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The Quantitative Propagation of Predatory mite, *Blattisocius dentriticus* (Berlese) (Acari: Gamasida: Blattisociidae) on eggs of Some Stored Wheat Pest

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Abstract
The predatory mite, *Blattisocius dentriticus* (Berlese) (Blattisociidae) was propagated by feeding on eggs of three different types of pests, *Lepidoglyphus destructor* (Shrank) (Glycyphagidae), *Goheria fusca* (Oudemans) (Labidophoridae) and khabra bettle, *Trogoderma granarium* Everts (Dermestidae) under laboratory conditions at 30±2°C and 60% RH. The predator has shown promising traits for mass rearing by stored wheat pests. The results revealed that the longest predatory mite longevity (33.18& 27.7 days), when fed on eggs of *G. fusca* for females and males, respectively. Whereas, the high fecundity averaged 78 eggs through an oviposition period of 20.5 days when the predator fed on eggs of *L. destractor* while the lowest fecundity on eggs of labidophorid mite, *G. fusca* was (53.7 eggs) during oviposition period averaged (25 days). Significant differences between three wheat pests were noticed. In studing population growth parameters, The highest intrinsic rate of natural increase (r_m) was reached as 0.197 individuals/female/day when fed on eggs of *L. destractor* which considered as the ideal prey for this mite followed by eggs of *T. granarium* was reached 0.143 ind./female/day while lower r_m value was 0.112 ind./female/day that obtained when feeding on eggs of *G.fusca*. Time for population doubling was determined as (3.51, 4.84and 6.18 day) at different studied prey, respectively. It was concluded that the predatory mite can be maintained successfully on the alternative food, Acaridida species; *L.destuctor*, *G.fusca* and insect *T. granarium* for the mass-production of *B. dentriticus* as biocontrol agent for wheat pests in field in future. These results suggest that augmentative release of this predator would offset the lower *rm* of the predator, there by contributing to the control of mite pests. Combined with the benefit of early releases determined in companion studies, future field studies with *B. dentriticus* are being planned.

Keywords: Population growth parameters, mass production, acaridida mites, *lepidoglyphus destructor*, *goheria fusca* *trogoderma granarium*, *triticum aestivum*, store

Introduction

Wheat (*Triticum aestivum* L.) is the most important cereal crop. Wheat consumption is increasing progressively during the last decades due to a shift in the food habits. Wheat is grown as a winter crop in almost all the irrigated schemes. The extensive activities of the insect or mite symptoms have attracted the attention of several authors. The mites may be considered as a beneficial organism, when reducing the pest population; while on the other hand, seem to be harmful when infesting useful insects (Hassan *et al*., 2011) [11] who carried out several studies on the relationship between insects and mites.

Predacious mites contain a group of considerably harmful actives. Blattisocids consider very similar in its biological aspects to those of Phytoseiids and unlike only in details, (Mohamed, 2013) [19] and are free-living predators which found in abundance in stored products feeding on acarid mites and small insects.

Blattisocius mite species are found in several different habitats and often mentioned as predators of pests of stored food (Erika *et al*., 2012) [10]. *B. dentriticus* (Berlese) was noticed on stored garlic; (Baggio *et al*., 1987) [4] and on stored onion; (Mohamed, 2013) [19] investigated on stored grains by (Palyvos *et al.*, 2008) [22] surveyed on wheat, rice, bean, maize, hay barley, wheat flour by (Metwally *et al.*, 2016) [18] associated with acarid mites and insects.

This investigation had been devoted to three types of pests causing spoilage of stored wheat that are safely controlled by the predatory mite, *B.dentriticus* and its life table parameters at optimal temperature 30+2°Cand 65±5 %R.H. The current study would help us to gain abetter insight into practical application techniques of apredator in biological control programs. Some *Blattisocius* species found in stored foods have been studied to determine their potential as predators of pest arthropods (Thind and Ford 2006) [28] and for *Blattisocius keegani* Fox in the control of some Coleoptera species, (Thomas *et al*., 2011) [27].

