

## Original papers

# Intestinal parasitoses and schistosome infections among students with special reference to praziquantel efficacy in patients with schistosomiasis in Hajjah governorate, Yemen

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**ABSTRACT.** The majority of the population in Yemen lives in rural areas and suffers from parasitic infections. Therefore, the present study aimed to determine the prevalence of intestinal parasitoses and schistosome infections among the students enrolled in the primary schools in Hajjah governorate – north of Yemen, along with an assessment of praziquantel (PZQ) in the treatment of microscopy-confirmed cases of *Schistosoma mansoni* and *Schistosoma haematobium*. For this purpose, 780 samples (320 stool and 460 urine) were examined microscopically. The present study revealed an overall infection rate of 75.3% (241/320) with intestinal parasites and *Schistosoma mansoni*. The detected parasite species included *Entamoeba histolytica* (27.8%), *Hymenolepis nana* (12.2%), *Giardia lamblia* (9.7%), *Entamoeba coli* (9.4%), *S. mansoni* (9.1%), *Ascaris lumbricoides* (6.9%), *Trichuris trichiura* (3.1%), *Enterobius vermicularis* (2.8%) and *Ancylostoma duodenale* (2.2%). *Schistosoma haematobium* was prevalent among 1.7% (8/460) of the investigated students. On the other hand, PZQ yielded a cure rate of 75.7% of *Schistosoma*-infected students when administered at 40 mg/kg body weight. However, a 100% cure rate was achieved when administered at 60 mg/kg body weight. Therefore, the findings of the present study highlight the importance of monitoring PZQ efficacy through large-scale studies in different settings endemic for schistosomiasis in the country.

**Keywords:** Intestinal parasitoses, schistosomiasis, praziquantel, effectiveness, Yemen

## Introduction

Protozoal and helminthic parasitoses have a worldwide distribution, particularly among children in the low- and middle-income countries in the tropics and subtropics [1]. In particular, the soil-transmitted helminthiasis and intestinal schistosomiasis have been associated with significant morbidity and mortality among young malnourished and immunosuppressed children [1–3]. The distribution of such infections is influenced by several factors such as suitable climatic conditions, environmental sanitation and human activities including population movements as well as poor sanitation.

Helminthic parasites can be transmitted throughout the year in temperate regions. Soil-

transmitted helminths (STHs) infections caused by *Ascaris lumbricoides*, *Trichuris trichiura* and hookworms usually prevail in areas with favorable soil, warmth and moisture together with poor sanitation. More than two billion people are estimated to be infected with STHs worldwide, with the highest burden and risk being among children [4]. Furthermore, *Schistosoma* species were estimated to infect 261 million people in 78 endemic countries in 2013 [5]. Intestinal protozoan infections also represent a major public health problem in developing countries, predominantly among children [1].

In addition to being one of the least-developed countries [1], Yemen is one of the countries most afflicted with neglected tropical diseases (NTDs), including parasitic infections [6]. Of which, STHs

infections have a significant countrywide impact on both the individual and public health scales. However, the prevalence of intestinal parasitoses differs according to the parasite species, geographic areas and the population categories. For instance, rates of STHs infections among children reported in previous studies were 0.4–68.0% for ascariasis, 0.5–21.0% for trichuriasis and <1.0% for hookworm infection [7–16]. Very low rates of 0.2–2.0% have been reported for infection with *Fasciola hepatica*, while *Taenia* species infection rate ranged 0.3 to 13.0% [11,13,15–17].

Directly-transmitted parasites often spread more easily among children at both the household and community levels. In this context, the prevalence rates of parasitic protozoa among Yemeni children reported in previous studies were 3.0–64.0% for *Entamoeba histolytica/dispar* and 9.0–19.7% for *Giardia lamblia* [7,9–11,14,15]. With respect to helminthic parasites among Yemeni children, the prevalence rates of *Hymenolepis nana* and *Enterobius vermicularis* were 2.0–13.0% and 0.3–1.0%, respectively [7,10–15].

