Might of the Mite: A review

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Abstract

Mites (Acari) are the most diverse and abundant of all arachnids but because of their small size they are rarely noticed. Mites are truly ubiquitous and have successfully colonized nearly every known habitat with their domicile ranging from earth to water to air and from sea to mountain peak. Acari show a wide variety of adaptations regarding life cycle and feeding habits which allow rapid escalation to pest status. On one hand, phytophagous mites as pests of field crops and mites associated with granaries and warehouses cause heavy financial losses, other species have attained prominence as household pests and causative agents of allergic reactions in human beings and other mammals. Many parasitic forms act as vectors of disease causing organisms. An unquantified but major positive contribution of Acari is their normal functioning in ecosystems, especially their roles in the decomposer subsystem. Acari are among the major sources for biological control of various classes of pests including insects, nematodes and weeds. In the current scenario, mites are on a stage of considerable economic significance and there is an urgent need to make awareness about Acarines and their behavior in different ecosystems so that timely management of harmful species and utilization of beneficial species can progress.

Keywords: biological control agents, decomposers, mites, pests, parasites

Introduction

Mites: the tiny creatures

Acari, because of small size and cryptic appearance, are difficult to detect and most of the time infestations are overlooked. Once established in a new area, certain biological characteristics such as high fecundity, various modes of reproduction, short life cycle, a myriad of dispersal techniques and adaptability to diverse ecological conditions allow rapid escalation to pest status. There is an urgent need to make awareness about acarines and their behavior in different ecosystems so that timely management of harmful species and utilization of beneficial species can progress in order to save the sustainability of agro ecosystems.

Mites as pests causing huge economic losses

Acarines have come a long way from the mere mention of ‘small little waxies’ by Aristotle to causing damage upto 80 percent in agricultural crops and causative agents of allergy in more than 75 percent persons associated with farm produce and their storage. Phytophagous mites of the four families Tetranychidae, Eriophyidae, Tenuipalpidae and Tarsonemidae have been reported as pests causing economic losses (Chhillar et al., 2007). They are important crop pests of agricultural crops such as paddy, sugarcane, sorghum etc.; vegetable and fruit crops such as beans, okra, raspberry, pear, pines, coconut, tomato, cucumber, strawberry etc.; horticultural crops such as rose, marigold, jasmine etc.; timber,
ornamental and shade trees such as elm, mountain ash, oak etc. and stored products such as oats, wheat, legumes etc. Nymphs and adults of Tetranychidae feed on leaf surface leading to chlorosis of leaves and extensive webbing thus reducing flowering, growth and yield. Eriophyds cause gall and erineum formation on buds, leaves and stems leading to deformation, curling and falling of leaves. Bronzing and rusting symptoms are shown by Tenuipalpids on the lower surface of leaves due to feeding of nymphs and adults while Tarsonemids lead to curling, crinkling and brittleness of foliage by sucking the cell sap from buds, leaves, shoots, flowers etc.

The two-spotted spider mite (TSSM), *T. urticae* is a member of the family Tetranychidae that contains many harmful species of plant-feeding mites. It was first described by Koch in 1836 and thought to originate from temperate climates (Fasulo and Denmark, 2000). It is a ubiquitous and economically important agricultural pest with a global distribution which feeds on a wide range of host plant species throughout the world (Farouk and Osman, 2011). *T. urticae* is known to attack about 1200 species of plants, of which more than 150 are economically important (Geroh, 2011). Pest status of *T. urticae* on greenhouse vegetables, ornamental and horticultural crops is well documented worldwide (Haque et al., 2011). Short generation time, high fecundity and webbing by *T. urticae* are responsible for causing loss in number of fruits and yield in various crops. The major principles behind yield loss due to spider mite infestation in various crops have been established as biomass reduction, disturbance of water conduction, dry matter partitioning, CO2 gas exchange, chlorophyll reduction and shedding of immature flowers (Park and Lee, 2002). The leaves infested by mites show white specks first which later coalesce and turn the leaf to rust red which later fall off to the ground. The reduction in leaves affecting the photosynthetic rate in turn reduces the number of fruits formed and yield. Severe infestation may cause flower and fruit shedding and also the fruits become smaller because the capacity of plant to meet the nutritional requirement of developing fruit is reduced (Reddy et al., 1987).

