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Full Length Research Paper

Malaria-intestinal helminthes co-infection among patients in Wolkite Health Center and Attat Hospital, Gurage Zone, Southern Ethiopia

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To initiate the prevention and control methods for overlapping distribution of intestinal helminthes and malaria, collecting adequate, updated and reliable information is required. Thus, the objective of this study was to assess the prevalence of Malaria-intestinal helminthes co-infection among patients attending Wolkite Health Center and Attat Hospital, Gurage Zone, Southern Ethiopia. Cross sectional parasitological study of 460 patients was conducted from April to June 2016. Giemsa-stained blood film was examined to detect malaria parasite, while the formal-ether concentration technique was used to diagnose intestinal helminthes. Data was entered and analyzed using SPSS version 16.0 soft ware. Overall prevalence of malaria infection was 18.3% (84). *Plasmodium vivax* 12% (55/460) and *Plasmodium falciparum* 5.9% (27/460) were the only malaria species identified. Mixed malaria species were 0.4% (2/460). The overall prevalence for at least one intestinal helminthes was 43% (198/460). *Ascaris lumbricoides* (16.7%), Hookworm (11.7%), *Hymenolepis nana* (12.4%), *Enterobius vermicularis* (8.0%) and *Taenia species* (13.0%) were the identified species. Malaria-intestinal helminthes co-infection was 10% (46/84). The most common among co-existed helminthes was *A. lumbricoides* (4.1%) followed by *Taenia species* (3.7%). The co-infection prevalence was higher in females 13% (29/224) compared to males 7.2% (17/236) (χ^2= 4.212, *P*- value= 0.04). Possible control methods such as public health education on bed net use and cleaning environment, provision of IRS and ITN/ILLN as well as providing community based control strategies should be the major focusing area of regional as well as federal health institutions in the country. This co-infection of malaria and intestinal helminthes may increase the risk to anaemia. Therefore, further studies on the association of co-infection with anaemia and assessment on the mechanism involved in such interaction is needed to support this current finding as well as provide useful information necessary to design control management for malaria in the context of co-infection.

Key words: Co-infection, malaria, intestinal helminths, Wolkite Health Center, Attat Hospital.

INTRODUCTION

A high rate of co-infection of intestinal helminths and malaria results because of their overlapping distribution

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(Keiser et al., 2002; Adrienne et al., 2005), which may result both in synergism and antagonistic interaction between helminths and malaria parasites (Mathieu, 2002; Kirsten et al., 2005). Infection with helminths appears to polarize the immune response towards T-helper-2 type, characterized by high level of cytokines such as interleukin-4 (IL-4), IL-5, IL-13 and high serum level of immunoglobulin-E (IgE) (Hartgers and Yazdanbakhsh, 2006). This revealed that helminths could influence the host immunity to mediate immune responses that are beneficial to malaria parasites during co-infection (Nyamongo et al., 2015). Co-infections with helminthes and malaria parasites cause a significant problem against the host. For instance, they have negative impact upon host nutrition through a number of mechanisms which may have additive or multiplicative impacts, especially in childhood (Crompton and Nesheim, 2002). Another main impact of malaria and helminthes infections is anaemia. Malaria causes anaemia, among other mechanisms through haemolysis and increased spleenic clearance of infected and uninfected red blood cells and cytokine induced dyserythropoeisis (Crawley, 2004; McDevitt et al., 2004). Similarly, intestinal helminthes are significant causes of anaemia as a result of direct blood loss, nutritional theft and impairment of the appetite due to immunological factor (Stephenson et al., 2000; Hotez et al., 2004). Most gastrointestinal helminths and Plasmodium affect host nutrition in a similar manner. Hence, it seems plausible to consider different gastrointestinal helminth species together while assessing the impact of helminth coinfection on malaria (Abrahm and Berhanu, 2016). In general, individuals coinfected with more than one parasite species are at risk of increased morbidity (Kinung'hi et al., 2014).

Intestinal parasite infections still continue to be the major health problem worldwide. Such infection present a persistent and intolerable threat to the health of millions of people mainly in the tropic and subtropics and their cost in terms of human life and economic loss is incalculable. In Ethiopia, the prevalence and distribution of intestinal helminthes varies from place to place (Erosie et al., 2002; Mengistu and Berhanu, 2004; Jemaneh, 2000). This might be because of the diversity of the country environmental and living condition of individuals.

Malaria constitutes a major public health problem and impediment to socioeconomic development in Ethiopia. It is estimated that about 75% of the total area of the country and 65% of the population is estimated to be at risk of infection (Federal Ministry of Health (FMOH), 2007). According to WHO (2010) report, malaria is present everywhere in Ethiopia, except in the central highlands, and 56 million people are at risk. The disease is one of the country's leading health problems in terms of morbidity, mortality and impediment to socioeconomic development and top ranking in the list of common communicable diseases, consistently ranking in the top10 causes of outpatient visits, admissions, and deaths at health centers and hospitals (Federal Ministry of Health (FMOH), 2004). Though there has been a growing interest to investigate co-infections and their related clinical consequences worldwide, there is no previous study reported in the area on the concomitant occurrence of malaria and intestinal helminthes infections, their clinical manifestations and the association of the infections. Knowledge about the prevalence of malaria and intestinal parasites in particular areas is essential for the initiation and implementation of parasite control programmes in the region and give evidence-based propositions for timely interventions. Such information is required to guide policy makers in deciding on the type of preventive and control strategies in controlling intestinal helminthes induced anaemia. Therefore, this study investigates the prevalence of malaria and intestinal helminthes co-infection among patients attending in Wolkite health center and Attat hospital during the study period.

MATERIALS AND METHODS

Study area and subjects

This study was conducted at Wolkite Health Center and Attat Hospital in Gurage Zone located 158 km south west of Addis Ababa along the Jimma Road in the Southern Region of Ethiopia. Both the health center and hospital were found under Wolkite town, the capital of Gurage Zone. This town has a latitude and longitude of 8°17′N37°47′E and an elevation between 1910 and 1935 m above sea level. It is surrounded by Kebena Woreda and it was part of former Goro Woreda. Malaria and intestinal parasites are the most prevalent public health problems in the area. Malaria transmission in Gurage Zone is unstable, seasonal and depends on altitude and rainfall. There are two main seasons for transmission of the disease; September to December, after the heavy summer rains, and March to May, after the light rains.

