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Certain biological aspects of the copra mite, *Tyrophagus putrescentiae* (Schrank, 1781) (Acari: Acaridae), extracted from termite nests

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Abstract

Several biological aspects and life table parameters of *Tyrophagus putrescentiae* (Schrank), commonly known as the copra mite, were studied at a temperature of 30± 2°C and relative humidity of 45 ± 5%. The mites were reared on different food diets including yeast, wheat germ, and wheat flour. The findings revealed that *T. putrescentiae* successfully completed its life cycle when fed on all three diets. Both male and female mites exhibited the longest life cycles on wheat flour, with durations of 9.71 and 9.95 days, respectively. Conversely, the shortest life cycles were observed when the mites were fed on wheat germ, with durations of 6.31 and 6.85 days for males and females, respectively. The *T. putrescentiae* female demonstrated the longest lifespan of 29.53 days when fed on wheat flour, whereas the shortest lifespan of 21.30 days was recorded when fed on yeast. The highest average total fecundity was observed on yeast, with a value of 391.5 eggs / female and a daily rate was 19.29 eggs/ female / day. The sex ratio, expressed as a percentage of females to the total population, ranged from 50 to 60%. The intrinsic rate of increase (rm) was the highest on yeast, with a value of 0.367 individuals / female /r day, while the lowest value of 0.187 individuals / female / day was recorded on wheat flour. The mites exhibited the ability to double their population in the shortest time (1.88 days) when provided with yeast as their food source, whereas the longest doubling time (3.70 days) was observed on wheat flour. In conclusion, previous studies have shown the ability of this species to coexist in a wide range of environmental conditions and the ability to feed on a wide range of foodstuffs, in addition to its high fecundity, which causes a lot of damage where it is found. In the other side, the current study demonstrated that yeast resulted in the highest fecundity among the mites, suggesting its potential use for mass production of *T. putrescentiae*.

Key words: Acari, Acaridae, biology, life table, the copra mite, *Tyrophagus putrescentiae*, diets.

INTRODUCTION

About 400 species pertaining to 90 genera in the large and widely distributed family Acaridae are known, with many more still to be identified, particularly in the tropical regions (Zhang, 2003). Some of the Acarididae species are found in the bodies or nests of both vertebrate and invertebrate animals. They can also be found in the topsoil and leaf litter of organic-rich soils (Gerson et al., 2003). *Tyrophagus putrescentiae* is a significant species in the Acaridae family, commonly known as the mold mite, and it inhabits various habitats in subtropical and tropical regions (Zhang, 2003 and Colloff, 2009). This mite has the ability to develop and reproduce within a wide range of temperatures (10–34 °C) and relative humidity (60–100%). It utilizes complex food resources (Duek et al., 2001, Osman et al., 2016; Hubert et al., 2004, Ramos and Castañera, 2001, Ramos and Castañera, 2005). *T. putrescentiae* is the most abundant and prevalent mite species found in organic materials, cereal-based food products, soil, plant roots, and it feeds on various stages of insect development, including eggs (Eraky, 1992a and b; Papadopoulou, 2006; and Kheradmand et al., 2007). This mite is commonly found in habitats with high humidity (Walter et al., 1986; Brust and House, 1988). Furthermore, it is considered a pest of stored food items (Ramos and Castañera, 2001). However, it has been observed that *T. putrescentiae* also feeds on nematodes and insects that reside in the soil (Walter et al., 1986; Bilgrami, 1994; Walia and Mathur, 1995). According to Okabe et al. (2001) and Czajkowska (2002), *T. putrescentiae* is a common pest mite in mushroom cultivation and plays a significant role in spreading weed fungus within mushroom farming facilities. Rack (1984), Smarz and Catska (1987), Duek et al. (2001), and Hubert et al. (2004) have reported that this species also consumes various fungi, including molds (Eutorium and Penicillium), Fusarium, Alternaria, Geotrichum, Mucor, and Trichophyton. The aim of the work herein was to study the life table parameters and biological characteristics of *T. putrescentiae* when fed on different diets of food

