HAZARDS FROM PESTS IN FOOD PREMISES

Food Protection and Pest Management

A Guide to pest management in the food industry

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For further information on events and publications relating to pest control in the food industry, please contact:

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1. Introduction
The control of pests is an important part of the maintenance of hygiene and sanitation in any society. Their presence in food manufacturing, preparation and retailing areas is unacceptable for several reasons.

Some pests carry and transmit disease-causing pathogens, whilst others can cause shock and death through their stings or cause allergic reactions in consumers.

However all have one thing in common. Their mere presence in food or food preparation areas causes distress and makes consumers unhappy and, above all, makes food unsafe and unsaleable.

2. Pests as vectors or transmitters of disease
Potential human pathogens have been isolated from a wide variety of pests. However, simply finding a pathogenic micro-organism in or on a pest is not sufficient evidence that the pest is acting as a vector for that organism.

For this reason, significant research has had to be carried out both into the potential for pests to act as disease vectors as well as their ability to transmit and cause disease. The most important organisms themselves have been researched with a view to determining the possibility that transmission of disease by pests could occur.

A few of these generalist pests (in particular, cockroaches, rodents, ants and flies) have been the subject of extensive studies, in a large part because they are found extensively in restaurants, hospitals and kitchens.

Cockroaches
Cockroaches are ubiquitous pests, which feed on faeces, human and animal waste and on human foodstuffs. They have been found in sewers and toilets and are particularly associated with areas where food is stored or prepared.

They are also common pests in hospitals and laboratories and have been known to feed on sputum and other clinical specimens. There is increasing evidence that they are capable of causing serious allergic reactions such as asthma, and that they are second only to dust mites as insect causes of these conditions.

A wide range of species of bacteria have been shown to survive on the cuticle and in the gut (particularly the hindgut) of these insects and they are therefore prime candidates to act as vectors of pathogenic organisms either mechanically or via their faeces. For example, scientists who examined the carriage of bacteria by German cockroaches in multi-family dwellings in Rennes, France, found 30 different bacterial species in the insects.

Rodents
Of all the rodent species, rats and mice pose the greatest risk to humans due to their commensal nature, i.e. their ability to live in close association with man and his dwellings.

Rats and mice are capable of rapid reproduction and are omnivorous feeders, being able to survive on the smallest amounts of food and water. House mice, Mus musculus sp., in addition, can live without free drinking water when the moisture content of their food is 15 to 16%, allowing their survival in seemingly inhospitable environments such as warehouses storing dried foodstuffs.

Rodents often become problematic during colder spells, when they enter buildings and warehouses seeking shelter and food. Sewer systems also provide ideal habitats for rodents, and faults in drainage passages are common routes by which these animals can breach building structures.

Diseases carried by commensal rodents can be spread in a number of ways, either by direct contact between man and animal via bites or urine, or by indirect contact via excrement coming into contact with food or water which is subsequently consumed by humans. In addition, parasites living in or on host animals may also act as vectors of disease, capable of transmitting pathogenic organisms onto humans.

Ants
Several species of ants are found in buildings, one of the most important pest species in temperate regions being the Pharaoh's ant Monomorium pharaonis. Pharaoh's ants are a tropical species which, in temperate regions, have to rely on artificial heat for survival. They therefore tend to be confined to places, such as hospitals and large stores or restaurants, which are constantly heated. They are omnivorous but show a preference for raw and cooked meats and sweet items of food.

They have been found in wards, kitchens and operating theatres in hospitals and visit moist areas such as bedpans, toilets, drains, sinks and sluices. Pharaoh's ants have been reported from inside sterile packs and intravenous giving sets. They have been found feeding on discharges inside dressings of patients with suppurating lesions, a behaviour that could lead to wound infection.

Flies
Many species of flies are pests but although most of these are of no particular public health importance some species do act as carriers or vectors of pathogens. Of the non-biting flies associated with humans the most common are members of the genus Musca (particularly the housefly M. domestica).

