011) and Scolari et al. (2000). The observed low hookworm infection rate (21.5%), compared to that of *Ascaris* and *Trichuris* to which most respondents have only light infection, could be attributed to the intrinsic characteristic of hookworm eggs to disintegrate after smear preparation (Belizario et al. 2009).

The numerous cases of co-infection with *A. lumbricoides* and *T. trichiura* can be explained by their similar fecal-oral route transmission pattern. Co-infection among these children with two or three STH even at low intensity can have adverse health outcomes and can increase chances of significant morbidity (Ezeamama et al. 2005, Belizario et al. 2011, Sorensen et al. 2011).

Overall, the parasitological parameters examined do not vary significantly across the three age groups. The differences among the values or percentages obtained may be small or negligible to bring about significantly different results. The respondents' age ranges from three to 15, the age range considered to be most vulnerable to helminth infections. The frequency and intensity of *A. lumbricoides* and *T. trichiura* infections normally peak during childhood and decline in adulthood, while most intense hookworm infections occur in childhood but remain high in adulthood (Bethony et al. 2006, Hotez et al. 2008). While STH infections were common in both genders, more males were infected and showed a significant gender-related infection with

Table 5. Association of age, gender, and *Ascaris*, *Trichuris*, and hookworm intensity of infection with hemoglobin levels.

Variable	Mean (±SD) Hb levels	p-value
Age Group		
3 to 5 years	10.61 (±0.38)	
6 to 9 years	11.67 (±0.30)	<0.01
10 to 15 years	12.31 (±0.32)	
Gender		
Male	10.61 (±0.38)	0.322
Female	11.84 (±0.37)	
Ascaris		
None to Light	10.61 (±0.38)	0.058
Moderate to Heavy	11.09 (±0.33)	
Trichuris		
None to Light	10.61 (±0.38)	0.600
Moderate to Heavy	10.73 (±0.39)	
Hookworm		
None to Light	10.61 (±0.38)	0.013
Moderate to Heavy	8.64 (±0.87)	

Ascaris, Trichuris, and *Ascaris-Trichuris* co-infection. These data are in agreement with the findings of Uneke et al. (2007).

In this study, the overall sensitivity of field microscopists in the detection of STH was high at 100% (90.6-100.0, 95% CI), while the specificity was only 50% (2.7-97.3, 95% CI). This could be explained by limitations in the ability of field microscopists to detect hookworm eggs. This limitation is a major concern in the detection of helminth infection in peripheral health care settings (Belizario et al. 2011). Continued training in laboratory diagnosis of STH infections will play an important role in the accurate diagnosis of helminth infections.

Despite the heavy-intensity STH infection, only 18.3% of the schoolchildren had anemia and the overall mean hemoglobin level was 12.18 ± 1.26 g/dl. Other anemia-contributing factors such as host's nutrition may underlie the reason behind the proportion of anemic children. Only age and intensity of hookworm infections were found to be significantly associated with hemoglobin levels. Children belonging to the youngest age group (three to five) had significantly lower mean hemoglobin levels than older children, which is in fact accounted for by their higher demands for iron making them more prone to anemia (Tsuyuoka et al. 1999). Hookworms, on the other hand, are known to cause blood loss leading to iron-deficiency anemia, a consequence of the parasites' feeding on blood from vessels and mucosal tissues (World Health Organization 2011). The association between hookworm infections and hemoglobin levels means higher risk of morbidity for the schoolchildren. Although most of the schoolchildren had low hookworm load, the observed decreased hemoglobin levels may be possibly explained by the exacerbation due to the hookworm infection, in addition to other anemia-contributing factors such as low iron intake or low iron stores of the host. A limitation of this study was the inability to identify other possible factors contributing to the anemia, such as the nutritional status of the hosts.

The high STH prevalence and intensity, the presence of anemic children, and the association of hookworm infection with the lower hemoglobin level of the children, all call for immediate attention and for support of these children. Local Government Units in collaboration with DOH and DepED can help cater to the needs of these children in terms of treatment and health education. Sustainable deworming strategies, combined with improvements in water/washing, sanitation, hygiene, and education (WASHED), must also be ensured for effective STH control and, thereby, for the health improvement of the Aeta schoolchildren.

ACKNOWLEDGEMENTS

We thank the entire community of Katutubo Village, Planas, Porac, Pampanga for their participation and assistance during the conduct of the field work. We also acknowledge the contributions of Ms. Raezelle Ciro, Ms. Quennie Lou Manigbas, Ms. Fatima Martinez, Ms. Melody Ocampo, and Ms. Bianca Ong for their assistance during project implementation. We extend our gratitude to Prof. Winifreda de Leon, Prof. Paulyn Claro, Dr. Glenn Sia Su, Prof. Marilen Balolong, Ms. Kim Cochon, Dr. John Paulo Ng, and Mr. Jasper Obico for sharing their expertise in this study. Special thanks to the National Institutes of Health, University of the Philippines Manila for providing the research grant for this study.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

CONTRIBUTIONS OF INDIVIDUAL AUTHORS

JN performed the data collection and wrote the manuscript. VB conceptualized the topic and initial study design. VB and FC supervised the data analyses and revisions of the manuscript.

REFERENCES:

Beaver PC, Jung RC, Cupp EW. *Clinical Parasitology*. 9th ed. Philadelphia, PA: Lea & Febiger, 1984:4.

Belizario Jr VY, Amarillo ML, Mataverde C. School-based control of intestinal helminthiasis: Parasitologic assessment and monitoring Philippine J Microbiol Infect Dis 2006; 35:18-28.

Belizario Jr VY, Mataverde CP, de Leon WV, Esparar DG, Lucero A. Common Soil-transmitted helminthiasis in private elementary school children in two areas of Metro Manila. Philippine J Microbiol Infect Dis 2007; 36:1-2.