Second to malaria, schistosomosis is the most important disease in terms of morbidity and mortality in Yemen, particularly among children. However, the prevalence rate varies among children from different geographical areas of the country over the past 25 years, ranging from <1.0% to 76.3% for *S. mansoni* and from 3.3% to 52.2% for *S. haematobium* [9,11,14,16,18–23]. Reducing morbidity at individual and community levels through the use of effective chemotherapy is the mainstay for the prevention and control of schistosomosis [24]. Praziquantel (PZQ) is the drug of choice that has been used for a long time for the treatment of intestinal and urogenital schistosomosis. In the light of conflicting published data concerning PZQ efficacy, the current study was undertaken to determine the prevalence of intestinal parasitoses and schistosome infections among the students enrolled in the primary schools of Hajjah governorate along with the assessment of the response by both *S. mansoni* and *S. haematobium* infections to PZQ in microscopy-confirmed cases.

## Materials and Methods

**Study design, population and area.** A cross-sectional study was conducted among students aged 6–16 years of both genders and enrolled in four public primary schools in Kohlan Afar District in

Hajjah governorate, north of Yemen in the period from May 2008 to June 2009.

**Ethical considerations.** This study was approved by the Research Ethics Committee of the Faculty of Medicine and Health Sciences, Sana'a University, Yemen.

**Sample size and sampling strategy.** The present study recruited students from those attending the schools of 12 villages of Kohlan Afar in Hajjah. A total number of 780 (320 stool and 460 urine) samples from 500 students were included in the current study.

**Data and sample collection.** Socio-demographic data were collected using a pre-designed, structured questionnaire. Stool and urine samples were collected into separate containers pre-labeled with the student's name, age and identification number as well as the date and time of collection. Stool samples were preserved with 10% formal saline solution until the time for microscopic examination. The identification numbers of collected samples and questionnaires were double-checked and matched before leaving schools. Samples were then transferred to Sana'a to be examined for parasites in the laboratory unit of Al-Ameen Medical Center in Sana'a to look for the cystic stages of protozoa and ova of helminths.

**Pre-treatment microscopic examination of samples.** Stool samples were examined using formol-ethyl acetate sedimentation technique following standard guidelines [25]. On the other hand, urine samples were centrifuged at 2000 rpm for 2 minutes, and the sediment was examined for the ova of *S. haematobium* under the 10x objective of a light microscope.

**Treatment and follow-up of *Schistosoma*-infected cases.** *Schistosoma*-infected individuals were initially treated with a single dose of praziquantel (PZQ) (40 mg/kg body weight) under the observation of medically qualified physician working in Hajjah city. Treated children were informed that they were going to be followed to assess their response to the medication. In addition, they were clearly instructed not to come in contact with water for any reason, including swimming activities, to avoid any possible re-infection with schistosomes after the intake of the first dose of PZQ.

Three months after treatment with the first dose, stool and urine samples were collected and examined microscopically for *S. mansoni* and *S. haematobium*, respectively. Those still positive for

Table 1. Infection rates with intestinal parasitoses and schistosome infections among students in primary schools of Hajjah governorate (2008–2009)

Character	N	Infection rate n (%)
Overall intestinal parasitoses	320	241 (75.3)
<i>S. mansoni</i>	320	29 (9.1)
<i>S. haematobium</i>	460	8 (1.7)

N – number examined; n – number positive

either species were classified as non-responders to the first dose of PZQ and were given a second PZQ dose of 60 mg/kg body weight. Three months after treatment with the second dose of PZQ, stool and urine samples were collected and examined microscopically for schistosomes.

## Results

Table 1 shows an overall intestinal parasitic infection rate of 75.3% (241/320) among the students enrolled in the schools of Hajjah governorate. Of the examined students, 9.1% (29/320) were positive for *S. mansoni*. On the other hand, *S. haematobium* was prevalent among 1.7% (8/460) of the investigated students.

