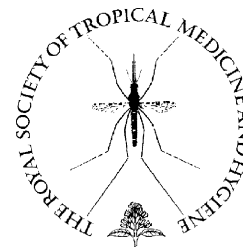




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Cockroaches as carriers of human intestinal parasites in two localities in Ethiopia

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Summary A study was undertaken to assess the role of cockroaches as potential carriers of human intestinal parasites in Addis Ababa and Ziway, Ethiopia. A total of 6480 cockroaches were trapped from the two localities from October 2006 to March 2007. All the cockroaches trapped in Addis Ababa ($n=2240$) and almost 50% (2100/4240) of those trapped in Ziway were identified as *Blattella germanica*. The rest of the cockroaches trapped in Ziway were identified as *Periplaneta brunnea* (24.52%), *Pycnoscelus surinamensis* (16.03%) and *Supella longipalpa* (9.90%). Microscopic examination of the external body washes of pooled cockroaches and individual gut contents revealed that cockroaches are carriers of *Entamoeba coli* and *Entamoeba histolytica/dispar* cysts as well as *Enterobius vermicularis*, *Trichuris trichiura*, *Taenia* spp. and *Ascaris lumbricoides* ova. Besides their role as a nuisance, the present study further confirms that cockroaches serve as carriers of human intestinal parasites. The possible association of cockroaches with allergic conditions such as asthma is also discussed. Hence, appropriate control measures should be taken particularly to make hotels and residential areas free of cockroaches as they represent a health risk.

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1. Introduction

Cockroaches are insects with a worldwide distribution, thriving best in warm, humid, lowland areas throughout the tropics. Of 4000 species of cockroaches (Dictyoptera: Blattodea) known to exist, approximately 30 species are

cosmopolitan inhabitants of human dwellings and approximately 16 species are associated with human health problems (Naumann, 1991). The cockroach species that are closely associated with human dwellings, food processing industries, service rendering facilities and/or occupational environments include *Blattella germanica*, *Blatta orientalis*, *Periplaneta australasiae* (Fabricius), *Periplaneta americana* (Linnaeus) and *Supella supellectilium* (Serville) (Kang, 1990; Ross, 1965).

Domestic pest cockroaches have been documented to affect human health in several ways. They serve as

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intermediate hosts of some helminths (Beaver et al., 1984) and as mechanical vectors of numerous human intestinal protozoa and helminth parasites (Ash and Greenberg, 1980; Chan et al., 2004; Tatfeng et al., 2005) and are also known to harbour a wide variety of microbial pathogens for which they serve as potential transit hosts (Baumholtz et al., 1997; Roth and Willis, 1957; Salehzadeh et al., 2007). Besides serving as mechanical transmitters of parasites or pathogens, large indoor cockroach populations are also one of the leading causes of allergies, asthma and other bronchial disorders in humans (Kang, 1990; Miller and Koehler, 2003).

The filthy breeding habits, feeding mechanisms and indiscriminate travel between filth and food make cockroaches and other synanthropic insects efficient vectors of human enteric protozoan parasites (Graczyk et al., 2005). Cockroaches frequently feed on human faeces (Fotedar et al., 1991; Graczyk et al., 2005; Pai et al., 2003) and hence can disseminate cysts, ova and larvae of gastrointestinal parasites mechanically in the environment. In Ethiopia, a number of human intestinal parasites were isolated from cycloraphan flies (Getachew et al., 2007). However, no work has been done to elucidate the role of cockroaches as carriers of human intestinal parasites. The aims of this study were therefore to assess the role of cockroaches as potential carriers of human intestinal parasites and to identify species that serve as mechanical vectors of the parasites.

2. Materials and methods

This study was carried out in Addis Ababa and Ziway, Ethiopia, from October 2006 to March 2007. The city of Addis Ababa lies in the central highlands at an altitude of approximately 2500 m above sea level. The average annual temperature and rainfall are 21 °C and 1800 mm, respectively. Addis Ababa has a relative humidity that varies from 70–80% during the rainy season and from 40–50% during the dry season. The human population of Addis Ababa is estimated to be approximately 5 million.

Ziway is a town in central Ethiopia, located approximately 160 km to the south of Addis Ababa at an elevation of 1643 m above sea level. The average annual temperature of the area is approximately 20.5 °C and the mean annual rainfall is approximately 702 mm but can be as high as 1400 mm. The annual relative humidity of Ziway area ranges from 65% to 75%. Based on figures from the Central Statistical Agency of 2005, Ziway has an estimated total population of 35 931, of whom 19 034 were males and 16 897 were females.

