

## **Iraqi household cockroaches collected from Diyala Province are potential vectors of medically-important parasites**

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### **Abstract**

Household cockroaches constitute a significant public health threat due to their capacity of transmitting medically-important parasites and other pathogens. The role of Iraqi household cockroaches as potential vectors of medically-important parasites was evaluated in the present study. Fifty cockroaches (*Periplaneta americana*) were collected from different dwelling places of Baquba City, Diyala Province during the period from October to December 2022. The contents of their guts and external body surfaces were examined for the presence of medically-important parasites. The overall prevalence rate of parasitic infestation on the external body surfaces was 60.0%, while the overall prevalence rate of parasitic infection in the guts was 56.0%. Based on capture sites, cockroaches trapped in the toilets had more parasites than those caught from kitchens and rooms. Four species of medically important parasites were isolated from the external body surfaces of the cockroaches; three species were identified as protozoa and only one species was helminth. The protozoan parasites were identified as *Blastocystis* spp. (36.0%), *Giardia* spp. (14.0%) and *Cryptosporidium* spp. (4.0%). In addition, five species of medically important parasites were isolated from the gut contents; four species were identified as protozoa and only one species was helminth. The protozoan parasites were identified as *Blastocystis* spp. (24.0%), *Giardia* spp. (10.0%), *Cryptosporidium* spp. (8.0%), and *Entamoeba histolytica/ E. dispar* (2.0%). *Enterobius vermicularis* was the only helminth parasite isolated from both gut contents (2.0%) and external body surfaces (2.0%). In conclusion, the results showed that cockroaches were found to harbor intestinal parasites of public health importance and awareness on the potential role of these insects in the transmission of human intestinal parasites needs to be established.

**Keywords:** Iraqi cockroaches, external body surfaces, gut contents, medically-important parasites

## Introduction

Cockroaches belong to the order Blattodea and they preferentially inhabit tropical and temperate forests [1]. Although there are more than 4,400 species of cockroaches found worldwide, only 30 species are highly adapted to human habitation and *Periplaneta americana* (American cockroach), *Blattella germanica* (German cockroach), and *Blattella orientalis* (the Oriental cockroach) are considered the most common pests to humans [2, 3].

Cockroaches are an important public health pest in urban areas and can cause significant health problems for humans. They are the greatest potential mechanical vector of various pathogenic microorganisms (fungi, bacteria, viruses, and parasites) [4], some of which cause serious diseases in humans and domestic animals. The high prevalence of human pathogens carried by the cockroach has been reported in many countries and these reports showed the difference between prevalence rates for the various species of pathogens isolated from cockroaches in each geographical location of the study. In addition, a cockroach can produce important indoor allergens that are a common cause of human asthma [4, 5].

Haile et al. [6] investigated the role of cockroaches as carriers of intestinal parasites in Wolkite town, southwestern, Ethiopia and reported that 75.1% of the cockroaches were found infected with one or more of intestinal parasites including *Ascaris lumbricoides*, *Hymenolepis nana*, *Taenia* spp., *Enterobius vermicularis*, *Strongyloides stercoralis*, *Trichiuris trichuira*, *Giardia lamblia*, *Entamoeba histolytica/dispar* and hookworms. The authors concluded that the high frequency of parasites in cockroaches indicates that these insects are carriers of several zoonotic parasites that could infect humans. Consequently, the authors suggested that in order to minimize the transmission of intestinal parasites by cockroaches, this requires controlling the population of these insects together with generating awareness of the community about personal hygiene and environmental sanitation.

Besides their role as a nuisance, the results of some recent studies confirmed that cockroaches serve as carriers of human intestinal parasites and suggested that appropriate control measures should be taken to make hotels and residential areas free of cockroaches as they represent a health risk [6 - 8].

In Iraq, Abul-Hab and Kassal [9] reported that the most common species that live inside residential units and hospitals are the German cockroach (*Blattella germanica*) and the brown-belted cockroach (*Supella supellectilium*). The authors indicated that there are 11 species of cockroaches in Baghdad city which belong to three families: family Blattellidae which includes 5 species (*Blattella germanica*, *B. vaga*, *Supella supellectilium*, *Ectobius pallidus* and *Parcoblotta* spp.), family Blattidae which includes the following species (*Periplaneta americana*, *P. australasiae*, *P. brunnea*, *Blatta orientalis*, and *B. loteralis*), and family Polyphagidae which includes the following species (*Polyphaga aegyptiaca* and *P. sausseri*). Al-Fahdawi [10] found 11 species of cockroaches in Ramadi city, Ramadi Province, including all the above-mentioned species except *P. australasiae*, and reported that both *B. germanica* and *S. supellectilium* (S.) were the most common species found inside the residential units and kitchens. Ali and Ahmed [11] reported that 80% of residential units in

Baghdad city were infested with the German cockroach, *Blattella germanica* (L.), while 50% of these residential units were also infested by brown-banded cockroach, *Supella Supellectilium* (S.).

