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Risk factors associated with intestinal pathogenic parasites in schoolchildren

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ABSTRACT

Diseases caused by intestinal parasites impose a substantial burden on population of middle income countries including Pakistan. This research was aimed to assess the risk factors for intestinal parasites in school children of Malakand, Pakistan. Two hundred and eighty eight students were enrolled between February and June 2016. Out of the total enrolled 184 were agreed to collect stool specimens. A questionnaire was also used to collect the data on socio-demographic and socio-economic characteristics of the participants. All the students were guided to collect at least 10g of their own stool specimens. Each of the stool specimens was diagnosed for the presence of any stage of helminth or protozoal parasites. Formal ether concentration method and wet mount techniques were applied. One way ANOVA was used for calculation of P value when it was less than 0.05 which was considered significant. Eighty two percent of the participants were found infected with one species of parasite while 69.9% of the participants were infected with more than one species of intestinal parasites. The most prevalent parasite was hook worm 33.4% (n = 99/296) followed by *Taenia saginata* 28.7% (n = 85/296), *Ascaris lumbricoides* 27.7% (n = 82/296), *Hymenolepis nana* 6.08% (n = 18/296), *Entamoeba histolytica* 3.37% (n = 10/296) and least for each *Enterobius vermicularis* and *Fasciola hepatica* 0.37% (n = 1/296). Previously used drugs, level in school, ages, weight and upper arm circumference were the most significantly (P < 0.05) related factors for the occurrence of intestinal parasite infection. Present research endorsed that risk factors play a key role in the transmission of parasitic diseases. Lack of safe water supply, using raw vegetables, animal keeping, which should be considered for sustainable strategies in the control of these infections preferably in remote parts of the world.

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1. Introduction

Intestinal parasites are the organisms that inhabit intestine and lives on the expense of their host. The factors like social customs, religious affairs, environmental factors, availability of the intermediate hosts, notorious habits and personal cleanliness of the individuals are affected on the distribution of parasites (Khan et al., 2021).

Intestinal parasitic infections (IPIs) are widely prevalent and have described as constituting the maximum single global cause of sickness and diseases. Parasites in the intestine of human beings are associated to lack of sanitation, lack of safe water and improper hygiene. The poor people in developing countries experience for

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under nutrition and continuous infections lead to excess morbidity that can continue from generation to generation (Steketee, 2003).

The most common intestinal parasites are *Ascaris lumbricoides*, *Trichuris trichiura* and hookworms, are collectively called soil-transmitted helminths (Bethony et al., 2006). Among them *Ascaris lumbricoides* are the most common and largest helminth abode in the intestine of human beings, while *Hymenolepis nana* in cestodes is the most common tapeworm infect human population globally. Giardiasis caused by the most prevalent protozoan parasite called *Giardia duodenalis/ Giardia intestinalis*. In the past these parasites infect over 200 million people in the world (Pillai and Kain, 2003). Approximately 30 billion people are harshly sick with intestinal worms and of those, at least 50% are school-age children (Mineno and Avery, 2003).

Intestinal parasitic infections are more common among children as compared to other people. About 12% of the overall illness cause by intestinal parasites among children with age ranges from 5 to 14 years in under developed countries (Awasthi et al., 2003). Approximately 270 million preschool and 600 million school children are inhibited in area where high transmission of parasitic worm take place (WHO, 2016). These showed that children are the most important risk group for parasitic infection in many developing countries of the world. High prevalence of intestinal parasitic infection was reported among school children in Sub Saharan African countries.

Pakistan even located in diverse climatic conditions, a considerable number of scholars conducted their studies on intestinal parasitic infection as D.I Khan (Mirza et al., 2012), Kohat (Ayaz et al., 2013), Multan Punjab (Tasawar et al., 2013), Banu (Alamir et al., 2013), Swat (Khan et al., (2015)), North Waziristan (Ahmed et al., 2015), Upper Dir (Khan et al., 2016), Peshawar (Akbar et al., 2014), Punjab (Kosar et al., 2017), AJK (Khan and Khan, 2017), Swat (Khan et al., 2017), Peshawar (Haider et al., 2018), Peshawar (Ilyas et al., 2018), Swat (Khan et al., 2018a), Swat (Khan et al., 2018b), Mardan (Niaz et al., 2019), Islamabad (Shakoor et al., 2018) and Karachi (Arshad et al., 2019), Lower Dir (Khan et al., 2021), Lower Dir (Rahman et al., 2021) and Lower Dir (Ulhaq et al., 2021). Present study was aimed to investigate the relationship of intestinal parasitic infection with respect to risk factors in school children of the region.

