

Species Composition of Cockroaches, Their Potential as Mechanical Vectors of Intestinal Parasites and Associated Factors Among Households in Sekota Town, Northeast Ethiopia; A Community-based Cross-sectional Study

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Abstract

Background: Cockroaches pose a significant nuisance, and public health threat due to their ability to transmit pathogenic organisms including intestinal parasites. Due to little attention given to mechanical transmission of parasitic diseases by various vectors, appropriate interventions are not implemented to date. The extent to which cockroaches may harbor parasites is poorly understood in Ethiopia, particularly in the study area. This further overwhelms the already fragile program of prevention and control of parasites.

Objectives: To assess species composition of cockroaches, their potential as mechanical vectors of intestinal parasites and associated factors among households in Sekota town, Northeast Ethiopia.

Methods: A community-based cross-sectional study was conducted in households found in Sekota town from February to April 2020. A total of 402 households were selected by a systematic random sampling technique. Possible risk factors were collected via a structured questionnaire, and 1750 cockroaches were collected using jars. Species identification of cockroaches was performed using taxonomic keys, and parasite isolation was done using formol-ether and modified modified acid-fast techniques. The data analysis was done using SPSS version 23. P-value of less than 0.05 was considered statistically significant.

Results: All cockroaches collected were identified as a species of *Blattella germanica* (*B. germanica*). Overall, 63 (36.0%) of the 175 batches were found to harbor intestinal parasites, *E. histolytica/dispar* (14.3%) and *H. nana* (8.6%) being the predominant species. About 38 (21.7%), and 49 (28.0%) of cockroaches were found to harbor parasites on external parts and gut contents, respectively. Improper latrine utilization ($P=0.006$), presence of domestic animals ($P=0.032$), and presence of parasite-infected child in the household ($P=0.001$) were significantly associated with parasite carriage of cockroaches. Moreover, houses attached via two or more sides with neighboring houses ($P=0.045$), houses with cracks on their walls ($P=0.001$), and households with poor solid waste disposal ($P=0.001$) were at a significantly higher odds of cockroach infestation.

Conclusion: Human and environmental factors have favoured infestation by *Blattella germanica* in the study area. Therefore, households housing condition, latrine utilization, and waste management systems should be improved.

Background

Cockroaches are the most notorious insects distributed throughout the world and they are inhabiting most human made structures [1]. There are more than 4,400 species of cockroach, of which 30 species are highly synanthropic (adapted to human habitation), thriving in so many habitats and consuming virtually any organic matter [2]. Of these, *Periplaneta americana* (American cockroach), *Blattella germanica* (German cockroach) and *Blattella orientalis* (the Oriental cockroach) are considered the most common pests to people [3]. Majority of these species live in tropical and subtropical areas where they

are not recognized as pests. They feed on human faeces as well as human food and they can spread pathogenic bacteria, fungi and parasites in human dwellings [4]. The potential exists therefore, for mechanical transmission through physical dislodgement, regurgitation, or fecal pellet deposition onto and/or into exposed human food [5]. They are also source of potent environmental aeroallergens which provoke allergic reactions especially in children [6].

Cockroaches have an association with human waste and are able to traffic from sewers into homes and are attracted to dark and moist-warmth environment such as toilets, bathrooms, kitchens and basements [7]. Some cockroach species are not only a domiciliary pest but also the most frequent species in sewers which colonize there, and turning in to suitable environment for reproduction and growth [8].

The infestation of cockroaches in the human dwellings is increasing year after year, mainly due to insufficient dumpsites, domestic waste accumulation, poor housing standards, over-crowding and ignorance [9]. Poor environmental sanitation is believed to encourage the spread of cockroaches and sustenance of parasitic infections. Many parasitespecies have been found to be naturally associated with cockroaches. These relationships probably represent incidental associations with the omnivorous feeding behavior of cockroaches (Brenner & Kramer, 2019). Those parasites that are spread by cockroaches can pose serious public health problems in developing countries [10].

The mechanical transmissions of parasitic diseases by cockroaches are neglected. However, cockroaches can be potential reservoirs and possible vectors for intestinal parasites [11-13]. Moreover, epidemiological information on species composition of cockroaches, their potential as mechanical vectors of intestinal parasites and associated factors is very limited in Ethiopia. So, this study aimed to assess species composition of cockroaches, their potential as mechanical vectors of intestinal parasites and associated factors among households in Sekota town, Northeast, Ethiopia.