Belizario V, de Leon W, Lumampao Y, Anastacio MB. Sentinel surveillance of soil-transmitted helminthiasis in selected local government units in the Philippines. Asia Pac J Public Health 2009; 21:26-42.

Belizario Jr, VY, Totañes FI, de Leon WU, Lumampao YF, Ciro RN. Soil-transmitted helminth and other intestinal parasitic infections among school children in indigenous people communities in Davao del Norte, Philippines. Acta Trop 2011; 120 (Suppl 1):S12-S18.

Bethony J, Brooker S, Albonico M, Geiger S, Loukas A, Diemert A, Hotez P. Soil-transmitted helminth infections: ascariasis, trichuriasis, and hookworm. Lancet 2006; 367:1521-1532.

Blum L, Pelto P, Pelto G, Kuhnlein H. Community assessment of natural food sources of vitamin A: Guidelines for an ethnographic protocol; 1997.

Bóia MN, Carvalho-Costa FA, Sodré FC, Porras-Pedroza BE, Faria EC, Magalhães GAP, da Silva IM. Tuberculosis and intestinal parasitism among indigenous people in the Brazilian Amazon region. Rev Saúde Pública 2009; 43:176-178.

Department of Health Philippines. National Objectives for Health; 2011.

Ezeamama A, Friedman J, Olveda R, Acosta L, Kurtis J, Mor V, McGarvey S. Functional significance of low-intensity polyparasite helminth infections in anemia. J Infect Dis 2005; 192:2160-2170.

Holt DC, McCarthy JS, Carapetis JR. Parasitic diseases of remote indigenous communities in Australia. Int J Parasitol 2010; 40:1119–1126.

Horton J. Albendazole: a review of anthelmintic efficacy and safety in human. Cambridge University Press, 2000:113-132.

Hotez PJ, de Silva N, Brooker S, Bethony J. Soil transmitted helminth infections: The nature, causes and burden of the condition. Disease Control Priorities Project. Maryland: Fogarty International Center 2003; 1-40.

Hotez PJ, Bundy DAP, Beegle K, et al. Helminth Infections: Soil-transmitted Helminth Infections and Schistosomiasis. In: Jamison DT, Breman JG, Measham AR, et al., editors. Disease Control Priorities in Developing Countries. 2nd ed. Washington (DC): World Bank; 2006. Chapter 24. Available from: http://www.ncbi.nlm.nih.gov/books/NBK11748/

Hotez PJ, Brindley PJ, Bethony JM, King CH, Pearce EJ, Jacobson J. Helminth infections: the great neglected tropical diseases. J Clin Invest 2008; 118:1311–1321.

Hurtado AM, Lambourne CA, James P, Hill K, Cheman K, Baca K. Human rights, biomedical science, and infectious diseases among South American indigenous groups. Ann Rev Anth 2005; 4:639-665.

Lewis SM, Bain BJ, Bates I. *Dacie and Lewis Practical Hematology*. 9th ed. Churchill Livingstone, London, 2001.

Lim YAL, Romano N, Colin N, Chow SC, Smith HV. Intestinal parasitic infections amongst Orang Asli (indigenous) in Malaysia: Has socioeconomic development alleviated the problem? Trop Biomed 2009; 26:110–122.

National Statistics Coordination Board, 2013. Pampanga province, http://www.nscb.gov.ph/activestats/psgc/province.asp?regName=REGION+III+%28Central+Luzon%29&regCode=03&provCode=035400000&provName=PAMPANGA (accessed 02.07.14)

Osazuwa F, Ayo O, Imade P. A significant association between

intestinal helminth infection and anaemia burden in children in rural communities of Edo state, Nigeria. North Am J Med Sci 2011; 3:30-34.

Scolari C, Torti C, Beltrame A, et al. Prevalence and distribution of soil-transmitted helminth (STH) infections in urban and indigenous schoolchildren in Ortigueira, State of Paranà, Brasil: implications for control. Trop Med Int Health 2000; 5:302–307.

Sorensen WC, Cappello M, Bell D, DiFedele LM, Brown MA. Poly-helminth infection in east Guatemalan school children. J Global Infect Dis 2011; 3:25-31.

StataCorp. Stata Statistical Software: Release 11. College Station, TX: StataCorp LP. 2009.

Thomas M, Woodfield G, Moses C, Amos G. Soil-transmitted helminth infection, skin infection, anaemia, and growth retardation in schoolchildren of Taveuni Island, Fiji. NZ Med J 2005; 118:1-12.

Tsuyuoka R, Bailey W, d'Avila A, Guimarães N, Gurgel R, Cuevas L. Anemia and intestinal parasitic infections in primary school students in Aracaju, Sergipe, Brazil. Cad Saúde Pública 1999; 15:413-421.

Uneke CJ, Eze KO, Oyibo PG, Azu NZ, Ali E. Soil-transmitted helminth infection in school children in South-Eastern Nigeria: the public health implication. The Internet Journal of Third World Medicine 2007; 4.

Vercruysse J, Behnke JM, Albonico M, et al. Assessment of the antihelmintic efficacy of albendazole in school children in seven countries where soil-transmitted helminths are endemic. PLoS Negl Trop Dis 2011; 5.

World Health Organization. *Guidelines for the Evaluation of Soil-Transmitted Helminthiasis and Schistosomiasis at the Community Level*. Geneva, Switzerland: World Health Organization; 1998.

World Health Organization. *Prevention and control of schistosomiasis and soil-transmitted helminthiasis: report of a WHO Expert Committee*. Geneva, Switzerland: World Health Organization; 2002.

World Health Organization. *Useful information on schistosomiasis and STH.* Geneva, Switzerland: World Health Organization; 2011.