2.1. Trapping and identification of cockroaches

After a pilot inspection to estimate the population and concentrated locations, indoor cockroaches were trapped from houses and their surroundings both in Addis Ababa and Ziway. Cockroaches were trapped during the night in empty jars coated with a thin film of Vaseline baited with a slice of bread soaked in beer or water. The outsides of the jars were wrapped with paper to allow the grasp of cockroaches as they climb up the sides of the jars. The sticky traps were placed in and around houses at different sites (kitchens, toilets and bedrooms) overnight along lines where the vertical and horizontal planes meet. Trapped

cockroaches from both localities were placed in labelled jars and transported to the laboratory for identification and processing for parasite examination. Cockroaches processed after a few days were placed in a refrigerator at –4 °C. Identification of cockroaches was then done using the procedures and keys described by Ross (1965). Furthermore, the identified species were confirmed by an experienced entomologist from Addis Ababa University.

2.2. Processing of cockroaches for parasite examination

Cockroaches trapped from the study localities were killed in a jar using diethyl ether-soaked cotton. Cockroaches were grouped into species and pooled into batches. Based on size difference among the species, *B. germanica* and *Supella longipalpa* were pooled in a batch of ten and *Periplaneta brunnea* and *Pycnoscelus surinamensis* were pooled in a batch of four. The cockroaches in a pool were immersed in sterile physiological saline, stirred for 5 min and vortexed for 2–3 min to wash off the parasite cysts, eggs or larvae that might be attached to the external body of the cockroaches. The washed cockroaches were then removed with forceps and the whole gut of each washed cockroach was dissected out on an autoclaved microscope slide under a stereoscopic microscope using entomological needles and macerated to liberate the lumen contents. To avoid cross-contamination, the needles and forceps were dipped in ethanol and flamed between dissections. Both the pooled external washes and the gut contents of cockroaches were microscopically examined for parasite material after being processed using the formol-ether concentration technique (WHO, 1991). The modified Ziehl–Neelsen staining method was used for examination of *Cryptosporidium* spp. (Adegbola et al., 1994). The specimens were then examined under the microscope at 10× or 40× magnification for helminth ova/larvae and for protozoan cysts/oocysts. The parasites were then identified based on morphology of their eggs and cysts (WHO, 1991) and their number was recorded.

2.3. Statistical analysis

All data obtained from this study were entered into Microsoft Excel (Microsoft Corp., Redmond, WA, USA) and analysed using SPSS version 13.0 statistical software (SPSS Inc., Chicago, IL, USA). Both descriptive and analytical statistics were employed. Comparison based on localities, cockroach species and body parts with respect to parasite burden was performed using χ^2 test.

3. Results

A total of 6480 cockroaches were trapped from Addis Ababa and Ziway. Cockroach species and associated protozoan and helminthic parasites from the body wash and gut contents of the cockroaches as well as parasite load and number of pools examined/positive are presented in Table 1. All cockroaches trapped from Addis Ababa and approximately 50% of cockroaches trapped from Ziway were identified as *B. germanica*. The rest of the cockroaches trapped in Ziway were

Table 1 Cockroach species trapped in Addis Ababa and Ziway, Ethiopia, and associated protozoan and helminthic parasites from the body wash and gut contents of the cockroaches

Locality	Species	Body part	Protozoan ^a		Helminth ^a				No. of pools examined	No. (%) of positive pools
			Ec	Eh/d	Al	Tt	Ev	Ts		
Addis Ababa	<i>Blattella germanica</i>	Body surface	0.13	0.09	0	0.13	0.18	0	448	30 (6.70)
		Gut	0.13	0.13	0	0.22	0.31	0		
Ziway	<i>B. germanica</i>	Body surface	0.09	0	0	0.19	0	0	420	16 (3.81)
		Gut	0.09	0	0	0.29	0.09	0		
	<i>Periplaneta brunnea</i>	Body surface	0.29	0.38	0.19	0	0	0.29	520	44 (8.46)
		Gut	0.38	0.78	0.29	0	0.19	0.48		
	<i>Pycnoscelus surinamensis</i>	Body surface	0	0	0.29	0	0	0.29	340	18 (5.29)
		Gut	0.29	0	0.44	0.74	0	0.59		
	<i>Supella longipalpa</i>	Body surface	0	0	0	0	0	0	84	0
		Gut	0	0	0	0	0	0		

Ec: *Entamoeba coli*; Eh/d: *Entamoeba histolytica/dispar*; Al: *Ascaris lumbricoides*; Tt: *Trichuris trichiura*; Ev: *Enterobius vermicularis*; Ts: *Taenia* spp.
^a Parasite load was expressed as no. of ova/cysts per 100 cockroaches.

identified as *P. brunnea* (24.52%), *P. surinamensis* (16.03%) and *S. longipalpa* (9.90%).