Materials And Methods

Study design, period and area

A community based cross-sectional study was conducted from February to April, 2020 among households of Sekota town, Northeast Ethiopia. The area is located 720 km far from the country's capital, Addis Ababa. It has latitude and longitude of (12°38'N39°02'E) and an elevation of 2266 meters above sea level. The town has also an average annual temperature of 29°C, an annual average rainfall of 786 mm and 35% humidity. Humid and hot climate makes the area conducive for cockroaches.

Sample size and sampling technique

A stratified sampling technique was employed to allocate households to four kebeles (the smallest administrative unit in Ethiopia). Then, the allocated households in each kebele was selected via a systematic random sampling technique. A total of 402 households were included, and cockroaches were

collected from the selected households. Insecticide sprayed houses within two weeks prior to cockroach collection were excluded for cockroach collection. During sampling, the trapped cockroaches were labeled and sorted by capture sites in households (living room, kitchen and toilet) and kebele.

Data collection

Questionnaire. A face to face interview and observation was conducted by a trained nurse with the representatives of the households using a structured and pre-tested questionnaire. The questionnaire was used to collect demographic data and risk factors for cockroach infestation such as, housing condition, environmental hygiene and other independent variables.

Collection and identification of cockroaches:The cockroaches were collected using empty jars coated with a thin film of Vaseline baited with a piece of bread soaked in water. The collection jars were put at 19:00 hr and retrieved at 7:00 hr the next morning. The trapped cockroaches were transported in jars to the Tefera Hailu Memorial hospital laboratory for identification and parasitological analyses. Then, morphological identification of the cockroach species was performed using standard taxonomic keys after they were anaesthetized and killed by exposure to ether [18]. One hundred seventy five batches of cockroaches (each batch with 10 cockroaches) were processed. External body surfaces and internal (gut) contents of the cockroaches were processed as described by Haile *et al*/to isolate parasite species [17].

Isolation of parasites from cockroach body surface:After species identification, each cockroach batch was placed in a tube containing 10 ml of normal saline. The tube was shaken vigorously for two minutes to detach parasite stages from the external body of the cockroaches. Cockroaches were removed from wash solutions using forceps and fixed in 90% alcohol. Then, the wash solutions were centrifuged at 2000rpm for 5minutes. The supernatant was discarded and the sediment was used for formol-ether concentration technique and modified acid fast staining [20].

Isolation of parasites from cockroach guts:After external body examination, the cockroaches were fixed in 90% ethanol for 5 minutes. Afterwards, cockroaches were washed in saline to remove the traces of alcohol from the body of the cockroaches and allowed to air-dry at room temperature. Then, cockroaches were put on a plate for dissection; the head was severed first, followed by trimming of the wings and legs, then the abdomen was opened using fine pointed forceps with small scissors and whole gut was removed using needles. After every dissection, instruments were decontaminated to prevent cross contamination by dipping in ethanol between dissections. The excised guts were homogenized in 5 ml of saline solution and the homogenate was filtered through gauze and centrifuged at 2000 rpm for 5 minutes. The supernatant was decanted and the sediment 0.5-1ml processed further using formol-ether concentration technique and modified acid fast staining to examine for parasites [21].

Quality assurance

The questionnaire was pre-tested, and the necessary amendments were made before data collection. Training was also given for the data collectors (laboratory technicians and nurses). The principal investigator had strictly supervised the data collection.

Data analysis

The data were entered in to Epi-data version 3.1 and analyze via SPSS version 23 statistical software. Descriptive statistics and chi-square test was performed. The strength of association between dependent and independent variables was checked via the bivariate analysis. Those variables with $P < 0.25$ in the binary logistic regression were taken to multiple regression analysis to control potential confounders. $P\text{-value} < 0.05$ was considered as statistically significant.

Results

A total of 1,750 cockroaches (175 batches) were collected indoors from three different sites (living room, kitche, and toilet) of the selected households. All the collected cockroaches were identified as a species of *Blattella germanica*. From the total batches of cockroaches, 63 (36.0%) batches were found to harbor atleast one intestinal parasite species. Regarding cockroach collection localities, the highest number of cockroach batches collected and the highest prevalence of intestinal parasites isolated were from kebele 02 and 04, respectively. The highest proportion (52.3%) of intestinal parasites was isolated from cockroaches collected from the toilets (Table 1).