Some studies have shown that the intestinal parasites are common among residents of Baquba City within Diyala Province [12, 13] and the warm environmental conditions of this city make it an ideal natural habitat for the cockroaches. As far as we know, no previous studies have been conducted on the role of cockroaches as carriers of human intestinal parasites in Diyala Province. Consequently, the objective of the present study was to evaluate the potential role of these insects in carrying medically-important human intestinal parasites via isolating parasites from the body surfaces and gut contents of household cockroaches (*Periplaneta americana*) collected from Baquba city, Diyala Province, Middle of Iraq.

## **Materials and Methods**

### ***Sample processing***

The study was conducted in Baquba City, Diyala Province, Middle of Iraq, during the period from October to December 2022. Fifty adult cockroaches were trapped (without using insecticides) from 45 households. The cockroaches were caught from different locations including kitchens, toilets, bathrooms, bed rooms and living rooms. As previously described [14, 15] the cockroaches were caught using gloved hands and placed in a plastic bag that had been hole-punched to allow for air flow and then transported alive to the laboratory (Biology Department, College of Sciences, Diyala University) where they killed by freezing at 0 °C for 10 min. The guts and external body surface contents were processed as described previously [2]. Parasite species isolated from cockroaches' gut and external body surfaces were identified as previously described [16].

### ***Identification of parasites on the external surfaces of the cockroaches***

After identification, each cockroach was thoroughly shaken in 5 ml of normal saline in a test tube for 30 sec using a vortex. The cockroach was removed and the solution was centrifuged at 3000 rpm for 5 min. A portion of the sediment was examined using a light microscope and the remaining sediment was stained using modified Ziehl-Neelsen staining method for characteristic features of coccidian protozoa. All the cockroaches were kept for the second part of the project (parasites of the guts).

### ***Identification of parasites in the guts of the cockroaches***

Each cockroach was placed in a sterile Petri dish and dissected under a dissecting microscope using sterilized entomological needles. The whole intestine was removed and washed in 5 ml of sterile physiological saline, filtered through gauze and centrifuged at 3000

rpm for 5 minutes. A portion of the sediment was stained with 1% iodine and then examined using a light microscope searching for protozoan and helminth parasites. The remaining sediment was stained using modified Ziehl-Neelsen staining method for characteristic features of coccidian protozoa.

### ***Statistical analysis***

Microsoft Excel (version 19) has been used to format, organize and calculate the data. Data were expressed as mean  $\pm$  SE and statistical differences were considered significant when  $P \leq 0.05$  using Fisher's Exact Probability test. The odds ratio (OR) was calculated using: Med Calc Software Ltd. Odds ratio calculator. [https://www.medcalc.org/calc/odds\\_ratio.php](https://www.medcalc.org/calc/odds_ratio.php) (Version 20.013; accessed September 17, 2023).

## **Results**

### **1. Parasites isolated from the external body surfaces of cockroaches**

A total of 50 cockroaches were collected from different dwelling areas of Baquba City, Diyala Province and were identified by the staff of the Department of Entomology and Invertebrates, Iraqi Natural History Research Centre and Museum as American cockroaches (*Periplaneta americana*). The overall prevalence rate of parasitic infestation on the external body surfaces of the cockroaches was 60.0% (Table 1). The percentage of infestation was the highest among the cockroaches captured in the toilets (65.2%) followed by those captured in the kitchens (56.3%), while none of those captured in rooms were found carrying parasites on their external surfaces (Table 1).

The cockroaches captured in the toilets were more capable of carrying parasites on their external surfaces than those captured in kitchens (OR=1.4) and rooms (OR=9.4). In addition, the cockroaches captured in the kitchens were more capable of carrying parasites on their external surfaces than those captured in the rooms (OR=6.3) (Table 1).