Flies have a strong affinity for humans and their dwellings and a propensity to breed in human and animal faeces. They are also highly mobile and move readily from faecal matter and rotting animal tissue to human food utensils. They are therefore potentially extremely important as vectors of human pathogens.

In 1998, the FDA reported that the presence of disease-causing flies in a food-handling establishment constituted a potentially hazardous HACCP situation. They also stated that the threat posed is a threat of a contributing factor that could cross-contaminate food with in-plant pathogens, contaminate food with pathogens or myiasis-causing larvae or circumvent an otherwise effective biocidal critical control point.

Specifically mentioned are 17 flies which are catagorized as "filth flies". Of these 14 are considered a serious threat to health in food premises. These are Musca domestica, Muscina stabulans, Stomoxys calcitrans, Fannia canicularis, Fannia scalaris, Chrysomya megacephala, Chrysoma putoria, Cochliomya macellaria, Phaenicia sericata, Calliphora vicina, Calliphora vomitoria, Cynomyopsis cadaverina, Sarcophaga carnaria and Sarcophaga haemorrhoidalis.

Fruit flies (Drosphila sp.) have also been implicated in the transmission of disease-causing pathogens in laboratory experiments and if they are proven to carry these pathogens in wild populations, then they can also be added to the above list.

In 1999, it was reported that synanthropic flies, ie those which feed on excreta etc. and invade food and domestic premises, can also serve as mechanical vectors for C. parvum and under poor sanitary conditions could be involved in the transmission of human and animal cryptosporidiosis. The biology and ecology of synanthropic flies indicate that their potential for mechanical transmission of C. parvum oocysts can be high.

Yellow Jackets (Wasps) and Bees

The stings of pests such as wasps and bees are generally painful and can cause severe, sometimes life-threatening, allergic reactions in some individuals due to the injection of toxins. Such pests are not thought to transmit pathogens to man. However, death can sometimes occur as a result of shock or an adverse reaction to the sting

3. Potential Pathogens Isolated from Arthropod Pests
Research has shown that many potential pathogens can be isolated from arthropod pests. For example:

Salmonella Salmonellas are broadly divided into those which cause enteric fever (S. typhi and S. paratyphi) and those which cause food poisoning. Enteric fever (typhoid and paratyphoid) is a serious, potentially life threatening systemic bacterial illness. Uncommon in many developed countries at present, it is a serious cause of mortality and morbidity in the underdeveloped countries.

The food poisoning salmonellas include a wide range of species and serotypes and this group has recently been the subject of considerable interest in the United Kingdom and continental Europe, in Scandinavia and in the United States.

This has been the result of an explosive upsurge in the numbers of cases, particularly of Salmonella enteritidis, reported in those countries in recent years. The most commonly identified sources of S. enteritidis are poultry and eggs, other salmonellas (eg. S. typhimurium) being associated with foods such as beef or milk.

Both enteric fever and salmonella food poisoning are transmitted by food and water contaminated with the Salmonella bacteria. Arthropod pests are a potential source of contamination of these items. Isolations of salmonellas from cockroaches in hospitals, or in situations where outbreaks have occurred include:

S. typhi from houses inhabited by typhoid patients;

S. bovis morbificans from a small number of cockroaches in a hospital in which an outbreak caused by that organism was occurring;

S. typhimurium, S. bovis morbificans and S. oslo from cockroaches collected in a hospital in India.

Some of the organisms isolated were resistant to one or more antibiotics. Laboratory studies in which salmonellas have been fed to cockroaches have shown that the bacteria survive in the gut and are passed out in the faeces although they do not appear to multiply to any great extent in the insects, at least in temperate climates.

In addition, it has been shown that salmonellas can survive for at least four years in cockroach faeces.