MATERIALS AND METHODS

In the present study, the *T. putrescentiae* adult and immature stages were extracted from termite nests at Al-Kawther farm, Faculty of Agriculture, Sohag University**.** The mite individuals were extracted by using modified Berlese's extractor apparatus. The stock culture of the mite was obtained by placing the mite stages in Petri dishes (9 cm in diameter) with wetted filter paper and enough food. The dishes were kept under laboratory conditions. Large populations were developed in these culture dishes in 20-30 days. For all experimental work, particular kind of plastic cell was utilized, which contained a floor plaster consisting of soil, plaster, and charcoal in a 2:1:1 ratio. The rearing cell which had a 1.5 cm diameter and a 2 cm depth-were employed. Each cell had a plastic cover to keep mites from getting out. Water droplets were added to the Paris floor's plaster as needed to maintain moderate level of moisture. Based on the type of food, three main groups of rearing cells were used to house the acarid cultures. Yeast was given to the first group, wheat germ to the second, and wheat flour to the third. Each group was kept at a temperature of 30 ± 2°C and 45 ± 5% relative humidity in the laboratory, and their eggs deposition were checked twice a day. Single deposited eggs were moved from the cultures into tiny cells. The newly hatched larvae were fed on the three types of food, and the duration of the incubation period was noted.Young males eating the same food were exposed to newly emerged females throughout their life; observations about its development were made twice a day. Each experiment began with a minimum of fifty newly hatched larvae. The number of eggs laid by a single female were recorded, in addition to the sex ratio and the female survival rate.

Statistical analysis:

Data were analyzed using one way analysis of variance (ANOVA), and the means were separated using Duncan's Multiple Range Test. Life table parameters were estimated according to (Birch 1948) using the Life 48, BASIC Computer programmed (Abou-Setta *et al*., 1986).

RESULTS AND DISCUSSION

The present study was conducted to focus on the effect of some food stuff: yeast, wheat germ and wheat flour on the main biological aspects of the copra mite, *T. putrescentiae* under laboratory conditions.

1. Developmental stages incubation:

The data presented in Table (1) revealed that varying diets had distinct effects on the duration of the egg stage in *T. putrescentiae* (F = 129.6, P = 0.0001). The longest incubation period was observed when individuals were fed with wheat flour (3.73 days), followed by yeast (2.75 days), while the shortest period (1.62 days) was recorded when the mites were fed on wheat germ. Similarly, *T. putrescentiae* male exhibited the longest incubation period when fed with wheat flour (3.73 days), whereas the shortest period (1.54 days) was observed when the mites were fed on wheat germ, demonstrating significant differences.

2. Life cycle:

The impact of different food sources on the life cycle of *T. putrescentiae* female can be summarized in Table (1), which illustrates that the average durations were 7.66, 6.85, and 9.95 days when fed on yeast, wheat germ, and wheat flour, respectively, with significant differences. However, these durations changed to 7.03, 6.31, and 9.71 days when the male mites were fed on the same sequence of food sources, respectively (Table 2). All immature stages exhibited long durations when fed on wheat flour, while the shortest durations were observed when fed on yeast, demonstrating significant differences. These results were slightly shorter than those reported by Yassin et al. (2018), where the life cycles of female of the copra mite, *T. putrescentiae* were 11.48, 11.84, and 12.2 days when fed on wheat flour, rice flour, and pure wheat at 25°C.

3. Longevity:

Regarding the longevity of adults, Tables (1 and 2) showed variations in the longevity of male and female of *T. putrescentiae* when they fed on different food types. The average longevity for females was 21.30, 21.74, and 29.53 days when fed on yeast, wheat germ, and wheat flour, respectively. For males, the average longevity were 24.70, 23.28, and 32.06 days when fed on the same food sources. In a study by Das and Das (2020), the average longevity of male *T. putrescentiae* was 23.11 ± 2.44 days on wheat flour and 17.25 ± 0.65 days on rice flour, respectively. The average longevity for females was 28.44 ± 2.82 days on wheat flour and 39.45 ± 3.20 days on rice flour.

Table (1): Mean duration (days) of *T. putrescentiae* females reared on three different diets of food

Developmental stages		Yeast	Wheat germ	Wheat flour	L.S.D	F–Test	Probability
Incubation period		2.75±0.33 b	1.62±0.36 c	3.73±0.13 a	0.26	129.6	0.0001
Larva	A.	1.79±0.07 a	1.43±0.13 b	1.71±0.14 a	0.10	26.87	0.0001
	Q.	0.55±0.05 a	0.54±0.05 a	0.52±0.08 a	0.05	0.60	0.5560
Protonymph	A.	0.62±0.06 c	0.79±0.07 b	1.30±0.08 a	0.06	233.2	0.0001
	Q.	0.49±0.06 a	0.54±0.05 a	0.52±0.08 a	0.05	1.57	0.2267
Tritonymph	A.	0.90±0.08 c	1.28±0.08 b	1.52±0.08 a	0.07	153.4	0.0001
	Q.	0.56±0.05 b	0.65±0.05 a	0.65±0.05 a	0.04	9.85	0.0006
Total immatures		4.91±0.14 c	5.23±0.2 b	6.22±0.20 a	0.17	127.73	0.0001
Life cycle		7.66±0.40 b	6.85±0.34 c	9.95±0.23 a	0.30	234.69	0.0001
Generation period		8.17±0.41 c	8.57±0.34 b	11.98±0.3 a	0.31	367.8	0.0001
Adult longevity		21.30±1.9 b	21.74±2.2 b	29.53±1.7 a	1.81	55.03	0.0001

A. = Active stage, Q. = Quiescent stage
Means followed by the same letter in the same raw are not significantly different at the 0.05 level.