Quantitative damage due to acaridida mites and susceptibility of the food grains to mite attack depends upon the optimum temperature, high humidity, softness and high nutritive value of the food grains. These together with improper storage are all conducive to mite attack. The losses aggravate due to the increasing densities of the mites. Numerous individuals of acaridida mites especially, *Goheria* species were found in wheat (seeds, straw, hay and grains). It´s feeding mainly on the germ part of the grains causing both qualitative and quantitative losses especially when stored in moist and high temperature (Mesbah *et al*., 2016 and Taha *et al*., 2010) [16, 25] determined the effect of different food types on the biology, fecundity and life table parameters of the stored grain mite, *Goheria fusca* when fed on crushed wheat as a sole food sources. Glycyphagid astigmatid mite, *Lepidoglyphus destructor* (Schrank) was noticed as most destructive for stored wheat and its products (El-Naggar *et al.*, 2007) [8]. Khabra bettle, *Trogoderma granarium* (Everts) (Dermestidae) is one of the most general insects which specialized in infesting stored wheat grains, (Oliveira and Matos, 2006) [21] and this pest is the most dangerous storage pest in the tropics and in sub-tropical regions as primary can give rise to a very large population in short time. The biology of predator mite, *B. dentriticus* and its life table parameters when fed on three different pests at constant temperature 30+2°Cand 65±5 %R.H. suggest that augmentative early release of this predator for controlling of mite pests and future field studies with *B. dentriticus* are being planned.

Materials and methods

The experiment was achieved at Mites of Cotton and Field Crop Research Laboratory, Plant Protection Research Institute (PPRI), Agriculture Research Center (ARC), Sharkia, Egypt during 2018.

Prey and feeding protocol

Eggs of two different Acaridida mites; *L. destructor* and *G. fusca*

Reproduction of two different Acaridida mites, *L. destructor* (Glycyphagidae) and *G. fusca* (Labidophoridae) were on an artificial diet (wheat germ, yeast granules and bran in a ratio 5:3:2) and incubated at 30°C and 65±5% relative humidity on big cages filled with a layer of mixture of (Cement: Clay: Charcoal in a ratio 6:3:1, respectively with depth of 0.5 cm. Water drops were added when needed (Mesbah *et al.* 2016 &2019) [16, 17].To avoid fungal infection, nutrition was being removed by fine brush under stereomicroscope and renewed every 2-3 days.

Khabra bettle, *T.granarium* was taken from Department of stored grains PPRI, Dokki, Giza, Egypt

Insect sources: For starting a culture of Khabra beetle, *Trogoderma granarium* (Everts.) pairs of adults beetle (male and female) were reared in glass jars To have an initial population of Khabra adults homogenous in age, (each of approximately 500 ml) were introduced into jars containing about 150 gm of wheat seeds for egg laying and then kept in an incubator at 30±2°c and 65±5 % R.H. After two days, all insects were removed from the media and the jars were kept again at controlled conditions. Each jar was covered with muslin cloths and fixed with rubber bands. Eggs of *T. granarium* were used in this experiments. The egg was cylindrical, milky white in color when first laid, but as development proceeds it takes a pale yellowish color.

Predator and feeding protocol

B. dentriticus was collected from Wheat grain samples at Zagazig district, Sharkia governorate, Egypt. The predator mass reared on immature stages of Acarid mite, *Tyrophagus putrescentiae* (Schrank) in big cages that incubated under 30±2°C and 65±5% relative humidity. Acarid mite, *T. putrescentiae* reproduced on crushed cereals as food.

Bioassay

The experiment was proceed to explain the effect of most suitable prey on quantitative propagation of predator mite, *B. dentriticus* at the optimal temperature of 30±2°C with 65±5% and relative humidity (RH) and 16L:8D photoperiod. The augmentative early release of this predator for controlling of mite pests and future field studies with *B. dentriticus* are being planned**.**

Statistical analysis

Life table parameters were estimated according to (Birch, 1948) [6] using the Life48, BASIC Computer Program (Abou-Setta*et al.*, 1986). Life table Parameters were determined by the following formula: Max Σ_0 Lx Mx / exp.r_m x = 1 Where "mx" is the number of daughters produced per female during the interval "x". "Lx" is the fraction of lively females at age "x". The values of "rm" is a natural logarithm of the intrinsic rate of increase and indicates the number of times of population multiplication in a of time unit. The net reproductive rate (R0) is the mean for female multiplacation in one generation ("T" is the mean length of generation period, expressed in days, while DT means time of population to double, and "GRR" means Gross reproduction rate calculated. These definitions were presented by Birch (1948) [6]. R0 = Σ(l*x* × m*x*); T = Σ(x × lx × m*x*) / Σ(lx × m*x*); rm = Ln (R0)/T; DT = Ln (2)/ rm, λ = exp(rm) and GRR= Σmx. Data were analyzed by one-way analysis of variance (ANOVA) and mean comparison using LSD to test the significant differences between mean values using SAS statistical software, SAS Institute (2003) [24].

