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Review

## The medical importance of cockroaches

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Cockroaches have great significance for the dermatologic community, if only because of the many reports and claims implicating the cockroach as a vector for human disease. This review discusses aspects fundamental to cockroach biology and summarizes some of the basic and clinical scientific works which contribute to the claims about roaches.

### History and background

According to a World Health Organization report, cockroaches have been in existence for about 360 million years (Upper Carboniferous).<sup>1</sup> During the intervening time, the roach has undergone very little structural change; nevertheless, there is a growing population of at least 3500 named species, which range in length from 5 mm to 90 mm.<sup>1</sup> Although one is apt to think of roaches primarily as pests, far less than 1% of roach species actually cause concern for humans;<sup>1</sup> however, some of the early records of human interaction with cockroaches might lead one to think otherwise. Consider these letters to *Nature* in 1870, "A [sailor] was marked for life by [roaches] on board a ship coming home from Jamaica."<sup>2</sup> The writer goes on to say, "I have known bread, &c., in the West Indies uneatable from being run over by the small dark Cockroach...while the great pale species...is utterly unbearable."<sup>2</sup> One might think these were great beasts with which to contend, given the following account, "In some ships infested with these insects, sailors frequently complain of having their toe and

finger nails, and other hard parts of the soles of the feet and palms of the hands, nibbled by [the roaches]."<sup>3</sup> Other reports, dating back to the early 1700s and continuing through the 1900s, confirm that roaches will bite humans,<sup>4</sup> although there do not appear to be any reports of someone actually dying from these attacks. One writer described the roach as "a destructive insect to clothes, books, &c...it avoided the light, and was fond of warm places...it frequented mills and exuded a greasy substance from its head...it was a disgusting creature."<sup>5</sup> The roach is not going to make a good travel companion, but the question remains whether the roach can act as a vector for human disease.

### Roach oddities

The current view of the roach appears to have come full circle from being an object of man's longing to an object of most people's loathing. Roaches have been used in one manner or another to treat about 30 medical conditions of humans, ranging from boils and indigestion to warts and heart disease.<sup>4</sup> Specifically, in the mid-1800s, a powder made from dried cockroaches was recommended as a diuretic;<sup>6</sup> however, the efficacy of these concoctions has never been substantiated.

While roaches are known to be found in kitchens, in cabinets, or on counters, even in the most clean homes, they have also been found in other places. Specifically, roaches have been reported to crawl into the most incon-

venient spaces, thereby requiring people to seek help in extracting the insect from nasal passages, auditory canals, and other orifices.<sup>4</sup> A distinctly Hollywood roach oddity is the contemporary movie “Joe’s Apartment.” In this movie, cockroaches can talk, sing, and even dance. But perhaps the most disturbing roach oddity is its recorded use as a food delicacy. Consider the following recipe: “a succulent dish is made from cockroaches simmered in vinegar all morning and then dried in the sun. The insects, freed of heads and intestines, are then boiled together with butter, farina, pepper, and salt to make a paste which is spread on buttered bread.”<sup>4</sup>

### Biology, life-cycle, distribution, ecology

Cockroaches are cold-blooded insects with three stages of development: egg, nymph, and adult. Once mature, and about a week after mating, the female cockroach produces eggs, which she deposits into a protective covering, referred to as the ootheca or egg case.<sup>1</sup> At the peak of her reproductive capacity, the female cockroach may produce up to two egg cases per week and a total of 10–84 egg cases in her life-time.<sup>7</sup> The ootheca’s primary function is to protect the eggs from drying out.<sup>7</sup> The egg case may be carried by the female internally or externally, depending on the species.<sup>1</sup> In most cases, the female cockroach tries to hide or bury her ootheca, but will attach it to most anything if a hiding place can not be found.<sup>7</sup> After the ootheca is deposited, the female is believed to leave it alone. At the point at which they hatch from out of the eggs, the nymphs resemble the adults, although they are smaller and have undeveloped wings and genitalia.<sup>1</sup> After hatching, the nymph’s transition to adults progresses through a series of 6–16 molts.<sup>1,7</sup> The most obvious marker of maturity which occurs during these molts is the appearance of wings. However, in some species of cockroaches these wings are either reduced in size or are completely absent.<sup>1</sup> Once fully matured, the adult roach may live from days to years, depending upon the environmental conditions and especially the availability of water.