Dysentery
Dysentery is a serious and important cause of morbidity (and in some areas of mortality) throughout the world. It is particularly characterised by the production of bloody diarrhoea. Although dysentery-like symptoms can result from infection with a range of organisms (eg. campylobacters) the true dysentery micro-organisms are the four species of Shigella, S. dysenteriae, S. flexneri, S. boydii and S. sonnei.

Shigellas have been isolated from several pest species. The Shiga bacillus (Shigella dysenteriae type 1) was isolated from flies in the early part of this century and other shigella species have also been isolated from these insects in other studies.

Experiments in 1973 showed that S. dysenteriae survived for about three days in the gut of oriental cockroaches (Blatta orientalis). It was reported in 1981 that when fifteen cases of dysentery caused by Shigella dysenteriae serotype 7 occurred in Northern Ireland over an eight week period, mainly among Asian food handlers working in sutler's shops, S. dysenteriae of the same serotype was isolated from one of ten cockroaches collected from one of the shops.

The manager of this shop was the first of the fifteen cases and the isolate from the cockroach was obtained two months later.

Klebsiella
Klebsiellas are opportunist pathogens, which can cause a wide range of infections, being responsible for about 10% of Gram negative infections in hospitals. Klebsiella penumoniae is often found in the respiratory tract of hospital patients and is capable of causing lower respiratory tract infections including Friedlander's pneumonia, a relatively rare pneumonia which can become chronic. Klebsiellas also cause bacteraemias, urinary tract infections and acute pyelonephritis; and are a cause of opportunistic infections in immunocompromised patients.

Numerous workers have reported the isolation of potentially pathogenic species of Klebsiella from cockroaches and flies and, in one hospital, these included multiple antibiotic resistant forms in the same proportions in which they were occurring in the patients.

In a study of the vector potential of houseflies (Musca domestica) which was undertaken in a hospital group and in a

residential area in India, Klebsiella bacteria were isolated from both the cuticle and the gut of the flies.

The rate of carriage was approximately the same (ca. 35%) in flies from both areas and most of the isolates were of Klebsiella pneumoniae. More than 80% of the isolates from flies in the hospital were resistant to four or more common antimicrobial drugs and 48% had the same resistance pattern as isolates from wounds of patients in the hospital suggesting that the flies had acquired the isolates from patients.

Escherichia coli
E.coli is a widespread intestinal parasite of mammals and birds. Humans are affected by a large number of serotypes, not all of which are of equal pathogenicity. The most common and important infections due to E.coli in humans are urinary tract infections, acute enteritis (including "travellers diarrhoea"), wound sepsis, and neonatal meningitis and septicaemia. Recently a serious condition, Haemolytic Uraemic Syndrome, has been shown to be caused by E.coli serotype O157.

E.coli is common in warm blooded hosts and has been isolated from arthropod pests. For example, three strains of E.coli were isolated from a large number of cockroaches from sewers, hospitals and hotels in London. In 1972, a UK scientist reported the isolation of E.coli from ants collected from kitchens, wards, washrooms and toilets in several hospitals in Britain. Elsewhere, E.coli was isolated from flies collected at a health care facility in Czechoslovakia.

Cockroaches can carry the organisms for some time after contact with contaminated material. In one study, cockroaches experimentally fed E.coli O119 cultures excreted the bacteria for up to 20 days post feeding.

Proteus
Widely distributed in nature, the bacteria of this genus are found in decomposing animal tissue, sewage, human and animal faeces and in garden soil and on vegetables. Proteus vulgaris and P.mirabilis are both pathogenic for man, are important causes of urinary tract infection, and are often isolated from infections of wounds and burns. Proteus spp have been isolated from cockroaches and from ants collected from wards in hospitals and from catering facilities.

Campylobacter
Campylobacters have only recently been recognised as important pathogens of man. The species most commonly found in man are C.jejuni and C.coli which cause acute gastro-enteritis (clinically indistinguishable from that caused by salmonellas or shigellas).

