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Storage mites: Small but threatening foe of stored grains

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Abstract

A pest of stored grains can be defined as any organism that causes infestation and damage to stored products. Bacteria and fungi, mites and insects, and rodents and birds are major pests of stored grain. Among these stored grain pests, mites are the predominant biotic factor that deduces the quantity as well as the quality of stored grains. These deteriorate animal feed, human food and agricultural products and damage the food either by direct feeding or indirectly. Under favorable conditions, cause indirect harm to human beings and induce allergic diseases such as allergic rhinitis, asthma, conjunctivitis, and contact dermatitis. The grains and food products are prevented from mite pests by safe storage and the use of physical, chemical, and biological control methods.

Keywords: Mite, stored grain pest, allergic disease, safe storage

Introduction

Agriculture contributes 14% of the nation's GDP and 11% of its export. About half of the population of the country depends on agriculture as it is the principal source of income. In agriculture, grain production has increased due to scientific advancements in technology. But grains undergo several operations before they reach the consumer's plate & losses occur during these operations. About 10% of losses appear during post-harvest conditions out of which only 6% are due to a lack of proper storage of grains (Yoo et al., 2014). Grain is an excellent source of nutrients for a variety of species and the micro-environment, in which the grains are stored, which might lead to grain bio-deterioration, is mostly responsible for grain-pest interactions (Shaaya et al., 1997). A pest of stored grains can be defined as any organism that causes infestation and damage to stored products. Bacteria and fungi (microorganisms), mites and insects (arthropods), and rodents and birds (vertebrates) are major chunks of stored grain. Among these stored grain pests, mites are the predominant biotic factor that deduces the quantity as well as the quality of stored grains. Under favorable conditions, mites and insect pests can reduce Global grain production by up to 9 percent (Rahman et al., 2009). Globally, more than 60,000 species of mites are present, out of which 150 are observed in conjugation with stored grains. It is very problematic to detect their infestation in stored grain due to their microscopic size (Palyvos & Emmanouel, 2006).

Storage mites can be found wherever their living conditions are ideal, which includes microclimatic environmental factors such as temperature and relative humidity. Up to 30 generations can be produced annually under ideal conditions for rapid development, including 25°C ambient temperature and 90% relative air humidity. At less than 60% relative air humidity, they are practically unable to develop (Sánchez et al., 2017). These are also known as flour mites, grain mites, and forage mites because they can be found in "stocks" such as wheat, gram, maize, pulses, oats, barley, bran, rice, dried fish, straw, hay, mustard oil cake, cottonseed cake, groundnut cake, and plant leftovers (Wilkin & Thind, 1984; Prickett, 1997).

Mites are members of the Phylum Arthropoda, Class Arachnida, and Subclass Acari. The majority of mite species found infesting stored food belongs to the order Astigmata, and among the most economically important astigmatic mites, the family Acaridae includes several species commonly found in a wide range of food products (Hughes, 1976). The most relevant species are *Acarus siro*, *Glycyphagus domesticus*, *Lepidoglyphus destructor*, *Tyrophagus putrescentiae*, *Chortoglyphus arcuatus*, *Suidasia medanensis*, *Suidasia nesbitti*, *Aleuroglyphus ovatus*, and *Suidasia pontifica*, etc. Infestations of stored grains by these storage mites cause three types of harm which include firstly damage to human health by contaminating food with allergens (Stejskal & Hubert, 2008; Olsson & Hage-Hamsten, 2000). Second, as vectors of toxicogenic fungus, these mites indirectly contribute to mycotoxin contamination of food and feed (Hubert et al., 2004). Third, mites reduce grain weight and germinability (Rodionov, 1940; Solomon, 1946; Zdarkova & Reska, 1976). Thus Storage mites are becoming more important because of their increasing prevalence and interaction with fungus and insects, leading to the serious qualitative and quantitative deterioration of grains.