The study subjects were patients that attended Wolkite Health Center and Attat Hospital during the study period. Individuals who had no history of anti-malarial drug administration in the two weeks prior to screening, absence of any other serious chronic infection, had ability to give blood and stool samples were included in the study.

Study design and sampling procedure

This cross sectional study was carried out among patients that visited Wolkite Health Center and Atta Hospital during the study period. Systematic random sampling was used to select the individuals in the sample by selecting one of the elements at random from sampling frame at the starting point, and then onward from this point, the rest sample was selected systematically by applying pre-determined interval of every third elements.

Sample size calculation

Sample size was estimated using the statistical formula of sample size calculation $n=p(1-p)z\ 2/d^2$, where, n = required sample size, z=confidence level at 95% which is standard value of 1.96, p= estimated prevalence of intestinal parasite and d= marginal error at 5%, standard value of 0.05 (Danile, 1995). Since the overall prevalence of malaria-intestinal helminthes co-infection was not known for this study area, prevalence (p) was taken to be 50% and

Table 1. Age related prevalence of malaria and malaria species among patients in Wolkite Health Center and Attat Hospital in 2016.

Characteristics \ Malaria species		Pv {No. (%)}	Pf {No. (%)}	Total malaria {No. (%)}
Age group	≤ 5	1 (2.1)	0 (0)	1 (2.1)
	6-14	15 (12.3)	5 (4.1)	21 (17.2)
	≥15	39 (13.5)	22 (7.6)	61 (21)
	Total	55 (12)	27 (5.9)	84 (18.3)
	χ^2	5.071	5.233	10.395
	P- value	0.079	0.073	0.006

IHs= Intestinal helminthes, Pv= *Plasmodium vivax*, Pf= *Plasmodium falciparum*.

this gave the minimum sample size of 384. To lessen errors arising from the likelihood of non compliance or possible drop out, 20% of the sample size was added to the normal sample size. Thus, the minimum sample size for this study was 460 with 20% contingency for non- respondents.

Ethical considerations

Prior to data collection, consent was collected from participants as well as the stakeholders of the study area and only volunteer individuals were included in the study. Diagnosis was done using sterile and disposable materials. Only laboratory technicians were allowed to take the blood sample and all other activities on clinical examination as well as diagnosis was supervised by specialized healthcare personnel.

Data collection

Socio-demographic survey and clinical diagnosis were made by trained physicians of the health center and hospital. The laboratory techniques that were used in this study are: Blood film smear for malaria diagnosis and Formalin-Ether concentration techniques for stool parasite diagnosis.

Blood film determination for malaria parasites

Laboratory technicians collected the samples and malarial infections were determined from thick and thin films of finger-prick blood fixed and stained with Giemsa stain. Thick and thin blood smear wear prepared for each subject from capillary blood by finger prick using sterile lancet. The thick smear was stained with Giemsa solution and the thin smear was fixed with methanol before stained with Giemsa solution. Each blood smear was observed under the oil immersion objective of the microscope. The thick smear was used to determine whether the malaria parasite was present or not after observing 100 fields of vision. The thin smear was used to identify the *Plasmodium* species.

Formalin-Ether concentration technique for stool examination

Study subjects were provided with a dry, clean and leak proof stool cup labeled with identification number of each individual and applicator stick. Stool samples were preserved in 8 ml of 10% formalin solution, and transported to the Microbiology and Parasitology Laboratory of the Department of Biology, Wolkite University, for parasitic microscopic examination. Formalin-ether concentration technique was used for laboratory examination of the collected samples (WHO, 1991). Stool examination was conducted by experienced medical laboratory personnel.

Data analysis

The data was computerized using Excel 2007, cleaned and checked against original document before analysis. All statistical analyses were performed using SPSS for windows version 16 statistical package. Descriptive statistical tests were applied to calculate the prevalence of Plasmodium species and intestinal helminthes as percentages and proportions. Pearson chi-square (x^2) test was used to verify the relationship between independent factors and the outcome variables. The 95% CI was used to show the accuracy of data analysis. P-value less than 5% was considered statistically significant.

RESULTS

Malaria and intestinal helminthes infection

Malaria infection

Out of 460 patients examined, 84(18.3%) were positive for malaria parasites. *Plasmodium vivax* 12% (55/460) and *Plasmodium falciparum* 5.9% (27/460) were the only malaria species identified in this study. Mixed malaria species were 0.4% (2/460).

Prevalence of malaria was higher among females 9.8% (45) when compared to males 8.5% (39) though there is no significant difference (χ^2= 0.978, P= 0.323). Age related malaria infections were observed (χ^2=10.395, P=0.006). The age group ≤5 years was the most affected (21%) followed by the age group 6-14 years old (17.2%) (Table 1).

The prevalence of malaria was higher among patients that visited Attat Hospital compared to Wolkite Health center though it was not significantly different (Figure 1).