Manjinatha (1982) reported that the height of plant decreased according to the severity of damage caused by tetranychids during the seedling stage along with an adverse effect on yield as a result of reduction in fruit number due to shedding of fruits. Also, the fruits retained were smaller in size. Various workers reported significant yield loss due to mite feeding induced damage to fruit and foliage. According to studies of Palanisamy and Chelliah (1987), spider mite infestation resulted in reduction of 28 percent fruit yield, in accordance with studies conducted at Varanasi (Anonymous, 1994) where 13.64 percent loss in yield was observed. Sugeetha and Srinivasana (1999) found 6.7 to 7.9 percent yield loss in okra due to the infestation of *T. cinnabarinus* (=*T. urticae*). Similarly, 26.5 percent (Anonymous, 1996) to complete loss (Jeppson et al., 1975) in yield of okra crop has been reported. The probable reason for this difference in bibliographic results may be the variation in host plant, ecological conditions, time of incidence of spider mite and severity of occurrence. Patil (2005) reported a maximum per cent reduction of 18.99 in plant height, 29.83 in number of branches, 38.81 in number of fruits and 32.21 in yield of brinjal plants at highest release level of 200 *T. macfarlanei* plant over unreleased plants in brinjal. A yield reduction of 10.36 and 16.03 percent was noticed during 2003-04 and 2004-05,
respectively. Uninfected plants recorded highest growth and yield parameters viz., plant height, branches, fruits and yield due to total absence of the mite population which encouraged plant to put more biomass and also yield. A significant negative correlation was observed between *T. urticae* infestation and okra yield which emphasized the fact that quantitative losses occur due to *T. urticae* infestation in okra (Geroh, 2011). The bean yield and its components i.e. pod number per plant, pod yield/plant and pod length as well as yield quality (expressed as total protein, ascorbic acid, total carbohydrates contents and the total percentage of soluble solid, total acidity percentage, phosphorous percentage and potassium percentage) were observed to be significantly lower after artificial *T. urticae* infestation compared to untreated controls. Infested plants were significantly smaller, had significantly fewer branches and fewer leaves that were significantly smaller while shoot fresh and dry weight was significantly lower compared to uninfested plants (Farouk and Osman, 2011).

Tehri et al. (2014) reported that *T. urticae* infestation showed corresponding decrease in the yield and fruit parameters of cucumber with increase in initial inoculum density, depicting negative correlation between mite population and various parameters recorded. The percent reductions of 6.15 to 12.42 in number of fruits, 0.59 to 1.56 in fruit length and 0.93 to 3.28 in fruit width at different inoculum of *T. urticae* were observed over uninfested plants. The cumulative effect of all these yield parameters influenced the ultimate reduction in average fruit weight from 10.16 to 17.19 percent in plants from lowest (5 mites/ grown up leaf) to highest (20 mites/ grown up leaf) number of mites released, respectively.

The coconut mite, *Aceria guerreronis* Keifer, attacks young fruits of the coconut palm, *Cocos nucifera*. Although the mites are small (the largest stage is around 250 µm in length), populations can be extremely large and their feeding can cause scarring and distortion of fruit, which may cause premature fruit drop. It is one of the most serious arthropod pests of coconut palm, whether grown as a crop tree or as an ornamental. The coconut mite is distributed in many tropical countries where coconuts grow. The vernacular name coconut mite has also been applied to both *Aceria trymatus* and *Raoiella indica* Hirst (Tenuipalpidae) in addition to *Aceria guerreronis*. The latter species, which is highly destructive to coconut palm foliage, is native to southern Asia but was recently found on several Caribbean islands and could be a threat to coconut palms in Florida and throughout the region (Navia et al., 2006).

