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Development and Life Table of *Tyrophagus putrescentiae* (Astigmata: Acaridae) on Mushroom and Phytonematode

[1]*Hajar Pakyari and* [2]*Mona Maghsoudlo*

[1]Department of Plant Protection, Faculty of Agriculture, Islamic Azad University, Takestan Branch-Iran
[2]Department of Plant Protection, Faculty of Agriculture, Islamic Azad University, Gorgan Branch-Iran

Abstract: The life table parameters and development of an acarid mite, *Tyrophagus putrescentiae* on mushroom, *Pleurotus ostreatus* and phytonematode, *Ditylenchus destrutor* were investigated at 25±1°C, 60±5% r.h. and a photoperiod of 16:8 (L:D) h. *T. putrescentiae* had a significantly shorter developmental time when reared on phytonematode compared with mushroom. The pre-oviposition and post-oviposition period was not affected by the species of mushroom and nematode, but the oviposition period showed significant changes and female longevity was affected by host type. The net reproductive rate (R_0) for *T. putrescentiae* when reared on mushroom was 20.50 and the intrinsic rate of increase (r_m) was 0.10 which were significantly different from the 22.28 and 0.16, respectively, when reared on nematode. The doubling times were 6.9 and 4.15 days for the mushroom and nematode, respectively.

Key words: *Tyrophagus putrescentiae* · Life table · Development · Mushroom · Phytonematode

INTRODUCTION

The mould mite, *Tyrophagus putrescentiae* (Schrank), has a worldwide distribution and is found in a variety of habitats including stored products, cultivated mushrooms, plant seeds, greenhouse, soil and nests of different animals [1-3]. This species feed on decaying organic material in the soil and can damage stored produces [4]. A fall in the quality of the grain, its germination and its hygienic condition are observed to be the most serious effect of mite infestation [5]. In addition, this species is also considered to have an important impact on health and medicine. Solarz and Solarz [6] investigated the allergic mites in dust and debris samples from 135 coal-mines and found most of them to be *T. putrescentiae*.

The mould mite is also a common mushroom pest and an important vector of weed fungi throughout mushroom cultivation facilities [3, 7]. *T. putrescentiae* feeds different fungi including moulds (*Eutorium* and *Penicillium*), *Fusarium*, *Alternaria*, *Geotrichum*, *Mucor* and *Trichophyton* [8-12]. It is an unpleasant pest that cause damage in fungal cultures, the use of this species in biological control may be considered in the future [13]. This mite has also been reported in house dusts based on the examination carried out in Caracas and Venezuela, *T. putrescentiae* was occasionally a large contributor to the bedding dust fauna. It is recommended that sensitivity to this mite should be routinely examined in house-dust-sensitive patients [14]. Terrestrial mites play roles in fragmentation of litter, soil formation, nutrient cycling, dispersal of microbes, and stimulation of the soil microflora (bacteria and fungi) by grazing.

Gazeta *et al.* [15] demonstrated an association between *T. putrescentiae* and pathogenic bacteria and other microorganisms, such as *Klebsiella* sp., *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Candida albicans*. In their researches, when agar mediums were infested artificially with these mites, 100% of the plates developed bacterial colonies. The bacterial association of *T. putrescentiae* was also studied by Smarz [16].

A second level of indirect regulation results from predation on other microarthropods and nematodes [17]. Nematodes are probably the most abundant multicellular animals that inhabit virtually every environment on earth and are found in oceans, fresh water, and soil [18]. Various studies have evaluated nematophagous mites as to their potential in the biological control of phytonematodes [19-24]. Imbriani and Mankau [19]

Corresponding Author: Hajar Pakyari, Department of Plant Protection, Faculty of Agriculture, Islamic Azad University,Takestan Branch-Iran.

demonstrated that the mesostigmatid mite, *Lasioseius scapulatus*, fed voraciously on nematodes and drastically reduced *Aphelenchus avenae* populations. Sell [22] reported that *Sancassania* (=*Caloglyphus*) sp. Fed the root-knot nematodes *Meloidogyne* spp., and Walia and Mathur [23] found that two nematophagous mites, *Tyrophagus putrescentiae* and *Hypoaspis calcuttaensis*, were voracious feeders of nematodes consuming as many as 726 and 811 juvenile *Meloidogyne javanica* (Treub), respectively.