Biology

All mites have four phases in their life cycle: egg, larva, nymphal stage, and adult. Adult mites have four pairs of legs (Krantz, 1970). Male and female mites often have significant differences. During periods of adverse environmental conditions, certain species have a stage called the hypopial stage that conveys resistance. Mites are ectothermic, which means that raising the ambient temperature within a particular range stimulates mite population development (Lin, 2013).Because the mite body has a weakly sclerotized cuticle and a significant surface-to-volume ratio, humid conditions may affect mite population growth directly. The optimal environmental conditions for storage mites are similar to the pyroglyphid mites which are about 25-30°F temperature and 80% relative humidity (Van Hage-Hamsten &Johansson, 1992). The storage mite *Acarus siro*, on the other hand, has a far higher tolerance for cold temperatures. The lower threshold is 50 C with a humidity of 67.5 percent (Cunnington, 1976). Food availability, in addition to temperature and humidity, is known to influence the biology, ecology, and population dynamics of stored food product mites (Palyvos & Emmanouel, 2008). As a result, it is more sensitive to low relative humidity than high relative humidity (Spieksma, 1997), or indirectly through the rapid development of some fungus and bacteria living in mite habitats (Nascimento et al., 2016).

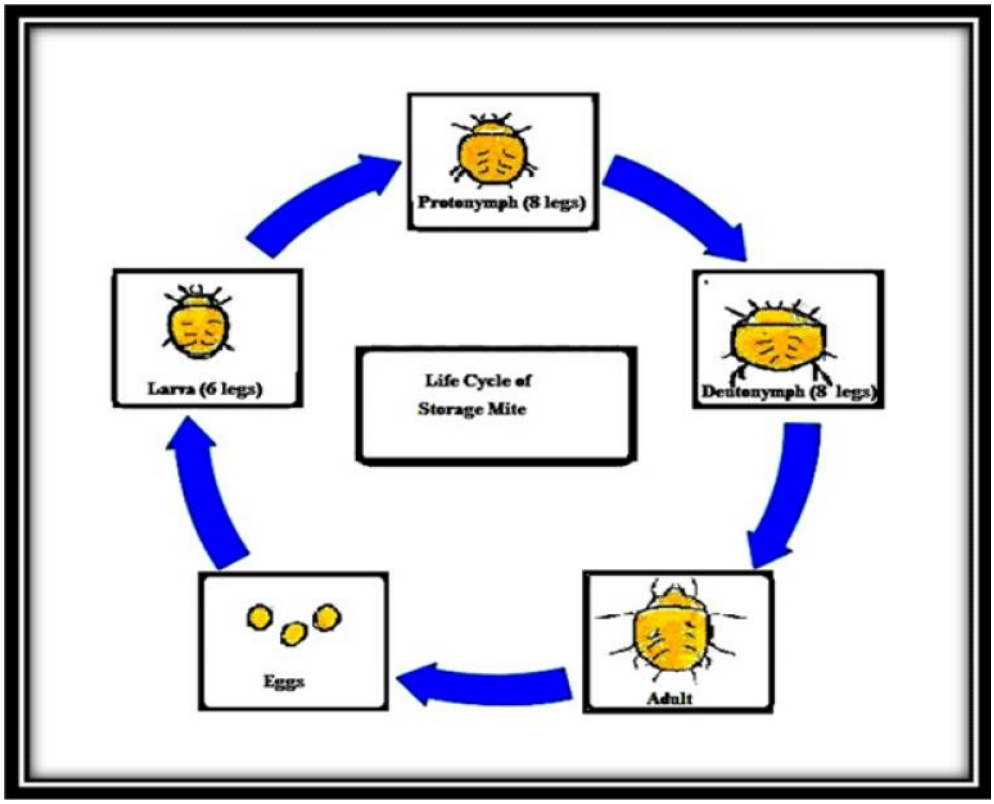

Fig 1: Life cycle of storage mite

Implications of storage mite infestation in stored grains:

Stored mites are a major group that deteriorates animal feed, human food and agricultural products shown in figure 1 (Chambers *et al., 2003).* Hubert *et al,* 2021 found the presence of storage mite in large populations of different food items which are described in table no 1. They damage the food either by direct feeding or by introducing contaminants, including their bodies, allergen-containing feces, and microorganisms. They act as secondary intruders among storage pests because they cannot infest whole grain rather they feed on grain damaged by primary insect pests like broken grain, debris, high moisture-containing seeds. After establishment, these intruders contribute directly to grain spoilage, just as primary pests do (Barton et al., 2009). They produce sufficient heat for the growth of infectious bacteria and fungi, reduce the value of seed and malting and also contaminate the space between grains with their dead bodies, cast skins, and with droppings (Colloff, 2009; Collins, 2012). As other pests do, they also attack the germ of the grains in infested products and reduce the pullulating capability of seeds (Mahmood et al., 2012). They also spread fungi and infectious bacteria in the stock (Franzolin et al., 1999; Hubert et al., 2003).

