Chapter 3

Stored Mites

Mites are the smallest of the stored-product pests. Storage mites include mites belonging to acarid families, predatory and parasitic mites, which are found regularly in stored grains, human and animal food, nutrient ingredients and processed stored products or materials. These are gaining importance due to their increasing incidence and their association/ interaction with fungi and insects causing rapid qualitative and quantitative deterioration of grains. Several species of mites infest stored foods and other organic debris such as grain, flour, cereals, dried fruits and vegetables, pet foods, cheese, dried milk, ham, sugar, tobacco, molds, bird and animal nests, etc. These mites often prefer a moist, damp location (Jeffery, 1976; Hage-Hamsten and Johanson, 1992). Sometimes the surface of infested material appears to move due to the enormous numbers of mites (barely visible to the unaided eye). Heavy infestations of grain mites have a "minty" odor, best detected when mites are crushed between the thumb and forefinger, and held to the nose. Also, a coating or piles of brownish "mite dust" may appear on open shelving, around the base of flour sacks, on the surface of cheese or in other foods. Such piles consist of dead and living mites, cast skins and feaces.

In India, food grains pass through an average of fifteen points between the farmer and the consumer, which enlarges the scope for

quantitative and qualitative losses. At each point, mites can enter the food grain ecosystem, which have the potential to turn the grains unpalatable and unfit for human and animal consumption. Under suitable conditions, many of the mite species multiply rapidly to form extremely dense populations and attain pest status.

3.1 Distribution

Several exhaustive reports are available from Czechoslovakia (Zdarkova, 1996), India (Pillai, 1957; Ghai, 1964; 1976; Prasad, 1974; Mathur, 1979; Mathur and Mathur, 1982; Putatunda *et al.*, 1997; Putatunda, 2001; Singh and Gulati, 2001), UK (Hughes, 1976) and USA (Sinha, 1964). In India seventy species of stored product mites have already been reported. The important acarid pest species are *Acarus* sp., *Tyrophagus* sp., *Suidasia* sp., *Glycyphagus* sp., *Lardoglyphus* sp. and *Lepidoglyphus* sp. Table 3.1. In UK based study, 21 per cent of 571 samples were infested with stored mites, which increased to 38 per cent after six months storage in volunteers home. Increase in the percentage of contaminated samples following storage in a domestic situation suggests that the domestic environment is an important factor in developing infestation.

Among the different groups, Astigmata constitutes a dominant group in stored grain ecosystem followed by Prostigmata and Mesostigmata.

3.2 Morphology

Most of the stored product mites are microscopic to minute in size. They are colour less white dull coloured mites, which mostly go unnoticed in large bulk of samples. The important families are Acaridae, Carpoglyphidae, Glycyphagidae and Pyroglyphidae.

3.2.1 Acaridae

Majority of the storage mite fauna belongs to family Acaridae. Mites possess a pallid, soft cuticle varying in colour from pearly white to yellow brown, which helps in respiration. All the species are free living. The gnathosoma, although very mobile, is only partially retractile with in the body. A dorsal propdosomal shield is present. The body setae are usually smooth or sparsely pectinate. Claws are well developed and articulate with a pair of sclerites joined to the end of the tarsus.

3.2.2 Carpoglyphidae

Absence of stigmata, coxal field I is totally closed which is an important taxonomic character of this family

3.2.3 Glycyphagidae

This is another important stored mite family in which males donot possess anal suckers. Females are with genital opening at the level of coxa III and IV or if large at the level of coxa I and II.

3.2.4 Pyroglyphidae

Pyroglyphidae mites belong to the Astigmata so they do not bean stigmata. Vertical setae are absent in both sexes, which is a charactestic feature of the family.

3.3 Commonly Occurring Genera (Putatunda, 2005)

Acarus

Sigma I is more than three times sigma II. In male on leg I, femur is highly enlarged and bears a conical part.

Aleuroglyphus

Chelicerae and legs reddish brown in colour, vertical setae at the same level.