2. Materials and methods

2.1. Study area

District Lower Dir is situated at 34.9161° N, 71.8097° E. The total given area is 1,582 km². Approximately 1,435,917 population. The density of citizens was 908 (people/km²). The normal rain fall and annual hotness reported as 723mm and 20.2 °C respectively. January is the coldest while June is the hottest month of the year recorded 8.3C° and 42C° temperature respectively (Khan et al., 2020a, b).

2.2. Ethical approval

This study was approved by the committee board of study, Department of Zoology, University of Malakand, Pakistan. The section head and school principal received official letter for the information. The parents / guardians of students were educated through a consent letter. Stool samples were gathered out only from volunteer children. Those children who were infected with any of the protozoan or helminth infection were informed to be treated with relevant drugs.

2.3. Study design

From February to June 2016 a cross sectional study was designed in Public School students, University of Malakand. One hundred eighty four children were participated for the present study. Children were grouped according to their education level (grade 6–10). Questions were asked regarding age of the student, height and weight, number, width and upper arm circumference as socio demographic while water supply system, animal keepings, consumption of fresh vegetable, habit of hand washing and profession of father through a semi-structured questionnaire.

2.4. Data collection

Each of the students was instructed to gather 20 g of his/her own stool sample. For preservation, we have added 10% formalin for the stool specimens to every container. For identification after collection of the specimen the container was tagged with a voucher number. The collected stool specimen was carrying to the laboratory of parasitology, Department of Zoology, University of Malakand for parasite analysis.

2.5. Parasite analysis

Each of the samples was observed first by naked eyes for any segmental or adult stage of the helminth parasite and then were seen using the microscope by applying normal saline and Lugol's solution as concentration techniques and direct smear methods.

2.6. Statistical analysis

Data was observed for the difference between examined and infected participants (table #3) by using Graph Pad version 5. P value which was less than 0.05 was measured significant.

3. Results

Total enrolled students (n = 288), only 63.8% (n = 184) were participated in the study. The mean and standard deviation of the students age was 14 and 3.05 years. Female students were not participated due to cultural background (Table 3).

3.1. Prevalence and pattern of infection

Present study informs a new sight on infection of school children with intestinal protozoan and helminthes parasite. Single infection was observed in 39.1% (59/151) and mixed in 60.9% (92/151) (Table 1).

Among the helminth the most common parasites is hook worm, having incidence 33.4% (n = 99/296) after that *T. saginata* 28.7% (n = 85/296), *A. lumbricoides* 27.7% (n = 82/296), *H.nana* 6.08% (n = 18/296), *E. vermicularis* and *F. hepatica* each with 0.33% (n = 1/296) of prevalence, while among the protozoan parasite *E. histolytica* was found in 3.37% (n = 10/296), Table 2.

3.2. Socio-demographic characteristics of the students

Ages, weight, upper arm circumferences in inches and level of students were significant socio-demographic characteristics studied (Table 3).

Table 1
Pattern of infection with single or multiple parasite infection in Malakand university schoolchildren.