Mature cockroaches will breed all year long if the conditions are favorable. Consequently, the roach poses a more formidable threat to humans as a potential vector when compared with other vectors such as flies which are dormant in the winter.<sup>4</sup>

Moisture is essential to the roach’s well-being. If adult roaches are placed in a dry atmosphere, they will die within 2–4 weeks, while nymphs or eggs would deteriorate even more rapidly.<sup>8</sup> Other environmental considerations include lighting; cockroaches love the dark.<sup>8</sup> Consequently, their nocturnal activity often goes unnoticed and unrecorded. Adjunct to the roach’s need for moisture is its need for food. Experiments with *Blattella germanica* and *Periplaneta*

*americana* have shown that adult roaches can survive for 3–6 weeks without food, while newly hatched roaches will usually die within 8–9 days.<sup>8</sup> There appear to be no dietary restrictions for the cockroach, as they will eat just about anything, including biologic wastes such as garbage and sewage.<sup>1</sup> It is, in part, due to this indiscrimination of food requirements that the cockroach is able to thrive in so many dark, wet places such as sewers and trash bins.

Currently, approximately 16 species of cockroaches represent a potential threat to human health and well-being.<sup>1</sup> *Blattella germanica*, *P. americana*, and *Blatta orientalis* are three of the most important cockroach species with regard to their impact on man, because they are so common as pests.<sup>1</sup> They are described below and a summary of pertinent information for the other cockroaches of human concern is given in Table 1.

Because of its distribution, *B. germanica* (the German cockroach) (Fig. 1) is probably the most important cockroach pest on a world-wide basis.<sup>1</sup> Although this roach is found in virtually all parts of the world,<sup>1</sup> some evidence suggests that this species originated in Northeast Africa.<sup>9</sup> Adult *B. germanica* generally measure 10–15 mm in length with a light yellowish-brown color in males and a slightly darker color in females. Both nymphs and adults have two longitudinal, black, parallel bands separated by a lighter stripe on the pronotum. Males and females mature at the same time and mate within the first 7–10 days of adult life. Males will mate repeatedly while females usually mate only once. After mating, the incubation period of the ootheca is 2–4 weeks with 37–44 eggs per ootheca and a 90% hatch rate. Generally, females will produce 4–8 egg cases per life-span, which usually lasts about 100 days. Although seemingly adaptive to most conditions, this species prefers places with easy access to warmth, moisture, and food.

*Periplaneta americana* (the American cockroach) (Fig. 2) is distributed throughout the temperate, tropical, and subtropical regions of the world. This roach is much larger than *B. germanica*, averaging 35–40 mm in length. Its coloring is also distinct in that all stages are a shining red to chocolate brown color. Males and females are about the same size and adults live a year or longer.<sup>1</sup> After mating an ootheca is produced every 4–10 days and one feeding may suffice for several oothecae.<sup>1</sup> The average number of egg cases deposited in a female’s life-span is 21–59, with an average of 16 eggs per case. That means that the average female cockroach generates almost 650 (40 × 16) offspring! It is not hard to see how their numbers can increase dramatically in a short period of time. Like *B. germanica*, this species is very adaptive but its preferred temperature is 28 °C, although it is still active from 21–33 °C.

