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Explores of the Cockroaches (Dictyoptera: Blattidae) Roles as Carriers of Medically Important Parasites and Microorganisms

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Abstract

Cockroaches (Insecta: Blattaria) are distributed worldwide and mainly found in human dwellings. Cockroaches are scavengers and while walking on spoiled food in garbage containers, they pick up various pathogenic organisms on their legs that can later deposit on uncovered food. In this way, they play an important role in transmitting of diseases either mechanically or occasionally biologically. Numerous bacteria and parasites of medical importance have been isolated from cockroaches; therefore this article has been designed to pinpoint microorganisms of health importance from external surfaces and gastrointestinal tract of cockroaches. The Blattodea order includes many species of cockroaches associated with humans, and these feed on man and pet food and can leave an offensive odour. They can passively transport pathogenic microbes on their body surfaces, particularly in environments such as hospitals. Cockroaches are linked with allergic reactions in humans. One of the proteins that trigger allergic reactions is tropomyosin and these allergens are also linked with asthma. Ova and cycts of some human parasites have been found from the gut of cockroaches including *Trichu ristrichura*, *Ascaris lumbricoides*, *Entamoeba instolytica*, hookworm and *Enterobius vermicularis*, and also some species of bacteria and fungi isolated from the body of the cockroaches. Some microorganisms of medical important have also been recovered such as *Staplylococcus aureus*, *Staphylococcus epidermidis*, *Bacillus cereus* and *Escherichia coli*. This indicates that cockroaches as a domestic pests could pose a health problem to human. Therefore, cockroaches must be controlled particularly in indoors, sewage and solid wastes. Keep cooking, eating and food storage areas clean and dry. Service technicians must use a variety of treatment methods and combinations, usually including baits, dusts and aerosol treatment of cracks and crevices. There should be no visible residue of the materials used after treatment. Several non-chemical techniques may also be utilized including vacuum removal of floor debris can more easily detect the presence of pests, it could also suck up cockroaches and their eggs, and monitoring of populations with glue traps or other devices is helpful. Keep a spotless kitchen, pick up spilled food and crumbs immediately, do not leave dirty dishes out overnight, store dry foods such as cereal in airtight containers, put garbage in a sealed container, and seal cracks and crevices with caulk to help keep roaches out. Use roach baits in areas where cockroaches live in which a service Technician can install bait materials and find the best placement in home to maximize their effectiveness.

Keywords

Micro-organisms, Parasites, Cockroaches, Antibiotic Resistance, Household Pests

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1. Introduction

The medical and veterinary arthropods are an extraordinarily important group of pests, and have tremendous impacts on humans [1-10] and animals [11] histories. However, cockroaches have previously been implicated in the direct and indirect mechanical transmission of a number of human and animal diseases. They have been reported to harbour more than 100 causative pathogens of over 65 diseases of humans and animals [12].

Cockroaches (Dictyoptera: Blattidae) are insects, which have been in existence since ancient times, thriving in so many habitats and consuming virtually any organic matter, including fresh and processed human foods, stored products, garbage and sewage. However, only a few species are considered as pests in homes, grocery stores, hospitals, offices, schools, warehouses and other establishments. Cockroaches can withstand long periods of starvation and can live for many days without water [13, 14].

Cockroaches are characterized by an oval, flat-bodied shape, leathery wings, long antennae, long legs and a flat extension (or thoracic shield) that extends dorsally to conceal the head, and have become the most common insects in a majority of households. Cockroaches feed on a wide variety of food (grease, crumbs, pet food, wax, gum, leftover food in empty food cans etc.). They also eat paper if it has glue on it and some will feed on soap bars. Their presence has always raised safety concerns, especially as carriers of food-borne pathogens and food-spoilage organisms. Cockroaches are commonly found in buildings and homes because they prefer warm environments close to food and water [15, 16].