Pattern of infection	Number	Prevalence in %
Mono parasitism	59	39.0
<i>A.lumbricoides</i>	15	9.93
Hook worm	28	18.5
<i>T.saginata</i>	13	8.60
<i>H. nana</i>	2	1.32
<i>E.histolytica/dispar</i>	1	0.66
Poly parasitism		
With 2 species	44	29.1
<i>T. saginta</i> + hookworm	16	10.5
Hookworm + <i>A.lumbricoides</i>	13	8.60
<i>A.lumbricoides</i> + <i>T.saginata</i>	10	6.62
<i>H.nana</i> + <i>T.saginata</i>	3	1.98
hookworm + <i>E.vermicularis</i>	1	0.66
hookworm + <i>H.nana</i>	1	0.66
With 3 species	41	27.1
<i>A.lumbricoides</i> + <i>T.saginata</i> + hookworm	28	18.5
<i>A.lumbricoides</i> + <i>T.saginata</i> + <i>H.nana</i>	4	2.64
<i>A. lumbricoides</i> + <i>T.saginata</i> + <i>E.histolytica</i>	3	1.98
Hookworm + <i>T.saginata</i> + <i>H.nana</i>	2	1.32
<i>A.lumbricoides</i> + <i>A.duodenale</i> + <i>H.nana</i>	2	1.32
<i>T.saginata</i> + <i>H.nana</i> + <i>E.histolytica</i>	1	0.66
<i>T.saginata</i> + hookworm + <i>E.histolytica</i>	1	0.66
With 4 species	7	4.63
<i>A.lumbricoides</i> + hookworm + <i>T.saginata</i> + <i>E. histolytica</i>	3	1.98
<i>A.lumbricoides</i> + hookworm + <i>F.hepatica</i> + <i>H.nana</i>	3	1.98
<i>A.lumbricoides</i> + <i>T.saginata</i> + <i>E. histolytica</i> + hookworm	1	0.66
Gross polyparasitism	92	60.9
All the students infected	151	82.0
All the samples examined	184	

Table 2
Prevalence of intestinal protozoan and helminth infection in schoolchildren, University of Malakand, Pakistan.

Parasite species	Number	Prevalence in %
Helminth		
hookworm	99	33.4
<i>Taenia saginata</i>	85	28.7
<i>Ascaris lumbricoides</i>	82	27.7
<i>Hymenolepis nana</i>	18	6.08
<i>Fasciola hepatica</i>	1	0.33
<i>Enterobius vermicularis</i>	1	0.33
Protozoa	10	3.37
<i>Entamoeba histolytica/dispar</i>		
Total number of infection	296	
Total number of individual infected	151	

Table 4
Relationship between socio-economic factors and intestinal parasitic infection in schoolchildren, University of Malakand, Pakistan.

Factors	Number Examined	Number infected	%	P.Value	
Father literacy status	Illiterate	70	61	87.1	0.1043
	Literate	114	90	78.9	
Father occupation	Government employee	111	85	76.5	0.2809
	Non-government employee	73	66	90.4	
Animal keepers	Yes	144	124	86.1	0.0138
	No	40	27	67.5	
Raw vegetables use	Yes	157	137	87.2	0.0088
	No	27	14	51.8	
Water source	Well	139	121	57.0	0.0109
	Spring	39	30	76.9	
Hand washing	After defecation	113	94	83.1	0.788
	Before meal	71	57	80.2	
Gastrointestinal complaint	Yes	81	67	82.7	0.2403
	No	103	84	81.5	
Previously used drugs	Yes	61	51	83.6	0.0474
	No	123	100	81.3	

Table 3
Relationship between socio-demographic factors and intestinal parasitic infection in schoolchildren, University of Malakand, Pakistan.

Variables	Number examined	Infected	%	P Value	
Sex	Male	184			
Ages (Years)	10–11	19	15	9.93	0.0004
	12–13	25	17	11.2	
	14–15	114	99	65.5	
	16–17	26	20	13.2	
Grade level	6	27	21	13.9	0.0075
	7	40	33	21.8	
	8	55	47	31.1	
	9	38	34	22.5	
Height (inch)	10	24	16	10.5	0.1641
	55–61	70	65	43.04	
	62–68	62	47	31.12	
	69–74	52	39	25.82	
Weight (kilograms)	26–44	88	69	45.6	0.0048
	45–63	90	80	52.9	
	64–82	6	2	1.32	
	8–9	97	83	54.9	
Upper arm circumference (inch)	6–7	65	54	35.7	0.0066
	10–11	22	14	9.27	

3.3. Socio-economic characteristics of the students

The factors: raw vegetable, animal keeping, water supply system, consumption, and usage of drugs previously were having significant association with intestinal parasitic infection (Table 4).

4. Discussion

Research data on the risk factors of intestinal parasitic infection is limited in Pakistan. The present study was therefore designed to understand the prevalence and risk factors of intestinal parasitic diseases. Present result supports that intestinal protozoa and worms are one of the most important threats to school children in the region. Amongst the infected students more than half were infected with multiple infections.