Table 2. Distribution of intestinal parasitoses and schistosome infections among the students enrolled in primary schools of Hajjah governorate (2008–2009)

Parasite species	n (%)
<i>E. histolytica/E. dispar</i>	89 (27.8)
<i>H. nana</i>	39 (12.2)
<i>G. lamblia</i>	31 (9.7)
<i>E. coli</i>	30 (9.4)
<i>S. mansoni</i>	29 (9.1)
<i>A. lumbricoides</i>	22 (6.9)
<i>T. trichiura</i>	10 (3.1)
<i>E. vermicularis</i>	9 (2.8)
<i>A. duodenale</i>	7 (2.2)

Total number of infected students was 241

Table 2 shows the frequency distribution of intestinal parasitoses among 241 students, where the protozoan infections with *E. histolytica/E. dispar*,

*G. lamblia* and *E. coli* were prevalent among 27.8%, 9.7% and 9.4% of the students, respectively. On the other hand, *H. nana* (12.2%), *S. mansoni* (9.1%), *A. lumbricoides* (6.9%), *T. trichiura* (3.1%), *E. vermicularis* (2.8 %) and *A. duodenale* (2.2%) were the helminthic parasite species prevalent among the investigated students.

Table 3 shows that the infection rates with *S. mansoni* and *S. haematobium* among school students who performed swimming activities were higher than those among students not performing such activities, being 86.2% vs. 13.8% and 75.0% vs. 25.0%, respectively.

Table 4 shows that 75.7% (28/37) of the cases found to be *Schistosoma*-infected were cured three months after a single PZQ dose of 40 mg/kg body weight. Moreover, those not cured with the first dose (24.3%; 9/37) were parasitologically cured three months after a second PZQ dose of 60 mg/kg body weight, totaling the cure rate to 100.0% after the second dose.

## Discussion

Rural communities of Yemen are afflicted with parasitic infections as a public health problem that worsens the quality of life and cognitive functions of schoolchildren and students. In this respect, the present study revealed the infection of about three-quarters of students in the rural districts of Hajjah governorate. This infection rate is higher than the rates recently reported among schoolchildren from Ibb and Sana'a governorates (57.0% and 54.3%, respectively) [12,14]. However, it is lower than that (90.0%) recently reported among schoolchildren

Table 3. Pattern of infections with *S. mansoni* and *S. haematobium* among students in primary schools of Hajjah governorate according to swimming activity (2008–2009)

Parasite species	N	Performing swimming activity	
		Yes n (%)	No n (%)
<i>S. mansoni</i>	29	25 (86.2)	4 (13.8)
<i>S. haematobium</i>	8	6 (75)	2 (25)

Table 4. Parasitological cure rate of *Schistosoma*-infected students in primary schools of Hajjah governorate with a dose administered at either 40 or 60 mg/kg body weight of PZQ (2008–2009)

PZQ treatment	Number of treated	Cured n (%)	Not cured n (%)
Dose at 40 mg/kg body weight	37	28 (75.7)	9 (24.3)
Dose at 60 mg/kg body weight	9	9 (100.0)	0 (0.0)

Total infected cases treated with PZQ was 37; 29 infected with *S. mansoni* and 8 with *S. haematobium*

from Al-Mahweet governorate [13]. The considerably high rates of parasitic infections in the present and previous studies reflect the deteriorating health status of schoolchildren and students in rural communities of the country. On the other hand, the parasitic infection rate among rural students from Hajjah is higher than the rates reported among schoolchildren from Saudi Arabia (27.2%), Oman (38.7%) and Egypt (30.7–55.7%) [26–30], but lower than that (98.4%) reported among rural schoolchildren from Malaysia [31].

Infection with *E. histolytica/dispar* was the most predominant parasitic infection (27.9%) among rural students in the primary schools of Hajjah. This finding is higher than those reported among schoolchildren from rural Sana'a (21.5%) and Hadhramout (16.4%) [11,14], but lower than those recently reported among children from Al-Mahweet (64.0%) and Ibb (33.7%) [12,13]. On the other hand, *G. lamblia* among students in the present study was lower than those reported among children from Ibb (23.6%), Hadhramout (16.8%) and rural Sana'a (16.1%) [11,12,14], but higher than that recently reported among schoolchildren from Al-Mahweet [13].