Table 1. Percentage of infestation of human pathogenic parasites on the external body surface of Iraqi cockroaches collected from different locations in the residential houses (rooms, kitchens and toilets).

Capture sites	Number examined	Number infested	% infestation
Toilets	32	21	65.6

Kitchens	16	9	56.3
Rooms	2	0	0.0
Total number	50	30	60
Odds ratio (Toilets vs. kitchens)	1.4		
Odds ratio (Toilets vs. rooms)	9.4		
Odds ratio (Kitchens vs. rooms)	6.3		

It can be seen from Table 2 that out of 30 infested cockroaches, 29 (96.7%) were found infested with protozoa and only one cockroach (3.3%) was infested with helminths. Four species of medically important parasites were isolated from cockroaches; three species were identified as protozoa and only one species was helminth (Table 2). The protozoan parasite infestations on the external body surfaces of the cockroaches were identified as *Blastocystis hominis* (36.0%), *Giardia* spp. (14.0%) and *Cryptosporidium* spp. (4.0%). In addition, three cockroaches (6.0%) were found infested with both *Blastocystis* spp. and *Giardia* spp., and two cockroaches (4.0%) were found infested with both *Blastocystis* spp. and *Cryptosporidium* spp.

Regarding the helminth parasite infestations on the external body surfaces of the cockroaches, only one cockroach (3.3%) was infested with *Enterobius vermicularis* (Table 2).

Table 2. Parasite species isolated from the external body surfaces of Iraqi cockroaches and the percentage of infestation (n=50).

Parasites	Number infested (n= 30)	% infestation
<i>Blastocystis</i> spp. (mostly vacuolar forms)	18	36
<i>Giardia</i> spp. (cysts)	7	14
<i>Cryptosporidium</i> spp. (oocysts)	2	4
<i>Enterobius vermicularis</i> (eggs)	1	2
<i>Blastocystis</i> spp. + <i>Giardia</i> spp.	3	6
<i>Blastocystis</i> spp. + <i>Cryptosporidium</i> spp.	2	4
Total	30	60

## 2. Parasites isolated from gut contents of cockroaches.

It can be seen from Table 3 that the overall prevalence rate of parasitic infection in the guts of the cockroaches was 68.0% (Table 3). The percentage of infection was the highest among

the cockroaches captured in the toilets (78.1%) followed by those captured in kitchens (50.0%) and rooms (50.0%) (Table 3).

The cockroaches caught in toilets were more capable of harbouring parasites in their guts than those from kitchens (OR=3.6) and rooms (OR=3.6). In contrast, no difference (OR=1.0) was detected in the infection rate between the cockroaches captured in the kitchens and those captured in the rooms (Table 3).

Table 3. Percentage of infection of medically important parasites in the guts of Iraqi cockroaches collected from different locations in the residential houses (toilets, kitchens and rooms).

Locations	Number examined	Number infected	% infection
Toilets	32	25	78.1
Kitchens	16	8	50.0
Rooms	2	1	50.0
Total number	50	34	68.0
Odds ratio (Toilets vs. kitchens)	3.6		
Odds ratio (Toilets vs. rooms)	3.6		
Odds ratio (Kitchens vs. rooms)	1.0		

It can be seen from Table 4 that out of 50 examined cockroaches, 28 (56.0%) were found infected with one or more intestinal parasites. Out of 28 infected cockroaches, 27 (96.4%) were found infested with protozoa and only one cockroach (3.6%) was infected with helminths. Five species of medically important parasites were isolated; four species were identified as protozoa and only one species was helminth (Table 3). The protozoan parasite isolated from the guts were identified as *Blastocystis hominis* (24.0%), *Giardia* spp. (10.0%), *Cryptosporidium* spp. (8.0%) and *Entamoeba histolytica* / *E. dispar* (2.0%). In addition, mixed infection with both *Blastocystis* spp. and *Giardia* spp. was recorded in one cockroach (2.0%), and four cockroaches (8.0%) were found infected with both *Blastocystis* spp. and *Cryptosporidium* spp. Regarding the helminth parasite infection in the guts of the cockroaches, only one cockroach (2.0%) was infected with *Enterobius vermicularis* (Table 3).

Table 4. Parasite species isolated from the guts of Iraqi cockroaches and the percentage of infection (n=50).