Intestinal helminthes infection

From a total of 460 stool samples examined, 43% (198)

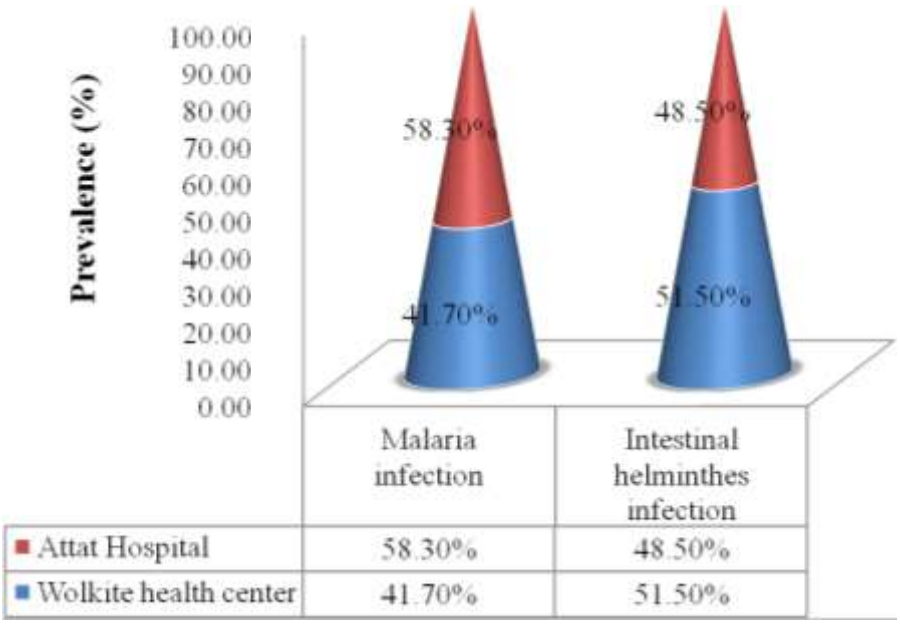

Figure 1. Comparing prevalence rate of malaria and intestinal helminthes among patients who visited Wolkite Health center and Attat Hospital in 2016.

Table 2. Gender related prevalence of Intestinal parasites (malaria species and Helminthes) among patients in Wolkite Health Center and Attat Hospital in 2016.

Intestinal helminthes infection	Gender		Total (n=460) {No. (%)}
	Males (n=236) {No. (%)}	Females (n=224) {No. (%)}	
Ascaris lumbricoides	44 (18.6)	33 (14.7)	77 (16.7)
Hookworm	33 (14.0)	21 (9.4)	54 (11.7)
Enterobius vermicularis	19 (8.1)	18 (8.0)	37 (8.0)
Hymenolepis nana	28 (12)	29 (13)	57 (12.4)
Taenia species	32 (13.6)	28 (12.5)	60 (13)
Plasmodium vivax	22 (9.3)	33 (14.7)	55 (12)
Plasmodium falciparum	15 (6.4)	12 (5.4)	27 (5.9)

were positive for one or more of intestinal helminthes. Five species of intestinal helminthes were identified with variable prevalence: *Ascaris lumbricoides* (16.7%), Hookworm (11.7%), *Hymenolepis nana* (12.4%), *Enterobius vermicularis* (8.0%) and *Taenia species* (13.0%).

The majority 134 (29.1%) of infected individuals had multiple infection and 64 (13.9%) were infected with single intestinal helminthes parasites. The result showed that distribution of intestinal helminthes was slightly higher in males (22.6%) than in females (20.4%) but it was not significant difference (χ^2=0.207, P=0.649) (Table 2). Age related difference was observed among intestinal helminthes species though only Hookworm showed statistically significant (χ^2 = 6.183, *P*- value=0.045 (Table 3).

Malaria-intestinal helminthes co-infection

From 84 malaria infected patients, 46 were positive for one or more intestinal helminthes which make a co-infection prevalence of 10%. The most common among co-existed helminthes was *A. lumbricoides* (4.1%) followed by *Taenia species* (3.7%) (Figure 2). Patients infected with intestinal helminthes were more likely to be infected with malaria 10.9% (50/460) compared to patients with no intestinal helminthes infection 7.4% (34/460) (χ^2= 11.385, *P*- value= 0.001).

DISCUSSION

The overall prevalence of malaria observed in the present

Table 3. Age related prevalence of Intestinal helminthes species among patients in Wolkite Health Center and Attat Hospital in 2016.

Age group	No. of examined {No. (%)}	Intestinal helminthes species (His)				
		Al {No. (%)}	Hw {No. (%)}	Hn {No. (%)}	Ev {No. (%)}	Ts {No. (%)}
≤5	48 (10.4)	9 (18.8)	8 (16.7)	8 (16.7)	6 (12.5)	7 (14.6)
6-14	122 (26.5)	26 (21.3)	7 (5.7)	21 (17.2)	12 (9.8)	14 (11.5)
≥15	290 (63.1)	42 (14.5)	39 (13.5)	28 (9.7)	19 (6.4)	39 (13.5)
Total	460 (100)	77 (16.7)	54 (11.7)	57 (12.4)	37 (8)	60 (13)
χ^2		3.029	6.183	5.421	2.691	0.407
P- value		0.220	0.045	0.067	0.260	0.816

Al= Ascaris lumbricoides, *Ev= Enterobius vermicularis, Hn= Hymenolepis nana,* Hw= Hookworm, Ts= *Taenia species*, IHs= Intestinal helminthes.