Cockroaches crawl through dirty areas and then walk around our homes tracking in lots of bacteria and germs. They can contaminate food by shedding their skins. Their casts off skin and waste by-products are allergens that can trigger allergic reactions, asthma and other illnesses, especially in children. Cockroaches are common in commercial premises associated with the production or handling of food. Also in public buildings and domestic premises, for instance, apartment blocks. They are gregarious and nocturnal; spend the day hiding in cracks and crevices around such areas as sinks, drains, cookers, the backs of cupboards, and in refrigerator motor compartments. They are especially found in buildings with service ducts and complex plumbing installations. Infestations may be introduced as egg cases or adults in incoming laundry, on raw materials, in crates and packaging, or arise as the insects enter buildings via such routes as drains or refuse chutes [17-19].

Cockroaches can be found infesting everything from homes to restaurants, ships and planes. They may follow water pipes and electrical lines through walls from one room to another and even from one apartment to another. Cockroaches live in groups and are attracted to humidity, warmth and darkness, and are common in bathrooms, kitchens, dining rooms and sometimes bedrooms. Cockroaches secrete a pheromone (an attractant chemical) in their faeces, which attracts other cockroaches. Egg cases (oothecae) of some cockroaches species can be found cemented to or dropped inside kitchen cabinets, behind refrigerators and under or behind stoves. Though not all types of cockroaches drop their egg cases, empty shells of egg cases are an indicator of their presence [20, 21].

2. Significance of Cockroaches

Cockroaches are potential vectors of diseases such as dysentery, gastroenteritis, typhoid and poliomyelitis. Their diet is omnivorous and includes fermenting substances, soiled septic dressings, hair, leather, parchment, wallpaper, faeces and food for human consumption. The latter may be contaminated either by the mechanical transfer of causative agents of diseases from the insect's body, or by transmission in the faeces. Cockroaches and their faeces may cause allergic reactions especially amongst sensitive individuals, for instance, asthmatics. Exposure may result from ingestion or through the inhalation of materials derived from cockroaches in airborne dust. In addition, food may be tainted with the characteristic smell of the cockroach, which is produced by faeces and salivary or abdominal gland secretions, or by the dead insects [22, 23].

Unfortunately, cockroaches can cause allergies and trigger asthma attacks, especially in children. They can also spread nearly thirty three different kinds of bacteria. Cockroaches have been trapped and collected from different location and examined using standard parasitological and microbial techniques [24, 25]. Normal saline has been used in the washing and examination of external surfaces, and dissection and examination of gastrointestinal tract. Ova and cysts of some human parasites have been found from the gut of cockroaches; *Trichus ristrichura, Ascaris lumbricoides, Entamoeba instolytica*, hookworm and *Enterobius vermicularis*. Also some species of bacteria and fungi are isolated from the body of the cockroaches. Some microorganism of medical important are also recovered; *Staplylococcus aureus*, *Staphylococcus epidermidis*, *Bacillus cereus* and *Escherichia coli.* The prevalence of human intestinal parasites in cockroaches are as; *Entamoeba histolytica/ dispar, E. coli, Giardia lamblia, Cryptosporidium* sp., *Ascaris lumbricoides, Trichuris trichiura,* hookworms, *Strongyloides stercoralis*, Taenia/ Echinococcus spp., *Enterobius vermicularis* and Hymenolepis nana [26].

The makeup of the microbial composition of the cockroach gut content has shown that cockroaches harbour eggs of seven species of helminths (hookworm, giant human roundworm, pinworm, tapeworm and whipworm) and three protozoa species (*Entamoeba histolytica, Naegleria fowleri* and *Giardia intestinalis*) [27].

Cockroaches themselves are not implicated in the transmission of any diseases. However, many disease-causing organisms can grow and multiply in their guts and then be deposited on silverware, plates etc., during defecation. For example, cockroaches can pick up disease-causing bacteria like Salmonella on their legs and later deposit them on foods and cause food poisoning.