Caloglyphus

All dorsal setae present.

Lardoglyphus

In female claws bified, in males legs III highly modified into two conspicuous process.

Mycetoglyphus

Vertical setae shorter than genu I.

Rhizoglyphus

In Legs I and II tarsi bears enlarged cone.

Tyroborus

Spine like setae on the dorsal apex of tarsus I.

Tyrolichus

Lateral setae are 4-6 times longer than dorsal setae.

Tyrophagus

Needle like setae on the dorsal apex of tarsus I.

Carpoglyphus

Coxal field I totally closed.

Austroglycyphagus

Sigma I and II on genu of leg I is of same length.

Blomia

Two pairs of vertical setae are closed to each other.

Glycyphagus

Crista metopica present sublateral scale absent.

Lepidoglyphus

Sigma II is three times longer than sigma I on genu of leg I.

Euroglyphus

Absence of long posterior terminal setae.

Dermatophagoides

Long terminal setae are present.

3.4 Nature of Damage

Mites have feeding preference for germinal portion of grains. Ground/broken forms are more preferred than whole grains because of many receptor sites on germ portion (Kohli and Mathur, 1994). When given choice, mites generally distribute in all the directions before selecting the more suitable of the two-offered substance (Gulati and Mathur, 1998). Protein-fat combination and concentration or the amount of particular substance plays a role in attraction.

Due to their feeding, colour of grains change from shiny to dull colour, which slowly turn into blackish colour. A layer of powdery mass is also visible during high infestation (Figure 3.1). The thickness of powdery mass depends on the infestation level.

Mites contribute towards the loss in germination (Gulati *et al.*, 1999), nutritive value (Braude *et al.*, 1980), weight and organoleptic properties of grains. Per cent losses in germination due to different mite species were in the range of 20-38 in wheat grains, 5-12 in

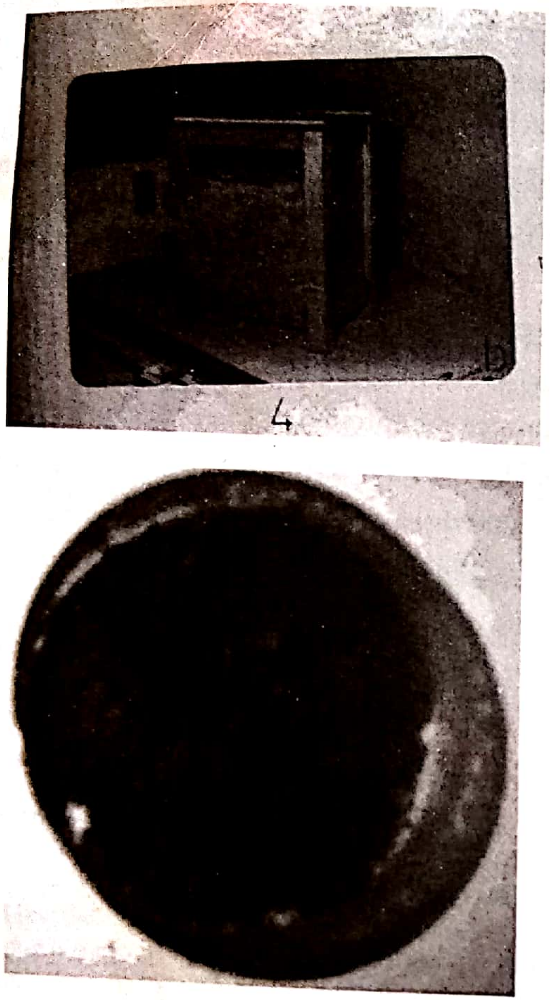

Figure 3.1: Damage Caused by Stored Mites

pulses and 35.8 in vegetable seeds after six months of infestation. Low fat acidity value, decrease in protein and starch content and increase in reducing sugars in mite infested grains were observed by many workers. Heavy infestation lead to tainting and minty smell in grains that become unfit for human consumption. Laboratory studies have shown the potential of acarid mites in reducing the weight of grains by 17.3, 20, 26 and 7-18 per cent in groundnut, sugar beet seeds, wheat and cheese, respectively, in six months.