Microscopic examination of the external body washes of pooled cockroaches and individual gut contents revealed that cockroaches are carriers of *Entamoeba coli* and *Entamoeba histolytica/dispar* cysts as well as *Enterobius vermicularis*, *Trichuris trichiura*, *Taenia* spp. and *Ascaris lumbricoides* ova. In our study, we did not employ molecular methods to differentiate *Ent. histolytica* and *Ent. dispar* from the samples collected; they were only identified as *Ent. histolytica/dispar* on the basis of cyst morphology. Since cockroaches were trapped inside houses and no porcine hosts are present in the two study sites, eggs of porcine *Ascaris* and *Trichuris* are not expected to be carried by cockroaches in these localities. Hence, *Trichuris* eggs detected in the external body wash and gut contents of the cockroaches trapped from Addis Ababa as well as *Ascaris* and *Trichuris* eggs detected in the external body wash and gut contents of the cockroaches trapped from Ziway were assumed to be *A. lumbricoides* and *T. trichiura*.

The percentage contamination of both the external body washes and the gut contents by parasites and the contamination level of cockroaches trapped in the two localities did not differ significantly ($P > 0.05$).

4. Discussion

To the best of our knowledge, this study was the first of its kind to investigate the role of cockroaches as potential carriers of human intestinal parasites in Ethiopia. The cockroach species trapped from the study sites were identified as *B. germanica*, *P. brunnea*, *P. surinamensis* and *S. longipalpa*. Among these, *B. germanica* was the most ubiquitous and also frequently seen in food preparation areas, restaurants, cafeterias, kitchens and toilets, showing that *B. germanica* plays an important role as a nuisance and mechanical transmitter of disease aetiological agents.

Microscopic examination of the body washes and gut contents of the cockroaches for parasites revealed the presence of cysts of *Ent. coli* and *Ent. histolytica/dispar* as well as ova of *E. vermicularis*, *T. trichiura*, *A. lumbricoides* and *Taenia* spp. A number of previous studies have also shown that cockroaches serve as mechanical carriers of human intestinal parasites (Ash and Greenberg, 1980; Chan et al., 2004; Tatfeng et al., 2005).

Cockroaches may play a more significant role in the epidemiology of enterobiasis. This assumption is based on the coincidence of the migration of female *E. vermicularis* out of the anus as well as deposition of eggs on the perianal skin with the nocturnal activity of cockroaches. Although *E. vermicularis* does not depend on vectors for its transmission, the fact that *Enterobius* eggs occur in the dust, on the beddings and on other pieces of furniture (Nolan and Reardon, 1939) also makes indoor cockroaches important mechanical vectors of this worm.

Several previous studies have documented that coccidian parasites such as *Blastocystis* are carried by cockroaches (Fathpour et al., 2003; Tatfeng et al., 2005; Yoshikawa et al., 2007). On the contrary, no coccidian parasite was encountered in the present study. This might be partly attributable to the examination procedure employed rather than the

absence of the parasites. For instance, *Blastocystis hominis* may be deformed or destroyed in the procedure of formol–ether concentration (Jobet et al., 2000; Stenzel and Boreham, 1996), which was the method used here for the examination of external body wash and gut contents of cockroaches.

In addition to their role as pathogen and parasite disseminators, cockroaches may serve as an important source of contactant, inhalant, injectant and ingestant allergens (Rosenstreich et al., 1997; Roth and Alsop, 1978). In Ethiopia, however, only limited studies were performed to investigate the association between allergic disorders and cockroach allergens in two urban and rural settings (Dagoye et al., 2003, 2004; Davey et al., 2005). The latter two studies have documented that the presence of a positive skin test to cockroach was found to be associated with wheeze to some degree (Dagoye et al., 2004; Davey et al., 2005). Nevertheless, further studies are indicated to determine the extent to which cockroach allergens are associated with allergic conditions in Ethiopia.

Finally, the present study further confirms that cockroaches play an important role as mechanical vectors of intestinal protozoan and helminth parasites. Hence, it is recommended that appropriate control measures be taken particularly to make human dwellings as well as food preparation areas, including hotels, free of cockroaches.

Authors' contributions: BE and AK identified the research problem; AK trapped and identified the cockroaches and performed the microscopic examination; AK and BE analysed and interpreted the data, and prepared the manuscript. Both authors read and approved the final manuscript. AK and BE are guarantors of the paper.

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Conflicts of interest: None declared.

Ethical approval: Not required.

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