Results and Discussion

The following is an account of the results obtained on biological aspects of the predatory mite, *B. dentriticus* (Berlese) to evaluate the possibilities of using predator on reproducing on different egg preys.

Incubation period

As shown in Table1, the incubation period of predator female, *B. dentriticus* was greatly affected by different preys. The incubation period was long when it fed on eggs of labidophorid mite, *G.fusca* reached 3.8 days while it was short when predator fed on Glycyphagid mite, *L.destructor* reached 2.48 day and Dermestid khabra bettle, *T. granarium* reached 3.3 day for the predator female.

Similar results by (Mohamed, 2013) [19] she summarized that lowest incubation period of *B. dentreticus* was noticed for resulted females when fed on immature of acarid bulb mite, *Rhizoglyphus robini* (1.3 days),but the longest period recorded fed on the fungus *Fusarium moniliforme* (3.7days).

Life cycle

It could be observed that the duration of life cycle was highly affected by the type of food employed. This total period average (11.25, 13.93 and 15.15 days) for females and (9.5, 11and 13.38 days) for males when *B. dentriticus* preyed on the three different tested eggs of *L. destructor*, *T. granarium* and *G. fusca*, respectively. Statistical analysis indicated that significant differences were found between the three rearing prey.

Generation period

The shortest generation was observed on *L. destructor* was 13.68 days, while the longest were 18.88 days recorded on *G. fusca*, with statistically differences (*F= 142.4; P= 0.0001*).

Adult longevity

As shown in Table (1&2) The predator female longevity lasted (25.7, 30.08 and 33.18 days) changed to (22.10, 25.0 and 27.7 days) for male when it fed on three tested eggs prey, respectively. The longevity of adult female *B. dentriticus* and the period of the pre-oviposition,

oviposition, and post-oviposition periods differed significantly between the three prey. The longest pre-oviposition and post-oviposition periods was recorded 3.73 and 4.45 days on *G. fusca* (Table 3, *P= 0.0001*). The longest oviposition period was observed on *G. fusca*2 5.0 days and the shortest period on *L. destructor* was 20.5 days with statistically differences (*F= 56.02; P= 0.0001*) (Table 3).

These results are agreement with finding by (Mohamed, 2013) [19] she observed that the duration of life cycle for both sexes was affected by the type of food employed. However, female adult longevity of *B.dentriticus* lasted (22.2days changed to19.2days) formales when fed on bulb mite compared with other prey types. Also, (Yassin *et al*., 2017) [29] investigated that *B. keegani* (Fox) has traditionally been as a biological control agent in stored products. at 25°C and 35°C and 75% R.H when fed on the acarid mites, *R.* robini showing similar results with the present study. (Kassem, 2019) [13] explained that B. tarsalis (Berlese) as potential biological control of astigmatid stored product mites and investigated the performance of B. tarsalis on immature stages of the acarid mites, T. putrescentiae and R. robini. (Gallego et al., 2019) [12] studied the possibility of using B. mali as a potential biological control agent of the Potato tuber moth, Phthorimaea operculella (Lepidoptera: Gelechiidae), and went to that the mite is an active predator to that insect pest. (Abass et al., 2020) reproduced *B. mali* at 25 °C and 75 % R.H. on the immatures of the bulb mite, *Rhizoglyphus robini* Claparede and the free-living nematodes, *Rhabditis sccanica*.

Table 1: Mean (±SD) duration (days) of *Blattisocius dentriticus* females reared on three different prey types.

Developmental stages		Mean (±SD) eggs of			L.S.D	F-value	Probability
		L.destructor	*T.granarium*	*G.fusca*			
Incubation period		2.48±0.32c	3.30±0.23b	3.80±0.28a	0.25	56.72	0.0001
Larva	A.	2.10±0.24b	2.18±0.29ab	2.40±0.41a	0.29	2.35	0.0050
	Q.	1.35±0.21c	1.65±0.24b	1.88±0.27a	0.22	11.85	0.0002
Protonymph	A.	1.58±0.24b	2.05±0.20a	2.08±0.26a	0.21	14.41	0.0001
	Q.	0.95±0.28c	1.38±0.13b	1.73±0.22a	0.20	30.99	0.0001
Deutonymph	A.	1.85±0.38b	2.38±0.24a	2.60±0.27a	0.27	16.28	0.0001
	Q.	0.95±0.33a	1.0±0.31a	0.68±0.24b	0.27	3.51	0.0442
Total immature		8.78±0.48c	10.63±0.77b	11.35±0.83a	0.65	34.97	0.0001
Life cycle		11.25±0.50c	13.93±0.69b	15.15±0.74a	0.59	94.16	0.0001
Generation period		13.68±0.72c	17.15±0.81b	18.88±0.70a	0.68	142.43	0.0001
Adult longevity		25.70±1.33c	30.08±0.93b	33.18±0.58a	0.91	126.80	0.0001
Life span		36.95±1.56c	44.0±1.11b	48.33±0.97a	1.13	214.58	0.0001

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

Table 2: Mean (±SD) duration (days) of *Blattisocius dentriticus* male reared on different prey types.

