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Damage potential of *Tyrophagus putrescentiae* Schrank (Acari: Acaridae) in mushrooms

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Abstract

Tyrophagus putrescentiae Schrank (Acari: Acaridae), is one of the most serious pests of high protein food including mushrooms. It is known to feed and disperse various pathogenic fungi in stored grain and products. It causes economic losses in stored products in addition to allergic disorder in workers handling stored products. Understanding *T. putrescentiae* multiplication on *Agaricus bisporus* compost, fruiting bodies, its role in transmission of disease is of paramount importance for the standardization of control measures. Documentation of the population abundance and selection of best compost for white button mushroom farming would open up new scope for farmers. Considering the above facts, efforts have been made to assemble the available literature in this article.

Keywords abiotic factors, diseases, mushrooms, mites, *Tyrophagus putrescentiae*

Introduction

Tyrophagus putrescentiae is a cosmopolitan pest of significant economic and health importance. The various feeding patterns are observed due to differences in various food preferences. Schuster [1] and Kaneko [2] had classified mites on the basis of food preferences. Luxton [3] reported that due to mite feeding, colour of produce changes from shiny to dull which slowly turns into blackish. Food is chosen by an organism on the basis of cheliceral structure. Accordingly, organisms are classified as microphytophagous (consuming fungi, bacteria, and algae), macrophytophagous (consuming plant litter) and panphytophagous (consuming both food types with no visible selection). Smrz et al., [4] further reported that mites do not follow a single pattern, but rather they can be classified into several sub-patterns depending upon the digested fungal species, its parts and other food materials. *T. putrescentiae* feeds on mycelium and sporophores resulting in small irregular pits on stalk and caps [5-6]. According to Thapa and Seth [7], inoculated mites into spawn run compost destroyed the mycelium within 40 days. *Tarsonemus mycophagus* [8] was found to damage the mycelium of cultivated mushroom. *Oppia sp*. was reported to cause pin holes in mushroom cap and was responsible for the stunting of mushrooms. Pygmephorid mites were found to cause damage to mushrooms [9].

Pediculaster mesembrinae (Canestrini) was found to thrive well on weed moulds, but it was unable to feed and reproduce on substrate colonized by mushroom mycelium. However, the mites can indirectly injure mushroom culture by favoring the development of parasitic fungi *Trichoderma harzianum* and *T. viride* [10].

Biology of Mites on Mushroom

Tyrophagus putrescentiae an astigmatid mite, belonging to the family Acaridae, is widely distributed throughout the world [11-13]. The biology of this mite has been studied on stored grains, products, nematodes, mushroom etc. by various authors. The life cycle consists of the egg, larva, protonymph, tritonymph, and adult stages. The larvae have six legs, but the juveniles (protonymph, tritonymph) have four sets of legs like adult mites [14]. The adults and juveniles are oval in shape with creamish or translucent body. Sánchez-Ramos et al., [15] reported positive correlation between oviposition of *T. putrescentiae* and host type. However, Kucerová and Stejskal [13] recorded that the preoviposition and post oviposition period was not affected by the species of mushroom. The female lived at least 2 to 3 days after egg laying and had total longevity of 23.2 days on mushroom. Eggs were laid for about 19 days on mushrooms and developmental time from the egg to adult was about 14 to 16 days [16].

The prey preference of *Parasitus bituberosus* (Acari: Parasitidae) was studied by Szafranek et al., [17] and found that rhabditid nematodes, pygmephorid mites, sciarid and phorid fly larvae provided as food affected the development of this predator. The shortest egg to adult development time was obtained on a nematode diet. On a diet of phorid larvae, mite development stopped at the deutonymph stage; none reached adulthood. All other diets sufficed to reach the adult phase. Female fecundity was observed when fed nematodes and sciarid larvae did not differ, but it was much lower when fed on pygmephorid mites. Other life table parameters confirmed that pygmephorid mites constituted the worst diet for *P. bituberosus*. The highest intrinsic rate of population increase (rm= 0.34) was obtained on the nematode diet; when sciarid larvae and pygmephorid mites were fed and it was 0.25 and 0.14, respectively.

Mites as Pest in Mushroom

Several species of mite pests are associated with cultivated mushrooms worldwide [18-22]. Mite infestation in mushroom has been reported from China [23-24], Denmark [25], India [26-27], Irish Republic, Japan [28], Korea [29], North America [30], Taiwan [9] and Turkey [31].