All species of STHs were detected among rural primary students in Hajjah in the present study, where *A. lumbricoides* was the most common (6.9%) while *A. duodenale* was the least common species (2.2%). This is in line with recent findings reporting comparable rates of *A. lumbricoides* as the highest of recovered STHs species among children from Al-Mahweet (10.0%) and rural Sana'a (8.5%) [13,14]. In contrast, a higher rate of 68.0% was reported for *A. lumbricoides* among schoolchildren from Ibb in 2016 [12]. Similarly, earlier reports documented higher infection rates (20.0–21.0%) with this parasite species among schoolchildren from Sana'a [7,15]. On the other hand, the lower infection rate with hookworms in the present study is in agreement with that (1.2%) recently reported among schoolchildren from Ibb [12]. It is noteworthy that hookworms were not reported in

several earlier studies conducted in different governorates in Yemen [7,10,14,15,32,33]. The prevalence of *T. trichiura* in the present study (3.1%) is lower than those recently reported among children from Al-Mahweet (18.0%) and Ibb (9.3%) [12,13]. In contrast, it is higher than that (0.5%) recently reported among schoolchildren from rural Sana'a [14]. Generally, the low infection rates with STHs could be attributed to the school-based control of STHs through albendazole administration to schoolchildren that has been ongoing by the time of the study since 2006 [34]. Such STHs infection rate is below the threshold (20.0%) recommended by the World Health Organization for implementing preventive chemotherapy for STHs among school-age children in endemic settings [35].

In spite of their direct transmission and persistence through autoinfection, low prevalence rates of *H. nana* (12.2%) and *E. vermicularis* (2.8%) were revealed among the students in the primary schools of Hajjah. However, these rates are higher than those recently reported (5.3% and <0.5%, respectively) among schoolchildren from rural Sana'a [14]. It is noteworthy that rates of 1.4–13.0% for *H. nana* and <0.5–13.0% for *E. vermicularis* were reported among children from different governorates in Yemen [7,9–15]. The unexpectedly low prevalence of *E. vermicularis* among such an age group could be attributed to the fact that the detection in the present study relied on stool examination. However, detection can be significantly enhanced by the Scotch-tape anal swab technique [36].

In the present study, infection rates with *S. mansoni* and *S. haematobium* among students who reported performing swimming activities were 86.2% and 75.0%, respectively. However, lower rates of 13.8% and 25.0%, respectively, were found among those who did not report the performance of swimming activities. The higher infection rates among students performed a swimming is perhaps an expected finding as the source of infection with both types of schistosomes is through cercariae

penetrating the skin and repeated swimming activity would naturally enhance the possibility of infection.

The potential resistance of *S. mansoni* to PZQ was first demonstrated in mice in 1994, raising concerns about the possibility of resistance development as a result of drug pressure [37]. Two years later, approximately 1–2.4% of the Egyptian villagers in the Nile Delta were found not to be completely cured of their *S. mansoni* infection with PZQ and three of every 1,000 treated patients were found to probably harbor parasites that can tolerate high doses of the drug [38]. In Yemen, there is a lack of studies on the resistance/tolerance of *S. mansoni* or *S. haematobium* to PZQ. Therefore, the present study assessed PZQ efficacy in the treatment of intestinal and urogenital schistosomiasis among students enrolled in the primary schools following a treatment strategy conducted by Ismail et al. [38].

Of 37 *Schistosoma*-infected cases treated with an oral dose of PZQ administered at 40 mg/kg body weight, the cure rate was 75.7%. However, repeated treatment with an oral dose of 60 mg/kg body weight for cases classified as non-responders to the concentration of PZQ at 40 mg/kg body weight achieved a cure rate of 100%. The reason for the relatively poor response to the initial treatment with PZQ at 40 mg/kg body weight among Yemeni students could not be elucidated but provides an alarming signal about the possibility of the development of drug resistance. In this respect, intensive use of PZQ may lead to the possible development of PZQ resistant parasites [38–40]. Other factors to be taken into account include host genetic factors and water contact patterns in the community.