The mites infest the abaxial (lower) surfaces of the perianth and the part of the fruit surface covered by the perianth. They penetrate between the tepals of the perianth and fruit surface a month after the fruit begins development; prior to this the tepals are too tightly appressed to allow entry of the mites. Presumably, a population is initiated by one or more fertilized females on the same or nearby plants.

The mites feed by piercing the superficial plant tissue and sucking the juices. A coconut mite develops from egg to adult in 10 days, so populations can build up rapidly, often producing thousands of mites in several aggregations on the same fruit. Massive populations of coconut mites may be present among the tepals and on the fruit surface beneath the perianth until about the sixth month of the coconut’s development after which populations decline. Coconut mites probably disperse...
from one palm to another on air currents or by phoresy (e.g. carried on insects or birds that visit palm flowers). Where coconut palms are dense, they can crawl from palm to palm. Their inefficient host-finding capabilities seem to be compensated for by a high reproductive rate. Globally, coconut occupies an area of 12 million hectares with a total production of about 56 billion nuts. India, Indonesia, Philippines and Sri Lanka are major coconut-growing countries, contributing 78 per cent of the total world production. Among the coconut producing states in India, Tamil Nadu ranks second in production. Coconut provides food, drink, medicine and altogether health to millions of consumers as well. This crop is attacked by various pests, of which, rhinoceros beetle, red palm weevil, leaf-eating caterpillar, etc. are important. Of late, incidence of nut infesting eriophyid mite, A. guerreronis has become a major problem in many of the coconut-growing countries. The mites infest and develop on the meristematic tissues of growing nuts under the perianth by desapping the soft tissues. Initial symptoms appear in the form of small, pale white or yellow, inverted triangular patches just below the perianth. As the feeding activity increases, it results in physical damage leading to necrosis. In the severely damaged condition, brown patches appear. As the nuts mature, longitudinal fissures and splits occur on the outer surface of the husk. Occasionally, brownish gummy exudate oozes out from the fissures of the nuts. Severe infestation leads to malformed nuts with hardened husk, resulting in reduced copra and fibre yield. Mites occur in large number in two to six months old buttons. Palms of all ages and nut colour are affected by this mite. All the coconut varieties/germplasms are susceptible to this mite. In the severely infested nuts, the husk becomes thick and hardened, making dehusking difficult, besides drastic reduction in fibre yield. The damage of husk extends to its hardening and losing of its fibrous characteristics, results in poor coir output, which has affected the coir industry. Reduction in the copra yield ranged from 15-42 percent in the severely damaged nuts. A loss of 40 percent in fibre yield has also been reported. Further, hardening of husk in highly damaged nuts cause 40 percent increased the time for dehusking. The effect of mite on quality aspects viz. reducing sugars, oil content and peroxidase value were compared in infested and un-infested nuts. The amount of reducing sugar in coconut water and kernel was found to be more in healthy nuts (nuts without any damage). The percent reduction in oil content in infested nuts compared to healthy ones did not show much variation. Increase in peroxidase value was observed in the infested nuts indicating that such nuts may quickly become rancid. As the oil becomes rancid, the amount of free fatty acid released from the oil increased which also acts as an indicator of rancidity. The quantity of reducing sugars and the acidity content were very low in the highly damaged nuts. There was drastic reduction in both quality and quantity of coir (Sharfon, 1997).