Mites are also associated with storage fungi (Griffiths *et al.*, 1959) and are involved in the initiation and spreading of hotspots. Under laboratory conditions, mites are able to raise the temperature of grain by 10°C. Mixed population of mite, insect and fungi leads to 15°C rise in grain temperature under storage conditions. Complete deterioration of grains occurs at this stage.

3.5 Biology

The life cycle of acarid mite is usually direct, a hexapod larva emerging from an egg, passes through three octapod nymphal stages, *viz.*, proto, deuto and tritonymph, before becoming an adult. In some acarid species deutonymphal stage does not occur and the protonymph moults directly into tritonymph. Each stage is separated by a resting period.

Mating is pre-requisite for egg deposition, which lasts for few hours. During their lifetime, male and female mate many times. Female lays an average of 100-120 eggs in her lifetime. Eggs are round to oval in shape. Hatching, larval and nymphal period varies between 1-2, 1-2 and 4-8 days, respectively. Stored product mites require 7-15 days to complete their life cycle. Generally females live longer than males. Acarid mites have short life span and high reproductive potential *i.e.* several hundreds of progenies can be produced from a single pair.

Under unfavourable conditions, in some acarid species, hypopus stage occurs which can exist for several months without feeding (Griffiths, 1966; Knutte, 1987). It does not move much under its own power but is transported from place to place by clinging to small animal forms such as insects or mice. Most hypopi rely on air currents for distribution. They have been known to survive for at least seven months in dry flour and can withstand lower temperatures than the active form. When the hypopi encounters favorable conditions, it sheds its skin and resumes normal growth and development.

3.6 Storage Mites as Energy Transformers

T. putrescentiae and *R. echinopus* are efficient energy carriers from producer to secondary consumer. 40-60 per cent of the foods consumed by these mites are transferred to body and egg production. Gross production efficiency of growth is generally higher in case of acarid mites (35-36 per cent) than beetles in which it is 10-20 per cent (Sinha, 1964). In different life stages of mites the cummulative net production efficiency value (Production assimilation) ranges from 77-89 per cent whereas in case of beetles the highest net production efficiency is recorded in *Rhizopertha dominica* during late larval stage which is 38 per cent. As a mite consumes energy, it is altering the ecosystem by transferring the energy into biomass, heat of respiration, egested materials and chewed uneaten material which is accumulated and pollute the inert granular space.

3.7 Storage Mites as Source of Allergens

Several stored-product insect and mite species are confirmed as sources of allergens. The most important are storage mites because they cause occupational asthma by inhalation and anaphylactic reactions when ingested in high numbers. Perennial respiratory diseases like chronic rhinopathy or bronchial asthma can often be related to an allergy to indoor allergens (Teho *et al.*, 1985; Musk *et al.*, 1989). Perennial respiratory diseases like chronic rhinopathy or bronchial asthma can also be related to an allergy to indoor allergens (Woodcock and Cunnington, 1980).

Some of the storage mites *e.g. Acarus, Tyrophagus, Glycyphagus, Lepidoglyphus, Cardoglyphus, Gohieria* are important source of allergens for farmers and workers in grain storage/transfer facilities (Cuthbert *et al.*, 1979; Blainey *et al.*, 1989; Iverson *et al.*, 1990; Van Hage-Hamsten *et al.*, 1990). *T. putrescentiae* bodies are the source of 20 antigens, out of which atleast five are allergens (Green and Woodcock, 1978; Wraith *et al.*, 1979).

Allergic reactions due to mites are reported in persons handling the grains. 73 eastern-Polish farmers growing hops and other crops were examined. Tests with storage mites showed positive reactions to *A. siro* in 9.6 per cent, *L. destructor* in 17.8 per cent, and to *T. putrescentiae* in 13.7 per cent (Spiewal *et al.*, 2001). Allergen sensitization, especially to mites and pollens, was significantly associated with asthma and rhinoconjunctivitis in a farming community.