People continuously exposed to dust containing cockroach faeces and crushed body parts become sensitized and may show allergic reaction and asthma after repeated exposure to such dust. Cockroaches develop their populations in moist, warm areas inside and out, but do not use human bodies as hosts. They may bite in the event of severe infestation and lack of other food sources, but this is also rare. Cockroaches prefer to feed on decaying organic matter and inanimate, starchy foods such as glue and wallpaper [28, 29].

German cockroaches collected in two hospitals have been examined bacteriologically. Twenty strains of different taxons are all considered to be potentially pathogenic to humans. Some strains are resistant to antibacterial drugs widely used for treatment of patients: Gram-negative rods are resistant to amoxicillin/ clavulanic acid, Pseudomonas spp., and additionally resistant to co-trimoxasole. The strains of *Staphylococcus equorum, S. hominis* are also isolated [30].

Cockroaches have appeared in human culture and are popularly depicted as dirty pests. They can burrow into human ears, causing pain and hearing loss, and may be removed with forceps, possibly after first drowning with olive oil [31].

3. Types of Cockroaches

There are approximately 4,600 living species of cockroaches in the world, but only a handful of them plague homes and businesses. There are about thirty species of cockroach associated with human habitations and about four species are well known as pests. Generally these bear two pairs of wings; forewings have well developed veins and tend to be hardened, they overlap down the mid-dorsal line; membranous hind wings are folded below forewings; long whip-like, many segmented antennae; omnivorous, with mouth parts adapted for biting; tarsi 5 segmented; incomplete metamorphosis, and with egg and nymph stages. The nymphs of all species are similar in appearance to the adults, but smaller. Immediately after hatching or moulting the nymphs are white, but the cuticle soon darkens to the normal colour [32, 33].

Some of the more common species include German cockroaches, American cockroaches, brown-banded cockroaches and Oriental cockroaches. The American cockroach *Periplaneta americana* and the German cockroach *Blattella germanica* are considered two of the most common and notorious cosmopolitan pest species globally. Both *B. orientalis* and *B. germanica* cockroaches are the most common species, and they occasionally found together, but *B. germanica* generally prefers warmer, humid environments, e.g., centrally heated buildings, whilst *B. orientalis* is frequently encountered in cooler, less humid areas such as basements and drains. Cockroaches *P. americana* and *Supella longipalpa* are tropical and sub-tropical species, but are also found in ports and shipping areas in temperate climates [34].

3.1. German Cockroaches *Blattella germanica* (Linnaeus)

German cockroaches (*Blattella germanica*), are one among the most common species usually found living and breeding indoors, including homes. Despite of their name, German cockroaches are found all over the world and often referred to as French cockroaches. They measure 13 to 16 mm long and are pale brown in colour, with two dark-brown stripes behind the head, which is the shield just behind their head. Adult German cockroaches have wings, but they cannot fly. If they fall, they can flutter their wings enough to break the fall, but cannot use their wings to get around. They are fast runners and move very quickly in their environment. Their antennae are relatively long, a little longer than the length of their body, and serve as powerful sensory devices for evaluating of their environment, finding food and receiving messages from other roaches [35].

Male adult German cockroaches are slender and a little smaller than the females, who are a little larger and wider in the abdomen. When female adult roaches are gravid or pregnant, they have an egg capsule, or ootheca, that can be seen protruding about one quarter-inch from the end of the abdomen. The egg capsule contains about 40 eggs, more or less, that will be carried with it until about 24 hours before the new roaches are ready to hatch. Female then drops the egg capsule in a concealed location; the new roaches open it and crawl out.

If a roach infestation is found, treatment will be applied in areas where roaches have been or may be hiding. Knowledge about the German cockroach is vital for effective treatment. For example, young roaches often feed on the faecal droppings of the adult cockroaches in aggregation areas, while the adults are out looking for food. By way of grotesque as this may sound, it is a key to pest control that

helps to achieve timely and effective cockroach elimination. Professional baits are slow-acting by design. When the adults start feeding on baits, they are preparing a final meal for the young roaches. They live just long enough to digest the bait, get back to their aggregation hangout, and leave their final legacy for the up and coming young roaches [36].