In current study total prevalence of protozoan and helminth intestinal parasitism was 82.0%. This was comparable with 83.1% (Khan and Khan, 2017), 79.2% (Noor-Un-Nisa, 2012), 73.2% (Khan and Khan, 2017), 65.9%, in Swat district respectively. Present survey is comparable with study conducted in south East Ethiopia 83.0 (Mangistu and Birhano, 2004).

Ascaris lumbricoides was the second most prevalent parasite in current study with 27.7% in prevalence, which is comparable with 30.0% study conducted in Kurram Agency (Ali et al., 2016), 39.8% in district Swat (Khan et al., 2011), 39.8% in district Swat, 30.1% in dis-

tract Swat (Noor-Un-Nisa, 2012), 31.7 % in district Swat (Khan et al., 2019) and 33.3 % in Punjab (Dar et al., 2013).

Ancylostoma duodenale (the old world hook worm) is the most commonly found parasites in present study. The prevalence of this hookworm infection are 33.4%. Studies from Pakistan have been reported 77% prevalence rate among young children (Hafeez et al., 2003).

Enterobius vermicularis commonly called the thread worm. The overall prevalence noted in this study was 0.33%. *E. vermicularis* infection among children are comparable with 3.5% in Peshawar, 2.38% in Larkana (Khan et al., 1988), 2.3% in Islamabad (Shaiket et al., 2000), 2.3% in Kuram Agency (Ali et al., 2016), 2.3% in Dir (Pal and Subhani, 1989), 1.8 in Quetta (Sajad et al., 2009), 1.5% in Peshawar, 1.5% in Lahore (Akhtar et al., 1993), 1.4% in District Peshawar, 1.35% in Upper Dir (Ullah et al., 2014), 1.7% in Shikarpur, 1.3 % in Muzafarabad (Qureshi, 1995) and 1.1% in Rawalpindi.

Taenia saginata (the beef tapeworm) is the most common intestinal cestodes parasite in the prevalence rate 28.7%. The findings of this study is comparable with 25% in Punjab (Dar et al., 2013), 21% in Swat (Khan and Khan, 2017), 20.9% Shikarpur, 19.7% in Swat, 16.7% in Lahore, 12.8% in Swat.

Hymenolepis nana commonly known as the dwarf tape worm was the less prevalent 6.08% in prevalence comparable with 21.5% in Larkana (Shaikh et al., 2000), 21% in Islamabad (Pal and Malik, 1979), 20.9% in Shikarpur (Shaikh et al., 2003), 18% in Peshawar (Siddique and Bano, 1979), 17.2% in Lahore (Akhtar et al., 1993), 15% in North Waziristan (Ahmed et al., 2015), 10.7% in district Swat (Khan et al., 2018b).

The pattern of infection in current study showed that more than half of the infected children were infected with multiple parasitic infection. This pattern was in accordance with those found by (Nisa et al., 2011; Khan et al., 2012). All these studies showed high prevalence in the combination with *T. trichura* + *A. lumbricoides* while in current study the association between *A. duodenale* + *A. lumbricoides* was stronger than others.

The students uses well water and parent keeping cattles were 4 times more infected with intestinal protozoan and helminth parasites than the practice spring water for drinking and parents do not keeping the cattles. The students who wash their hands after toilet are less infected than those who wash their hand before meal. The habit of washing hands prior to eat and after toilet and the material used to wash their hands found were more efficient. Study results reported by (Alemu et al., 2011) showed that hand washing only with water is less effective than washing with soap was more effective in reducing the infection. The study results reported by investigated that the students who wash their hands before and after defecation were found less at risk to the protozoan and helminth infection than those who wash their hands only prior to meal. Students who had not used antihelminthic drugs were ½ times more infected as compared to those who had already used anti helminths. Current study reveal that children whose fathers were government servant were found more infected as compared to those whose fathers were not on government job.