In India, mites in cultivated mushrooms are reported from Delhi [32], Himachal Pradesh [7], Punjab [33], West Bengal [34] and Haryana [27]. Gupta and Gupta [26] gave a comprehensive review on mites associated with mushrooms. Among the mites occurring in mushroom houses, species from the Acaridae, Tarsonemidae, Siteroptidae and Histiostomatidae were mentioned as economically important species [35]. Among the Astigmatid mites, *Caloglyphus mycophagus* [5], *Histiogaster sp*. [36], *Histiostoma sp*. [37], *Rhizoglyphus echinopus* [8, 29, 37], *Schwieba sp.* [38], *Tyroglyphus dimidatus* and *Tyrophagus putrescentiae* were found to be associated with cultivated mushrooms. Most of these mites feed on wild fungus (contaminants in cultivated mushrooms) and help in dispersal of their spores [39]. These wild fungi act as competitive fungi in cultivated mushroom beds thus affecting the overall yield [38]. There are some reports that suggested that Dipteran flies act as vectors for Astigmatid mites [19]. Among Cryptostigmatid mites, *Oppia sp*. is associated with cultivated mushrooms.

Mites of Mesostigmata constitute a major acarine fauna in mushroom houses. *Hypoaspis sp.* [40], *Parasitus sp*. [33, 41-42], *Prodinchus fimicolus* [33], *Bakerdania sp.* [33] were found associated with edible fungi. These are predators of dipteran flies, spring tails, other mites and nematodes. *Stratiolaelaps scimitus* (Womersley) was evaluated for controlling the populations of the sciarid fly *Bradysia matogrossensis* and fungus gnats in commercial production of *Agaricus bisporus* [43].

In Poland, occurrence of 19 mite species belonging to eight families was reported. Among them, 11 predatory species were from four families: Macrochelidae, Eviphididae, Ascidae and Rhodacaridae [44]. Parasitus consanguineus (Oudemans and Voigts) was found in a few Polish mushroom houses. This species was first found in mushroom houses by Gill et al., [33]. Another species of the Parasitidae family, Parasitus bituberosus Karg, was noted in cultivated mushroom beds by Binns [45] and Al-Amidi and Downes [46].

Luciaphorus sp. (Acari: Pygmephoridae) is considered as one of the most destructive pests of mushroom cultivation in Thailand. This pygmephorid mite is responsible for the severe production losses of

Lentinus squarrosulus (Mont.) Singer, *L. polychrous* Lev., *Auricularia auricula-judae* (Bull.:Fr.) Wettst and *Flammulina velutipes* (Curt.:Fr.) Karst mushrooms in the Northeast of Thailand [47].

Seasonal Incidence and Influence of Abiotic Factors

Mushroom mycelial growth and mushroom development is not only related to genetic factors but also depends on abiotic factors [48]. Abiotic factors like temperature, relative humidity and rain fall are found to influence the mite populations in mushroom houses. According to Snetsinger [49], generation time for *Siteroptes mesemberinae* was halved from 8 days to 4 days when the temperature was increased from 15 to 25ºC. Clift and Toffolon [19] reported that *S. mesemberinae* swarmed earlier in *A. bitorquis* than in *A. bisporus*. The biology and reproductive rates of *T. putrescentiae* have been studied under different temperatures and humidities and on different feeding sources [14, 50-53]. The life cycle of *T. putrescentiae* decreased significantly with an increase in temperature. The length of the full life cycle of the mites was shortest at 300°C (9.26 days), whereas it was longest at 200°C (20.64 days) [72]. Das et al., [37] reported the incidence of mites in sequence with the appearance of *R. echinopus* during January to March as this prefers mild climatic conditions. This mite was unable to withstand high temperature beyond 35ºC. After its disappearance, *T. dimidatus* appeared from April to June when the temperature was 33ºC. Gill et al., [33] also reported the presence of mites from September to March on temperate mushrooms and April to August on Oyster mushrooms. During winter season, a fall in mite number was reported by these authors. With the change in season, fluctuation in mite densities and succession has been noticed by many workers [55-56].

Clift and Terras [57] developed a simulation model based on various environmental factors for forecasting the pest populations in cultivated mushrooms. Temperature and relative humidity affected the population of Pygmephorid mite, *Luciaphous hauseri* [23]. *Histiogaster* sp. grew when the temperature ranged between 25 to 30°C. The mite was found to be absent when the temperature falls down to 15°C [28]. Eraky [58] reported the intrinsic rate of increase in mite population was lower in mushroom as compared to nematodes. Nematodes become more successful host for *T. putrescentiae* than mushroom [16].

Quantitative and Qualitative Losses due to Mites in Mushroom

T. putrescentiae feeds on mycelium and sporophores resulting in small irregular pits on stalk and caps [5-6] and Clancy [5] reported *T. putrescentiae* as most damaging mite species in mushrooms.

Outbreaks of mites cause serious damage to mushroom production worldwide [23, 59-61]. According to Broekhuizen [62], mites are most damaging pests of mushroom. *Rhizoglyphus echinopus* was found to feed on decaying mushroom [8], while *R. phylloxera* causes severe damage at fruiting stage. *Tarsonemus mycophagus* is major pest of mushroom in UK and Japan. *Histiostoma heinemanni* and *R. echinopus* prefer the bud stage of the crop inflicting 64.83 and 62.84 per cent reduction in yield, respectively. They rated mites as one of the most serious problems on mushroom farms. Feeding behavior and nature of damage varied with different mite species.