Its severity increases many folds due to its perennial nature and presence of multiple allergens (Revsbech and Anderson, 1987; Revsbech and Ducholam, 1990). Prolonged contact with mite-infested foods may produce a mild dermatitis known as „baker's" or „grocer's itch." Also, if mites are taken internally with infested food, stomach disorders may result. Dermatitis, Bronchial asthma and Chronic rhinopathy are observed in patients associated with mite allergens. Conjunctivitis and Perioral syndrome are also found to be related with stored mite infestation.

3.8 Polluters of Human Food

Mites' presence in the stored product makes the product unacceptable due to minty odour, change in colour and quality of food. Minty smell is associated with lipid secretion, which originates from paired oil glands. Mite attack accelerates the biological oxidation of fats, which causes rancidity. In heavily infested material, brown dust is accumulated, sometimes up to 2 cm depth or more. However, cheese containing thousands of acarid mites are now reported which is responsible for its sharp flavor.

3.9 Bioecology of important stored mites

3.9.1 *Acarus siro* L.

It is commonly called as grain mite (Table 3.1) and one of the most important pest of storage premises and processed cereal products. It occurs in dense populations. As many as 10,000 mites in 200 g wheat sample have been reported. In one study, grain mites comprised 42 per cent of the mites taken from 30 farm granaries in Central Canada (Lyeon). Body of the mite is almost colorless, but the mouthparts and legs are pale yellow to reddish-brown. The adult females are slightly larger than the males. The body of the male is smoothly rounded at the posterior end; that of the female is more oval with the posterior edges slightly indented in the middle. The body has a groove across it, dividing it into two areas. Two pairs of fairly long hairs trail at the end of the body.

At 25-31ºC temperature and 80-85 per cent relative humidity, the rate of reproduction is highest in *A. siro*, however, 61 per cent or lower RH is detrimental to grain mites (Cunnington, 1965). Grain mite development is extremely sensitive to humidity levels outside the range of 75 to 85 per cent. It is also known to feed on storage fungi belonging to genera *Aspergillus* and *Eurotium*. A life span of *Acarus* sp. is 13-16 days on wheat germ whereas it is 21 to 32 days on yeast. Synthetic diets containing vitamins and mineral salts increase the mite longevity.

3.9.2 *Tyrophagus putrescentiae* Schrank

It is an important pest of wheat, pulses, millets, groundnut, cheese, mushrooms and other stored products having a high fat or protein content and commonly called as mold mite. It is also recorded from mixed feeds, brewer's yeast, whole-wheat flour; soy flour; wheat germ, cheese, rye bread, white bread, and mixtures of oats and barley. Other known foods include cultivated mushrooms, various seeds, fruits, grain and straw stacks in the field, decaying animal and vegetable matter, onion, bacon, figs, dried milk, cheese, ham, dried bananas and copra.

Males and females (Figure 3.2) are about half mm long and have a small translucent body with almost colorless mouthparts and legs. The body, somewhat slender, bear hairs which are more numerous and longer than those on the grain mite. The fecundity of the mite varies considerably under different conditions of temperature and humidity. The temperature below 10ºC and above 30ºC is unfavourable for the development of mite although they can survive at these temperatures. On an average 118 eggs are laid by female in her life. Egg hatchability ranges between 90-94 per cent. Under optimum conditions (27±1ºC and 80-85per cent RH), duration of egg, larva, protonymph and tritonymph is 4.5, 3.4, 3.2 and 3 days, respectively, on wheat flour. Male and female longevity is 15 and 20 days, respectively. At 20ºC the female can live even for 150 days