Developmental stages		Mean (±SD)eggs of			L.S.D	F-value	Probability
		L.destructor	*T.granarium*	*G.fusca*			
Incubation period		1.38±0.21	1.93±0.24a	1.83±0.33	0.2446	12.08	0.0002
Larva	A.	1.63±0.32b	1.68±0.26b	1.98±0.22a	0.2478	4.91	0.0151
	Q.	0.80±0.33b	1.23±0.25a	0.70±0.16a	0.234	11.95	0.0002
Protonymph	A.	2.28±0.25b	2.45±0.35b	3.38±0.40b	0.309	30.80	0.0001
	Q.	0.48±0.18b	0.88±0.24b	1.25±0.50a	0.3103	13.14	0.0001
Deutonymph	A.	2.15±0.29c	2.0±0.31ab	1.83±0.35b	0.2945	2.57	0.0952
	Q.	0.80±0.39a	0.85±0.17b	1.15±0.24a	0.2589	4.50	0.0206
Total immature		8.13±0.78c	9.08±0.57b	10.28±0.93a	0.7084	19.47	0.0001
Life cycle		9.50±0.87c	11.0±0.58b	12.10±1.14a	0.8193	21.37	0.0001
Adult longevity		22.10±1.60c	25.00±1.33b	27.70±1.16a	1.2611	41.52	0.0001
Life span		32.53±3.10c	36.00±1.53b	39.80±1.53a	1.4945	63.48	0.0001

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

Predator female fecundity

Fecundity was significantly affected by introduced egg prey**.** Therefore, when predatory mite fed on glycyphagid mite, *L. destructor* which was the most favorable prey for female predatory mite with highest fecundity of deposited eggs reached (78 eggs/ female) in an oviposition period averaged (20.5 days), while the lowest fecundity on eggs of labidophorid mite, *G.fusca* was (53.7 eggs) during oviposition period averaged (25 days) as shown in (Table3).The longest female and male life span on *G. fusca* was 48.33 and 39.8 days, whereas the shortest period on *L. destructor* was 36.95 and 32.53 days, respectively with statistically differences (*P= 0.0001*). These results are similar with those obtained by (**Zhang and Fan, 2010**) [31], indicated that Blattisociids mites are predators of pests in biological control. To the best of my knowledge, little previous data has been made concerning the quantitative propagation of this species; however, there are numerous investigations on other researches such as in Egypt Alexandria, Zaher (1986) [30] found the predatory mite, *B. keegani* Fox associated with stored products in Cairo, and El-Qaluobia. EL Nenaey (1998) [9] studied that the efficiency of *B. keegani* Fox on potato tuber moth eggs. Also, The effect of the predatory mite, *B. keegani* as biological control agent on two date palm mites, *T. putrescentiae* and *B. freemani* was done by (Rezk, 2000) [23]. (Thomas *et al*., 2011) [27] Reported that *B. keegani* as a predator of insect eggs.

Table 3: Mean (±SD) Longevity and fecundity of *Blattisocius dentriticus* female reared on different prey types.

Developmental stages	Mean(±SD) eggs of			L.S.D	F-Test	Probability
	L. destructor	*T. granarium*	*G. fusca*			
Pre-oviposition	2.43±0.35c	3.23±0.49b	3.73±0.22a	0.3417	31.01	0.0001
Oviposition	20.50±1.35c	23.0±0.67b	25.0±0.67a	0.8741	56.02	0.0001
Post-oviposition	2.78±0.58c	3.85±0.17b	4.45±0.35a	0.3717	43.88	0.0001
Longevity	25.70±1.33c	30.08±0.93b	33.18±0.58a	0.91	126.80	0.0001
Fecundity	78.0±2.83a	53.70±2.91b	35.8±1.81c	2.3541	681.64	0.0001
Daily rate	3.82±0.31a	2.33±0.11b	1.43±0.09c	0.1826	367.47	0.0001

Population growth parameters

The purpose of our study was to evaluate biological aspects and population growth parameters of the predatory mite, where the mean generation time (T) of the predatory mite, *B.dentriticus* (Berlese) under laboratory conditions was significantly affected by the type of prey. Results presented in Table (4) clarified that, the shortest mean generation time (T) was observed on *L. destructor* was 17.9 days, while the longest was 24.74 days recorded on *G. fusca* at 30˚C. Whereas, the shortest time for population density doubling (DT) was 3.513 days while the longest period was 6.18 days on *G. fusca* prey.