The broad mite, Polyphagotarsonemus latus, is a microscopic mite species found on many species of plants, including important agricultural. USDA-ARS identified it for the first time on watermelons in the U.S. in 2006 (Pons, 2007). Broad mites infest many ornamentals, including African violet, ageratum, azalea, begonia, chrysanthemums, cyclamen, dahlia, gerbera, gloxinia, ivy, jasmine, impatiens, lantana, marigold, peperomia, pittosporum, snapdragon, verbena, and zinnia (Baker, 1997). The mites are found in many areas
throughout the world and are major pests in greenhouses. *P. latus* has a world-wide distribution and is known by a number of common names. It is found in Australia, Asia, Africa, Europe, North America, South America, and the Pacific Islands. In India and Sri Lanka it is called the yellow tea mite, while those in Bangladesh call it the yellow jute mite. In some European countries it is called, broad spider. In parts of South America it is called the "tropical mite" or the "broad rust mite". This destructive pest causes terminal leaves and flower buds to become malformed. The mite's toxic saliva causes twisted, hardened and distorted growth in the terminal of the plant (Baker, 1997). Mites are usually seen on the newest leaves and small fruit. Leaves turn downward and turn coppery or purplish. Internodes shorten and the lateral buds break more than normal. The blooms abort and plant growth is stunted when large populations are present (Wilkerson et al., 2005). On fruit trees the damage is usually seen on the shaded side of the fruit, so it is not readily apparent. Fruit is discolored by feeding and in severe cases premature fruit drop may occur (Pena et al., 1996).

Apart from phytophagous mites, stored product mites have been known to infest dry pet food, baking mixes, grain products, dried vegetable materials, cheese, corn and dried fruits. They are difficult to see and often go undetected until their numbers are significant. Mites can damage or contaminate food products both qualitatively and quantitatively. They can cause grocer’s itch, a contact skin irritation, in humans exposed to the mites (Chambers, 2002). Mites may also trigger allergic reactions in people and pets. They prefer warm temperatures (80-90 degrees F) and high humidity. Stored product mites look like spongy brown dust. They can be found in pegboards, on the shelves, between bags or boxes of product and underneath storage racks. Many infestations start on the floor where dust and spillage often accumulates. Sometimes the surface of infested materials appears to move due to the enormous numbers of mites (barely visible to the unaided eye). A coating or pile of pale brownish “mite dust” may appear on open shelving, around the base of bags containing seeds, pet food, and other foods. Such piles consist of dead and living mites, cast skins and faeces. Sass (2006) showed that in a wet condition, mold mites in the 20 and 25ºC temperature range remained alive for 31 days with no food. Under moist conditions (12-18% moisture content, MC) and warm summer temperature, a generation can be completed in 8 to 21 days. As the temperature falls, the length of the life cycle increases greatly. The mold mite will breed readily above 30ºC. It is less tolerant to low temperature and cannot develop below 10ºC. However, in an inactive state, this mite can survive 0ºC. At favorable temperatures and 90 to 100% relative humidity, the female can lay an average of 437 eggs (Rodriguez and Rodriguez, 1997). The mold mite *Tyrophagus putrescentiae* is a pest of many foods, especially those having a high fat or protein content. It spreads secondary infections and lead to the formation of hotspots in the infested commodities. **Medical significance of Mites**

Chiggers are the juvenile form (larvae) of a certain type of mite of the family Trombiculidae found throughout the world. They most commonly live in forests, grassy fields, gardens, parks, and in moist areas around lakes or rivers. Most of the larvae that cause chigger bites are found on plants that are relatively close to the ground surface, because they require a high level
of humidity for survival. Although the harvest mite chigger usually does not carry diseases in North American temperate climates, *Leptotrombidium deliense* is considered a dangerous pest in East Asia and the South Pacific because they often carry *Orientia tsutsugamushi*, the tiny bacterium that causes scrub typhus, which is known alternatively as the Japanese river disease, scrub disease, or *tsutsugamushi*. Symptoms of scrub typhus in humans include fever, headache, muscle pain, cough and gastrointestinal disorders (Service, 2008).