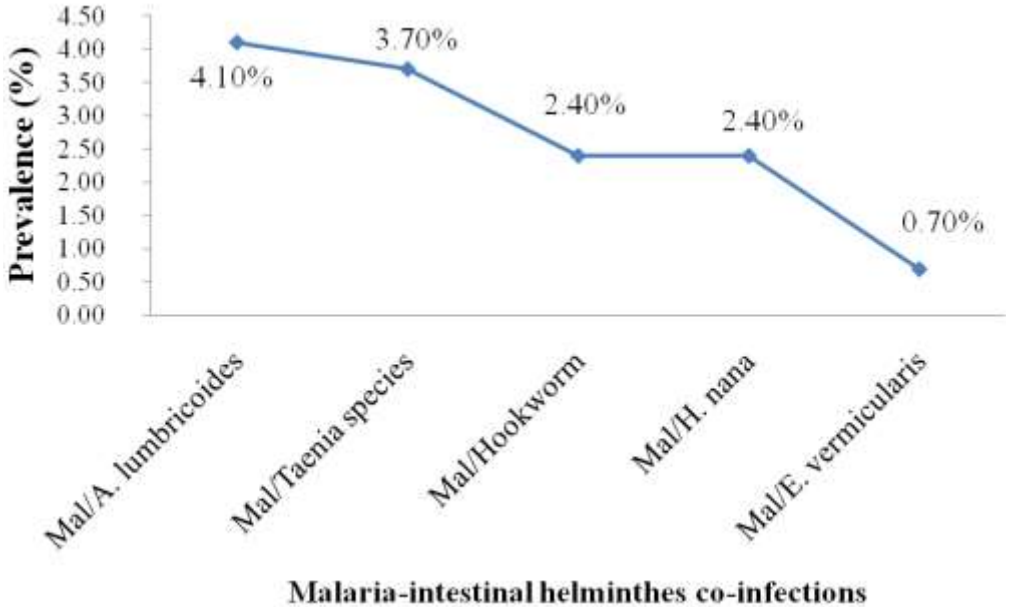

Figure 2. Prevalence of malaria-intestinal helminthes co-infections among patients who visited Wolkite Health Center and Attat Hospital in 2016. Mal/*A. lumbricoides*= Malaria-*Ascaris lumbricoides* co-infection, Mal/*Taenia species*= Malaria-*Taenia species* co-infection, Mal/Hookworm=Malaria-Hookworm co-infection, Mal/*H. nana*= Malaria-*Hymenolepis nana* co-infection and Mal/*E. vermicularis*= Malaria-*Enterobius vermicularis* co-infection.

study was relatively lower than study conducted in Alaba Kulito Health Center (27.9%), Southern Ethiopia (Abraham et al., 2012), Bumula District (46.4%) in western Kenya (Kepha et al., 2015) and in two rural communities in the mount Cameroon are (33.3%) (NKemnji et al., 2017) but higher than reported from Azzezo Heath Center (11.4%), Northwest Ethiopia (Abebe et al., 2012). The observed difference might be due to seasonal variation where the study was conducted, climatic condition that might influence malaria vector breeding and distribution in different areas. In Ethiopia, epidemiological pattern of malaria transmission is generally unstable and seasonal, with the level of transmission varying from place to place because of altitude and rainfall patterns. Some localities also experience perennial malaria because the environmental and climatic situations permit the continual breeding of vectors in permanent breeding sites (Abraham et al., 2009). Furthermore, the low prevalence of malaria in the present study might be due to the time when the study was conducted since the present study samples were collected during the dry season. Brooker and Michael (2000) and Hay et al. (2000), have shown that peak transmission of malaria occurs following the main rainy season and a minor transmission peak occurs following light rainy season in the tropics.

The prevalence rate of intestinal helminthes was 43% whereas the observed overall prevalence rate of the present study was found to be relatively lower than studies done in Alaba Kulito Health Center (55.7%),

Southern Ethiopia (Abraham et al., 2012) and Azzezo Heath Center (53.9%), Northwest Ethiopia (Abebe et al., 2012). The differences in findings among the studies might be due to variations in socio-economic conditions, individual behavioral habits of selected population, the methods employed for stool examination, the sample size taken as well as the time of study conducted. Further, Mengistu and Berhanu (2004) stated that the distribution and prevalence of various species of intestinal parasites also vary from region to region because of several environmental, social and geographical factors.

In the present study malaria-intestinal helminthes co-infection was 10%. This figure is higher compared to study conducted in Azzezo Heath Center (5.1%), Northwest Ethiopia (Abebe et al., 2012) and Gilgel Gibe dama area (7.7%), Southwest Ethiopia (Million, 2013). However, it was lower than the prevalence of co-infection reported from Thailand (Boel et al., 2010), Ghana (Yatich et al., 2009) and Nigeria (Egwunyenga et al., 2001). The observed difference might be due to seasonal variation where study conducted, climatic condition that might influence malaria vector breeding and distribution in different areas.

Patients infected with intestinal helminthes were more infected with malaria compared to patients with no intestinal helminthes infection. This finding was in line with study conducted in Gilgel Gibe dam areas (Million et al., 20013), Southern Ethiopia (Andargachew et al., 2013) and Ghana (Yatich et al., 2009). In addition, the findings of a meta-analysis by Naing et al. (2013) reported positive association between uncomplicated malaria and STH co-infection among school age children based on studies conducted globally. Furthermore, a systematic review and meta-analysis by Degarege et al. (2016) showed that *Plasmodium falciparum* density tended to be higher among children infected with STH than those uninfected with intestinal helminths. This might be due to the fact that some helminthes modulate the host response both to themselves and to concurrent infections. It has been suggested that the immune response evoked by helminthes infections may modify immune responses to *Plasmodium* and consequently alter infection and disease risk (Diallo et al., 2010; Hartgers et al., 2009; Sangweme et al., 2010). The biology of the parasite and the host, climate, socioeconomic status of the population and the like in the area are the major factors that influence the epidemiological and geographical patterns of infections and co-infections. Climate determines the survival of the mosquito vector of the malaria and the free living and infective stage of the helminthes (Brooker and Michael, 2000).

The most common among co-existed helminths was *A. lumbricoides*. This outcome was similar with study conducted in Southwest Nigeria (Dada-Adegbola et al., 2013) and in two rural communities of Cameroon (Zeukeng et al., 2014). Furthermore, different research outcomes revealed that positive association between *A. lumbricoides* infection and prevalence of malaria among patients in Ethiopia (Abrahm et al., 2012) and pregnant women in Ghana (Yatich et al., 2009). This might be due to the fact that it is the most prevalent helminthes that infects patients in the area. Furthermore, Natcher et al. (2002) and Hartgers and Yazdanbakhsh (2006) suggested that it could be that Th-2 profile-associated immunoglobulin E production seen in *Ascaris* infection may down-modulate Th-1 anti-malaria immune response, resulting in increased risk of malaria infection.