5. Conclusions

In northwestern parts of Pakistan intestinal parasitic infection remained an essential public health problem. Level of education, raw vegetable uses, weight and upper arm circumference as well as animal keeping, water supply resources and previously used drugs were the most important risk factors related to intestinal parasitic infection. We suggest that community should be involved in health initiatives to control intestinal parasitic infection.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

- Ahmed, W., Ahmad, M., Shah, F., 2015. Pervasiveness of intestinal protozoan and worm incursion in IDP's (North Waziristan agency, KPK-Pakistan) children of 6–16 years. *JPM* 65, 943–945.
- Akbar, N., Ayaz, S., Rahman, S., Khan, S., Khan, S.N., Noor, A.A., Waqar, M., 2014. Molecular detection of *Entamoeba histolytica* in different water sources of District Peshawar, Pakistan. *Ann. Res. Rev. Biol.*, 1461–1470.
- Akhtar, T., Tehsin, N., Usman, S., 1993. Intestinal parasitic burden in two local hospitals of Lahore. *Biologica* 38, 41–48.
- Alamir, M., Awoke, W., Feleke, A., 2013. Intestinal parasites infection and associated factors among school children in Dagi primary school, Amhara National Regional State, Ethiopia. *Health* 05 (10), 1697–1701.
- Alemu, A., Atnafu, A., Addis, Z., Shiferaw, Y., Teklu, T., Mathewos, B., Birhan, W., Gebretsadiq, S., Gelaw, B., 2011. Soil transmitted helminths and Schistosoma mansoni infections among school children in Zarima town, northwest Ethiopia. *BMC Infect. Dis.* 11 (1). <https://doi.org/10.1186/1471-2334-11-189>.
- Ali, U., Yousaf, I., Danish, S.H., Ahmad, F., Hassan, W., 2016. Worm infestation and associated factors in school children of district Zhob, Balochistan, Pakistan. *Pakistan J. Physiol.* 12 (1), 18–21.
- Arshad, S., Khatoon, N., Warind, J.A., Khan, A., Waheed, S., Khan, W., 2019. The prevalence of human intestinal protozoal and helminthic infection in Karachi. *Int. J. Biol. Biotech.* 16 (2), 319–323.
- Awasthi, S., Bundy, D.A., Savioli, L., 2003. Helminthic infections. *Bmj* 327 (7412), 431–433.
- Ayaz, S., Khader, J.A., Rubab, L., Ullah, R., Khan, S., Hussain, R., Abd, E., N. m., 2013. Prevalence and Molecular Detection of Giardia and Cryptosporidium spp in Communities Consuming Different Drinking Water Sources in Kohat, Khyber Pakhtunkhwa Pakistan. *Life Sci. J.* 10 (1), 2708–2711.
- Bethony, J., Brooker, S., Albonico, M., Geiger, S.M., Loukas, A., Diemert, D., Hotez, P.J., 2006. Soil-transmitted helminth infections: ascariasis, trichuriasis, and hookworm. *The lancet* 367 (9521), 1521–1532.
- Dar, U.F., Iqbal, M.S., Latif, M.Z., 2013. Worm infestation among Children of Rural Area of Central Punjab. *PJMHS* 7 (3), 713–715.