They prefer warm and damp spaces with food and water nearby, like kitchens, bathrooms, and places where people eat and drink. They typically first appear in the bathroom and kitchen, but since they spend about 80 percent of their time in the wall cracks and voids, infestations are almost always larger than they appear. Cockroaches are attracted to sweet and floury foods. They also eat non-organic items such as toothpaste and books. They refuse to eat sweetened baits, which present an obstacle to their control, and cockroaches that are not attracted to sugars take longer to grow and reproduce, whereas in the presence of poisoned sugared baits, sugar avoidance promotes reproduction [37].

Nymphal instars 1-2 are with thorax dark brown to black but having pale lateral margins, meso and metathorax pale or white centrally, but with a continuous dark stripe near each margin; and thorax and abdomen light brown ventrally. Later instars (3rd) are with 2 dark longitudinal stripes on pronotum continuing to dark abdomen, and abdominal segments usually with central areas pale on dorsum. Ootheca or egg capsule yellowish brown, but usually two-toned, paler end attached to female; about 6-9 mm long, with length more than twice of width; subdivisional furrows extending on entire width; slightly bowed or arched; and with about 15-20 (range 925) eggs on each side. The female of this species produces 4-8 egg capsules at approximately 1 month intervals. Each thick-walled resistant capsule is 6 mm long and contains up to 30 eggs, but unlike *B. orientalis*, the female carries the capsule until just before the eggs hatch, some 2.5-4 weeks later. Efforts are made to conceal the capsules near a food source, where the nymphs will hatch and pass through 5-7 moults before reaching to maturity. At a temperature of 25°C, maturity is reached in 3.5 months, but this time can be profoundly influenced by temperature. Adults live approximately for 8.5 months at 25°C. The German cockroach is particularly successful for the following reasons; a large number of eggs per capsule; the female protects the egg capsule, by carrying it until just before hatching; short development period to hatching and maturity; and small size, therefore readily conceals itself. These insects typically live up to 12 months and produce more eggs than other species [38].

3.2. American Cockroaches *Periplaneta americana* (Linnaeus)

The American cockroaches (*Periplaneta americana*) are the largest cockroaches commonly found in homes. Adults can grow up to 53 mm in length. American cockroaches are reddish-brown to brown in colour, with light yellow bands around the shield behind the head. Both males and females of this species have wings and are capable of flying short distances. American cockroaches can live up to two years and are commonly found in households where food is stored. The males of this species have a high sensitivity to the female cockroach pheromone, also known as periplanone-B. This makes the males dedicated to increasing their ranks. Female American cockroaches can be very productive, producing a sack of 16 eggs after mating. Without mating again, the female roach, which has a lifespan of about a year, can continue to produce egg sacks, or oothecae, using saved sperm [39].

In ideal circumstances, a female can produce an egg sack every six days, although it has the capacity to produce up to two in one week. Presumably to protect young, a female American roach will glue its egg sack in closed-off hiding spots and attempt to camouflage it by scraping up paint and cardboard, and covering the sack. On average, a female American cockroach will produce six to 14 egg capsules in her lifetime. Under perfect conditions, such as those in a laboratory, it could produce up to 22 egg sacks that are over 336 nymphs. Once ready to break free, nymphs in the ootheca put up a synchronized effort to break through the sack. Females produce many egg capsules, having 14-16 eggs hatching in 50-55 days into greyish-brown nymphs, first into whitish-brown nymphs and later turning more reddish-brown. Female American roaches prefer to deposit their eggs in protected and damp areas. Nymphs will moult 9 to 13 times before reaching to maturity. The nymphs are grey-brown when they come out of the egg capsule [40].