Parasite species	Number infected	% infection
<i>Blastocystis</i> spp. (mostly vacuolar forms)	12	24
<i>Giardia</i> spp. (cysts)	5	10
<i>Cryptosporidium</i> spp. (oocysts)	4	8
<i>Entamoeba histolytica</i> / <i>E. dispar</i> (cysts)	1	2
<i>Enterobius vermicularis</i> (eggs)	1	2
<i>Blastocystis</i> spp. + <i>Giardia</i> spp.	1	2
<i>Blastocystis</i> spp. + <i>Cryptosporidium</i> spp.	4	8
Total	28	56

## Discussion

In addition of being nuisance pests, the capability of cockroaches as potential mechanical vectors of medically-important human pathogens, including parasites is of great concern to humans and public health. The results of the previous studies conducted in other provinces of Iraq [17-19] and other countries [2, 20, 21] revealed that cockroaches captured from homes, hostels, hospitals, and markets carry a wide-range of medically-important human intestinal parasites.

In the present study, medically-important intestinal parasites have been identified from both the external body surfaces and gut contents of the Iraqi household cockroaches. About 60.0% of the examined cockroaches were found to harbor parasites on their external body surfaces, while 56.0% of these cockroaches were found to harbor parasites in their guts. Al-Mayali and Al-Yaqoobi [17] reported that 83.33% of the cockroaches collected from Al-Diwaniya province, Southern of Iraq were found harbouring at least one parasite on their external surfaces or in their guts and 2.0% harboured *E. vermicularis* ova. Al-bayati et al. [18] reported that 19.4% of the Iraqi cockroaches captured from houses were found harbouring *E. histolytica* cysts on their external surfaces, while 8.3% harboured this parasite in their guts. *Giardia lamblia* cysts were isolated from the external surfaces of 8.3% of these insects but not from their guts, while 19.4% harboured *E. vermicularis* ova on their external surfaces. Al-Aredhi [19] collected 50 adult German cockroaches from different parts of Al-Diwaniya city, Al-Qadisiya Province, Southern of Iraq and evaluated the role of these insects as a carrier of medically important parasites and reported that 78% of these insects were found infected with one or more species of protozoa and/or helminths.

Similarly, high parasite carriage rates have been recorded in studies conducted in other countries. Bala and Sule [22] reported that 77.5% of the Nigerian cockroaches were found carrying parasites on their external body surfaces. Hamu et al. [14] reported that 10.9% of Ethiopian cockroaches were found to harbor parasites on their external body surfaces, while 75.6% of these cockroaches were found to harbor parasites in their guts. Oyeyemi et al. [23] reported that 89.2% of cockroaches collected from dwelling places in Nigeria were found harbouring parasites on their external body surfaces. Haile et al. [6] investigated the role of cockroaches as carriers of intestinal parasites in Wolkite town, Ethiopia and reported that 75.1% specimens were infected with one or more intestinal parasites. Recently, Dokmaikaw and Suntaravitun [8] investigated the prevalence of human pathogenic parasite infestations on the external body surface of Thai cockroaches and reported that the overall prevalence rate of parasitic infestation on the external body surface of cockroaches was 46.4%.

Many factors are behind the observed variation in the parasite carriage rate among different studies such as differences in the hygienic condition of the environments, including human excreta disposal [23, 24].

Based on capture sites, the results of the present study revealed that cockroaches caught from the toilets had more parasites on their external surfaces and in their guts than those caught from kitchens and other sites. This finding matches the results of Al-Mayali and Al-Yaqoobi [17] who reported that the percentage of infestation/infection was higher in the Iraqi cockroaches trapped in the toilets than those trapped in the kitchens. Similarly, Atiokeng-Tatang et al. [25] evaluated the occurrence of medically important parasites carried by the cockroaches in the Melong Subdivision, Littoral Region, Cameroon and reported that cockroaches caught from the toilets had more parasites than those trapped from other sites. These differences could be due to the fact that cockroach in toilets are in direct contact with human faecal materials which are usually the source of parasites and other pathogens [25].