Dust mites, sometimes called bed mites, are the most common cause of allergy from house dust. Dust mites live and multiply easily in warm, humid places. They prefer temperatures at or above 70 degrees Fahrenheit with humidity of 75 to 80 percent. They die when the humidity falls below 50 percent. They are not usually found in dry climates. Dust mite particles are often found in pillows, mattresses, carpeting and upholstered furniture. They float into the air when anyone vacuums, walk on a carpet or disturb bedding and settle once the disturbance is over. Dust mites are a common cause of asthma in children. A house does not need to be visibly dirty to trigger a dust mite allergy reaction. The particles are too tiny to be seen and often cannot be removed using normal cleaning procedures. In fact, a vigorous cleaning can make an allergic person’s symptoms worse. Dust mites feed on organic detritus such as flakes of shed human skin and flourish in the stable environment of dwellings. House dust mites are a common cause of asthma and allergic symptoms worldwide. The mite's gut contains potent digestive enzymes (notably proteases) that persist in their feces and are major inducers of allergic reactions such as wheezing (Overtvelt, 2006). The mite’s exoskeleton can also contribute to allergic reactions. The European house dust mite (*Dermatophagoides pteronyssinus*) and the American house dust mite (*Dermatophagoides farinae*) are two different species, but are not necessarily confined to Europe or North America; a third species *Euroglyphus maynei* also occurs widely (Brooks and Bush, 2009). The stored product mites such as *Acarus* sp., *Tyrophagus* sp., *Suidasia* sp., *Glycyphagus* sp., *Lardoglyphus* sp. and *Lepidoglyphus* sp. are also important source of allergens causing baker’s or grocer’s itch and stomach disorders, if ingested.

Scabies, also known colloquially as the seven-year itch, is a contagious skin infection caused by the mite, *Sarcoptes scabiei*. The mite is a tiny, and usually not directly visible, parasite which burrows under the host's skin, which in most people causes an intense itching sensation caused by an allergic response. The infection in animals other than humans is caused by a different but related mite species, and is called sarcoptic mange. The elderly and people with an impaired immune system such as HIV, cancer, or those on immunosuppressive medications, are susceptible to crusted scabies (Hay, 2009). On those with weaker immune systems, the host becomes a more fertile breeding ground for the mites, which spread over the host's body, except the face. Sufferers of crusted scabies exhibit scaly rashes, slight itching, and thick crusts of skin that contain thousands of mites (Hicks and Elston, 2009). Such areas make eradication of mites particularly difficult, as the crusts protect the mites from topical miticides, necessitating prolonged treatment of these areas. Mange is a class of skin diseases caused by parasitic mites reserved only for pathological mite-
infestation of nonhuman mammals. Thus, mange includes mite-associated skin disease in domestic animals (cats and dogs), in livestock (such as sheep scab), and in wild animals (for example, coyotes, cougars and bears). Parasitic mites that cause mange in mammals embed themselves either in skin or hair follicles in the animal, depending upon their genus. *Sarcoptes* sp. burrow into skin, while *Demodex* sp. live in follicles.

The most economically important of the many external parasites of poultry are mites of the families Dermanyssidae (chicken mite, northern fowl mite, and tropical fowl mite) and Trombiculidae (turkey chigger) (Axtell and Arends, 1990). *Dermanyssus gallinae* infests chickens, turkeys, pigeons, canaries, and various wild birds worldwide. These bloodsucking mites may also bite people. While rare in modern commercial cage-layer operations, they are found in breeder and small farm flocks. Chicken mites are nocturnal feeders that hide during the day under manure, on roosts, and in cracks and crevices of the chicken house, where they deposit eggs. Populations develop rapidly during the warmer months and more slowly in cold weather; the life cycle may be completed in only 1 week. A house may remain infested for 6 months after birds are removed. *Laminosioptes cysticola*, the fowl cyst mite, is a small cosmopolitan parasite of chickens, turkeys, and pigeons that is most often diagnosed by observing white to yellowish caseocalcareous nodules ~1-3 mm in diameter in the subcutis, muscle, lungs, and abdominal viscera. The larvae of *Neoschongastia americana*, the turkey chigger, are parasitic on numerous birds. Across the southern USA, they are the major pest of turkeys ranged on heavy clay soils in the summer. The chiggers feed in groups of as many as 100 mites per lesion for 8-15 days. Turkeys may have 25-30 lesions each. One lesion, 3 mm in diameter, may cause significant downgrading at market time (Axtell and Arends, 1990).