Conclusion

The present study showed that malaria co-exists with intestinal helminthes infections among the studied patients found in Wolkite Health Center and Attat Hospital and may give a warning signal for the regional health office authorities to start focusing attention in this area by providing community based control strategies. This co-infection of malaria and intestinal helminthes may exaggerate the risk to anaemia. Therefore further studies on the association of co-infection with anaemia and assessment on the mechanism involved in such interaction needed to support this current finding as well as provide useful information necessary to design control management for malaria in the context of co-infection.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Full Length Research Paper

Cockroaches as carriers of human gastrointestinal parasites in Wolkite Town, southwestern Ethiopia

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Cockroaches are considered as vectors of different diseases caused by bacteria, fungi, viruses, protozoa and helminthes. The objective of this study was to examine the role of cockroaches as carriers of intestinal parasites in Wolkite town. Cockroaches were collected twice per month from five kebeles and 50 households, from March to April in 2016. A total of 209 cockroaches were collected in this study. In total, 157 (75.1%) specimens were infected with one or more intestinal parasites such as *Ascaris lumbricoides, Hymenolepis nana, Taenia* spp., *Enterobius vermicularis, Strongyloides stercoralis, Trichiuris trichuira, Giardia lamblia*, *Entameoba histolytica/dispar* and hookworm. The most frequent parasites found were *Taenia* spp. (29.7%) and *E. histolytica/dispar* (28.7%). Statistical difference was observed among the five kebelles (χ^2= 13.1, P = 0.011) and the body distribution of parasites (internal and external) (χ^2 = 28.415, P = 0.000). The high frequency of parasites in cockroaches in Wolkite town indicates that cockroaches are carriers of several zoonotic parasites that could infect Wolkite inhabitants. Therefore, controlling of cockroaches populations, creating awareness to the community about personal hygiene and environmental sanitation are essential to minimize the transmission of intestinal parasites by cockroaches.

Key words: Intestinal parasites, cockroach, Wolkite Town.

INTRODUCTION

Over 3,500 known species of cockroaches are found universally (Etim et al., 2013); thirty of these are considered as human pests (Lee and Lee, 2000). Of these, *Blattella germanica* (German cockroach), *Periplaneta americana* (American cockroach) and *B. orientalis* (the Oriental cockroach) are considered the most common pests to humans (Hamu et al., 2014; Shahraki et al., 2013).

Cockroaches are well known to cause considerable irritation and emotional distress in some people but they are not only nuisance in our houses (Kass et al., 2009). They also cause food poisoning with their feces or salivary gland excretions, and even the dead cockroaches (Etim et al., 2013). Some cockroaches are capable of biting human beings especially when they are sleeping (Okafor-Elenwo and Elenwo, 2014).

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Presence of body detritus and cockroaches feces causes allergy and asthma (Etim et al., 2013). Furthermore, they are considered vectors of bacteria, fungi, viruses, protozoa and helminthes (Tilahun et al., 2012). Although, some studies have been performed to assess the role of cockroaches as a mechanical carrier of pathogenic microorganisms in Ethiopia (Tachbele et al., 2006; Hamu et al., 2014), reliable information is not currently available in Wolkite. Therefore, this study was carried out to identify protozoa and parasite eggs present externally and internally in cockroaches collected from Wolkite town, south west Ethiopia.

MATERIALS AND METHODS

Study area and population

This study was conducted at Wolkite Town in Gurage Zone located at Global Positioning Systems coordinates 8°17′N and 37°47′ E in the southern region of Ethiopia. This town has an elevation of approximately 1935 m. The annual temperature ranges are between 13 and 30°C and the mean annual rain fall ranges between 600 and 1600 mm.

Collection and identification of cockroaches

Fifty households were randomly selected from the five kebeles (10 households from each kebele). Cockroaches were collected twice per month from March to April 2016. Cockroaches were captured directly using sterile hand-gloves and sterile screw-capped 250 ml jars (Paul et al., 1992).

During sampling, the number of trapped cockroaches were labeled and pooled as one sample from each of the sampling areas (kebeles). Then, numbers of trapped cockroaches were counted. Adult, whole and alive cockroaches were included in this study and those dead, or showing missing body parts were excluded. Finally, the number of trapped cockroaches' specimens were placed in labeled jars and immediately transported to the Microbiological Laboratory of Wolkite University, for identification and further processing. Morphological identification of the cockroach species was carried out using standard taxonomic keys (Lane and Crosskey, 1993).

Isolation and identification of parasites

Isolation and identification of parasites from the external surface of the cockroaches

Cockroaches were euthanized using chloroform. They were individually placed in a beaker and washed with 5 ml of sterile physiological saline by shaking for 2 min to detach the parasites of the cockroach surface. Solutions obtained from washing cockroaches were considered as external body homogenate samples. Subsequently, 2 ml of the washing fluid was transferred to a sterile test tube and centrifuged at 2000 rpm for 5 min. Supernatant was discarded and the deposits was stained with 1% Lugol's iodine on a clean glass slide, covered with a cover slip and viewed using light microscope 40x objective lens as described by Salehzadehah et al. (2007). Finally, parasites were identified and counted using standard keys (WHO, 2004). Parasites recovered were expressed as percentage abundance of the isolates (Iboh et al., 2014).

Isolation and identification of parasites from the internal body of the cockroaches

After external body examination, the cockroaches were individually placed in 90% ethanol for five min (to remove parasites from the external surfaces). Afterwards, cockroaches were washed in sterile saline solution to remove the traces of alcohol from the body of the cockroaches. They were allowed to dry at room temperature. Then, cockroaches were put on Petri-dish and dissected; the heads were severed first, followed by the legs, then the abdomen was opened using fine pointed forceps and discarded. Alimentary tract was dissected using auto-clave sterilized entomological needles under a dissecting microscope to locate gut homogenates. The gut and other abdominal organs were removed using fine needles and after every dissection, instruments were sterilized. The instruments were dipped in ethanol and flamed between dissections. The excised gut was then homogenized in 5 ml of sterile saline solution, and the sample was considered an internal body homogenate sample. Then, 2 ml of the macerate was centrifuged at 2000 rpm for 5 min from the homogenate sample (Etim et al., 2013). The sediments were examined using the direct wet mount. Briefly, a drop of the suspended sediment was placed on clean, grease-free microscope slides, and stained with 1% Lugol's iodine and each slide was examined for parasites under 10 and 40x magnification of a binocular microscope. Eggs and larvae of intestinal parasites present were identified using taxonomical keys. Adult worms were observed using magnifying glass or hand lens (Okafor-Elenwo and Elenwo, 2014).