Table1. The prevalence of intestinal parasites isolated from populations of *B. germanica* by kebeles and collection sites in Sekota town, Northeast Ethiopia, 2020.

Variables		Cockroach batches examined	Cockroach batches found to harbor parasites N (%)
Kebele	01	58	17 (29.3%)
	02	66	25 (37.9%)
	03	22	7 (31.8%)
	04	29	14 (48.3%)
	Total	175	63 (36.0%)
Collection site	Living room	84	27 (32.1%)
	Kitchen	47	13 (27.7%)
	Toilet	44	23 (52.3%)
	Total	175	63 (36.0%)

The prevalence of intestinal parasites isolated from cockroaches

Five species of medically important parasites were isolated from cockroaches. The overall prevalence of intestinal parasite was 36%. The predominant species were *E. histolytica/dispar* (14.3%), *Hymenolepis nana* (*H. nana*) (8.6%), and *Giardia lamblia* (*G. lamblia*) (8.0%). Other species such as *Cryptosporidium parvum* (*C. parvum*) (2.9%), and *Enterobius vermicularis* (*E. vermicularis*) (1.7%) were also isolated. Of the 175 batches of cockroaches examined, 38 (21.7%), and 49 (28.0%) batches were found to harbor intestinal parasites on their external body surfaces, and in their guts, respectively (Table 2).

Table 2. The prevalence of intestinal parasites isolated from the external body surfaces and gut contents of *B. germanica* in Sekota town, Northeast Ethiopia, 2020.

Parasites	Cockroach batches found to harbor parasites N (%)		
	External body surface n (%)	Gut contents n (%)	Overall n (%)
<i>E. histolytica/dispar</i>	16 (9.1%)	20 (11.4%)	25 (14.3%)
<i>G. lamblia</i>	7 (4.0%)	13 (7.4%)	14 (8.0%)
<i>H. nana</i>	10 (5.7%)	12 (6.9%)	16 (8.6%)
<i>E. vermicularis</i>	3 (1.7%)	0	3 (1.7%)
<i>C. parvum</i>	2 (1.1%)	4 (2.3%)	5 (2.9%)
Total	38 (21.7%)	49 (28.0%)	63 (36.0%)

The prevalence of cockroach infestation and associated factors

The overall prevalence of cockroach infestation in the surveyed households was 67.9% (273/402). The odds of cockroach infestation in houses that were attached via two or more sides with neighboring houses was twice (AOR=2.033; CI: 1.015-4.072, P=0.045) higher than detached houses. Houses having cracks on their wall were at 4.8 (AOR=4.821; CI: 2.631-8.836, P=0.001) times higher odds of cockroach infestation. Moreover, households with poor solid waste disposal were at 5.1 (AOR=5.124; CI: 2.847-9.222, P=0.001) times higher odds of being infested by roaches (Table 3).

Table 3. Bivariate and multivariate analysis of factors associated with cockroach infestation in Sekota town, Northeast Ethiopia from February to April, 2020 (N=402).

Variables		Roach-infested houses n (%)	Bivariable analysis		Multivariable analysis	
			COR (95% CI)	P-value	AOR (95% CI)	P-value
House type (physical attachment with neighboring houses)	Detached	60 (14.9)	1			
	Semi-detached house	96(23.9)	2.2 (1.3-3.6)	0.003	1.6 (0.8-3.4)	0.19
	Attached by 2/more sides	117 (29.1)	2.7 (1.6-4.7)		2.3 (1.1-4.1)	0.045
Wall type of houses	Concrete/brick	41(10.2)	1			
	Stone/wood with cement	84(20.9)	2.5 (1.5-4.1)	0.001	2.1 (1.0-4.5)	0.054
	Stone/wood with mud	148(36.8)	4.2 (2.4-7.4)	0.001	2.5 (1.3-4.9)	0.080
Cracks on the wall	Present	179(44.5)	7.5 (4.6-12.4)	0.001	4.8 (2.6-8.8)	0.001
	Absent	94(23.4)	1			
Family size	<5	84(20.9)	1			
	≥5	189(47.0)	1.6 (1.0-2.4)	0.47		
Solid waste disposal	Good	82(20.4)	1			
	Poor	191(47.5)	6.5 (4.1-10.4)	0.001	5.1 (2.8-9.2)	0.001
Liquid waste disposal	Good	67(16.7)	1			
	Poor	206 (51.2)	1.6 (1.0-2.5)	0.046	1.1 (0.6-2.2)	0.679
Availability of domestic animals	Yes	217(54.0)	4.2 (2.7-6.6)	0.021	2.6 (1.4-4.7)	0.082
	No	56(13.9)	1			
Proper latrine	Yes	89(22.1)	2.9	0.001	1.7	0.072