Table (2): Mean duration (days) of *T. putrescentiae* males reared on three different diets of food

Developmental stages		Yeast	Wheat germ	Wheat flour	L.S.D	F–Test	Probability
Incubation period		2.72±0.32 b	1.54±0.35 c	3.73±0.12 a	0.25	151.5	0.0001
Larva	A.	1.64±0.11 a	1.42±0.13 b	1.71±0.14 a	0.11	14.41	0.0001
	Q.	0.50±0.07 a	0.54±0.05 a	0.52±0.08 a	0.06	0.90	0.4184
Protonymph	A.	0.55±0.05 c	0.70±0.08 b	1.16±0.13 a	0.08	119.1	0.0001
	Q.	0.44±0.05 b	0.56±0.05 a	0.55±0.05 a	0.04	16.40	0.0001
Tritonymph	A.	0.71±0.07 c	0.90±0.08 b	1.39±0.07 a	0.07	210.4	0.0001
	Q.	0.47±0.08 b	0.65±0.05 a	0.65±0.05 a	0.05	26.27	0.0001
Total immature		4.31±0.20 c	4.77±0.17 b	5.98±0.18 a	0.16	221.7	0.0001
Life cycle		7.03±0.40 b	6.31±0.33 c	9.71±0.21 a	0.29	305.3	0.0001
Adult longevity		24.70±3.09 b	23.28±2.10 b	32.06±1.56 a	2.14	40.60	0.0001

A. = Active stage, Q. = Quiescent stage
Means followed by the same letters in the same raw are not significantly different at P=0.05.

4. Pre–oviposition, oviposition and post-oviposition periods of *T. putrescentiae* females:

Based on the tabulated data in Table (3), the pre-oviposition and post-oviposition periods of *T. putrescentiae* female varied depending on the type of food they were fed. The pre-oviposition periods were 0.51, 1.72, and 2.03 days when females were fed on yeast, wheat germ, and wheat flour, respectively. The average duration of the oviposition periods for *T. putrescentiae* females were 20.30, 18.00, and 25.00 days when reared on the same diets, respectively, with significant differences. The shortest post-oviposition period was 0.49 days when *T. putrescentiae* was fed on yeast, while the longest period was 2.50 days when fed on wheat flour. According to Yassin et al. (2018), the pre-oviposition periods of *T. putrescentiae* lasted, an average of 2.1, 2.2, 2.22, 2.26, 2.1, and 1.78 days when the mite females were fed on wheat flour, rice flour, pure wheat flour, semolina, maize flour, and wheat germ, respectively. Additionally, the average duration of the oviposition periods for *T. putrescentiae* were 34.92, 33.86, 32.17, 29.24, 22.4, and 21.0 days, respectively, when the mites were raised on the same diets.

5. Fecundity:

Data in Table (3), cleared the number of deposited eggs by the *T. putrescentiae* female which directly impacted by the food type, and this effect was found to be particularly significant when the food type was yeast, which is the most favorable feeding source for mites as compared to other kinds of food. On yeast, the maximum number of eggs observed was 391.5, with a daily rate of 19.29 eggs/female/day; on wheat flour, the lowest number was 91.5, with a daily rate of 3.67 eggs/female/day. However, Abd ElKhalik (2013) found that *T. putrescentiae's* fecundity was greatly impacted by the food source. When the female mite fed on wheat flour, 39.2 eggs were deposited, and the lowest number was observed, when the mite fed on fish powder (28.0 eggs). The female laid 30.0 eggs on granular chicken feed and 34.2 eggs on milk powder. Can't differences (F = 445.9, P = 0.0001; F = 1060.8, P = 0.0001).