American cockroach females deposit their eggs in bean-shaped cases (oothecae) in sheltered areas on or near the floor, usually close to a food source. Egg capsules protrude from the body for a few hours to four days. One egg capsule is formed each week until 6 to 14 have been produced. Each case contains up to 16 white or yellowish-white eggs. Development to adult averages about 15 months, varying between 9½ to 20 months. Adults live almost for 15 months and the average lifespan of an American cockroach from egg to adult is anywhere from 168 to 786 days. After reaching to adulthood, a female can live anywhere from 90 to 706 days and a male from 90 to 362 days [41, 42].

American cockroach is found all over the world. It is common to find them in crawl spaces, wood piles, dead logs, hollowed-out trees and other outdoor locations, as well as inside the home. These cockroaches will eat just about anything, including plants and other insects. American cockroaches prefer to live in warm, dark, wet areas, like

sewers and basements. They often enter structures through drains and pipes.

3.3. Brown-banded Cockroaches *Supella longipalpa* (Fabricius)

Brown banded cockroaches (*Supella longipalpa*) get their name from the two light bands they have across their dark brownish bodies. A pale brown band runs across the base of the wings in the adult and body of the nymph. These bands may appear irregular or broken, but are usually quite apparent on the nymphs and females. Another band runs across the body as well. The pronotal shield has a solid bell shaped pattern. Brown-banded cockroaches can grow up to 13 mm in length and are light brown. Females have reddish-brown to dark-brown wings. The wings of male brown-banded cockroaches are dark brown toward the base and lighten as the wings extend to the tip. Both males and females have two light yellow bands across their bodies. The male's wings are larger than the female's wings and only males are capable of flight. The male's wings cover the abdomen, whereas the female's wings are short, exposing the abdomen. Most cockroaches have a flattened, oval shape, spiny legs and long filamentous antennae. Nymphs and females are broad when viewed from above, while the male is slender. Immature stages are smaller, have undeveloped wings and resemble to adults. These insects feed on starchy materials, such as wallpaper paste and book bindings, and even non-food materials such as nylon stockings. These roaches are active at night, and nymphs and adults jump rapidly when disturbed. These pests do not require as much moisture as German cockroaches and tend to avoid light [43].

These cockroaches, like all other roaches, are scavengers that will eat almost anything organic, including bodily fluids and decaying matter. The brown banded cockroach sometimes eats glue or paste as well as starch or colour dyes, so they may be found nibbling on stamps, envelopes, books and wallpaper. They also search for body oils and skin cells, and can be found eating non-food items that contain traces of these cells. These roaches can eat food and other items in pantry and indoor storage areas. They may carry bacteria and protozoa that cause disease diarrhoea or gastroenteritis, and can deposit the germs on food and utensils. Brown banded roaches have been reported to spread at least 33 kinds of bacteria. Brown banded cockroaches can contaminate food by shedding of their skins. Their cast off skins and waste by-products are allergens that can trigger allergic reactions, asthma and other illnesses, especially in children [44].

Brown banded cockroach female carries the ootheca for 1 to 2 days before attaching it to the side or underside of shelves, furniture, bedding or other structural objects. Ootheca is 5 mm long and each female can produce approximately 14 ootheca each having 14 to 18 eggs. Egg capsules are reddish-brown and the brown banded cockroach female carries the egg capsule for 24 to 36 hours. The egg capsule contains 14 to 16 eggs and a female produces 10 to 20 cases in its lifetime. The yellowish-brown egg capsules are sometimes deposited in clusters on furniture, draperies and other areas. Eggs hatch in 50 to 75 days and nymphs develop in 90 to 270 day. Development from egg to adult averages 161 days with a range from 90 to 276 days depending upon temperature. They live an average of three to 11 months, but they usually live 5-6½ months. Brown banded cockroaches thrive in warm temperatures, ranging from 77 degrees to 91 degrees Fahrenheit [45, 46].

Brown banded cockroaches live inside buildings, feeding on food and household items, and spreading disease-causing bacteria. They can be found in apartments, houses, hotels, restaurants, stores and hospitals. Infestations can get out of hand as these roaches reproduce and spread. When the infested furniture is moved, the brown banded roaches spread to other areas of home.