utilization		(1.9-4.6)	(0.9-3.1)
No	184(45.8)	1	

Cockroach batches collected from houses with improper utilization of latrine (AOR=3.2; CI: 1.411-7.381, P=0.006), and houses with domestic animals (AOR=2.6; CI: 1.085-6.004, P=0.032) were at higher odds of carrying parasites. Moreover, the presence of a child with intestinal parasite infection in the household was significantly associated with cockroach's parasite carriage (AOR=6.7; CI: 2.775-12.223, P=0.001) (Table 4).

Table 4. Bivariate and multivariate analysis of factors associated with parasite carriage of cockroaches in Sekota town, Northeast Ethiopia, 2020 (N=175).

Variables		Roaches harboring IP n (%)	Bivariable analysis		Multivariable analysis	
			COR (95% CI)	P-value	AOR (95% CI)	P-value
Type of latrine	Flush latrine	2 (1.1)	1			
	Pit latrine with slab	16(9.1)	1.8 (0.9-3.8)	0.908		
	Pit latrine without slab	35 (20)	5.3 (1.1-24.4)	0.305		
Solid waste disposal	Good	31(17.7)	1			
	Poor	32(18.3)	2.8 (1.5-5.4)	0.002	2.4 (1.1-4.9)	0.054
Liquid waste disposal	Good	13(7.4)	1			
	Poor	50 (28.6)	2.2 (1.1-4.6)	0.030	1.9 (0.8-4.8)	0.128
Availability of domestic animals	Yes	46(26.3)	2.9 (1.5-5.7)	0.002	2.6 (1.1-6.0)	0.032
	No	17(9.7)	1			
Proper latrine utilization	Yes	15(8.6)	1			
	No	38(21.7)	3.8 (1.9-7.7)	0.001	3.2 (1.4-7.4)	0.006
Roach collection site	Kitchen	13(7.4)	1			
	Living room	23 (13.1)	2.3 (1.1-14.9)	0.83		
	Toilet	27 (15.4)	2.9 (1.2-16.8)	0.281		
Availability parasite-infected child in the HH	Yes	52 (29.7)	7.6 (3.6-16.2)	0.001	6.7 (2.8-12.2)	0.001
	No	11(6.3)	1			

Discussion

Cockroaches are nuisance pests and great concern to public health due to their ability to serve as mechanical vectors of pathogens including parasites [22]. Results from this study showed that *E. histolytica/dispar* (14.3%) was the predominant parasite isolated from cockroaches. It was lower than the prevalence reported by Bala & Sule (2012) in Nigeria [23]. The predominance of *E. histolytica* might probably be because of the ability of the cyst to survive days to weeks in the external environment, and hence it can be accessed by cockroaches. Adenusi *et al* [24], and Oyeyemi *et al* [25] reported that the presence of *E. vermicularis* signifies the obvious contact of cockroaches with infected persons in houses or clothing which confirms roaches' ability to transmit different parasites that are responsible for a number of disease conditions in man, some of which could be life-threatening. For example *E. histolytica* causes amoebiasis, a potentially severe and life threatening disease and the second most common cause of death from parasitic diseases, after malaria. *Cryptosporidium* spp. and *G. lamblia* are also nowadays, major causes of diarrhea especially in children [17, 22]. *Cryptosporidium parvum* and *Giardia* spp. are zoonotic protozoans isolated from cockroaches. This indicates that cockroaches can serve as mechanical vectors of several zoonotic parasites which cause zoonotic disease [24].