The hive of the honey bee is a suitable habitat for diverse mites (Acari), including nonparasitic, omnivorous, and pollen-feeding species and parasitoids. The common mite species inhabiting the hives include *Acarapis woodi, Varroa jacobsoni* and *Tropilaelaps clareae*. Varroa mites were first reported in Kentucky in the Bluegrass region of the Commonwealth in 1991. They have spread to and become a major pest of honey bees in many states since their introduction into Florida in the mid 1980's. About 90 percent losses have been reported in USA due to *A. woodi* infestation in bees (Sammararo et al., 2000). Varroa mites are external honeybee parasites that attack both the adults and the brood, with a distinct preference for drone brood. They suck the blood from both the adults and the developing brood, weakening and shortening the life span of the ones on which they feed. Emerging brood may be deformed with missing legs or wings.

Untreated infestations of varroa mites that are allowed to increase will kill honeybee colonies. Losses due to these parasitic mites are often confused with causes such as winter mortality and queenlessness if the colonies are not examined for mites. Visible symptoms of Varroa mite damage can be evident on newly-emerged bees due to feeding of mites on the immatures within the cell. The newly-emerged bees may be smaller than normal, have crumpled or disjointed wings, and shortened abdomens. The lifespan of the newly emerged bee is also reduced. Severe infestations of Varroa mites within the cell (5 or more foundresses) cause death of the pupa.
The end result of unchecked mite populations is an eroding adult bee population and eventual colony death. Mites develop on the bee brood. A female mite will enter the brood cell about one day before capping and be sealed in with the larva. Eggs are laid, mite feed and develop on the maturing bee larva. By the time the adult bee emerges from the cell, several of the mites will have reached adulthood, mated, and are ready to begin searching for other bees or larvae to parasitize. There is a preference for drone brood. Inspection of the drone brood in their capped cells will often indicate whether or not a colony is infested. The dark mites are easily seen on the white pupae when the comb is broken or the pupae are pulled from their cells. Mites spread from colony to colony by drifting workers and drones within an apiary. Honey bees can also acquire these mites when robbing smaller colonies. One of the serious problems caused by Varroa is the transmission of viruses to honey bees which cause deadly diseases. Viruses found in honey bees have been known to scientists for 50 years and were generally considered harmless until the 1980’s when Varroa became a widespread problem. Since then, nearly twenty honey bee viruses have been discovered and the majority of them have an association with Varroa mites, which act as a physical and or biological vector (Kevan et al., 2006). Therefore, controlling Varroa populations in a hive will often control the associated viruses and finding symptoms of the viral diseases is indicative of a Varroa epidemic in the colony. Many viruses can be directly transmitted by Varroa mites, such as: Deformed Wing Virus, those in the acute bee paralysis virus complex, and slow bee paralysis virus. Tracheal mites (e.g. *Acarapis woodii*) are microscopic internal parasites. The honey bee, *Apis mellifera*, and the Asian honey bee, *A. cerana*, are the only known hosts of this mite. They primarily infest the largest breathing tubes, or tracheae, near the base of the bee’s wings. They only infest adult honey bees. The mites feed by puncturing the walls of the tracheae and feeding on body fluids. Mites move from old bees to young bees that have just emerged from their pupal cells. Mite-infested bees have shorter life spans and a reduced ability to keep themselves warm during the winter months. These mites can cause winter die-offs of honey bee colonies if most of the adult bees become infested.