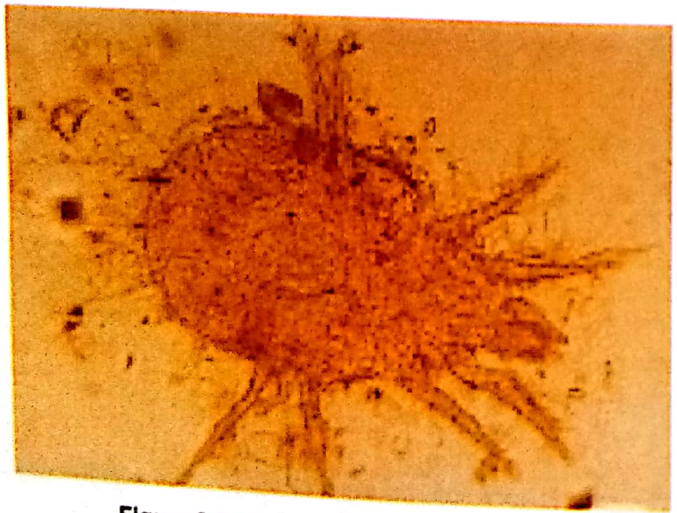

Figure 3.2: ***Tyrophagus putrescentiae***

(Boczek, 1975). Life cycle is completed in 10-14 days. Diet containing methyl p-hydroxy benzoate is best for *T. putrescentiae* as it completed its life cycle within 8-10 days at 25°C and 75per cent RH.

3.9.3 *Tyrophagus caseni*

The cheese mite, known to cause dermatitis, is larger than both the grain mite and the mold mite. It has stout, well tanned, faintly wrinkled legs and tanned mouthparts. Males and females are similar except that females are larger. The life cycle requires 15 to 18 days at the ideal temperature of 73°F and an RH of 87 per cent. No hypopi are formed.

3.9.4 *Suidasia nesbitti* Hughes

This mite is associated with wheat, wheat flour, rice bran, pearlmillet, pulses and other stored grains. Depending upon the food, fecundity ranged between 120-130 eggs per female. Egg, larva, protonymph and tritonymph period ranged between 2.7 to 3.7. 2.6 to 3.6, 2.4 to 3.6 and 2.3 to 3 days, respectively (Singh, 1985). Diet containing wheat germ is preferred by this mite out of various foods tested.

3.9.5 *Glycyphagus* sp.

The characteristic feature of this mite is the length of hair, which is longer than length of body (hairy). It has sharp pointed claws with hairy tufts. Body is cream coloured, small and pear-shaped. It shows jerky movement. It is recorded from grains, flour and cheese. At 23-25°C and 80-85 per cent relative humidity, it completes its life cycle in 20-22 days.

3.9.6 *Carpoglyphus* sp.

It has been found on all kinds of dried fruits, honey combs and food substances containing sugars. It can complete its life span at all temperatures varing from 5 to 35°C, however, egg laying stops below 10°C. The legs are slightly pinkish in colour, which are more slender in females as compared to males.

3.9.7 *Lardoglyphus* sp.

This mite is mainly associated with salted fish and other fish products. *L. konoi* is one of the best-studied species of this genus. The hypopus formation (inactive stage) is higher in nutrient deficient diets and minimal in fish/yeast powder diet.

3.9.8 *Rhizoglyphus* sp.

It is one of the most wide spread genera in stored food/grains and soil fauna. At 25°C and 75 per cent relative humidity, it completes its life cycle in 8-10 days. *R. echinopus* can utilize the lipid content of a number of substrates but are unable to digest the proteinoids *e.g.* collagen, casein, keratin etc.

3.9.9 *Aleuroglyphus* sp.

It is common in wheat, flour, bran, chicken meal and dried fish products where it multiplies and form large population.

3.9.10 *Tarsonemus granius*

It is commonly called as glossy grain mite due to white dot on cream-coloured body. It has very small, shiny and pod-shaped body with a large gap between second and third pairs of legs. The last pair of legs is stick-like in females. It is normally encountered in stored cereals and known as fungus feeder.