Table (3): Mean longevity and fecundity of *T. putrescentiae* females reared on three different diets of food

Developmental stages	Yeast	Wheat germ	Wheat flour	L.S.D	F-Test	Probability
Pre-oviposition	0.51±0.07 c	1.72±0.08 b	2.03±0.15 a	0.09	569.2	0.0001
Oviposition	20.30±1.89 c	18.00±2.26 b	25.00±2.05 a	1.90	29.0	0.0001
Post-oviposition	0.49±0.09 c	2.02±0.19 b	2.50±0.29 a	0.19	255.38	0.0001
Longevity	21.30±1.92 b	21.74±2.23 b	29.53±1.74 a	1.18	55.03	0.0001
Fecundity	391.5±40.5 a	140.90±7.5 b	91.50±6.33 c	22.10	445.9	0.0001
Daily rate	19.29±1.13 a	7.91±0.74 b	3.67±0.17 c	0.71	1060.8	0.0001

Means followed by the same letters in the same raw are not significantly different at P=0.05.

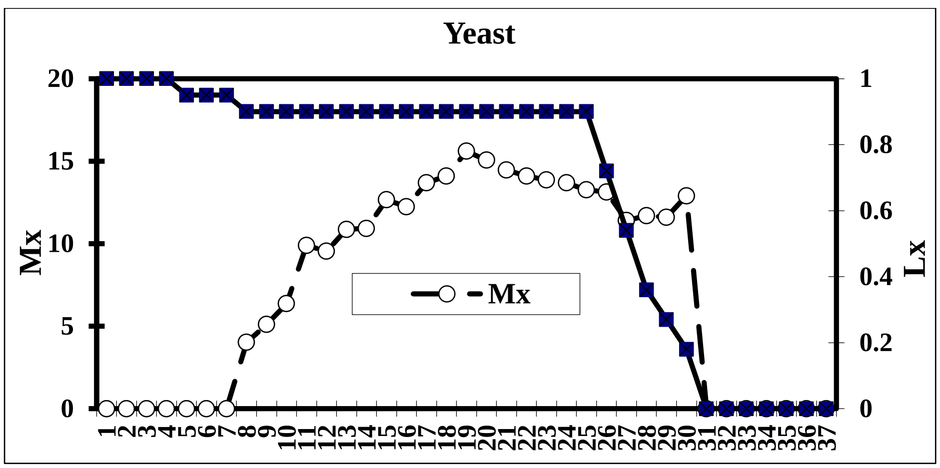
Life table parameters:

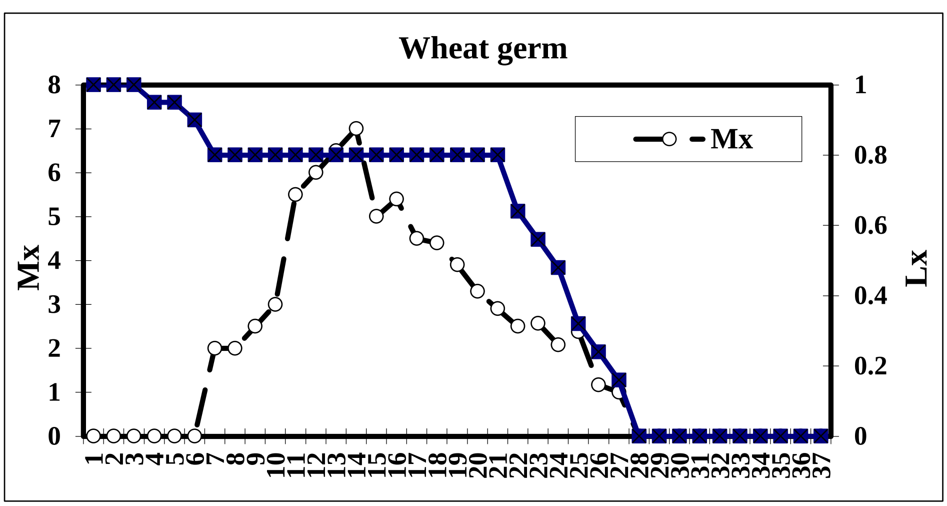
Data in Table (4) clearly demonstrated that the types of food had a considerable impact on the mean generation time (T).When the mite fed on wheat flour, the longest recorded generation duration (18.37 days) was observed,whereas the shortest generation duration (13.06 days) was observed when the mite fed on wheat germ. When the mite fed on yeast, wheat germ, or wheat flour, the population of *T. putrescentiae* could double every 1.88, 2.25, and 3.70 days, respectively. When given the aforementioned meal, the*T. putrescentiae's* net reproduction rate (Ro) and variance type were 213.73, 56.36 and 31.41 individuals/female, respectively. However, since the intrinsic rate of natural increase (r_m) represents an overall effect on the development, reproduction, and survival of an animal under specific environmental conditions, it is a crucial demographic parameter useful for predicting the animal's potential for population growth (Birch, 1948 & Southwood and Henderson, 2000). When the T. *putrescentiae* was fed on yeast, wheat germ and wheat flour, respectively. The r_m values were 0.367, 0.308 and 0.187 individuals/female/day (Table 4). Conversely, though, when the values of (r_m) was transformed into the finite rate of increase (λ), with1.44 individuals/female/day being the highest value when fed on yeast and 1.20 individuals/female/day being the lowest when fed on wheat.flour.When using wheat flour, the gross reproductive rate (GRR) increased from 53.29 offspring/individuals on wheat flour to 270.13 offspring/individuals on yeast.Female to total sex ratio percentages were 60.0, 50.0, and 54.0% on wheat flour, wheat germ, and yeast, in that order. While, it was demonstrated by Al-Rehiayani and Fouly (2006) that *M. javanica* eggs were the most appropriate. According to Osman et al. (2016), the T. *putrescenliae* females fed on yeast, dry cheese, and nematode egg masses deposited an average of 580.52, 422.60, and 143.47 eggs, with a daily rate of 30.01, 24.74, and 9. 86 eggs, respectively. Age specific survivorship (l_x) and fecundity (m_x) curves for *T. putrescenliae* are shown in Fig. (1) on yeast, the age-specific survival rate was the highest, while on wheat flour, it was the lowest. The highest quantity of eggs that yeast can make (day 16: 15.06 egg/♀/day), and on wheat flour, the lowest figure (day 25: 2.32 egg/♀/day) was recorded.On yeast, the female survival rate was the highest at 90,and on wheat flour, it was the lowest at 64.0%. These findings concur with those obtained byAbou ElAtta and Osman (2016), who found that, when compared to other prey or diets, mites (*T. putrescentiae*) fed on yeast had the greatest intrinsic rate of natural increase (rm). In summary, the determined biological parameters (Ro, GT, DT, rm, and λ) suggest that raising *the T. putrescentiae* in the presence of yeast and wheat germ appears to be a suitable food source for the organism's development and multiplication, but wheat flour appears to be outside this beneficial food source.