*Blatta orientalis* (the oriental cockroach) (Fig. 3) is distributed in the temperate zones of the world. The roach is

Table 1 Cockroaches of human concern

Scientific name	Common name	Distribution	Size (mm)	Description/ distinguishing marks	Life span	Reproductive capacity			Ecology
						Egg cases	Interval between egg cases	Eggs per case	
<i>Blaberus atropos</i> (Stoll)		American tropics							
<i>Blaberus craniifer</i> Burmesiter		American tropics	50–60	Yellowish-orange markings	425–475 days			34	
<i>Blaberus discoidalis</i> Serville		American tropics							
<i>Blattella orientalis</i> Linnaeus	Oriental cockroach	Temperate zones	20–27	Reddish brown to black	35–180 days	8		16	Cooler temperate environments
<i>Blattella germanica</i> (Linnaeus)	German cockroach	Universal	10–15	Light yellowish-brown (males), slightly darker (females)	100+ days	4–8		37–44	Warm and humid environments
<i>Eurycotis floridana</i> (Walker)	Florida cockroach	Southern USA	30–40	Dark brown to black			8 days	21–23	
<i>Leucophaea maderae</i> (Fabricius)	Madeira roach	Circumtropical	40–50	Forewings are speckled, tawny-olive color				34–36	Outdoors
<i>Nauphoeta cinerea</i> (Olivier)	Cinereous or Lobster cockroach	Tropical and subtropical	25–29	Ashy color	1 year	20	40–45 days	26–40	Outdoors
<i>Neostylopyga rhombifolia</i> (Stoll)	Harlequin cockroach	Circumtropical	20–25	Shining blackish brown with patches of yellow	156 days			22	Outdoors
<i>Periplaneta americana</i> (Linnaeus)	American cockroach	Universal	35–40	Shining red to chocolate brown color	1 year	10–90	4–10 days	16	Warm and humid environments
<i>Periplaneta australasiae</i> (Fabricius)	Australian cockroach	Tropical and subtropical	27–33	Lateral pale yellow stripe on each forewing	4–6 months	20–30	10 days	22–24	Warm and humid environments
<i>Periplaneta brunnea</i> Burmesiter	Large brown cockroach	Tropical and subtropical	31–37	Pronotum markings, 7–8 months pale but indistinct, similar to <i>P. americana</i>		30	6 days	24	Warm and humid environments
<i>Periplaneta fuliginosa</i> (Serville)	Smoky brown cockroach	Subtropical	31–35	Uniformly dark brown	215 days	19	6 days	24	Outdoors
<i>Polyphaga saussurei</i> (Dohm)	No common name	Southern part of Soviet Republic and Asian countries	32–44	Uniformly dark with lighter forewings (females are wingless)	3.5–4 years				Adapted to life in loamy or clay soils
<i>Pycnoscelus surinamensis</i> (Linnaeus)	Surinam roach	Universal	18–24	Dark brown to black	307 days	3	65 days	26	Outdoors
<i>Supella longipalpa</i> (Fabricius)	Brown-banded roach	Tropical and subtropical	10–14	Similar to <i>B. germanica</i> without stripes on pronotum	90 days	10–20	7–10 days	16	Warm and humid environments

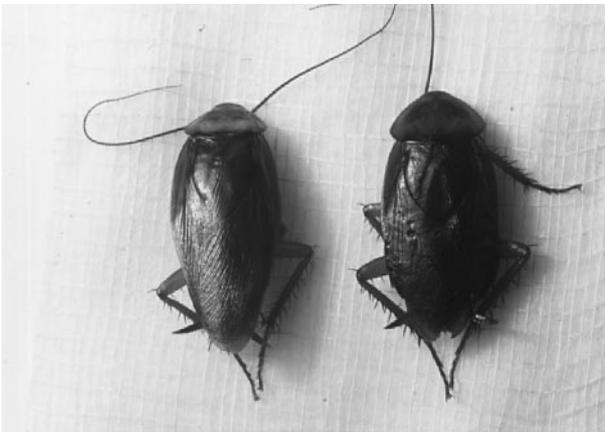
of intermediate size, measuring 20–27 mm in length,<sup>1</sup> and reddish brown to black in color. In urban areas *B. orientalis* is often mistakenly called a water bug. The sexes are easily distinguished because females have greatly reduced wings, while the wings on males cover two-thirds or more of the abdomen. Adults live for 35–180 days. After mating an

ootheca is produced in 8–10 days. Females produce an average of eight ootheca, which usually contain 16 eggs each. This species prefers a cool environment, usually living in basements, and often gains access to upper levels of dwellings by crawling through sewage pipes.