3.9.11 Tydeid mite

It is very small, shiny with pod–or diamond-shaped body. Sometimes have hairs on 1st appendages. All legs originate close together and are slightly orange in colour. It is reported from grain residues and known as fungus feeder

3.9.12 *Aeroglyphus robustus*

This warty grain mite has round body. It is comparatively a large mite with arched hairs. Hairs are shorter than body, most being equal in length. It is commonly encountered in farm-stored grain. This mite is reported to feed on seed germ and moulds.

3.9.13 *Androlaelaps casalis*

It is a predatory fast moving mite, which feeds on acarid mites. This large, brown scleratized mite has large legs. First legs are bowed and there are markings on the side of body.

3.9.14 *Blattisocius* sp.

It is a predator of other mites and stored insects. Body is white, plump and pear-shaped with well-developed mouthparts and no hairs on body. Mite body is white in colour and show fast movements.

3.9.15 *Cheyletus eruditus*

This mite predates on other mites and has well-developed pedipalps (= grasping mouthparts). Body is white colour, fairly large in size with legs usually spread out and shows fast movements.

3.10 Management of Storage Mites

Management of stored mites is complicated due their short generation time, high reproductive potential, broad food niche, interactions with other pests and pathogens and unique adaptations for dispersal. Historically, control of these acarine pests has relied on the use of synthetic miticides and insecticides, but this option is now limited due to documented resistance and withdrawal of registration of some products. Alternative control strategies, including cultural and biological control, have shown limited success, but need to be further developed and implemented.

3.10.1 Preventive Measures

Unfortunately, once large numbers of mites are noted, control becomes very difficult. Contamination during storage must be avoided. Grains should be stored below 12 per cent moisture content of grains. Low moisture content is critical for mite control than low temperatures. At temperatures below 5°C most storage insects die whereas, mites merely stop breeding. Cleansing and disinfections of stores, preventing breaking of packaging seals are some of the other factors, which should be taken into consideration before storing the grains or food products. Foods should never be stored under damp, poorly ventilated conditions. If necessary, air circulation should be increased to reduce the relative humidity.

If bins or large containers are used for storage, do not dump new replacement foods (flour, grains, etc.) on older unused foods. Allow the original contents to become used up or exhausted, if possible because unused materials may become damp, moldy over time and act as source on initial infestation. Avoid prolonged storage. Stored foods should be placed in containers with tight-fitting lids, ideally screw type. Flour or packaged foods should be stacked on pallets to permit air ventilation and to prevent possible floor dampness from penetrating sacks or packages. When products become infested with mites, locate the source of infestation and eliminate it. Remove any bird or rodent nests near the storage area.

3.10.2 Use of Fumigants

Fumigants are found to be ineffective on eggs and early stage larvae, which result in resurgence of mite population after few days. Moreover, mites need 1.5 times higher dose than recommended for insects. Spraying of lindane-malathion or Chlorpyriphos-phoxim mixture, etrimphos and primiphos methyl are reported to be effective against *A. siro*, *T. putrescentiae* and *G. destructor*. Bin walls treated with malathion provide a protective barrier against mite pests.

3.10.3. Use of Inert Dust

Innert dust @ 3 and 5 g/kg provide complete control against *A. siro* and *G. destructor* at 10°C and 14.5 per cent moisture content after 28 days of exposure (Cook and Armatage, 1999).

3.10.4 Use of Botanicals

Studies on biodegradable botanicals showed that spice oils (black pepper, mint, turmeric, garlic) have inhibitory/repellant activity against stored mites (Potts and Rodriquez, 1979; Gulati and Mathur, 1995; Gulati, 2002). Neem oil (Gulati, 1998), vegetables oils (Sesame, mustard, groundnut) and Tulsi, Mahua extract also provide effective protection against acarid species. Degree of effectiveness depends on the type of species and nature of product.

3.10.5 Use of Photoperiod

Photoperiod also exerts a powerful influence on their life processes as they generally remain in dark during post harvest storage. Increase in light exposure leads to decrease in fecundity, egg viability, growth and increase in hatching and life history durations (Kohli and Mathur, 1993).