Studies of the epidemiology of campylobacters are even less complete than those of salmonellas. The extent to which they are carried by insects is almost unknown, but Campylobacter jejuni was recently isolated from a small proportion (0.5%) of a sample of 690 American and Oriental cockroaches captured in domestic kitchens and near poultry houses in Vom, Nigeria.

Three of the four isolates were extracted from the guts of the insects and the fourth from the outer surface. Campylobacters have also been isolated from flies in several studies.

Tuberculosis
Tuberculosis caused by M.tuberculosis is usually transmitted directly from person to person by bacilli in airborne droplet nuclei produced when infected persons cough or sneeze. Direct invasion via mucous membranes or breaks in the skin can occur but this mode of transmission is rare. Bovine tuberculosis (M.bovis) is usually transmitted by the ingestion of contaminated milk or dairy products.

In general pest species probably do not play a role in the transmission of these diseases but tubercle bacilli from fresh, moist sputum from TB patients can remain viable in the cockroach gut.

As early as 1911 cockroaches were allowed to feed on fresh sputum from tuberculous patients and bacilli, still infectious were detected in their faeces. Other workers who performed similar experiments (with M. tuberculosis) were not only able to detect the organisms in the faeces of the cockroaches but also to infect guinea pigs with tuberculosis by injecting them with faecal material from the cockroaches.

Mycobacteria can remain viable even in dried, heat fixed material. Recent work has shown that, under laboratory conditions, M.tuberculosis could be isolated from faecal pellets of cockroaches allowed to feed on heat-fixed tuberculosis sputum smears and that the bacteria remained viable in their faeces for at least eight weeks.

Pseudomonas
Pseudomonads are widely distributed in soil, water, sewage and the mammalian gut. Some, such as P.aeruginosa, are capable of producing fluorescent pigments. They survive well in warm and moist environments of the type favoured by many pest species. P.aeruginosa is an important cause of hospital acquired infection.

Those particularly affected are patients with serious underlying conditions (such as burns or cancers) or who are subject to some form of therapeutic procedure such as an indwelling catheter or mechanical ventilation. Other pseudomonads

(eg. P.cepacia, P.maltophila) are also capable of causing infections in humans but these are rare.

Pseudomonads have been isolated from cockroaches in the hospital environment. Pseudomonas aeruginosa has been isolated from Pharaoh's ants collected from inside the protective bag around a container of sterile saline infusion in a hospital. In another hospital a patient who had undergone leg surgery complained of irritation and an extensive infestation of Pharaoh's ants was found in his bed.

A pseudomonad was isolated from a sample of these ants and the serious wound pathogen Pseudomonas aeruginosa was later isolated from ants found in the ward kitchen and from drain swabs. There had been a history of Pseudomonas contamination in the ward.

Streptococci and Enterococci
Streptococci are common inhabitants of the skin and intestinal tract of man. Some are largely saprophytic and cause little if any problem to their hosts. Others, such as Streptococcus pyogenes (group A streptococci - which cause wound infections, impetigo, erysipelas, scarlet fever, cellulitis, puerperal fever), pneumococci (S.pneumoniae, which can cause lobar pneumonia, otitis media and meningitis) and enterococci (including S.faecalis, which can cause sub-acute bacterial endocarditis and urinary tract infections) are potentially serious pathogens.

In common with other human pathogens streptococci have been isolated from cockroaches, flies and ants in the hospital environment.

Staphylococci
The two staphylococci of particular importance in infections of humans are Staphylococcus aureus, which is responsible for serious pyogenic infections and is a cause of food poisoning; and Staphyloccus epidermidis, normally a part of the typical skin flora, which can cause infective endocarditis and can infect artificial heart valves and sites where drains have been inserted into wounds. S.aureus has been isolated from cockroaches, ants and flies in hospitals.