In the present study, 36.0% of Iraqi cockroaches were found to harbor *Blastocystis* spp. on their external body surfaces, while 24.0% of these cockroaches were found to harbor *Blastocystis* spp. in their guts. Suresh et al. [26] reported that 10.0% of Malaysian cockroaches were found infected with *Blastocystis* spp. Chamavit et al. [27] evaluated the role of cockroaches in the transmission of parasitic organisms in the Samutprakarn province, Thailand and reported that 1.2 % of the cockroaches harbored *Blastocystis hominis*. Farah-Haziqah et al. [20] reported that 40.4% of cockroaches living in drainage systems in Malaysia were found infected with *Blastocystis* spp. Oguz et al. [21] evaluated the potential role of cockroaches as carriers of medically-important parasites in Van province, Turkey and reported that 41.0% of these cockroaches infested with *Blastocystis hominis*. Recently, Dokmaikaw and Suntaravitun [8] reported that 6.6% of Thai cockroaches were carrying *Blastocystis hominis* on their external body surface. Moreover, Ma et al. [28] investigated the role of cockroach as a vector of *Blastocystis* spp. and reported that the infection rate was 82.8% in cockroaches collected from Shijiazhuang Zoo, China. The authors concluded that in China, the role of cockroaches in the transmission of parasites that belong to the genus *Blastocystis* cannot be ignored. The differences between the above-mentioned studies may be related to the host animals grown in

different geographical environments. It is of interest to find out that *Blastocystis* spp. is prevalent in Diyala Province as recently Wadi et al. [12] reported that in the irritable bowel syndrome (IBS) patients living in this province, *Blastocystis* spp. was detected in 57.0%, while 12.0% of healthy subjects were found infected with this parasite. More recently, Ismail et al. [13] reported that 60.0% of IBS patients and 22.0% of healthy people who live in Diyala Province were found infected with *Blastocystis* spp.

In the present study, 2.0% of the Iraqi household cockroaches were found infected with *Entamoeba histolytica* / *E. dispar*, 8.0% harboured *Cryptosporidium* spp., and 10.0% harboured *Giardia* spp. in their guts, while 4.0% harbored *Cryptosporidium* spp., and 14.0% harboured *Giardia* spp. on their external surfaces. Chamavit et al. [25] reported that 4.6% of the Thai cockroaches harbored *E. histolytica* / *E. dispar*, and 28.1% harbored *Cryptosporidium* spp. Oguz et al. [21] reported that 16.7% of Turkish cockroaches were found infested with *E. histolytica/dispar*, and 13.6% were found infested with *Giardia* spp. Adenusi et al. [29] investigated the prevalence of human intestinal parasites in cockroaches caught by trapping from households in Somolu, Lagos metropolis, southwest Nigeria and reported that 13.9% harboured *Cryptosporidium* spp., 44.1% harboured *E. histolytica/dispar*, 17.2% harboured *E. vermicularis* and 18.7% harboured *G. lamblia*. The authors concluded that cockroaches carry a wide range of human intestinal parasites and may act as reservoirs and potential mechanical vectors for disease transmission. Recently, Dokmaikaw and Suntaravitun [8] investigated the prevalence of human pathogenic parasite infestations on the external body surface of Thai cockroaches and reported that 15.4% were infested with *Cryptosporidium* spp., and 8.5% were infested with *Entamoeba histolytica / dispar*. More recently, Debash et al. [24] assessed the parasite carriage rate of cockroaches among households in northeast Ethiopia and reported that 36.0% of the cockroaches were found to harbor intestinal parasites such as *E. histolytica/dispar* (14.3%) and *H. nana* (8.6%) being the predominant species.

In the present study, 2.0% of Iraqi cockroaches were found to harbor *Enterobius vermicularis* ova on their external body surfaces and 2.0% were found to harbor *E. vermicularis* ova in their guts. Al-Aredhi [19] reported that 6.0% of Iraqi cockroaches were infected with *E. vermicularis*. Kinfu and Erko [7] investigated the role of cockroaches as potential carriers of human intestinal parasites in Addis Ababa and Ziway, Ethiopia and their results revealed that cockroaches are carriers of *E. vermicularis* ova. Adenusi et al. [29] reported that 17.2% of Nigerian cockroaches harboured *E. vermicularis*.

In order to reduce / control the population of cockroaches and their bad impacts on public health, it has been recently suggested that environmental hygiene is very necessary and should be encouraged in every locality including human dwellings [25].

## Conclusions

The results of the present study revealed that medically-important human intestinal parasites were identified from the body surfaces and gut contents of Iraqi household cockroaches collected from Baquba city, Diyala Province and confirmed the role of these

insects in the transmission of these parasites to the inhabitants. Accordingly, close contact with these insects should be discouraged.

### **Conflicts of interest**

None declared.

### **Ethical approval**

Not required.

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