Statistical analysis

The data collected in the study was entered into MS Excel before analysis. Descriptive analysis was carried out on the various intestinal parasites carried by cockroach samples, including determination of their frequencies of occurrence and percentages/prevalence rates. Subsequently, a Chi-square test was used to compare external and internal carriage rates of the different intestinal parasites with significant differences at the $p<0.05$ level using SPSS software version 16.

RESULTS AND DISCUSSION

In total, 209 cockroaches were collected and examined for intestinal parasites from five kebeles in Wolkite Town, Southwestern Ethiopia. *Blattela germanica* was the only species of cockroach collected in this study. Samples from 157 (75.1%) cockroaches tested positive to at least one intestinal parasite. Nine species of medically importance parasites were identified (Figure 1). *Taenia* spp., 62 (29.7%) were the dominant parasite followed by *E. histolytica/dispar*, 60 (28.7%), *Giardia lamblia*, 50 (23.9%) and hookworm, 38 (18.2%).

There was a significant difference (χ^2= 13.1, P = 0.011, 95%CI = 0.000, 0.030) in the occurrence of intestinal parasites among cockroaches collected from the five selected kebeles. The highest infected cockroaches were collected from Ediget chora kebele, 28 (100%) followed by Selamber Kebelle, 48 (76.2%) (Table 1).

There was also a significant difference among each intestinal parasite species among the selected Kebelles (Table 2). The most significant difference observed

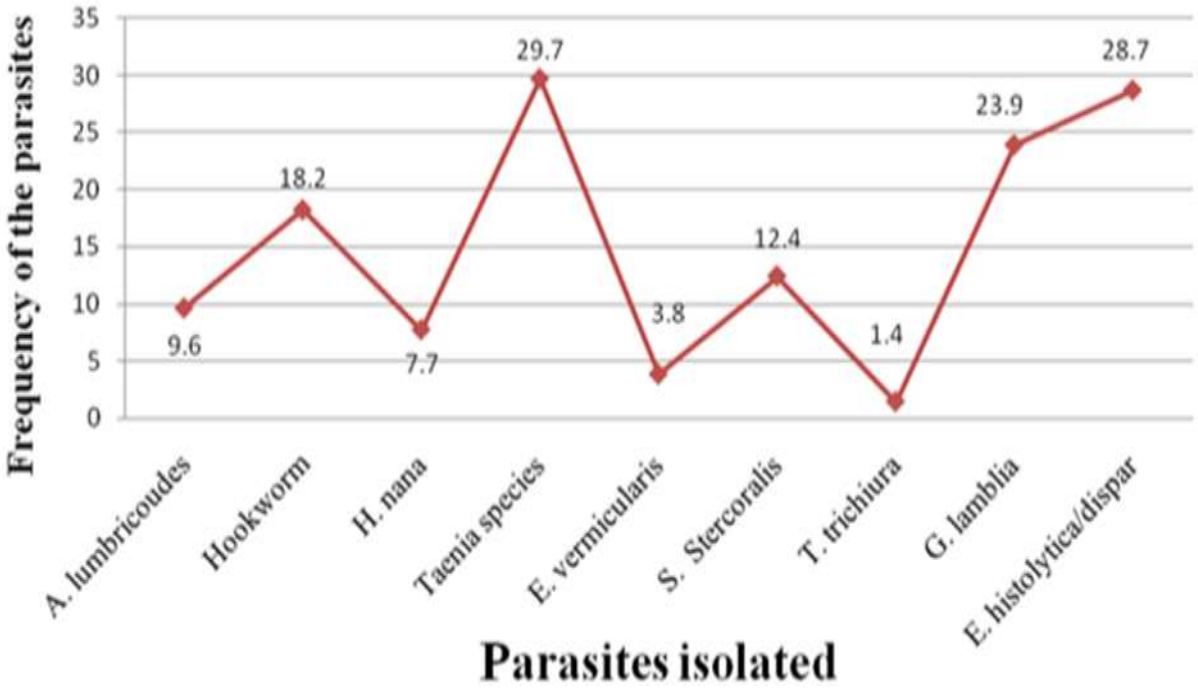

Figure 1. Percentage of parasite species isolated from populations of *B. germanica* in Wolkite Town, southwestern Ethiopia, 2016. *A. lumbricoides = Ascaris lumbricoides*, *H. nana = Hymenolepis nana*, *E. vermicularis = Enterobius vermicularis*, *S. stercoralis = Strongyloides stercoralis*, *T. trichiura = Trichiuris trichuira, G. lamblia = Giardia lamblia*, *E. histolytica/dispar = Entameoba histolytica/dispar*.

Table 1. Percentage of intestinal parasites isolated from populations of *B. germanica* by kebeles in Wolkite Town, southwestern Ethiopia, 2016.

Kebelles	No. of cockroaches examined	Infected cockroaches n (%)
Addis hiwot	40	27 (67.5)
Ediget chora	28	28 (100)
Ediget ber	39	25 (64.1)
Meneharia	39	29 (74.4)
Selamber	63	48 (76.2)

among Cockroaches infected with *Giardia lamblia* (χ^2= 26.1, P = 0.000, 95% CI = 0.000, 0.014).

Of the 157 infected cockroaches, 87 (55.4%) and 53 (33.8%) were found to harbor parasites on their internal and external parts, respectively (Figure 2). There was a significant difference between the infected parts of the cockroaches (χ^2 = 28.415, P = 0.000). The isolated intestinal parasite species showed significant differences in infecting the parts of the collected cockroaches (Table 3).