Cryptosporidiosis
Infection with Cryptosporidium parvum, a zoonotic and anthroponotic coccidian parasite, may be fatal for persons with impaired immune systems, for whom a low number of oocysts can initiate life-threatening diarrhea. Insects such as promiscuous-landing synanthropic flies are recognized transport hosts for a variety of parasites including C. parvum.

Other bacterial pathogens
A wide range of other bacteria which are capable of causing illness in humans, but which are less common than those discussed above, have been isolated from arthropod pests in hospitals and food outlets. These include:

Bacillus spp (which can cause food poisoning);
Clostridium perfringens (which can cause gas gangrene and food poisoning);
Acinetobacter (which occasionally causes infections in burns units); and
Serratia spp, Citrobacter and Enterobacter spp (which are responsible for small numbers of wound infections, septicaemias, urinary tract infections and upper respiratory tract infections).

Hepatitis A
Like poliomyelitis, hepatitis A is an enterovirus. The disease caused by the virus (infectious hepatitis, catarrhal jaundice) is characterised by an abrupt onset of fever, anorexia, nausea and abdominal discomfort. Jaundice follows a few days later. The disease is usually mild but a severe, disabling infection lasting months can occur. Spread is normally from person to person by the faecal-oral route. Contaminated food is frequently involved. The evidence that arthropods carry and transmit infectious hepatitis is largely circumstantial.

Observations made during World War II suggest that flies might have acted as vectors of infectious hepatitis in Egypt. A marked reduction in the incidence of hepatitis A infection in a housing project in Los Angeles following a cockroach control programme in 1962 suggests that the insects might have been carrying the disease.

Other viruses
Very few data exist about the carriage of other viruses by non-biting arthropod pests but some experimental work has been done to test the possibility that they could act as vectors. For example, it was reported in 1982 that cockroaches fed vaccinia virus in laboratory trials were still excreting the virus five days later, and in another experiment cockroaches fed suspensions of Coxsackie virus excreted detectable amounts of the virus for up to two weeks.

Chlamydia
Chlamydias are parasites very similar to bacteria. There are two species, C.psittaci which causes psittacosis and is a zoonotic disease transmitted mainly by birds, and C.trachomatis which causes a sexually transmitted disease of humans (Lymphogranuloma Veneereum) and also of trachoma, a progressive infection of the cornea which can lead to blindness.

Transmission of Chlamydia is usually said to be by contact with ocular or nasopharyngeal discharges from infected

persons, but evidence has been advanced that flies could also transmit it.

Fungi
Fungal infections can be broadly divided into superficial, subcutaneous and deep-seated. Superficial fungal infections are rarely serious although they may cause discomfort. Fungi associated with deep-seated mycoses are almost always pathogenic and can result in life-threatening disease. They can also be very difficult to treat.

Broad-spectrum antibiotics and the treatment of patients with immunosuppressive and cyto-toxic agents, together with the increase in patients with AIDS, have meant that fungi such as Aspergillus fumigatus and Candida species, formerly considered as of little clinical significance, are now the cause of serious and often fatal diseases. Candidiasis can be transmitted by contact with secretions from affected patients and from contaminated faeces.

Aspergilli occur in decaying vegetation and stored foodstuffs and are generally transmitted by the inhalation of airborne fungal conidia. Fungi which may be of medical importance have been isolated from cockroaches and houseflies. These include Candida spp, Rhizopus spp, Mucor spp, Aspergillus niger, A.flavus and A.fumigatus.

Protozoa
Protozoa, like other pathogenic organisms in an environment, can potentially be carried by insect pests. Toxoplasma gondii, an intracellular coccidian parasite of cats, is capable of causing infections which are generally mild in healthy individuals but which can cause life threatening infections in immunocompromised patients (including AIDS patients).

If a primary infection occurs early in pregnancy, it can lead to foetal death or to serious brain damage. Late in pregnancy it can lead to recurrent or chronic chorioretinitis in the infant.

