

MEDICAL IMPORTANCE OF DOMICILIARY COCKROACHES

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Introduction

Cockroaches are a successful primitive form of insect life. They are classified under the order of Dictyoptera with families including Blattellidae, Blattidae, Polyphagidae, Blaberidae and others (Cornwell 1968). More than 4000 species of cockroaches have been described, but only about 50 species of them are considered as pests. Most of them are found inhabiting the ground of rain forests and caves (Cochran 1982).

Three species of domiciliary cockroaches of cosmopolitan importance are the German cockroach (*Blattella germanica*), the American cockroach (*Periplaneta americana*) and the Oriental cockroach (*Blattella orientalis*). Out of these three species, the German cockroach is probably the most important pest cockroach in many parts of the world due to its high reproductive potential (Rehn 1945). In the Southeast Asian countries, the American cockroach is the predominant species in domiciles (Oothuman et al. 1984; Yap et al. 1991; Lee et al. 1993). While the German cockroach are not present in households in this region, they are of great importance to the pest control industries due to their presence in hotels and food handling outlets (Yap et al. 1991; Lee et al. 1993). A questionnaire survey conducted in Penang, Malaysia in 1995 revealed that the householders scored cockroaches as the most important household pest after mosquitoes (III Yap & CY Lee, unpublished data).

Lately, there has been a growing awareness of the health threats posed by cockroaches to humans. Various pathogenic organisms has been associated with cockroaches. In addition, there has also been numerous reports on the allergy and asthma problems caused by cockroaches. This brief review summarizes the human health-related problems caused by cockroaches.

What makes cockroaches an obnoxious insect pest?

Most domiciliary cockroaches have adapted to live in human dwellings. Cockroaches usually are found in the kitchen areas where food and water are readily available, together with the presence of a warm and moist environment. Their habit of foraging from one place to another and regurgitating some of their partially digested food and defaecating while feeding makes them an ubiquitous mechanical vector of human diseases. Their food preference is very diverse, ranging from human sputum and phlegm to the delicious



cake which is about to be served.

Association of cockroaches with human pathogens

Various pathogenic organisms have been associated with cockroaches. These include poliomyelitis viruses, bacteria, fungi, protozoa and helminths. These organisms have often been isolated from field-collected cockroaches. Roth & Willis (1957, 1960) published two annotated lists of the biotic association of cockroaches with microorganisms in monograph form.

The poliomyelitis virus has been isolated from field-collected German and American cockroaches (Dow 1955; Syverton et al. 1952). A study conducted by Tarshis (1962) provided a more concrete evidence of cockroaches being a mechanical vector of human disease. In that study, which was done in 582 houses in Los Angeles, California (of which 95% were badly infested with cockroaches), the author demonstrated a positive correlation between infectious hepatitis cases and cockroach population over a period of time.

Many isolations of bacteria have been done on cockroaches. To date, 36 species from 16 bacteria genera have been isolated from field collected cockroaches (Table 1). Many of these cockroaches were trapped in public places such as hospitals, food manufacturing plants, schools, restaurants, etc. Cornwell & Mendes (1981) reported a shocking finding in the oriental cockroach (*B. orientalis*) where they isolated 18 species of bacteria (eg. *Pseudomonas aeruginosa*, *Clostridium perfringens*, *Staphylococcus albus*, *Klebsiella aerogenes*, etc.) in field-collected cockroaches from 40 premises in UK. On the other hand, Rueger & Olson (1969) isolated *Salmonella anatum*, *S. oranienburg* and *Staphylococcus aureus* from more than 6000 specimens trapped from 19 cities through the USA.

In Malaysia, Rampal et al. (1983) isolated 14 species of bacterial pathogens from the intestinal tracts of various species of cockroaches trapped from kitchens of living premises and wards, kitchens and stores in a hospital. In a companion study, 22 species of bacteria, including pathogenic and potentially pathogenic species such as *Shigella boydii*, *S. dysenteriae*, *Salmonella typhimurium*, *Klebsiella oxytoca*, *K. ozonae* and *Serratia marcescens* were isolated from cockroaches trapped from four paediatric wards (Oothuman et al. 1989). Gazivoda & Fish (1985) published many interesting

electron micrographs showing the adhesion of pathogenic bacteria on the legs of cockroaches.