DISCUSSION

Results from this study showed that cockroaches play an important role in the transmission of intestinal parasite species that are medically important. The overall parasite carriage rate (75.1%) recorded in this study was comparable with reports from Jima, Southwestern Ethiopia (75.6%) (Hamu et al., 2014) and Nigeria (77.52%) (Bala and Sule, 2012). The study result is also higher than that of study conducted in Thailand (54.1%) (Chamavit et al., 2011), Calabar, Nigeria (58.6%) (Etim et al., 2013) but lower than 94.0% reported by Nagham et al. (2011) and 98% observed in Egypt by El-Sherbini and El-Sherbini (2011).The observed difference might be due to environmental condition differences of the area, socio-economic conditions, degree of presence of unsanitary conditions and individual habit difference of selected households. A number of studies has also noted that

Table 2. Prevalence of each isolated intestinal parasite species from populations of *B. germanica* among kebeles in Wolkite Town, southwestern Ethiopia, 2016.

Parasites	Ah n (%)	Ec n (%)	Eb n (%)	Me n (%)	Se n (%)	95% CI	χ^2	*P*- value
Al	3 (7.5)	2 (7.1)	2 (5.1)	0 (0)	13 (20.6)	0.000-0.014	14.3	0.006
Hw	8 (20)	5 (17.9)	3 (7.7)	11 (28.2)	11 (17.5)	0.164-0.276	5.6	0.228
Hn	4 (10)	1 (3.6)	8 (20.5)	2 (5.1)	1 (1.6)	0.000-0.014	13.7	0.008
Ts	17 (42.5)	14 (50)	5 (12.8)	11 (28.2)	15 (23.8)	0.000-0.014	15.1	0.005
Ev	2 (5)	0 (0)	5 (12.8)	0 (0)	1 (1.6)	0.000-0.014	12.2	0.016
Ss	9 (22.5)	2 (7.1)	0 (0)	5 (12.8)	10 (15.9)	0.003-0.045	10.7	0.031
Tt	0 (0)	0 (0)	0 (0)	0 (0)	3 (4.6)	0.003-0.101	7.1	0.133
Gl	6 (15)	17 (60.7)	10 (25.6)	8 (20.5)	9 (14.3)	0.000-0.014	26.1	0.000
Eh/d	9 (22.5)	15 (53.6)	10 (25.6)	8 (20.5)	18 (28.6)	0.006-0.051	10.7	0.031

Ah = Addis hiwot, Ec = Ediget chora, Eb = Ediget ber, Me = Meneharia, Se = Selamber, *Al = Ascaris lumbricoides, Hn = Hymenolepis nana, Ts = Taenia species, Ev = Enterobius vermicularis, Ss = Strongyloides stercoralis, Tt = Trichiuris trichuira, Gl = Giardia lamblia, Eh/d = Entameoba histolytica/dispar.*

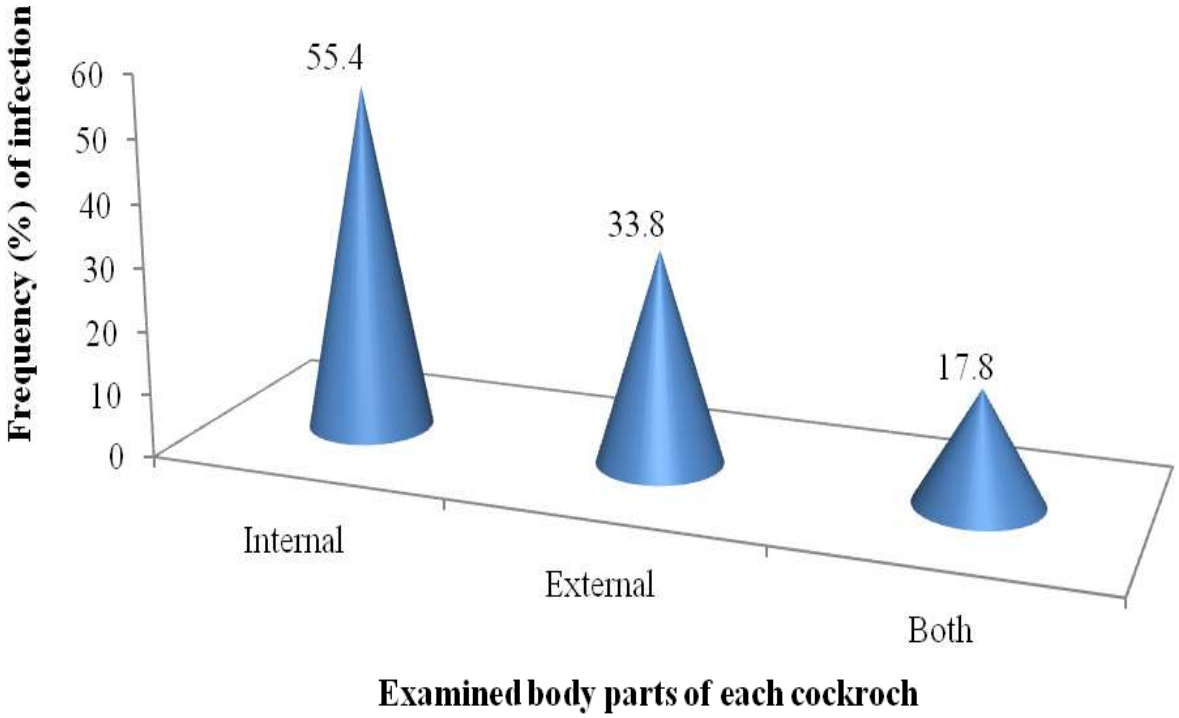

Figure 2. Percentage of intestinal parasites isolated from the internal and external body surfaces of the populations of *B. germanica* in Wolkite Town, southwestern Ethiopia, 2016.

environmental dirtiness, low levels of living standards, low income and ignorance contribute to the continued increase in prevalence and morbidity of parasitic infections in Africa (Myung and Kyu-Earn, 2012). Furthermore, the high infective rate recorded in cockroaches trapped might be an indication of their filthy feeding habit which makes them efficient carriers of parasitic worms, cysts or eggs (Nagham et al., 2011).

In this study, nine species of intestinal parasites were identified from the collected cockroaches. This might indicate that cockroaches serve as important vectors in the transmission of different parasite that cause numerous types of intestinal diseases. Findings from various studies have confirmed that cockroaches are not only nuisance in our houses but reservoirs and disseminators of pathogenic microorganisms to humans

Table 3. Percentage of each intestinal parasites species isolated from the gut contents and external body surfaces of the Populations of *B. germanica* in Wolkite Town, Southern Ethiopia, 2016.