Table 1: storage mites and their presence in different food items

Scientific name	Common Name	Family	Food preference	References
Acarus siro	Flour mite	Acaridae	Flour, grain, meals	Jogi et al.,2020, Hubert et al, 2021
Aleuroglyphus ovatus	Brownlegged grain mite	Acaridae	Stored bran, wheat, chicken meal and dried fish products	Siegert et al.,2018
Carpoglyphus lactis	Dried fruit mite	Carpogyphidae	Milk, honey, jams, cheese, fermenting pulp, dried and preserved fruit	Huges, 1976; Hubert et al., 2011
Cheyletus malaccensis	Predatory mite	Cheyletidae	Bengal gram, gram powder, black musturd	Rahouma, 2018
Lepidoglyphus destructor	Cosmopolitan food mite	Glycyphagidae	Cereals, dried vegetable materials and dried fruit	Ghallab & El-Sayed, 2019
Suidasia nesbiti	Scaly grain mite	Suidasiidae	Wheat, rice, bran and grain stocks	Klimek et al., 2018
Suidasia pontifica	Scaly mite	Suidasiidae	Dried and salted fish	Hubert et al., 2018
Tyrophagus castellani	Forage mite	Acaridae	Stored food	Dhooria, 2016
Tyrophagus longior	Grainstack mite	Acaridae	Grain, brans	Yassin et al., 2017
Tyrophagus puterscentiae	Mould or cheese mite	Acardie	Herbs, seeds, meals, diary produts, oilseeds	Jogi et al., 2020; Arlian et al., 2002

Due to the infestation of mite, there are numbers of changes appear in the chemical composition. Infected grain changes color over time from shiny to dull and eventually to blackish color due to the presence of excreta and carcasses of mites. This color change signifies an increase in the acidic environment which produces a fusty smell due to the secretion of certain lipids and causes a bitter taste which makes it unsuitable for milling and unpalatable for livestock and human being also (Nayak, 2006). Storage mite causes a rapid qualitative and quantitative deterioration of stored products when associated with fungus and insects (Hubert et al., 2006). So, the infestation of mite can diminish grain weight as well as nutritional quality such as protein, fat, vitamins, and carbohydrate content. Grain, dried fruits, and vegetables infested with mites become useless and harmful for eating (Zakhvatkin, 1941).

As storage mites mainly attack embryos, they decrease the vitality, viability, and germination capacity of seed stocks (Gulati, 2007). Stejskal et al., 2014 reported that storage mite causes a decrease in the germinability of seeds by 52 %. Direct damage of storage mite occurs either by penetrating and contaminating seeds and embryos or by consuming the germ of grain and, in rare cases, the endosperm (Parkinson, 1990).

They also contaminate grain-based processed foods such as flour, cereals, and baking mixes when stored in moist or humid settings (Arlian & Morgan, 2003).

Storage mites can get into pre-packaged food through holes formed by insects, causing several infestations and bringing them into the home of the consumer, which is a serious concern for livestock and humans as well (Thind & Clarke, 2001).