Because PZQ tablets were swallowed under supervision, the refusal of drug intake or vomiting could not be essentially argued in the present study. However, an important issue that cannot be ignored is the batch of PZQ used in the present study. In this regard, the used batch was not previously tested, and we assumed that the drug is effective prior to prescription.

In conclusion, intestinal parasitoses predominate among the students in the primary schools of Hajjah governorate, with *E. histolytica* being the most frequent protozoan parasite and *A. lumbricoides* being the most frequent helminthic parasite. On the other hand, *S. mansoni* was prevalent among 9.6% of the participants. PZQ has a cure rate of 75.7% when administered at 40 mg/kg body weight but achieves a 100% cure rate when administered at 60

mg/kg body weight among Yemeni students enrolled in the primary schools of Hajjah. PZQ efficacy should be monitored through large-scale studies in different settings endemic for schistosomiasis in the country.

## References

- [1] Harhay M.O., Horton J., Olliaro P.L. 2010. Epidemiology and control of human gastrointestinal parasites in children. *Expert Review of Anti-Infective Therapy* 8: 219-134. doi:10.1586/eri.09.119
- [2] Brito L.L., Barreto M.L., Silva Rde C., Assis A.M., Reis M.G., Parraga I.M., Blanton R.E. 2006. Moderate- and low-intensity co-infections by intestinal helminths and *Schistosoma mansoni*, dietary iron intake, and anemia in Brazilian children. *The American Journal of Tropical Medicine and Hygiene* 75: 939-944. doi:10.4269/ajtmh.2006.75.939
- [3] Hall A., Hewitt G., Tuffrey V., de Silva N. 2008. A review and meta-analysis of the impact of intestinal worms on child growth and nutrition. *Maternal and Child Nutrition* 4 (Suppl. 1): 118-236. doi:10.1111/j.1740-8709.2007.00127.x
- [4] World Health Organization. 2012. Soil-transmitted helminthiasis. Eliminating soil-transmitted helminthiasis as a public health problem in children: Progress report 2001–2010 and strategic plan 2011–2020. WHO, Geneva.
- [5] Anonymous. 2015. Schistosomiasis: number of people treated worldwide in 2013. *Weekly Epidemiological Record* 90: 25-32.
- [6] Hotez P.J., Savioli L., Fenwick A. 2012. Neglected tropical diseases of the Middle East and North Africa: review of their prevalence, distribution, and opportunities for control. *PLoS Neglected Tropical Diseases* 6: e1475. <https://doi.org/10.1371/journal.pntd.0001475>
- [7] Azazy A.A., Al-Tiar A.S. 1999. A study survey on intestinal and blood parasites among school children in Sana'a province, Yemen. *Saudi Medical Journal* 20: 422-424.
- [8] Raja'a Y.A., Sulaiman S.M., Mubarak J.S., El-Bakri M.M., Al-Adimi W.H., El-Nabihi M.T., El-Dhobri M.A., Raja'a J.A. 2000. Some aspects in the control of schistosomiasis and soil-transmitted helminthiasis in Yemeni children. *Saudi Medical Journal* 22: 428-432.
- [9] Raja'a Y.A., Assiragi H.M., Abu-Luhom A.A., Mohammed A.B., Albahr M.H., Ashaddadi M.A., Al Muflihi A.N. 2000. Schistosomes infection rate in relation to environmental factors in school children. *Saudi Medical Journal* 21: 635-638.
- [10] Al-Shibani L.A., Azazy A.A., El-Taweel H.A. 2009. Cryptosporidiosis and other intestinal parasites in 3