Cockroaches secrete materials which give off a persistent



**Figure 1** *Blattella germanica*: male (L), female (R)



**Figure 2** *Periplaneta americana*: male (L), female (R)



**Figure 3** *Blatta orientalis*: male (L), female (R)

and characteristic odor.<sup>1</sup> Because of this smell, a great deal of food which comes into contact with cockroaches must be destroyed as it is no longer fit for human consumption.

Some authors suggest that it would be impossible to calculate the loss to commerce caused by roaches through contamination of food materials.<sup>7,10</sup> In terms of affecting humans in other ways, one of the most threatening behaviors of the roach is its indiscriminate nature of regurgitating food and defecating in the same place it is eating.<sup>1</sup> The danger posed by this situation is the basis for much of the research into roaches as mechanical vectors of disease.

### Diseases and roaches

There are two main areas of concern with regard to cockroaches and their potential for causing disease in humans: the allergic reactions, including lung and skin reactions, and the vector potential of cockroaches for a variety of organisms. In short, it has been shown that the cockroach can provoke clinical reactions as a contactant, injectant, ingestant, and inhalant.<sup>11</sup>

### Allergy and roaches

Roaches have been proven to contribute to and actually cause asthmatic reactions in humans. In one study, homogenised *B. germanica* were administered via a nebulizer to test for bronchial irritation. All subjects with a positive skin test to the roach extract had bronchial irritation, but subjects with a negative skin test had no bronchial reaction.<sup>11</sup> It appears as though extract sensitivity is associated with the degree of exposure (and history of exposure).<sup>12</sup> Although others have been identified, there are three main cockroach extract allergens: Cr-I, Cr-II, and Cr-III.<sup>12</sup>

Many experts have disagreed in the past about whether cockroaches actually bite humans. If cockroaches are well controlled in a given area and their population is small, biting is a rare phenomenon. But in primitive areas, especially tropical regions, where there are not adequate means of insect control, such as insecticides and high standards of sanitation, cockroach bites have been well documented.<sup>4</sup> One research group experimentally induced *B. orientalis* to bite human skin. Although the bite itself only resulted in slight pain and itching, within 24 h the bitten areas were reportedly covered with crusts; the skin was damaged almost to the dermis and the damage to the epidermis was due to the mechanical action of the bite.<sup>4</sup>

Previous studies have shown that some species of cockroaches produce and store secretions which can produce an irritation reaction in humans.<sup>4</sup> In addition, there are many clinical reports to the ill-effects resulting from patients who come into contact with cockroaches;<sup>1, 13</sup> specifically, edema of the eyelids and dermatitis have been attributed to the cockroach,<sup>1</sup> although it has been suggested that this

dermatitis should be classified as protein contact dermatitis or contact urticaria.<sup>6</sup>

### Cockroaches as a potential vector of disease

Aside from the reports on allergies, there is also strong evidence that cockroaches are also involved in spreading infectious diseases. Most of the literature on this topic reports on one of two models of study: either (i) roaches were collected from a specific location and compared with control roaches from another area, or (ii) roaches were inoculated or fed with pathogenic organisms. In both models, the results were determined by testing for the external and/or internal presence of the pathogenic organism in the following general manner.<sup>14-17</sup> After capture, the outside of the roaches was washed with a sterile solution to test for any external pathogenic material. After the washings, the gut of the roach was usually removed to test for any internal pathogenic material; alternatively, the presence of internal pathogenic material was tested by collecting the roach fecal material. From these studies, authors often made the connection between the positive recovery of a pathogenic organism and the roach's potential to act as a vector for human disease (Table 2).