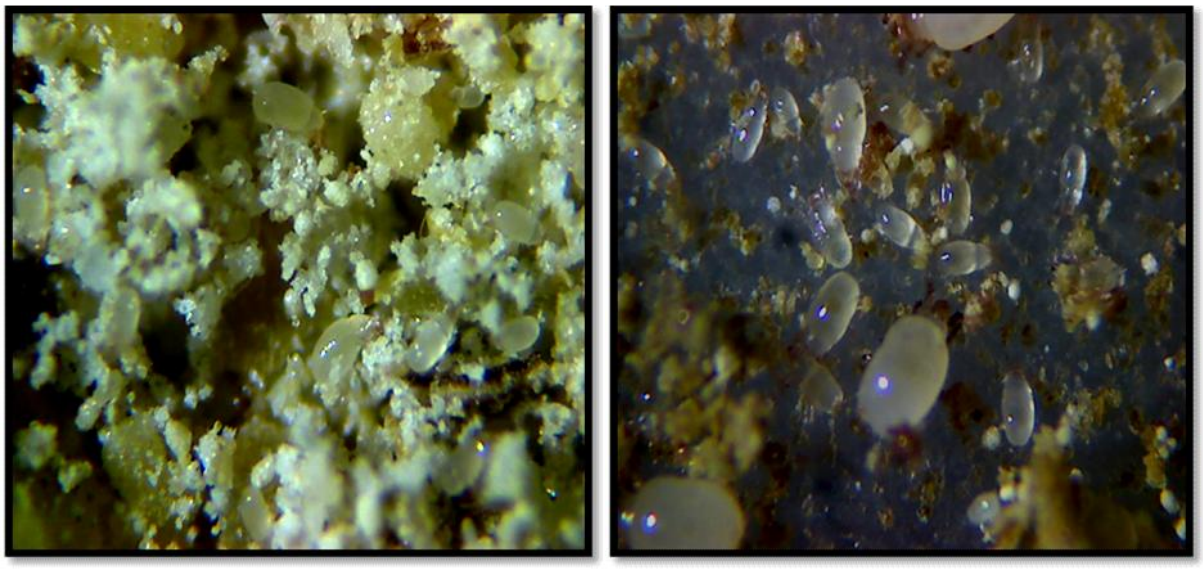

Fig 2: Presence of storage mite in different stored grains

Disease caused by storage mite

Infestation of mites on stored products is a major issue, not only for economic reasons but also because it poses a serious health risk to humans due to allergen contamination of food (Armitage et al., 2002). They reach great densities in suitable environmental conditions and have a direct or indirect impact on humans. These not only degrade the quality of the stored grain but also trigger allergic reactions (Kondreddi et al., 2006) and distribute toxigenic fungi and bacteria (Hubert et al., 2004). Stejskal & Hubert, 2008 found mites source of clinically significant allergens in farmers, grain workers, millers, bakers, and other occupations. Clinically important families of storage mites are Glycyphagidae, Pyemotidae, Pyroglyphidae, and Saproglyphidae, as well as genera including Acarus, Rhyzoglyphus, and Tyrophagus, which are stored mites that cause allergies (Curp, 2010; Stejskal & Hubert, 2008; Konishi & Uehara, 1995; Mercado et al., 2001; Broce et al., 2006).

Mites induce allergic illnesses such as allergic rhinitis, asthma, conjunctivitis, and contact dermatitis are caused by mite metabolic products or feces, as well as contact with dead or alive mites (Sánchez-Machn et al., 2010). These also cause chronic obstructive pulmonary disease, which is also known as 'heaves'. This is one of the most frequent respiratory diseases caused by mite in animals. Airway blockage, excessive mucus accumulation, and a neutrophil influx in the bronchial tree are all symptoms of it (Guerra et al., 2001; Matsumoto et al., 1996; Sanchez-Borges et al., 2005). The intake of mite-contaminated food causes oral anaphylaxis, naphylactoid, lesions, and digestive ulcers in livestock (Griffiths et al., 1959; Sánchez-Machn et al., 2010).

In addition, mites can infect humans by ingesting mite-contaminated foods or dust through the mouth or nasal cavity leading to oral anaphylaxis (Li et al., 2003; Iglesias-Souto et al., 2009).

Sometimes mites may evade the action of gastric acid or digestive juices and cause various degrees of mechanical injury, inflammation, or necrosis of the intestinal mucosa, or may stimulate the immune system with their metabolites when mistakenly consumed by humans in food or dust (Li et al., 2003). Stomach pain, diarrhea, and pyohemofecia are the most common symptoms of intestinal acariasis. Some of these symptoms may be mistaken as intestinal schistosomiasis, amoebiasis, allergic enteritis, or chronic colitis (Li et al., 2003). Kaur and Dhingra 2018 reported *Acarus siro* and *Tyrophagus longior* are the most allergenic mites found in stored grains that cause human allergic reactions such as copra itch and baker's itch. Furthermore, ingesting *Tyrophagus putrescentiae* causes acute enteritis and diarrhea (Aygun et al., 2007).

Additionally, these cause allergies in stored grain workers, grain millers, farmers, bakers, or who handle heavily infested stored products as shown in table no. 2 (Jeong et al., 2008; Stejskal & Hubert 2008). They cause asthma, diarrhea, and acute enteritis (Yadav et al., 2006). Cuthbert, 1978 investigated a survey of allergic respiratory disease in an Orkney farming community of 220 people, 15% were found to have asthma or allergic rhinitis, and many of them reported that exposure to mite contaminated hay, straw, or grain dust in barns triggered or aggravated their symptoms.