3.4. Oriental Cockroaches *Blatta orientalis* (Linnaeus)

The Oriental cockroach (*Blatta orientalis*) is typically dark-brown to reddish-brown in colour, though it can also seem to appear as a black cockroach in the dark places where this type of roach is generally found. Females can grow up to 32 mm in length, while males typically measure less than 25 mm long. They have no distinctive markings other than the disproportionately small size of their wings, which is the easiest way to identify them. Wings on males cover only part of the abdomen leaving 3 to 5 abdominal segments exposed and wings on the female are much reduced. Female wings look similar to nymphal wing pads, but are with veins. Middle segments of the cerci are about 3 times wide as long. Males generally do not fly, but may be able to fly just enough to avoid danger, if the need arises. On the other hand, the female adult oriental cockroach cannot fly at all. In fact, its wings are so small that they are barely visible, almost appearing as if they are attached to the wrong insect [47].

Some people call oriental cockroaches as 'water bugs' because they like very damp areas, or they might also be referred to as a 'black cockroach'. It can live outdoors as well as indoors. It can be found under stones, leaves, debris and in wall voids. In many cases, these large cockroaches find the inside area of buildings to be exactly what they are looking for a shelter. This is especially true during extreme weather conditions. When very hot, cold, dry, wet or even windy conditions occur outside, these roaches become distressed, human homes and buildings, unfortunately, often provide the comfort they are looking for.

Female oriental cockroaches drop or glue their ootheca within 30 hours of forming. One female can produce 1 to 18 oothecae in its lifetime. The thick-walled resistant oothecae are capsules, 12 mm in length; each contains up to 16 eggs and cemented to the substrate or dropped in the vicinity of a food supply. They may then be covered over with debris. Development time varies from 206 to 800 days depending upon temperature. At room temperature, development time is 575 to 602 days. Adult females live from 34 to 181 days and males live from 112 to 160 days. Adults live approximately 4.5 months at 25°C, but their life span is up to six months. The female produces 5 egg capsules at monthly intervals. Nymphs emerge 6-12 weeks later and progress through 7-10 moults before reaching to maturity, a process which takes 10 month to 2 years depending upon temperature and food supply. With each successive moult the wings, antennae and cerci develop and the nymph becomes progressively more like to the adult. The slow proliferation of *B. orientalis* will limit its success where reasonable standards of hygiene exist [48].

Oriental cockroaches feed primarily on decaying organic matter, and on all types of garbage and other organic material. Likewise, oriental cockroaches also require very wet areas when living outdoors. They are commonly found in storm and sanitary sewers, heavy vegetation, tree holes that collect water, under mulch beds and other similar areas. Oriental cockroaches also live in sewers and wet decaying areas, such as basements and crawlspaces, as well as firewood and piles of leaves. Condensation in walls or around air ducts may also create the damp environment they prefer. Plumbing leaks that are not promptly repaired, damp crawl spaces, and any other areas in and around home with a constant supply of moisture are also all very attractive to oriental cockroaches. One of the most likely indoor areas to find oriental cockroaches is in the basement, especially around sump pumps and water collection systems [49].

4. Managing of Cockroach Infestations

Many remedies have been tried in the search for control of the major pest species of cockroaches, which are resilient and fast-breeding. For cockroaches control, physical removal, exclusion, chemical contact pesticides, pesticide baits and other tactics can be used based on the infested area inside or outside. Inside areas usually focused on are related to doorways, drains and basement related areas [50].

4.1. Preventing of Cockroach Infestation

The most effective way to deter cockroaches is to deny them food, water and shelter. Do not leave liquids in sinks or buckets; do not leave food sitting out on counters; store dry foods in tightly sealed containers; rinse cans, bottles and plastics before putting them in recycling bins; and empty the rubbish on a daily basis. Clear all waste food and liquid spillage, and cleaning up food debris from food preparation areas, under sinks and appliances. Remove pet food, drink and litter trays before nightfall.