The mortality rate may range from moderate to high. Early signs of infection normally go unnoticed, except for a slow dwindling in the colony size. Only when infection is heavy does it become apparent. This is generally in the early spring after the winter clustering period when the mites have bred and multiplied undisturbed into the longer living winter bees. This applies mainly to the Northern Hemisphere where there are seasonal variations in the reproduction of bees. Infection spreads from one bee to another by direct contact. Generally, only newly hatched bees under 10 days old are susceptible (Giordani, 1970). The life span of the mites in dead bees is approximately 1 week. Reproduction occurs within the tracheae of adult bees, where female mites may lay 8-20 eggs. The mites in the genus, *Tropilaelaps* are parasites of honey bee brood. Feeding on bee larvae and pupae causes brood malformation, death of bees and subsequent colony decline or absconding. Development requires about 1 week, and the mites are dispersed on bees. There are at least four species in the genus Tropilaelaps. Each species is closely associated with a particular giant honey bee in Asia. Two species (*Tropilaelaps clareae* and
Tropilaelaps mercedesae) are damaging pests of Apis mellifera (Anderson and Morgan, 2007). Invasion of A. mellifera colonies by T. clareae appears to be more destructive than that by V. jacobsoni and some believe that T. clareae could become a more serious pest of honeybees worldwide than V. jacobsoni (Burgett et al., 1983).

Acarines as biocontrol agents

Predatory mites can provide natural pest control by eating unwanted pests. These beneficial mites are one way to maintain pest populations at non-damaging levels, known as biological control. By encouraging predatory mite populations, plants can be protected from excessive pest attack and damage. Predatory mites occur naturally in varied habitats from agricultural fields to small backyard gardens. It is best to encourage native populations through recognized conservation practices. These practices include scouting for pests and predators and using soft pesticides rather than broad-spectrum chemicals. Many beneficial species can also be purchased and released. It is crucial to choose the mite species appropriate for the environment. Most beneficial mites prefer higher humidity and lower temperatures. The predatory mites are very small (about 0.5 mm or 1/50 inch), typically requiring at least a hand lens to see them. The adults are teardrop-or pear-shaped arachnids with four pairs of legs. They do not have antennae, segmented bodies, or wings. Using a microscope, the piercing-sucking mouthparts can be seen sticking out in front of the head. Predatory mites can be purchased through commercial suppliers and they also occur naturally. Augmentation is the practice of timing the introduction of a fresh population of predators to help the current native population keep up with an observed or anticipated flare-up of a pest population. Inoculation is the practice of introducing predators into an area where the population is low or non-existent. Predator releases are more successful if early scouting has detected pests before the population gets too high. Several species of predatory mites can be purchased through commercial suppliers. The mites are typically combined with a carrier material, such as vermiculite, corncob dust, or sawdust. A light spray of water on the application area will help the mites and carrier material stay in place when they are applied to the infested area. It is best to apply them to the field, garden, or greenhouse as soon as possible to ensure their survival. To avoid extreme heat or cold that can decrease predator success, apply them in the early morning or late evening. Depending on the predatory species and the pest mite population level, recommendations are for a release of 2000-5000 predators per acre and should be released at first sign of mite infestation. Predatory mites can be successfully employed for the control of Brown Almond Mite (Bryobia rubrioculus), Mites (Tetranychus sp.), Spider Mite (Mult), Two-Spotted Spider Mite (Tetranychus urticae), mosquitoes, stored product insects, citrus thrips, scale insects, aphids, locusts, grasshoppers and beetles (Chhillar et al., 2007). Acarines feed on weeds that repress/ compete with agricultural crops causing yield reduction. The Acarine families Tetranychidae, Eriophyidae, Tarsonemidae and Galuminidae are associated with control of weeds such as narrah, bhakoo, karund, button weed, Calotropis etc. (Dhooria, 2003).