The literature includes both clinical and basic science research, although no study has conclusively demonstrated disease transfer from one organism to a human with the cockroach as the vector. Most major categories of pathogenic organisms have been discovered or introduced into cockroaches. Many authors go to great lengths to indicate which diseases are associated with the pathogenic material found in and on roaches, implying that the mere presence of a pathogenic agent is a strong connection to the disease process. This could present a misleading picture since the presence of a microbial, even if it is multiplying in a tissue, does not necessarily mean that disease will follow.<sup>18</sup>

### Categories of pathogens detected in roaches

#### Bacteria

As with the other disease categories, that cockroaches can acquire and excrete bacteria is undisputed. In one study, 221 cockroaches were collected in the southwest region of India, and of these 4.1% harbored *Salmonella* species. The authors concluded that the presence of the microbial suggests the roach as a possible vector.<sup>19</sup> In a second study, the incidence of *Klebsiella* species in patients was compared with its incidence in cockroaches. Out of the 159 test and 120 control roaches, 67 carried *Klebsiella* spp. (45 test, 22 control). Wound swabbings from 96 patients tested positive for *Klebsiella* spp. in 27. Drug-resistant *Klebsiella* spp.

**Table 2** Roach contaminants: bacteria

Naturally occurring	Experimentally induced
<i>Clostridium perfringens</i>	anthrax
<i>Escherichia coli</i>	Asiatic cholera
<i>Mycobacterium leprae</i>	black leg
<i>Pasteurella pestis</i>	cerebrospinal fever
<i>Pseudomonas aeruginosa</i>	chicken cholera
<i>Salmonella bredeney</i>	diphtheria
<i>Salmonella oranienburg</i>	glanders
<i>Salmonella schottmuelleri</i>	pneumonia
<i>Salmonella typhosa</i>	rat leprosy
<i>Shigella alkalescens</i>	tetanus
<i>Shigella paradysenteriae</i>	tuberculosis
<i>Staphylococcus aureus</i>	undulant fever
<i>Staphylococcus</i> spp.	

from the hospital patients and the roaches appeared in roughly equal percentages (85.9% and 96.3% respectively). The authors contended that because cockroaches could be acting as vectors for the drug-resistant *Klebsiellas* spp., effective measures should be taken to curb their infestation in clinical areas.<sup>14</sup> In a third study, roaches were fed *Pseudomonas aeruginosa* in incremental doses of 10<sup>2</sup>, 10<sup>5</sup>, or 10<sup>7</sup> bacteria. In the roaches fed the 10<sup>5</sup> and 10<sup>7</sup> doses, the *Pseudomonas* multiplied in the gut of the roach and there were detectable traces in the feces for up to 114 days. Because there is the possibility of the organism multiplying in the gut, the authors contended that the roach could play a significant role in the epidemiology of *P. aeruginosa* infections.<sup>16</sup>

About 40 species of bacteria which are pathogenic to humans have been found in cockroaches;<sup>4</sup> another 45 species of bacteria which are not pathogenic to humans have also been found.<sup>4</sup> Experimentally, 20 other species of bacteria have been introduced into cockroaches in the hopes of finding a connection between roaches and human disease.<sup>4</sup>

The diseases caused by the pathogenic bacteria which have been found occurring naturally in or on cockroaches include both general and specific infections such as bubonic plague (*Pasteurella pestis*), dysentery (*Shigella alkalescens*), diarrhea (*Shigella paradysenteriae*), urinary tract infection (*P. aeruginosa*), abscesses (*Staphylococcus aureus*), food poisonings (*Clostridium perfringens*, *Escherichia coli*, *Streptococcus faecalis*, *P. aeruginosa*), gastroenteritis (*Salmonella schottmuelleri*, *S. bredeney*, *S. oranienburg*), typhoid fever (*Salmonella typhosa*), leprosy (*Mycobacterium leprae*), and nocardiosis (*Actinomyces* spp.).<sup>1-4</sup>

The diseases caused by the pathogenic bacteria experimentally introduced either into or onto cockroaches include Asiatic cholera, pneumonia, diphtheria (*Corynebacterium diphtheriae*), glanders (*Pseudomonas mallei*), anthrax

(*Bacillus anthracis*), black leg (*Clostridium chauvoei*), tetanus (*Clostridium tetani*), and tuberculosis (*Mycobacterium* spp.).<sup>1,4</sup>