On cockroach association with fungi, Fuch (1976) found 27 species of fungi on the exocuticle and 13 species in the gut of 180 German cockroaches, collected from 8 kitchens in Koblenz, Germany. These fungi included dermatophytic and toxin-producing species such as *Aspergillus*, *Trichoderma*, *Cladosporium*, *Fusarium*, *Penicillium* and *Alternaria*. About 15 species of fungi have been isolated from cockroaches (Table 2).

Many non-pathogenic protozoans have also been isolated from cockroaches. However, only four of them are pathogenic to vertebrates, i.e., *Entamoeba histolytica*, *Giardia intestinalis*, *Toxoplasma gondii* (through experimental evidence) and *Trichomonas hominis* (Roth & Willis 1957; Wallace 1972). (*Editor's note: Blastocystis species very similar in morphology to B. hominis was isolated in 8 of 10 cockroaches, suggesting that cockroaches may be a vector in the transmission of this protozoan parasite (Zaman et al. 1993).*)

The helminths constitute the second largest group of pathogenic organisms which are mechanically transmitted by cockroaches (Roth & Willis 1957; 1960). Eggs of seven helminth species have been found naturally in cockroaches, whereas eggs of another five species passed through the guts of cockroaches unharmed and appeared in the cockroach faeces. A list on some helminths which have been isolated naturally from cockroaches is shown in Table 3.

A study conducted in Penang, Malaysia on the nematode abundance in the American cockroach (*Periplaneta americana*) demonstrated that 98% of the field-collected cockroaches (n = 150) were infected. Of these, 65.8%, 28.4% and 57.4% were infected with *Hammerschmidtella diesingi*, *Leidynema appendiculata* and *Thelastoma malaysiense*, respectively (Anuar 1987). Two other studies showed that *Moniliformis moniliformis*, an acanthocephalan, is a common parasite in the American cockroach (Anuar & Paran 1976; Oothuman et al. 1985). A female *P. americana* can harbour more than 300 cystacanths (Oothuman et al. 1985).

Association of cockroaches with allergies and asthma

Inhalants and allergens produced by cockroaches have received much attention recently with the increase in household allergy and asthma problems (Brenner et al. 1991). Allergy is an abnormal response of the immune system to antigens which results in the release of tissue damaging substances, such as histamines. In cockroach associated allergy, the problem occurs when the immunological system becomes sensitized to cockroach allergens. When subjected to subsequent exposures, the immune system will over-react and cause damage to host tissues and organs in the process of neutralizing the proteins (Brenner 1995).

Here is a short summary on how a man develops allergy to cockroaches. When cockroach proteins (cockroach allergens) enter the circulatory system through inhalation, dermal abrasion or ingestion, immunoglobulin E (IgE) will be produced and will be attached to the epitopes of the proteins. As hypersensitivity occurs, cells in the immunological system will mass-produce IgEs. These antibodies will circulate in the blood-stream. Due to their large

numbers, most of them will bind to mast cells commonly found in the mucosal linings of lungs and sinuses, skin and intestines. When two or more IgEs bind to the same cell, the mast cell will degranulate, releasing histamines and other substances that will cause vascular permeability, vasodilation, bronchoconstriction, and disrupt the cardiac electrical pathway. Extreme cases can result in anaphylaxis and death (Brenner 1995)

An estimated 10–15 million people in the USA are allergic to cockroaches, according to the National Institute of Health (NIH), USA. Reactions usually ranged from a running nose and skin irritation to difficulty in breathing. In addition, about 50–60% of asthmatic and atopic populations demonstrated intense reaction to cockroach extracts, as compared with only about 20% of those who are in the non-atopic group (Kang & Chang 1985). A further study on bronchial asthmatic patients showed that 76% of them lived in crowded homes which were badly infested with German cockroaches (Kang et al. 1987). Schulaner (1970) reported that in dwellings where German cockroach infestations are visible, sensitivity among asthmatic children can reach as high as 80%.