Mites in ecosystem services

Soil is a complex of living and non-living components which are present in different combinations. Small arthropods, including several groups of mites,
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contribute to the humus fraction and permit complexes of soil organisms to exist. Even though the role of mites in soil mixing may be small in comparison with that of larger invertebrates such as earthworms, insects, crustaceans and millipedes, mites exercise an important function in mineral turnover, vegetation succession and as decomposers of organic matter. Densities of 50,000-250,000 or more mites per square meter may be found in the upper layers of soil (Hoy, 2008). Dozens of species may be found in a small area when soil is rich in organic material such as decaying vegetation, dung or animal remains. In combination with microflora, which the mites may disperse, soil mites help in decomposing organic matter which they cannot digest. Mites exist in all soils in land with high species richness, abundance and diversity. As they are vulnerable to land use changes, soil mites are often used as a significant indicator of soil quality and soil health (Valerie, 1999; Ruf et al., 2003).

Soil is a fundamental resource base for maintaining environmental quality and providing for plant, animal, and human health (Hulsmann and Wolters, 1998). Soil quality and soil health describe the soil’s ability to perform these critical functions. With increasing attention being paid to soil quality and soil health, there has been growing interest in recent years on the impact of land use on soil mites (Peachey et al., 2002; Kinnear and Tongway, 2004).

The use of soil mites as indicators of soil quality and soil health may benefit greatly from the techniques and mass of information available about soil mites under different land uses. Considering the importance of soil mites in terms of indicating the quality and health of soil, determining the impact of land uses on the soil mite community is now a desirable scientific goal. There is evidence that the litter of stand floors is important to soil fauna. Bengtsson et al. (1998) examine the long-term effects of removing forest harvesting residues (above-ground whole-tree harvesting; WTH) in the soil food web, using data from two different experiments on slash removal and addition in Sweden (Ruf, 1998). Bengtsson’s results indicated that predators such as gamasid mites decreased by 30-50% after WTH. The removal of organic matter had fairly long-term effects on the soil food web. Removal of harvesting residues had negative effects on the abundance of animals at higher trophic positions and mobile animals. Soil animals are an integral part of the soil ecosystem and sensitive to the effects of land uses changes. Of all soil animal groups, soil mites are the best bio-indicator in terms of soil quality and soil health because of their relatively short lifespan, the ease of collecting them in the field and their sensitivity to land use changes. The relationships between land use and soil mites should be known, before soil mites are used to reflect the changes of land uses and in further indicate soil quality and soil health.

Environmental factors such as high soil organic matter content, proper soil moisture conditions throughout the year, soil temperatures without heat extremes in summer, nearly neutral pH levels, and low incident radiation due to plant cover are favorable conditions for soil mite development. It is well known and documented that a high soil organic matter content is usually beneficial for most soil animal groups (Andrén and Lagerløf 1983; Bandyopadhyaya et al., 2002), and that biodiversity is relatively strongly linked to available energy resources and essential nutrients (Pokarzhevskii and Krivolutskii, 1997). Generally, studies of mites in natural soils have mainly been conducted in forest soils.
For this reason, there are few adequate comparative studies reporting soil Acari abundance in natural soils in the vicinity of agroecosystems. Soil mites from windbreaks, hedges, uncultivated ditches, and grassy margins are poorly researched (Behan-Pelletier, 1999).

The most directly comparable study is that by Bedano and Cantú (2003), who reported a soil Acari population density of 35,000 individuals/m² from natural soil undisturbed for 40 years in the El Banado Basin located 40 km to the east of the La Colacha Basin. The Oribatida and Mesostigmata were the most-abundant taxa. Oribatida dominance is normally the case for temperate grasslands. This taxon generally maintains the highest numerical abundance followed by the Mesostigmata, Prostigmata, and Astigmata (Curry and Momen, 1988).

Conclusion

Acari are considered among the most successful arachnids of universal distribution. The science of Acarology is also steadily gaining the status of a branch of plant protection science concurrent with the development of Nematology and Entomology. Mites have gained considerable economic importance in the current scenario. Some species act as pests of agricultural produce and vectors/ causative agents of diseases in humans and other animals, while others act as biological control agents also aiding in ecosystem services. These good and bad mites need to be properly managed so as to avoid the devastating situations that may threaten the sustainability of agro ecosystems.

References


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