Histiogaster species failed to develop on *Lentinula edodes*, however, *Rhizoglyphus* species and *Histiostoma* species damaged the lamella of *L. edodes*. *Tyrophagus putrescentiae* and *Oppia* species cause numerous dark brown pin holes in the Velum and cap and *Oppia* sp. was observed to be responsible for the stunting of mushrooms. *T. myceliophagus*, *T. confuses* and *T. floreicolus* occur in thousands on mushroom body and the affected tissue becomes reddish while base and stalk turn brown in color [35]. According to Wicht [59], *Pygmephous* sp. feed on mushroom mycelium below the casing layer.

T. putrescentiae and *Caloglyphus mycophagus* were found to feed on the mycelium and destroy the grain spawn before the impregnation of the compost [5]. Former has been found to be the most damaging mite in Himachal Pradesh and adjoining areas. According to Thapa and Seth [7], these mites when inoculated into spawn run compost in bottles and kept at 27ºC, destroyed the mycelium within 40 days. According to Das [37], infestation by *Rhizoglyphus achinopus*, *Tyroglyphus dimidatus*, and *Histiostoma heinemanni* produced specific type of symptoms characterized by change in shape, size and color of mushrooms and out of these *H. heinemamni* was found to be most serious inflicting nearly 90 per cent loss in yield. *Brennandania lambi* is the most serious pest of mushroom in China and has been found to feed on mycelia of *A. auricula*, *Hericium erinaceus*, *Tremella fuciformis* and *A. bisporus*. *Lecanicillium fungicola* causes severe infections that result in significant crop losses [63].

Simultaneous infestation of *P. mesembrinae* and *Histiostoma feroniarum* (Dufour) resulted in 20–40 percent reduction in mushroom yield [57]. Symptoms that can be noticed after their feeding are bare patches or sunken areas of bed. Fortunately, these species are not as common in the mushroom environment as bacterivorous rhabditid nematodes. Presence of the mites in the compost delayed development of mushroom mycelium [64].

Mites as Vector of Diseases

T. putrescentiae, a common mushroom pest was reported as an important vector of dispersing weed fungi throughout mushroom cultivation facilities [65]. These include *Fusariurm* sp., *Alternaria* sp., *Geotrichum* sp., *Mucor* sp. and *Trichophyton* sp. Gazeta et al., [66] recorded an association between *T. putrescentiae* and other microorganisms, such as *Klebsiella* sp., *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Candida albicans*. Red pepper mites are often associated with the green mould disease. The causative agent is *Trichoderma* which serious losses in *A. bisporus* [10]. In the early 1990s, a similar disease appeared in mushroom crops in North America causing losses of more than $ 30 million [67-68]. Mushroom cultivation is also affected by Bacterial blotch disease caused by *Pseudomonas tolaasi* [67]. The main source of bacterial blotch in the mushroom farm is the casing soil. Mushroom flies and mites also spread the disease. Seriously diseased mushrooms can become deformed and the caps can decay giving a foul (unpleasant) odour. Young pins affected by the disease become brown and do not further develop [68]. Kredics et al., [69] also reported Green mould as a major problem in button mushrooms, which gains entry through contaminated personnel and equipment. Mushroom is farmed under ambient conditions designed to suit its growth, but can be found in all highly humid regions between spring and autumn [70]. It grows mainly on substrates that must be partly decomposed so that they are free of soluble sugars conducive to the growth of mould and bacteria [71]. Various factors then induce the mycelium to produce fruiting bodies under controlled climate conditions [72-73]. Mushrooms were originally grown in caves, but the process has gradually shifted to climate-controlled chambers where growing conditions can be controlled. This entails energy consumption andrequires cooling systems [74]. It hampers the yield [75-76].The mycopathogen adheres to and penetrates A. bisporus during any stage of fruiting body development causing either the characteristic undifferentiated lumps of primordia or the fruiting body's color changes to brown. These tumorous bodies are covered with wet bubbles, white and fluffy mycelium, and amber droplets [77-78]. In commercial cultivation, *M. perniciosa* can commonly causes yield losses of about 15–30 percent once WBD develops. Mites can affect fungi by grazing, and they may be integrally involved in the dominance of mycotoxigenic fungal species due to their role in dispersal of fungal spores and also influences the increased of aflatoxin production from the fungus [79-80].

Susceptibility of Compost

Mushroom substrate based on peat, manure and straw may constitute a perfect environment for *P. bituberosus* (Hyatt). In mushroom beds, various kinds of food can be found, such as nematodes, saprophagous and mycophagous mites, springtails, and dipteran larvae of the families, Sciaridae, Phoridae and Cecidomyiidae [35, 47, 81].

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