The objective of this study was to monitor the development of *T. putrescentiae* fed commercially produced mushroom *Pleorotus ostreatus* and phytonematode, *Ditylenchus destrutor*. Specifically, we wanted to determine that mushroom or nematode could greater influence on the population growth of *T. putrescentiae*.

MATERIALS AND METHODS

The experiments were conducted in the laboratory at 25 ± 1°C and 60 ± 5% r.h. and a photoperiod of 16L: 8D h. During the summer of 2010, samples of *Tyrophagus putrescentiae* were collected from mushroom compost beds at Tehran, Iran. A mite-rearing cage was designated for the present study in order to rear mites individually. Glass plates having four holes 10 mm in diameter were used as rearing cages. Paper tape was used to cover the holes. To culture *Ditylenchus destructor*, eggs were first extracted from roots of infected tomato plants [25] and subsequently left for three days to hatch at 25°C. Second-stage (J_2) juveniles were then collected daily using the Baermann-type extraction technique, adapted for a glass plate [26]. *Pleorotus ostreatus* and *D. destructor* were cultured on a water-agar medium in these rearing cages. *T. putrescentiae* females from stock culture were introduced into a new Petri dish containing of *P. ostreatus* and *D. destructor* and allowed to lay eggs for 24 h. Then 50 newly deposited eggs were removed and isolated in separate cells and the developmental stages were recorded every 24 h. The survival was determined for each developmental stage as well. After adults emergence they were paired (each pair (1♀ + 1♂) was placed into a separate rearing cage) for mating. Longevity of adult males and females was recorded and the number of deposited eggs counted every day until the last female died. The newly laid eggs were removed every day from rearing cages for better counting. Fresh food was added if necessary. Daily schedules of mortality and fecundity were integrated into a life table format [27] that was used to calculate net reproductive rate (R_0), mean generation time (T_c), and intrinsic rate of increase (r_m). A jackknife technique [28] was used to calculate the variance of the r_m and other estimates for the life table parameters.

RESULTS

Average immature development times of *Tyrophagus putrescentiae* on mushroom and nematode are shown in Table 1. The time from egg to adult, was about 16 and 14 days on mushroom and nematode, respectively. Significant differences were observed in the development times of the different immature stages but larvae and protonymph stages were insignificantly.

Length of pre-oviposition, oviposition and post-oviposition periods, and longevity for females was tested on mushroom and nematode (Table 2). The females lived at least 3 and 2 days after egg-laying and had total longevity was 23.2 and 18.99 days on mushrooms and nematode, respectively. The oviposition period was the longest stage of the reproductive period and was significantly greater on mushroom. The length of pre-oviposition and post-oviposition periods was not affected by the species of mushroom and nematode (P>0.05), but the oviposition period showed significant differences on the two hosts. Eggs were laid for about 19 days on mushroom, significantly higher than for nematode.

The demographic parameters for the two host species are given in Table 3. The intrinsic rate of increase (r_m) and the net reproductive rate (R_0)

Table 1: Mean development times and survival rates of different stages of *T. putrescentiae* reared on mushroom and nematode

Stage	Mushroom	Nematode
Egg	4.32±0.43^a	2.87±0.39^b
Larvae	4.51±0.36^a	3.04±0.34^a
Protonymph	4.08±0.39^a	3.13±0.43^a
Tritonymph	2.96±0.41^a	5.05±0.36^b
Total	15.87±0.57^a	14.09±0.52^b

Mean followed by different letters in the same row are significantly different (P< 0.05, N=50).

Table 2: Pre-oviposition, oviposition and post-oviposition periods and female longevity (day±SEM) of *T. putrescentiae*

Stage	Mushroom	Nematode
Pre-oviposition	2.2±0.20^a	2.06±0.23^a
Oviposition	18.5±0.05^a	14.89±1.12^b
Post-oviposition	2.5±0.35^a	2.04±0.80^a
Female longevity	23.2±0.90^a	18.99±1.10^b

Different letters in the same row indicate significant differences (P<0.05) between the two types of host.