- Hafeez, R., Tahir, Z., Chughtai, A.S., 2003. Incidence and intensity of soil transmitted helminths of Lahore. *Int. J. Pathol.* 1, 36–38.
- Haider, J., Mohammad, N.S., Nazli, R., Fatima, S., Akhtar, T., 2018. Prevalence of parasitic infestation in children of a rural community of Peshawar. *Khyber Med. Univ. J.* 10 (1), 14–18.
- Ilyas, M., Khan, I., ur Rehman, F., Shahid, M., 2018. Frequency of gastrointestinal parasites among children in clinical practices Peshawar, KPK, Pakistan. *KJMS* 11 (1), 31.
- Khan, M.N., Hayat, C.S., Iqbal, Z., Hayat, B., 1988. Survey of gastrointestinal parasites in students of University of Agriculture, Faisalabad. *Pakistan Vet. J.* 8, 194–196.
- Khan, W., Noor un Nisa, Aly, K., 2011. An investigation on incidence of intestinal parasites in under and above 15 years age in farmers of SWAT, Pakistan. *Proc. Parasitol.* (52), 43–53.
- Noor-Un-Nisa, Khan W., Khan, A., 2012. A Prevalence of intestinal parasites in male and female shepherds of Swat, Pakistan. *International J.Biol Biotechnology.* 8 (4):597-603.
- Khan, W., Khan, A., 2017. Soil transmitted helminthiasis in different occupational groups in Swat, Khyber Pakhtunkhwa, Pakistan. *Pakistan J. Pharmaceut. Sci.* 30 (4).
- Khan, W., Arshad, S., Khatoon, N., Khan, I., Ahmad, N., Kamal, M., UIHassan, H., Khan, N., Haq, A.U., Ilyas, M., Ullah, S., Ullah, I., Mahmoud, A.H., Mohammed, O.B., 2021. Food handlers: an important reservoir of protozoans and helminth parasites of public health importance. *Brazilian J. Biol.* 82. <https://doi.org/10.1590/1519-6984.238891>.
- Khan, W., Imran, Wahab, A., 2016. Intestinal obstruction by *Ascaris lumbricoides* in a 12 year old boy: A case report in Pakistan. *Journal of Bacteriology and Parasitology* 7 (1), 1–3. <https://doi.org/10.4172/2155/9597.1000262>.
- Khan, W., Iqbal, M., Omer, D.A.D., 2020a. Have We Forgotten the Threat Posed by Fascioliasis? A Potent Threat to Public Health. *Iranian J. Public Health* 49 (4), 814–815.
- Khan, W., Khan, N.I., Bukhari, S.N.F., Begum, N., 2019. Prevalence of intestinal parasitic infection among drug addicts in district swat, Khyber Pakhtunkhwa, Pakistan. *Iranian J. Parasitol.* 14 (2), 359–361.
- Khan, W., Nisa, N.U., Khan, A., Naqvi, S.M.H.M., 2012. Endemicity of intestinal parasites with special reference to nematodes in individuals related to education (students, staff & workers) in Swat KP, Pakistan. *Pak. J. Nematol.* 30 (1), 77–85.
- Khan, W., Nisa, N.N., Khan, A.R., Rahbar, B., Mehmood, S.A., Ahmed, S., Kamal, M., Shah, M., Rasool, A., Pahanwar, W.A., Ullah, I., Khan, S., 2020b. Roosting ecology and morphometric analysis of *Pteropus medius* (Indian flying fox) in Lower Dir, district, Pakistan. *Brazilian J. Biol.* 81 (1), 77–82.