3.10.6 Pheromones as Repellants

T. putrescentiae contains neryl formate in its body fluids which acts as an alarm pheromone when released. Citral, a closely related compound, serves as the alarm pheromone of four other astigmatid mite species. Potts and Rodriguez (1979) reviewed techniques for protecting stored foods with natural mite allomones. Filter paper discs impregnated with these oils were placed adjacent to a food product inside the food wrapper. This treatment provided complete protection when applied at a concentration of 0.5 per cent.

Table 3.1: Stored Product Mites Associated with Stored Products/ Grains

Family	Mite-pest	Store Product
Acaridae	*Aleuroglyphus ovatus*	Wheat flour, cotton seed, Coconut, eliachi powder, suji
	Acarus sp.	Wheat flour, wheat dalia, pea, rice, cotton
	A. farris	Wheat flour
	A. siro	Wheat flour
	Caloglyphus sp.	Wheat flour, gram, suji
	C. berlesei	Wheat flour
	C. mycophagus	Wheat flour
	C. rhizoglyphoides	Wheat flour
	Mycetoglyphus sp.	Stored grains
	Rhizoglyphus sp.	Wheat flour
	Tyrophagus longior	Wheat flour, gram, dhania, debris of shops
	T palmarnum	Wheat
	T. putrescentiae	Wheat flour, pulses
	Thyreophagus entomophagous	Wheat, wheat flour, gram, oat, sugar, animal feed, debris of shops, bajra
	Tyroborus lini	Stored grains
	Tyrolichus casei	Stored grains
Chortogly-phidae	*Suidasia nesbitti*	Wheat flour in mills, bajra
Glycyphagidae	*Austroglycyphagus geniculatus*	Rice, animal feed capsules
	Glycyphagus sp.	Wheat flour
	G. domesticus	Wheat
	Lepidoglyphus destructor	Wheat, wheat flour
	Blomia sp.	Wheat flour
Pyroglyphidae	*Dermatophagoides farinae*	Wheat flour
	Euroglyphus sp.	Wheat flour
Urodinychidae	*Leiodinychus parasiticus*	Gram, wheat flour, dry coconut, jeera
Carpoglypidae	*Carpoglyphus* sp.	Wheat
Hisiostomidae	*Rhizoglyphus sp., R. robini*	Bulbs
	Lardoglyphus konoi	Fish products

Table 3.2: Predatory/Parasitic Mites Associated with Stored Products

Cheyletidae	
Acaropsis sollers	Gram, gram dal, bajra, mustard, oat, rice
A. docta	Gram dal, urd dal, wheat
Cheletopsis major	Gram dal
Cheletonella sp.	Wheat, rice
C. sugosa	Wheat, rice
Cheletonata sp.	Wheat
Chelonotus sp.	Wheat
Cheletomorpha sp.	Wheat
Cheyletus sp.	Wheat dalia, debris of shops
C. fortis	Mango, powder, coffee
C. malaccensis	Bajra, rice, wheat, gram, barley, wheat flour, mango powder, mustard debris
C. malayensis	Rice, gram, debris of shops
C. strenuus	Urad dal
Neoacaropsis granulatus	Wheat
Eucheyletia sp.	Wheat
Eucheletopsis sp.	Wheat, gram dal
Hemicheyletia sp.	Wheat
Stigmaeidae	
Eustigaeus sp.	Wheat, dry coconut, debris of shops
Indostigmaeus sp.	Wheat
Tydeidae	
Pronematus sp.	Kabuli grâm, pea, rice paper, wheat dalia
Acarophenaxidae	
Acarophenax nidicolus	Wheat
A. tribolii	Wheat
Pygmethoridae	
Pygmethoride sp.	Debris of shops
Cunaxidae	
Cunaxa sp.	Wheat

Contd...

Table 3.2–Contd...