In one laboratory study cockroaches were allowed access to cat faeces containing infectious oocysts of Toxoplasma gondii. Toxoplasma was isolated from their digestive tracts for up to seven days later and from their faeces for up to ten days.

Experiments have also shown that flies (Musca domestica and Chrysoma megacephala) are capable of transmitting oocysts of Toxoplasma to human food for up to 48 hours after feeding on cat faeces containing the oocysts.

Other protozoan parasites, including Entamoeba histolytica, Entamoeba coli, and Endolimax nana have been isolated from wild caught cockroaches.

Helminths
It was reported in 1929 that a wide range of parasitic worms was found in pest species and cockroaches have been reported as carrying eggs of Enterobius vermicularis and Trichuris trichiura in food preparation areas. The eggs of roundworms (Ascaris lumbricoides) and of hookworms (Ancylostoma duodenale and Necator americanus) have also been isolated from cockroaches.

4. Do arthropod pests transmit disease?
The role of the non-biting pests as vectors of disease is, in general, far from clear. It has been proven that such pests carry a wide range of disease causing organisms but can they transmit them? There is a lack of studies properly designed to test this role and hence relatively little evidence to suggest that they actually do so. Simply finding an organism in a pest species is not sufficient evidence that the pest is acting as a vector for that organism. Equally it is not sufficient to show that a pest could theoretically act as a vector, it must be shown actually to do so.

However, associations have been shown between the removal of a pest species shown to carry an organism and the disappearance of the organism from a human population, or the reduction of the number of cases of illness caused by that organism in that population.

There is, in fact, very little good evidence that pathogens are transmitted by “non-biting” pests to any significant extent, particularly in temperate regions. Most is purely circumstantial. The best evidence is for shigellas.

Human infection can occur following the ingestion of very small numbers of these organisms and they are readily transmitted from person to person and by infected food and fomites. There is also good evidence that they can be transmitted by flies. Much of the early evidence was circumstantial and consisted largely of observations linking seasonal peaks in the prevalence of flies and of diarrhoeal disease. Some experimental evidence to support these observations came from fly control programmes undertaken in the southern United States following the introduction of effective insecticides in the 1950s. These showed that a reduction in the prevalence of shigellosis occurred following the reduction in density of flies. Much firmer evidence came from a prospective crossover intervention study recently undertaken in Israel. A fly control program carried out at military bases found that a reduction in the fly population led to a significant decrease in the number of clinic visits for shigellosis and for seroconversion for antibodies to shigellas (and also to enterotoxigenic E.coli).

5. The Need for Control

The absence of specific evidence that non-biting pests are acting as reservoirs or vectors of human pathogens does not mean they are not potential sources of such organisms. Most medical entomologists do believe that these pests can transmit disease in food premises. This, together with their potential as serious causes of allergies and the distress caused by their mere presence, means that active and aggressive control of these pests is essential.

Current HACCP regulations found in 21 CFR 123.11(b)(8) (Food and Drug Administration, 1997a) and related Good Manufacturing Practice (GMP) regulations in 21 CFR 110..20(a)(1), 21 CFR 110.35(c), and 21 CFR 110.37(f) require the exclusion of pests from areas where food is manufactured, packed, or held (Food and Drug Administration, 1997b). Flies are specifically named in 21 CFR 110.3(j) as an example of the kind of pest that shall be excluded from food-processing and food-storage establishments (Food and Drug Administration, 1997b). The control of flies and other pests would not normally be accomplished through the critical control points (CCPs) of a HACCP plan, but rather through prerequisite Sanitation Standard Operating Procedures. The proper venue for controlling the transmitters or vectors of foodborne pathogens is an effective sanitation and pest-exclusion program. Such a program controls and eliminates pests from food-processing areas is a mandatory prerequisite to a HACCP plan (Food and Drug Administration, 1997b).

Further reading

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