Parasites	Examined body part		X^2	P value
	Internal contents n (%)	External surface n (%)		
A. lumbricoides	12 (5.7)	13 (6.2)	27.422	0.000
Hookworm	28 (13.4)	12 (5.7)	0.117	0.732
H. nana	9 (4.3)	8 (3.8)	1.355	0.244
Taenia spp.	38 (18.2)	36 (17.2)	6.712	0.010
E. vermicularis	8 (3.8)	0 (0)	-	-
S. stercoralis	26 (12.4)	0 (0)	-	-
T. trichiura	3 (1.4)	0 (0)	-	-
G. lamblia	40 (19.1)	26 (12.4)	34.494	0.000
E. histolytica/dispar	49 (23.4)	37 (17.7)	54.923	0.000

A. lumbricoides = Ascaris lumbricoides, *H. nana = Hymenolepis nana*, *E. vermicularis = Enterobius vermicularis*, *S. stercoralis = Strongyloides stercoralis*, T. trichuira = *Trichiuris trichuira, G. lamblia = Giardia lamblia*, *E. histolytica/dispar = Entameoba histolytica/dispar.*

in our homes (Alam et al., 2013). The research by Etim et al. (2013) showed that the discovery of *Trichiuris trichuira* and *Ascaris lumbricoides* ova in the external surface and gut of cockroaches agrees with the pre-position that cockroaches are seriously involved in the epidemiology of soil transmitted helminthes (STH). According to Dehghani et al. (2014), cockroaches are the carriers of many pathogenic organisms, they pick up from contaminated places such as sewers, drains, garbage, landfills, bathrooms and toilets. In addition, Chan et al. (2004) and Iboh et al. (2014) reported that the presence of *Enterobius vermicularis* signifies the obvious contact of cockroaches with infected persons in houses or clothings which confirm their ability to transmit pathogens. Furthermore, Kassiri and Kazemi (2012) stated that cockroaches can bear pathogenic agents both on their teguments and in their intestines, and cause many intestinal diseases and illnesses.

Several researches revealed that cockroaches are considered to be vector for zoonotic parasites (Caccio and Ryan, 2008; Alam et al., 2013). Similarly, *Etamoeba* spp. and *Giardia lamblia* were zoonotic protozoan parasites isolated in the present study. This indicates that cockroaches can serve as a means of mechanical or biological vector of several zoonotic parasites which cause zoonotic disease. For instance, *Cryptosporidium* spp. and *Giardia* spp. are zoonotic protozoan isolated from cockroach specimens (Adam, 2001; Alam et al., 2013). Hamu et al. (2014) also reported that *Giardia doudenalis*, *Entamoeba* spp. and *Balantidium coli* were isolated from cockroaches collected in Jima Town, southwestern Ethiopia. The study conducted in Nigeria reported that *Balantidium coli* and *E. histolytica* were isolated from cockroach sample (Etim et al., 2013; Iboh et al., 2014). Furthermore, the report of El-Sherbini and El-Sherbini (2011) indicated that oocysts of Coccidian parasites such as *Cryptosporidium* and *Cyclospora* spp. had been isolated from cockroach specimen.

In the current study, more parasites were isolated from the internal body (55.4%) than external parts (33.8%) of the cockroaches with a significant difference between the infected parts ($X^2 = 28.415$, P = 0.000). This might be due to the fact that most of the cockroaches were infected through feeding on contaminated fecal materials which had an egg or cyst of intestinal parasites rather than body contact. In contrast, a report by Etim et al. (2013) showed that 65.3% of total parasites obtained were isolated from the external surface than the gastro-intestinal tract that had 34.6%.

Moreover, in this study, there was a significant difference (P = 0.011, $X^2 = 13.1$, 95% CI = 0.000, 0.030) in the occurrence of intestinal parasites among the five selected kebeles. The differences in the hygienic condition of the environments, including human excreta disposal, may account for the observed variation in the parasite carriage rate among different settings (Hamu et al., 2014). Previous studies carried out by Iboh et al. (2014) and Tachbele et al. (2006) showed that most times, cockroaches inhabit area with poor sanitation or dirty environments, feed on dirty materials including human faeces which may be colonized by parasites and other pathogenic organisms.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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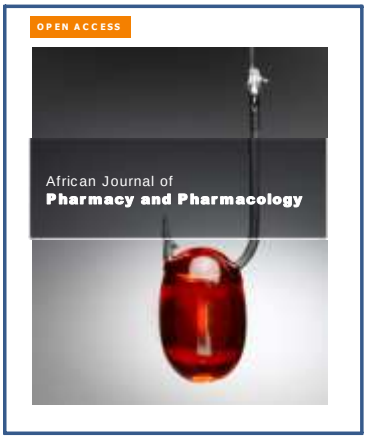

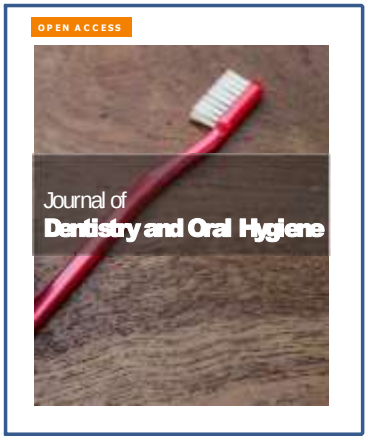

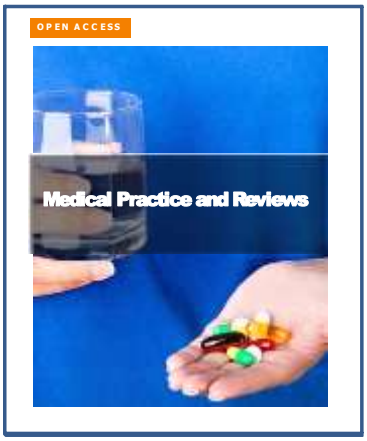

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