Table 2: Clinical symptoms cause by different mite species

Mite species	Clinical Symptoms	References
Acarus siro	Allergy, Cough, wheeze, acute enteritis, headache, high fever, and myalgias, possibly nausea, vomiting, diarrhea, and cough	Arilan 2009; Athanassiou et al., 2005
Carpoglyphus passularum	Scabies-like eruption of the arms and face	O'Donel Alexander, 1984
Chortoglyphus arcuatus	Allergy	Halliday 2003
Glycyphagus domesticus	Cough, wheeze, nasal discharge, vesicular dermatitis in skin	Blainey et al., 1988
Lepidoglyphus destructor	Allergy, Cough, wheeze & Asthma, dermatitis	Gafvelin et al., 2001
Tyrophagus putrescentiae	Allergy, Cough, wheeze, increased respiratory effort emerge, airborne contact dermatitis, Asthma, rhinitis, rhinoconjunctivitis, and possible anaphylaxis	Mullen & Durde, 2009; Vidal & Rial, 1998 Sanchez-Borges et al.,1997
Suidasia nesbitti	Itching, anaphylaxis	Sanchez-Borges et al., 1997

Although it is virtually impossible to eradicate storage mites from the environment, can minimize by certain appropriate management strategies.

Mitigation of Stored grain mites

It's very difficult to Control storage mites when moisture and temperature conditions and storage duration favor their development. So, the grains and food products are prevented from mite pests by safe storage (Márquez et al., 2020) and the use of different physical, chemical, and biological control methods.

Physical methods:

The most essential elements influencing mite development are temperature and relative humidity. The number of mites is reduced as the temperature and relative humidity fall. Grain mites in storage can only survive and reproduce in a small temperature range (35°C). When the temperature drops or rises outside of this range, the mite population dies and remains immobile. The creation of hot spots caused by the interaction of microbes and arthropods can also influence temperature in certain locations (Cook & Armitage, 2003). Mites survive when relative humidity lies between 70-85 %. So mite populations can be managed by drying harvested grains in the sun or with artificial heat to lower relative humidity below 12%; stored mites cannot complete their development at this low moisture content.

This is critical to place all vacuumed items in a plastic bag and dispose of them outside. Locate and eradicate the source of mite infestation when products become infested with mites. Inspect all high-moisture food and grain products thoroughly. Foods with a high moisture content that have been purchased in bulk and stored in bags for a long time should be examined regularly. Food materials should be rotated to remove the oldest ones first. Farmers are advised to avoid long-term storage and to thoroughly clean food containers with hot water or detergent before reusing them.

Chemical methods:

To further protect stored food against mites, adequate disinfection measures are required, which are often accomplished using chemicals such as aluminum phosphide and methyl bromide in appropriate quantities. Contact a professional pest control operator if the stored food mite infestations cannot be successfully controlled. Approved fumigants can only be applied by qualified, certified pesticide applicators. Diatom soil is made up of silica oxide derived from algal fossils and algae. It absorbs oils from the exoskeleton's outer layer. Mineral salt or ashes are used in the storage of cereal and legume seeds. The physical death of mites happens due to the loss of body water when silicates, mineral salt, talc, and volcanic ash are combined with dust.

Biological methods

Chemical residues are detrimental to human health, so natural insecticides derived from biological sources, such as plants, are employed to manage stored mite. The toxic effects of many plant extracts and oils have been studied as alternatives to manufactured poisons for controlling stored grain pests. To combat stored grain mites, botanicals such as turmeric powder, neem powder extract, mentha leaves powder, lemon peels, garlic, Mahua extract, black pepper, Clove oil, Ocimum sanctum oil, and Eucalyptus oil are employed. These botanicals are simple to produce and, in the vast majority of situations as they act as antifeedants, repellents, and reproduction inhibitors.

Conclusion

Storage mites can be found in huge numbers in stored products because it provides them with a food source, water, housing, and little temperature variation, all of which are necessary for their growth and development. Stored mites cause product deterioration, health issues, and financial losses. Controlling mite infestations on stored food by changing physical parameters (temperature and humidity) is a simple and

environmentally friendly strategy. Some chemicals and Plant-derived extracts, powders, and essential oils may be more effective for mite control in stored grains.

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