Association of cockroaches with entomophobia and other implications on human behaviour

Entomophobia or fear of insects is common, especially among women. Many people find cockroaches disgusting. There is an association in the mind of many people between the presence of cockroaches and a dirty environment. As a result, cockroach infestations in households can serve as psychological stressors to the residents. To these people, the mere presence of cockroaches will bring on modified behavioural responses. For example, they will avoid going to the kitchen at night or avoid going into the store-room, fearing that they will encounter a foraging cockroach in such places.

In some cases, the presence of cockroaches caused irrational behaviour in the people exposed. Schrut & Waldron (1963) reported that a family was so distressed by 'bad' infestation of cockroaches in their home, that as a result, they moved to another house. In reality, there was only a low infestation of American cockroaches. This behaviour is known as delusory parasitosis. In this respect, cockroaches are the victims of their reputation!

Other importance of cockroaches

Roth & Willis (1957) reported about 20 cases of cockroaches biting humans while the latter were sleeping. Heiser (1936) reported that cockroaches on ships gnawed on the calluses, fingernails and eyebrows of sleeping sailors. *In fact, as a child, the author himself had experienced being bitten by cockroaches on the fingers while sleeping after going to bed without washing his hands (he had dried squids for supper !)*

Cockroaches (*P. americana* and *Leucophaea maderae*) have also been shown to excrete compounds which are either mutagenic or carcinogenic. The compounds excreted, i.e., xanthurenic, kynurenic and 8-hydroxyquinaldic acids, are tryptophan derivatives. They are present in small, but consistent quantities in faeces (Mullins & Cochran 1973).

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Table 1: List of pathogenic bacteria species associated with cockroaches (compiled from Roth & Willis 1957; Cornwell & Mendes 1981; Oothuman et al. 1989; Brenner 1995).

Pathogen	Associated diseases	Cockroach species
<i>Alcaligenes faecalis</i>	Gastroenteritis	<i>Periplaneta americana</i> , <i>Blatta orientalis</i>
<i>Bacillus subtilis</i>	Conjunctivitis	<i>Blaberus craniifer</i> , <i>B. orientalis</i> , <i>P. americana</i>
<i>Bacillus cereus</i>	Food-poisoning	<i>Blaberus craniifer</i>
<i>Clostridium novii</i>	Gas gangrene	<i>B. orientalis</i>
<i>Clostridium perfringens</i>	Food-poisoning	<i>B. orientalis</i>
<i>Enterobacter aerogenes</i>	Bacteremia	<i>Blattella germanica</i> , <i>P. americana</i>
<i>Escherichia coli</i>	Diarrhoea, wound infection	<i>B. orientalis</i> , <i>B. germanica</i> , <i>P. americana</i>
<i>Klebsiella aerogenes</i>	-	<i>B. orientalis</i>
<i>Klebsiella oxytoca</i>	-	<i>P. americana</i>
<i>Klebsiella ozaenae</i>	-	<i>P. americana</i>
<i>Klebsiella pneumoniae</i>	Pneumonia	Not known
<i>Mycobacterium leprae</i>	Leprosy	<i>B. germanica</i> , <i>P. americana</i> , <i>P. australasiae</i>
<i>Nocardia sp.</i>	Actinomycetoma	<i>P. americana</i>
<i>Proteus morgani</i>	Wound infection	<i>P. americana</i>
<i>Proteus rettgeri</i>	Wound infection	<i>P. americana</i>
<i>Proteus vulgaris</i>	Wound infection	<i>B. craniifer</i> , <i>B. orientalis</i> , <i>P. americana</i>
<i>Proteus mirabilis</i>	Gastroenteritis	<i>P. americana</i>
<i>Pseudomonas aeruginosa</i>	Respiratory infections	<i>B. craniifer</i> , <i>B. orientalis</i> , <i>B. germanica</i> , <i>P. americana</i>
<i>Salmonella bredeny</i>	Food poisoning	<i>P. americana</i>
<i>Salmonella boydii</i>	-	<i>P. americana</i>
<i>Salmonella newport</i>	Food poisoning	<i>P. americana</i>
<i>Salmonella oranienburg</i>	Food poisoning	<i>P. americana</i>
<i>Salmonella panama</i>	Food poisoning	<i>P. americana</i>
<i>Salmonella paratyphi-B</i>	Food poisoning	<i>P. americana</i>
<i>Salmonella typhi</i>	Typhoid	<i>B. orientalis</i>
<i>Salmonella typhimurium</i>	Food poisoning	<i>B. germanica</i>
<i>Salmonella bovis-morbificans</i>	Food poisoning	<i>P. americana</i>
<i>Salmonella bareilly</i>	Food poisoning	<i>P. americana</i>
<i>Serratia marcescens</i>	Food poisoning	<i>P. americana</i> , <i>B. orientalis</i> , <i>B. germanica</i>
<i>Shigella dysenteriae</i>	Dysentery	<i>B. germanica</i>
<i>Staphylococcus albus</i>	-	<i>B. orientalis</i>
<i>Staphylococcus aureus</i>	Skin infection, infection of internal organs	<i>B. craniifer</i> , <i>B. orientalis</i>
		<i>B. germanica</i>
<i>Streptococcus faecalis</i>	Pneumonia	<i>B. orientalis</i> , <i>B. germanica</i> , <i>P. americana</i>
<i>Streptococcus pyogenes</i>	Pneumonia	<i>B. orientalis</i>
<i>Vibrio spp.</i>	-	<i>B. orientalis</i>
<i>Yersinia pestis</i>	Plague	<i>B. orientalis</i>