In our study the prevalence of intestinal parasites was 28.0% in the gut, and 21.7% on the external body surface of cockroaches. The difference was statistically significant ($\chi^2 = 176.5$, $P = 0.001$, 95% CI = 0.001, 0.017). It is supported by Hamu *et al.* (2014), that reported higher rate of parasite isolation in the cockroaches' gut (75.6% in the gut & 10.9% on external surface). This might be due to the voracious feeding habit of cockroaches that might end up with ingestion of parasites from the fecal material [19]. In contrast, a report by Edwin (2019) showed that 65.3% of total parasites obtained were isolated from the external surface, while gut contents had 34.6% [7].

In this study, overall parasite carriage rate (36.0%) of cockroaches recorded was lower than previous studies in Ethiopia with 75.1-75.6% (17, 19), Cameroon with 47.39% [22] and Nigeria with 96.4% [24]. However, it was higher than an earlier finding in Palestine with 17.3% [26]. The differences in hygienic conditions, socio-economic status of the people, transmission dynamics, and prevention & control measures taken for intestinal parasites in these various areas might account for the variation.

The highest prevalence of intestinal parasites was isolated from cockroaches collected in toilets (15.4%), while the lowest record was in kitchens (7.4%). The difference was statistically significant ($\chi^2 = 7.0$, $P = 0.029$, 95% CI = 0.004, 0.053). Alzain (2013) revealed in his study that almost all cockroaches collected from toilets were contaminated with various parasite species which were significantly higher in comparison to other sites. Ojjanwuna *et al* also observed that the cockroaches collected from the toilets had more parasites, probably because they are easily exposed to and contaminated by fecal matter [16].

The current study identified that houses that are attached by two or more sides with neighboring houses were twice at higher odds of cockroach infestation (AOR=2.0). This finding is supported by a study done

in Nigeria [24]. This might be due to cockroaches' tendency to congregate in corners while foraging, and traveling along the edges of walls or other surfaces. Moreover, the odds of cockroach infestation was higher for houses having cracks on their wall (AOR= 4.8). This might be because of cockroaches would love to hide in dark, and warm areas especially narrow spaces. Furthermore, our study indicates that households with poor solid waste disposal were at 5 times higher odds of cockroach infestation than those having good waste disposal systems. Poor environmental sanitation is believed to encourage the spread of cockroaches and sustenance of parasitic infections [10].

In this study, different factors were found to be significant predictors of parasite carriage by the cockroaches. Consequently, cockroaches present in households the owned domestic animals were at 2.6 times higher odds of parasite carriage. This is supported by a study done in Cameron [22]. This might be due to the zoonotic nature of some parasites, and animals can also carry parasites on their body from the outdoors bring them to the indoors for easy access by cockroaches. Moreover, cockroach batches collected from households with improper utilization of latrine were at 3.2 times higher odds of harboring parasites. In the same way, the presence of parasite infected child in the household puts cockroaches at higher odds of parasite carriage (AOR= 6.7). This might be partially explained by the fact that the improper human excreta disposal might end up with piles of faecal matter that can attract cockroaches [19,25].

Conclusion

Blattella germanica was found to be the only cockroach species in the study area. A significant number of cockroaches also harbored intestinal parasites. Various human and environmental factors have favoured cockroach infestation in the area..Therefore, it is imperative to institute control measures like improving housing condition, utilization of latrine, proper domestic waste management and environmental sanitation in order to minimize cockroach infestation.

Declarations

Ethics approval and consent to participate

Ethical approval was obtained from the Ethical review board of College of Medicine and Health Sciences, Bahir Dar University. After the purpose of the study explained to the selected households, informed written consent was obtained from each study participant. All information obtained at each course of the study was kept confidential. The findings of the study was communicated and oriented for their better management of their house and environment to avoid the cockroaches.

Consent for publication

Consent for publication is not applicable as individual data such as images and videos did not accompany this manuscript.

Availability of data and materials

Data were collected and analyzed based on the stated methods and materials to generate findings of this study. All the data were incorporated into the manuscript and no supplementary files accompanied the submission. The original data supporting this finding will be available at any time upon request.

Competing interests

Authors declared they have no conflicting interest.

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Authors' contributions

Considerable contributions were made by all authors during the conception, design, and acquisition of data, analysis, and interpretation of data to this study. They have drafted and approved the final version of the manuscript and declared to bear the responsibility of all aspects of the research work.

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