Pyemotidae	
Pyemotus sp.	Wheat, pulses
Urodinychidae	
Leiodinychus krameri	Stored products
L.parasiticus	Stored products
Laelapidae	
Androlaelaps casalis	Stored products
Hypoaspis aculifera	Stored products
Proctolaelaps sp.	Stored products
Ameroseiidae	
Klemania plumigera	Stored products
K. plumosus	Stored products
Ascidae	
Arctoseius butleri	Stored products
Blattisocius sp.	Stored products
B. keegani	Stored products
B. tarsalis	Stored products
Melicheres sp.	Stored products

3.10.7 Use of HTST Technique

Infested grains are treated to an appropriate lethal temperature/ time combination. Research on high temperature control has focused on using hot air in a fluid bed, pneumatic conveyer equipment and on the use of high frequency waves, microwaves and infra-red radiations to heat the grain/ flour before rapidly cooling the commodity. High temperature of 300-350 °C for 6 seconds was found to kill mixed population of acarid species in grains (Mourier and Poulsen, 2000). At this temperature/time combination, reduction in moisture content was 0.5-1 per cent and no adverse effect on the functional properties of seeds.

3.10.8 Use of Biocontrol Agents

Biological control of mites is being exploited using several predatory mites *viz. Chelytus eruditus, C. malaccensis, A. docta, Androlaelaps casalis, Blattisocius* sp. *P. tritici* which are known to feed on acarid mites. These agents belong to four main families *viz.* Ascidae, Acarophenaxidae, Cheyletidae and Pyemotidae (Table 3.2).

3.10.8.1 Ascidae

Stigma between IIIrd and IVth legs with straight peritremes, metasternal shield small, female genital shield not flasked shape and dorsal shield with more than 23 pairs of setae. Majority of the mites species belonging to this family feed on insects and nematodes and are dealt in relevant chapters. Among the acarines, *Arctoseius cetratus* (Sellnick) limit the population of Mushroom pest, *Tarsonemus myceliophagus* Hussey. *Lasioseius parberlesi* Tseng is a natural enemy of rice pest, *Steneotrasonemus spinki* Smiley (Tseng, 1984) and hold its numbers at non-injurious level.

3.10.8.2 Acarophenaxidae

Leg I modified into a club like form with claw. Anterior propodosoma projects over the gnathosoma. The genus *Acarophenax* is mainly associated with stored grain pests.

3.10.8.3 Cheyletidae

They are white, yellow or orange colour mites with prominent thumb-claw complex. Chelicerae and rostrum fused into a cone, peritremes arched or forming an M-shaped configuration. *Cheyletus eruditus* (Schrank) is a biocontrol agent, which is currently being used for *Acarus* spp. (Pulpan and Verner, 1965; Zdarkova, 1986). It completes its life cycle in foúr weeks and prefers slightly higher temperature and lower humidities than the prey mites (Solomon, 1969). It can survive long periods of food scarcity but in case of choice, prefers immature stages of prey (Berreen, 1984). It has a natural tolerance to certain organophosphate insecticides (Zdarkova and Horak, 1987). Release of one predator/ 20-50 pests in oilseeds and 2000 predators/100 m^2 in empty store houses get full protection from acarid mite population.

3.10.8.4 Pyemotidae

They are milky white, spindle shaped and rounded segmented mites. Female possess pseudo stigmatic organs. Leg IV of female with pretarsus, claw and pulvillus but without apical whip like setae, idiosoma is elongated, gravid female with sac like hysterosoma. These parastic mites have a reduced life cycle. Mated females seek out hosts and attach to the host, sometimes paralyzing

the hosts with an injected toxin. Some species of genus *Pyemotes* casue dermatitis in humans. However, work on biosystematic research has shown that genus *Pyemotes* contains two groups of species (Moser *et al.*, 1987); one is parasitic only on scolyted beetles and are venomless, the other is venomous, polyphagous and very lethal to its prey but of reduced dermatological risks to humans. Some species are discussed in insect control chapter.