Cockroaches release an aggregation pheromone in their droppings informing others that they have found a safe harbourage. Remove old stacks of newspapers and magazines, unused cardboard boxes and all other forms of clutter from the floor or bottom of cupboards where these pests have easy access. Check key risk areas where cockroaches may gain entry into the home, cracks, crevices, vents, sewers and pipe drains. Seal areas such as cracks in walls, around skirting boards, behind electrical sockets, under kitchen sinks and bathroom cabinets to reduce potential hiding areas [51].

Inspecting and treating of available hiding places in which cockroaches might live includes electric motors, electronic equipment, false ceilings, wall voids and accessible cracks and voids. Vacuuming may be used in some cases to provide immediate reduction in the number of cockroaches. A variety of application techniques and methods may then be used to provide a comprehensive cockroach treatment, including crack and crevice treatments, void treatments and baits placement [52, 53].

The key to prevent cockroach infestation indoors is sanitation both in and around the house. Empty garbage daily and keep the lid tightly closed at all times. Do not accumulate empty soda cans, bottles, food cans and especially not in brown paper bags and cardboard boxes inside the house. Tape openings around pipes under the kitchen and bathroom sinks to prevent infestation from neighbouring apartments. To prevent the entrance of cockroaches into homes: eliminate potential habitat areas outside the houses; seal cracks; and install screens on vents, windows and doors [54].

Successful control of cockroaches is a complex subject, and depends very much upon tailoring control measures to the species concerned. An assessment of the infestation must be made to determine the species and extent of the infestation. The entire site of the area should be inspected, including where appropriate adjoining premises, normally inaccessible places, drains etc. A night survey is useful as this is the time of maximum insect activity. The survey may also be carried out using cockroach monitoring traps, searching for droppings, cast skins and egg cases etc., [55].

4.2. Control Measures

When a cockroach problem presents itself, it is time to take

action and get control of the situation immediately as cockroaches pose an infestation problem, which can quickly get out of hand. Garden herbs including bay, catnip, mint, cucumber and garlic have been proposed as repellents [56].

4.2.1. Hygiene Management

A high standard of hygiene is important in the control of cockroaches, and it involves the deny access to food and water that will increase cockroach activity and directed movement improving the opportunity for the insects to encounter insecticides. Deny access to harbourages in buildings or equipment, which would otherwise provide hiding places that are means of gaining access and dispersing, and breeding sites. Buildings and equipment should be designed to minimize the accumulation of debris and facilitate ease of cleaning. Keep surveillance of incoming materials including packaging and laundry. Environmental controls, such as ventilation will accelerate dehydration of the insects and interfere with the operation of antennal chemoreceptors [57].

4.2.2. Insecticidal Control

Insecticides are chemicals used to control cockroaches by killing them or preventing their entrance to an area [58].

(i). Surface Sprays

Effective treatment depends upon the selection and thorough application of a suitable insecticide. Many insects and egg cases are well hidden; therefore, the insecticide must be placed at and around these harbourages and maintained over the developmental period of the particular species [59].

(ii). Space Sprays

Regular treatments are necessary at weekly intervals until the infestation is brought under control. Thereafter, maintenance treatments, at less frequent intervals, should keep the insect population at an acceptable level. Initially, there will be a massive kill of adults and nymphs resulting in only the appearance of young nymphs from time to time. The technique is particularly useful using pyrethroid insecticides to flush cockroaches from their harbourages and over surface deposits of insecticide [60].

(iii). Insecticidal Baits

Baits offer the opportunity for controlled placement of insecticides formulated in attractive food bases. When placed in areas infested with cockroaches, the insects feed on the baits picking up a lethal dose of insecticide in the process. Baits offer the opportunity for continuous control of cockroaches over extended periods. They can be integrated with surface or space spray treatments. Insecticide should ideally persist until all egg cases have been hatched, but continued immigration may demand routine treatments. Poisoned bait containing hydramethylnon or fipronil and boric acid powder is effective on adults [61].