The evidence for cockroaches acting as vectors for bacterial disease transmission remains circumstantial.<sup>4</sup>

#### Viruses

In the laboratory, cockroaches have been proven capable of acquiring, maintaining, and excreting a number of viruses such as poliomyelitis viruses (Coxsackie A-12, Type 4, Type B5, etc.) and Hepatitis B virus.<sup>1,4,7</sup> In these experiments, the roaches were artificially inoculated with the viral material. To date, natural transmission of viral disease by roaches is unproven.<sup>1,4</sup>

#### Fungi

There are at least two fungi, namely *Aspergillus fumigatus* and *Aspergillus niger*,<sup>4,7</sup> which occur naturally in cockroaches and which are pathogenic to humans, although there is indication that there are many more.

#### Protozoa

Four protozoa have been either found or inoculated into cockroaches,<sup>4</sup> although it appears there have been other attempts to introduce or demonstrate the presence of many more protozoan species.<sup>7</sup>

#### Helminths

Cockroaches have been shown to harbor a large number of helminths.<sup>4</sup> At least 12 species have been demonstrated as naturally occurring helminths and 11 others have been experimentally introduced into the roach.<sup>4</sup>

#### Diseases incorrectly associated with roaches

There are at least seven diseases which have been falsely attributed to roaches; these include beriberi, cancer, malaria, and scurvy.<sup>4</sup>

#### Prevention and control

Cockroaches are everywhere, including in houses, grocery stores, and hospitals. Once roaches infiltrate a building, it is unlikely that anything will totally eradicate them. For example, cleanliness is a good step towards controlling cockroaches, but roaches can still exist and thrive even when facilities are immaculate; however, their numbers can be reduced and what population remains can be controlled and confined to certain areas. We suggest the following modalities: (i) a clean and well kept facility, be it a house or hospital, will reduce the number of places roaches can hide and breed; and (ii) if necessary, chemical insecticides should be used. Insecticides are poisons which either kill or deter the roaches from nesting, and they are sold in a

variety of preparations including powder, spray, and pellet form. The insecticides dioxacarb and chlorpyrifos are reported to be effective, but their mechanisms of action is not discussed.<sup>10</sup> A problem with insecticides is the emerging resistance cockroaches are developing to some chemicals. The first reported case of resistance came in 1951–52 and was limited to *B. germanica*.<sup>1</sup> Since then, resistance has been noted in other species of roaches.<sup>1</sup> To overcome this developing resistance, scientists have attempted to design poisons from other chemicals to which the roach would be sensitive. Other methods of overcoming this resistance involve applying poisons in higher concentrations and using more than one formulation of poison to control a given roach population.

Finally, one of the most important steps in controlling roaches is preventing their entry into a given facility. The Trojan horse movements of roaches into buildings is responsible for their presence in many situations. For example, roaches can be carried into the home in grocery bags, in cardboard boxes, and even in food containers. Roaches can be delivered to the home or office in the boxes and envelopes of any courier or delivery service. Once in the home or workplace, it is important to reduce the likelihood of the roaches staying. Food should be kept in sealed containers. Any unused boxes should be discarded. Recyclables such as brown paper bags and other materials should be kept outside if possible or in a closed container away from other food. Be aware that roaches will seek out places such as damp warm basements and crawl into small spaces. Loose food and debris in kitchens are a powerful incentive for these insects to remain and multiply.

#### Conclusions

Roaches pose a danger to people for a variety of reasons, including contamination of food, dermatological reactions, and asthmatic reactions. Although there is a great deal of material demonstrating the roaches' ability to pick up and later excrete pathogens, there is not yet proof that the roach is a vector for human disease. In 1952, it was felt that there was enough evidence to put the roach under suspicion as a possible vector of human disease.<sup>1</sup> Almost 45 years later, we are still searching for a conclusion. Without question, it is important to continue to understand the roach's possible role as a vector and, concomitantly, to learn more effective ways to control or exterminate the roach, especially in places such as hospitals and food service areas.

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