- Yemeni orphanages: prevalence, risk, and morbidity. *Journal of the Egyptian Society for Parasitology* 39: 327-337.
- [11] Al-Haddad A.M., Baswaid S.H. 2010. Frequency of intestinal parasitic infection among children in Hadhramout governorate (Yemen). *Journal of the Egyptian Society for Parasitology* 40: 479-488.
- [12] Alsubaie A.S.R., Azazy A.A., Omer E.O.M, Al-Shibani L.A., Al-Mekhlafi A.M.Q, Al-Khawlani F.A. 2016. Pattern of parasitic infections as public health problem among school children: a comparative study between rural and urban areas. *Journal of Taibah University Medical Sciences* 11: 91-178. doi:10.1016/j.jtumed.2015.10.006
- [13] Alwabr G.M.A., Al-Moayed E.E. 2016. Prevalence of intestinal parasitic infections among school children of Al-Mahweet governorate, Yemen. *European Journal of Biological Research* 6: 2.
- [14] Al-Mekhlafi A.M., Abdul-Ghani R., Al-Eryani S.M., Saif-Ali R., Mahdy M.A. 2016. School-based prevalence of intestinal parasitic infections and associated risk factors in rural communities of Sana'a, Yemen. *Acta Tropica* 163: 135-141. doi:10.1016/j.actatropica.2016.08.009
- [15] Azazy A.A., Raja'a Y.A. 2003. Malaria and intestinal parasitosis among children presenting to the paediatric centre in Sana'a, Yemen. *Eastern Mediterranean Health Journal* 9: 1048-1053.
- [16] Raja'a Y.A., Mubarak J.S. 2006. Intestinal parasitosis and nutritional status in schoolchildren of Sahar district, Yemen. *Eastern Mediterranean Health Journal* 12 (Suppl. 2): S189-S194.
- [17] Farag H.F. 1985. Intestinal parasitosis in the population of the Yemen Arab Republic. *Tropical and Geographical Medicine* 37: 29-31.
- [18] Nagi M.A., Kumar A., Mubarak J.S., Bamashmoos S.A. 1999. Epidemiological, clinical and haematological profile of schistosomiasis in Yemen. *Eastern Mediterranean Health Journal* 5: 177-181.
- [19] Al-Shamiri A.H., Al-Taj M.A., Ahmed A.S. 2011. Prevalence and co-infections of schistosomiasis /hepatitis B and C viruses among school children in an endemic areas in Taiz, Yemen. *Asian Pacific Journal of Tropical Medicine* 4: 404-408. doi:10.1016/S1995-7645(11)60113-2
- [20] Abdulrab A., Salem A., Algobati F., Saleh S., Shibani K., Albutthigi R. 2013. Effect of school based treatment on the prevalence of schistosomiasis in endemic area in Yemen. *Iranian Journal of Parasitology* 8: 219-226.
- [21] Sady H., Al-Mekhlafi H.M., Mahdy M.A., Lim Y.A., Mahmud R., Surin J. 2013. Prevalence and associated factors of schistosomiasis among children in Yemen: implications for an effective control programme. *PLoS Neglected Tropical Diseases* 7: e2377. doi:10.1371/journal.pntd.0002377
- [22] Sady H., Al-Mekhlafi H.M., Webster B.L., Ngui R., Atroosh W.M., Al-Delaimy A.K., Nasr N.A., Chua K.H., Lim Y.A., Surin J. 2015. New insights into the genetic diversity of *Schistosoma mansoni* and *S. haematobium* in Yemen. *Parasites & Vectors* 8: 544. doi:10.1186/s13071-015-1168-8
- [23] Al-Waleedi A., El-Nimr N., Hasab A., Bassiouny H., Al-Shibani L. 2013. Urinary schistosomiasis among schoolchildren in Yemen: prevalence, risk factors, and the effect of a chemotherapeutic intervention. *Journal of the Egyptian Public Health Association* 88: 130-136. doi:10.1186/s13071-015-1168-8
- [24] WHO Expert Committee. Prevention and control of schistosomiasis and soil-transmitted helminthiasis. 2002. *World Health Organization Technical Report Series* 912: 1-57.
- [25] Cheesbrough M. 2006. *District Laboratory Practice in Tropical Countries: Part 1*. Cambridge University Press, Cambridge.
- [26] Mohammad K.A.E., Abu El-Nour M.F., Saad M.A., Timsah A.G. 2014. The prevalence and associated risk factors of intestinal parasitic infections among school children living in rural and urban communities in Damietta Governorate, Egypt. *Academia Arena* 4: 90-97.
- [27] Yones D.A., Galal L.A., Abdallah A.M., Zaghlol K.S. 2015. Effect of enteric parasitic infection on serum trace elements and nutritional status in upper Egyptian children. *Tropical Parasitology* 5: 29-35. doi:10.4103/2229-5070.145581
- [28] Abdel Fatah N.K., Nofal L.M. 2016. Anthropometric status, anemia and intestinal parasitic infections among primary school children in Alexandria, Egypt. *Bulletin of the High Institute of Public Health* 42: 82-102.
- [29] Al-Mohammed H.I., Amin T.T., Aboulmagd E., Hablus H.R., Zaza B.M. 2010. Prevalence of intestinal parasitic infections and its relationship with socio-demographics and hygienic habits among male primary schoolchildren in Al-Ahsa, Saudi Arabia. *Asian Pacific Journal of Tropical Medicine* 3: 906-912.
- [30] Patel P.K., Khandekar R. 2006. Intestinal parasitic infections among schoolchildren of the Dhahira Region of Oman. *Saudi Medical Journal* 27: 627-632. doi:10.1016/S1995-7645(10)60218-0
- [31] Al-Delaimy A.K., Al-Mekhlafi H.M., Nasr N.A., Sady H., Atroosh W.M., Nashiry M., Anuar T.S., Moktar N., Lim Y.A., Mahmud R. 2014. Epidemiology of intestinal polyparasitism among Orang Asli school children in rural Malaysia. *PLoS Neglected Tropical Diseases* 8: e3074. doi:10.1371/journal.pntd.0003074.
- [32] Alyousefi N.A., Mahdy M.A., Mahmud R., Lim Y.A. 2011. Factors associated with high prevalence of intestinal protozoan infections among patients in Sana'a City, Yemen. *PloS ONE* 6: e22044. doi:10.1371/journal.pone.0022044