Table 2: List of pathogenic fungi species associated with cockroaches (compiled from Roth & Willis 1957; Brenner 1995)

Pathogen	Associated diseases	Cockroach species
<i>Alternaria sp.</i>	Skin & lung infection	<i>Blattella germanica</i>
<i>Aspergillus niger</i>	Pneumomycosis	<i>Periplaneta americana</i> , <i>Blatta orientalis</i>
<i>Aspergillus flavus</i>	Mycotic granuloma	<i>B. germanica</i>
<i>Aspergillus fumigatis</i>	Pneumomycosis, bronchomycosis	<i>B. orientalis</i>
<i>Candida krusei</i>	Candidiasis of mucosal membranes in infants,	<i>B. germanica</i>
<i>Candida parapsilosis</i>	skin, respiratory passages,	
<i>Candida tropicalis</i>	gastrointestinal tract; endocarditis.	
<i>Cephalosporium</i>	Facultatively pathogenic, mycetoma	<i>B. germanica acremonium</i>
<i>Cladosporium sp.</i>	Dermatomycosis	<i>B. germanica</i>
<i>Fusarium sp.</i>	Otomycosis	<i>B. germanica</i>
<i>Geotrichum candidum</i>	Chronic bronchitis,	<i>B. germanica</i>
	skin & gastrointestinal tract infections	
<i>Mucor sp.</i>	Occasional infection of lung and otomycosis.	<i>B. germanica</i>
<i>Penicillium</i>	Not available	<i>B. orientalis</i>
<i>Rhizopus sp.</i>	Occasional infection of lung, otomycosis	<i>B. germanica</i>
<i>Rhodotorula rubra</i>	Rare opportunistic infections	<i>B. germanica</i>
<i>Trichoderma viride</i>	Rare alimentary toxic aleukia	<i>B. germanica</i>
<i>Trichosporon cutaneum</i>	White hair-nodule disease	<i>B. germanica</i>

Table 3: List of pathogenic helminth species associated with human diseases (compiled from Roth & Willis 1957; Brenner 1995).

Pathogen	Associated diseases	Cockroach species
<i>Ancylostoma duodenale</i>	Hookworm	<i>Periplaneta americana</i>
<i>Ascaris lumbricoides</i>	Giant human roundworm	<i>Periplaneta americana</i>
<i>Ascaris sp.</i>	Roundworm	<i>Blatta orientalis</i>
<i>Enterobius vermicularis</i>	Pinworm	<i>B. orientalis</i> , <i>Blattella germanica</i>
<i>Hymenolopsis sp.</i>	Tapeworm	<i>P. americana</i>
<i>Necator americanus</i>	Hookworm	<i>P. americana</i>
<i>Trichuris trichuria</i>	Trichuriasis	<i>B. orientalis</i> , <i>B. germanica</i> , <i>P. americana</i>