- Khan, W., Noor un, Nisa, Khan, A., 2015. Diversity of intestinal parasites in male and female students and workers of education departments of Swat, Pakistan. *Pakistan Journal of Zoology* 47 (2), 565–568.
- Khan, W., Noor Un, Nisa, Khan, A., 2017. Prevalence and risk factors associated with intestinal parasitic infections among food handlers in Swat, Khyber Pakhtunkhwa, Pakistan. *Journal of Food and Nutrition Research* 5 (5), 331–336. <https://doi.org/10.12691/jfmr-5-5-7>.
- Khan, W., Noor Un, Nisa, Khan, A., 2018a. Prevalence of pathogenically important pathogenic protozoan parasitic infections in different occupational groups of Swat, Pakistan. *Pakistan Journal of Zoology* 50 (1), 123–129. <https://doi.org/10.17582/journal.pjz/2018.50.1.123.129>.
- Khan, W., Noor Un, Nisa, Khan, A., 2018b. Incidence of tapeworm infection in human population of Swat, Pakistan: An occupation based study. *Pakistan Journal of Zoology* 50 (2), 639–645. <https://doi.org/10.17582/journal.pjz/2018.50.2.639.645>.
- Kosar, S., Afshan, K., Salman, M., Rizvi, S., Naseem, A.A., Firasat, S., Qayyum, M., 2017. Prevalence and risk factors associated with intestinal parasitic infections among schoolchildren in Punjab, Pakistan. *Trop Biomed.* 34, 770–780.
- Mangistu, L.E., Birhano, E.R., 2004. Prevalence of intestinal parasite among school children in rural area closed of south east of lake Langano. *Ethop J. Health Dev.* 18, 116–120.
- Mineno, T., Avery, M.A., 2003. Giardiasis: Recent Progress in Chemotherapy and Drug Development (Hot Topic: Anti-Infective Agents Executive Editors: Mitchell A. Avery/Vassil St.) *Georgiev. Curr. Pharm. Des.* 9 (11), 841–855.
- Mirza, I.A., Kazmi, S.Y., Yasir, M., 2012. An analysis of intestinal parasitic infestation in Dera Ismail Khan, Pakistan. *J. Ayub Med. College Abbottabad* 24 (1), 123–124.
- Niaz, S., Arif, M., Zubair, N., Khan, S., Zeb, M.A., 2019. Prevalence of Enterobius vermicularis in children of district Mardan, Pakistan. *PSM Biol. Res.* 4 (2), 58–62.
- Pal, R.A., Malik, Z., 1979. Prevalence of intestinal parasites in primary school children of Islamabad. *Pakistan J. Zool* 11, 105–108.
- Pal, R.A., Subhani, F., 1989. Prevalence of intestinal helminth parasites in primary school children of Dir District (NWFP). *Pakistan J. Sci. Tech* 13, 99–102.
- Pillai, D.R., Kain, K.C., 2003. Common intestinal parasites. *Curr. Treatment Options Infect. Dis.* 5, 207–217.
- Qureshi, R.Q., 1995. Intestinal helminth parasites with emphasis on hookworms of man in and around Islamabad (Doctoral dissertation, M. Phil. thesis, Department of Biological Sciences, Quaid-i-Azam University, Islamabad).
- Rahman, H., Khan, W., Mehmood, S.A., Ahmed, S., Yasmeen, S., Ahmad, W., Haq, Z., Shah, M.I.A., Khan, R., Ahmad, U., Khan, A.A., Escalante, P.D.L.R., 2021. Prevalence of cestodes infection among school children of urban parts of Lower Dir district, Pakistan. *Brazilian Journal of Biology* 82, 1–6. <https://doi.org/10.1590/1519-6984.242205>.
- Shaikh, G.S., Harani, M.S., Rathi, S.L., Khatri, P.R., Harani, P.K., 2000. Pattern of intestinal parasitic infestation in Larkana. *Proc. Parasitol.*, 61–66.
- Shaikh, G.S., Shaikh, R.S., Shaikh, A.H., 2003. Intestinal parasitic infections in the Population of Shikarpur, Sindh. *Proc. Parasitol.* 36, 59–67.
- Shakoor, M.A., Khan, I.A., Ahmed, H., Safdar, M., Ahmed, Z., Afreen, A., 2018. Prevalence of Worm Infection in Relation to Body Mass Index in Children of 5–10 Yrs of Age in Tehsil Narowal, Pakistan.
- Stekete, R.W., 2003. Pregnancy, nutrition and parasitic diseases. *J. Nutrition* 133 (5), 1661S–1667S.
- Tasawar, Z., Lashari, M.H., Anjum, A., Aziz, F., 2013. Human amoebiasis in Multan, Punjab, Pakistan. *J. Cell Animal Biol.* 7 (6), 73–76.
- Ullah, W., Shah, A., Jamal, Q., Ullah, S., Muhammad, I., Ullah, H., 2014. Prevalence of intestinal parasites among school children in District Upper Dir, Khyber Pakhtunkhwa Pakistan. *IJB* 5, 1–8.
- Ullah, Z., Khan, W., Khan, M.F., Kabir, M., Ujjan, A.A., Ullah, W., Masood, Z., Khan, S., De los Ríos Escalante, P., 2021. Prevalence of intestinal parasitic diseases in school children of rural areas of district Lower Dir, Pakistan. *Brazilian Journal of Biology* 82.
- Who, 2016. Soil-Transmitted Helminth Infections. WHO, Geneva, p. 2016.

Further Reading

- Chaudhry, Z.H., Afzal, M., Malik, M.A., 2004. Epidemiological factors affecting prevalence of intestinal parasites in children of Muzaffarabad district. *Pakistan J. Zool.* 36 (4), 267–271.
- Hafeez, S., Ali, Z., Zafar, A., 2018. Prevalence of intestinal parasitic infestation at children hospital of Lahore. *Pak. J. Med. Health Sci.* 12 (2), 645–648.
- Khan, W., Noor, un Nisa, Khan, A., 2014. Fasciola hepatica infection in Swat, Pakistan. *Pakistan Journal of Zoology* 46 (6), 1789–1790. In this issue.
- Naheed, S., Yasmin, N., Jawaria, N., Mohammad, N., 2009. Gastro intestinal tract parasites study among disable centers in Quetta city, Pakistan. *Proc. Parasitol.* 47, 53–59.
- Rahoo, A.M., Mukhtar, T., Bughio, B.A., Rahoo, R.K., 2019. Relationship between the size of Galleria mellonella larvae and the production of Steinernema feltiae and Heterorhabditis bacteriophora. *Pakistan J. Zool.* 51 (1).