Table (4): Effect of three different diets of food on the population parameters of *T. putrescentiae* females under laboratory conditions

Parameters	Yeast	Wheat germ	Wheat flour
Net reproduction rate (R_o)[b]	213.73	56.36	31.41
Mean generation time (Tc)[a]	14.59	13.06	18.37
Intrinsic rate of increase (r_m)[c]	0.367	0.308	0.187
Finite rate of increase (λ)[c]	1.44	1.36	1.20
Generation doubling time (DT)[a]	1.88	2.25	3.70
Gross reproduction rate (GRR)[b]	270.13	75.6	53.29
Survival rate %	90%	80%	64%
Sex ratio (female/total) %	60.0	50.0	54.0

[a] Days [b] per generation [c] Individuals/female/day





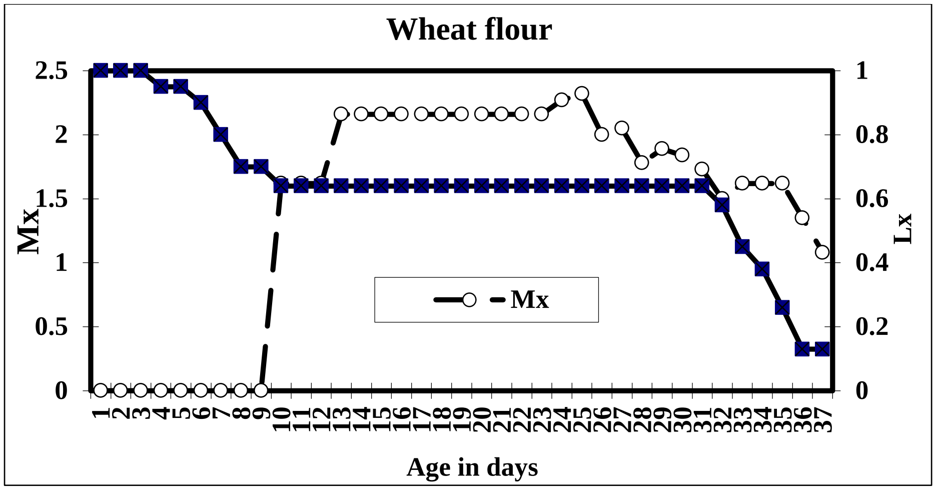


Figure (1): Age– specific survival rate (Lx) and age specific fecundity rate (Mx) of *T. putrescentiae* females reared on three different diets of food.

CONCLUSION

We can conclude here that the yeast is the best food to *T.putrescentiae*, It can be concluded that kind of food has a considerable effect on the number of eggs, and increasing the fecundity of female.

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