When the oriental cockroach infestation is located, there are a variety of control measures which are routinely used by professionals. Insecticide baits, dusts, aerosols as well as liquid treatments are all valuable tools that are very effective when used properly. More than one of these formulations is usually required for effective control of oriental cockroaches. It is imperative that dampness be reduced when oriental cockroaches are infesting a structure. This usually involves fixing leaks, properly ventilating areas or locating other issues that result in trapped moisture inside the structure. Eliminate potential harbourages outside of the home, seal cracks in the outer walls, and install screens on vents that lead to indoors [62].

4.3. Biological Control

Some parasites and predators are effective for biological control of cockroaches [63]. Parasitic wasps such as *Ampulex* wasps (large cosmopolitan wasps belonging to the family Ampulicidae) sting nerve ganglia in the cockroach's thorax, causing temporary paralysis and allowing the wasp to deliver an incapacitating sting into the cockroach's brain. The wasp clips the antennae with its mandibles and drinks some hemolymph before dragging the prey to a burrow, where an egg (rarely two) is laid on it. The wasp larva feeds on the subdued living cockroach [64]. Another wasp considered to be a promising candidate for biological control is the ensign wasp *Evania appendigaster* of the family Evaniidae, which attacks cockroach oothecae to lay a single egg inside [65]. Widow spiders (Araneae: Theridiidae) commonly prey on cockroaches, though their venomous bite introduces its own problems for humans and pets [66].

Cockroaches can be trapped in a deep, smooth-walled jar baited with food placed inside, so that cockroaches can reach the opening, for example, with a ramp of card or twigs on the outside. An inch of water in the jar can be used to drown any insects thus captured. Insect growth regulators (IGRs) that mimic hormones can control many types of insects including cockroaches and are generally low in toxicity to humans. Although they are rarely fatal for adult insects, they can prevent reproduction, egg-hatch and moulting from one stage to the next [67, 68].

5. Conclusion

Domiciliary cockroaches are obnoxious pests of significant medical importance. Cockroaches carry transmissive stages of human intestinal parasites, and may act as reservoirs and potential mechanical vectors for disease transmission.

Managing of cockroaches is important because they are germ and disease carriers. They contaminate food products, countertops, dishes, and anything else they come in contact with; are highly destructive to paper products; and they eat holes in fabrics, which includes clothing. On the health front, they can cause allergies and intestinal disorders and diseases. Although insects management for medical and veterinary shares common features with insects management of plant, however there are more differences than similarities. The basic distinction between the two systems is that in most instances fewer medical or veterinary pests can be tolerated than plant pests. In other words, the economic injury levels (EIL's) for medical and veterinary pests are lower than for plant pests. Additionally, more management techniques are available for plant pests than for medical and veterinary pests. Moreover, the use of a given technique may be more limited with medical and veterinary pests than with plant pests. For example, although host plants can be treated with insecticides to control pests, usually humans cannot be so treated (although insecticides are used for louse control on humans). Because of their ease of rearing and resilience, cockroaches have been used as insect models in the fields of research. In fact, many cockroaches live in warm tropical areas and feed on decaying wood and leaves. They help to break down this organic debris, and in the process, they add nutrients to the soil through their waste. They are also a food source for small reptiles and mammals. In other words, in spite of their bad reputation, cockroaches are an important part of many ecosystems. Unfortunately, in many parts of the world, just one species, the German cockroach is responsible for most of infestations. Homeowners attempting tocontrol with over-the-counter products are often met with frustration at the growing infestation and soon call pest management professionals. For controlling of the diseases, cockroaches in the human and animal habitations must be controlled by making the environment less favourable to them by the use of insecticides, gum traps, ensuring proper food storage facilities, and effective disposal of household refuse. The high prevalence of parasites in cockroaches justifies the need for improvements in existing standards of household hygiene and environmental sanitation in order to minimize cockroach contact with unhygienic sites or substrates from which parasites are acquired.

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