Table 3: Demographic parameters (±SEM) for *T. putrescentiae* reared on mushroom and nematode

Parameters	Mushroom	Nematode
Intrinsic rate of increase (r_m)	0.10±0.0084[b]	0.16±0.0097[a]
Net reproductive (R_0)	20.50±0.040[b]	22.28±0.05[a]
Mean generation time (T_c)	24.60±0.02[a]	18.16±0.017[b]
Doubling time (D_t)	6.90±0.04[b]	4.15±0.02[a]
Finite rate of increase (λ)	1.10±0.0008[a]	1.17±0.00007[a]

Different letters in the same row indicate significant differences (df= 46, P<0.05) between values on the two hosts.

were higher when reared on nematode. From these values, the population doubling times (D_t) on mushroom and nematode were 6.90 and 4.15, respectively. The finite rate of increase (λ) was 1.10 and 1.17, respectively. The mean generation time (T_c) was 24.60 days on mushroom, compared with 18.16 days on nematode. This shows that all the demographic parameters except the finite rate of increase were food-dependent.

DISCUSSION

This study provides population parameters and demographic data of *Tyrophagus putrescentiae* on mushroom and nematode under the above-mentioned laboratory conditions. Biological data can be easily used in population development models and also for developing control strategies [29]. Total development times varied from approximately 14-16 days when *T. putrescentiae* was reared on mushroom and nematode.

Host type significantly affects oviposition period as well as female longevity, with significantly higher durations when reared on mushroom. Other studies have also observed the effect of host types on the reproductive characteristics of *T. putrescentiae* [30, 31]. Female longevity increased when mould mites were fed on *Fusarium oxysporum* f.sp. tulipae (Apr.) and *F. oxysporum* f.sp. lilii (Fol.) [7] when contrasted with data from button and oyster mushrooms studied here. The reproductive data indicated significant differences in the two host types. The effect of two host types on oviposition period of *T. putrescentiae* was reflected in significant differences in longevity of females, concurring with the generally observed tendency within *T. putrescentiae* for a positive correlation between host type and duration of oviposition [30, 32].

This study demonstrates that host has a pronounced effect on the biological characteristics of *T. putrescentiae*. All demographic parameters except the finite rate of increase were significantly different on mushroom and nematode. The intrinsic rate of increase (r_m) was higher on button mushroom than was studied earlier by Eraky [31]. An intrinsic rate of increase on mushroom was lower than those reported by Czajkowska [7]. This demonestates that *Fusarium* appeared to be a more appropriate host for *T. putrescentiae* than mushroom. A net reproductive rate (R_0) was 20.50 on mushroom, which were different from the rates reported by Eraky [31] and Czajkowska [7]. These differences can mainly been attributed to different host [7, 33], to different experimental conditions [36, 37] and probably to different mite strains [30, 31]. The mean generation time (T_c) and population doubling time (D_t) increased when *T. putrescentiae* was reared on mushroom. These values decreased when they were reared on *F. oxysporum* f. sp. tulipae (4.15 and 2.39, respectively) [7]. Survival of immature stages and total life span were higher on mushroom than on nematode. Quantitative data on the predation of phytonematodes by mites were obtained mostly in laboratory studies [19, 36-38, 23]. The suitability of *Ditylenchus destructor* as prey for *T. putrescentiae* has not been examined before. That predation of *T. putrescentiae* on major phytonematode species can be considerable was confirmed in this study. The use of *T. putrescentiae* as biocontrol agents of pest nematodes, at least in greenhouses and under other favorable environmental conditions, should therefore be investigated in complementary studies. Our results also indicate that, in common with reports for some microbial antagonists, mostly fungi and bacteria, nematode predators may play an important part in the expression of so-called "nematode suppressive soils".

The data presented here provided some of the fundamental information required to understand the life table parameters are affected significantly by host type. The rapid generation time and high reproduction capacity of *T. putrescentiae* on *D. destructor* suggest that it could be an important host affecting mould mite population growth. Muraoka and Ishibashi [39] were able to rear another acarid, *Caloglyphus* sp., on nematodes, and to demonstrate larger populations of the mites in soil microcosms when nematodes were present, than when nematodes were absent. If *T. putrescentiae* actively consume nematodes during both their active and inactive stages, they may be an important regulator of grassland nematode populations. Therefore, more studies are needed to determine the effect of environmental factors on biology of *T. putrescentiae*.

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