- [33] Bin Mohanna M.A., Al-Zubairi L.M., Sallam A.K. 2014. Prevalence of *Helicobacter pylori* and parasites in symptomatic children examined for *Helicobacter pylori* antibodies, antigens, and parasites in Yemen. *Saudi Medical Journal* 35: 1408-1411.
- [34] Oshish A., AlKohlani A., Hamed A., Kamel N., AlSoofi A., Farouk H., Ben-Ismael R., Gabrielli A.F., Fenwick A., French M.D. 2011. Towards nationwide control of schistosomiasis in Yemen: a pilot project to expand treatment to the whole community. *Transactions of the Royal Society of Tropical Medicine Hygiene* 105: 617-627. doi:10.1016/j.trstmh.2011.07.013
- [35] World Health Organization. 2006. Preventive chemotherapy in human helminthiasis. WHO, Geneva.
- [36] Cho S.Y., Kang S.Y. 1975. Significance of Scotch-tape anal swab technique in diagnosis of *Enterobius vermicularis* infection. *Korean Journal of Parasitology* 13: 102-114.
- [37] Fallon P.G., Doenhoff M.J. 1994. Drug-resistant schistosomiasis: resistance to praziquantel and oxfamiquine induced in *Schistosoma mansoni* in mice is drug specific. *The American Journal of Tropical Medicine and Hygiene* 51: 83-88. doi:10.4269/ajtmh.1994.51.83
- [38] Ismail M., Metwally A., Farghaly A., Bruce J., Tao L.F., Bennett J.L. 1996. Characterization of isolates of *Schistosoma mansoni* from Egyptian villagers that tolerate high doses of praziquantel. *The American Journal of Tropical Medicine and Hygiene* 55: 214-218. doi:10.4269/ajtmh.1996.55.214
- [39] Brindley P. 1994. Drug resistance to schistosomeicides and other anthelmintics of medical significance. *Acta Tropica* 56: 213-231. doi:10.1016/0001-706X(94)90064-7
- [40] Fallon P.G., Sturrock R.F., Niang A.C., Doenhoff M.J. 1995. Short report: diminished susceptibility to praziquantel in a Senegal isolate of *Schistosoma mansoni*. *The American Journal of Tropical Medicine and Hygiene* 53: 61-62. doi:10.4269/ajtmh.1995.53.61

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