Table 4: A comparison between population growth parameters of predatory mite, *Blattisocius dentriticus* (Berlese) and its different preys; *L.destructor*, *T.granarium*, and *G.fusca* under laboratory conditions.

Parameters	*L. destructor*	*T.granarium*	*G.fusca*
Net reproduction rate (R_o)[b]	34.61	24.3	16.02
Survival rate %	0.93	0.9	0.95
50% Mortility	31	36.5	39.7
Mean generation time (T)[a]	17.90	22.15	24.74
Intrinsic rate of increase (r_m)[c]	0.197	0.143	0.112
Finite rate of increase (λ)[c]	1.219	1.154	1.119
Generation doubling time (DT)[a]	3.51	4.84	6.18
Gross reproduction rate (GRR)[b]	40.78	28.04	18.69

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

$R_o = \Sigma(lx \times mx)$; $T = \Sigma(x \times l_x \times mx) / \Sigma(lx \times mx)$; $r_m = \ln(R_o)/T$; $DT = \ln(2)/ rm$ and $\lambda = \exp(rm)$

The maximum net reproductive rate (R_o) occurred on *L.destructor* recorded 34.61 individuals/ generation, followed by on *T.granarium* was 24.3 individuals/ generation, while the lowest value on *G. fusca* was 16.02 individuals/generation.

The maximum intrinsic rate of natural increase (r_m) the difference between birth rate and death rate. These values were 0.197, 0.143 and 0.112 individuals/♀/day at 30˚C on *L.destructor*, *T.granarium* and *G.fusca*, respectively.

The finite rate of increase (**λ**) ranged from 1.119offspring/ individual/day on *G.fusca* to 1.219 offspring/ individual/day on *L.destructor*. Gross reproduction rate (GRR) recorded the highest value on *L.destructor* was 40.78 eggs/ individual and the lowest value 18.69 eggs/ individual on *G.fusca*.

These findings are in a close agreement with that presented by (Mohamed, 2013) [19] she investigated that the population of predator mite, *B.dentriticus* had the capacity to double (DT) every (2.34 days) within asingle generation when fed onacarid bulb mite, *Rhyzoglypus robini*. Also, (Nasr *et al.*1990) investigated that the intrinsic rate of increase (r_m) of the *B.dentriticus* predator female was maximized when provisioned *T. putrescentiae* and *R. robini* nymphs (0.164,0.137 individual/ female per day) respectively.(Bianca *et al*., 2018) noticed that the potential biocontrol agents amongst mites present in poultry farms were *Blattisocius keegani*, and *B. dentriticus* (Berlese).

Similar results shown by (Tawfik *et al*., 2017) [26] she studied Life table parameters and behavior of the Ascidae mite, *Lasioseius athiasae* (Acari: Ascidae) from grassland soils on various kinds of foods asnymphs of the mould mites *T.putrescentiae* Schrank, the bulb mite, *R.robini* Claparede and the faster development of larval stage was obtained when provided both of mould mite and bulb mite than that offered other prey. These results are also in consistent with (Abou-Awad *et al*., 2001) [1] reared Ascidae mite, *L. athiasae* on various kinds of food substances and (Lesna *et al*., 1995) [14] who mentioned that *L. bispinosus* along with several other predatory mites were recorded as effective natural enemies and a biocontrol agents against the bulb mite, *R. robini*. *T. putrescentiae*.(Nasr *et al.* 1990) [20] reported that the average number of eggs per female *L. athiasae* when offered the two acaridids*; R. robini* and *T. putrescentiae* was equal to or higher than that observed for the same predator on eggs of free-living nematodes. (Mashaya 2002) [15] studied the Predation of the book louse *Liposcelis entomophila* (Enderlein) by *B. dentriticus*.(Thind and Ford, 2006) [28] explained the performance of two predatory mite species, *Cheyletus eruditus* (Schrank) and *Blattisocius tarsalis* (Berlese), for controlling small numbers of the flour mite *Acarus siro* (L.).The maximum reduction in prey population of 80% was noticed with eight *B. tarsalis* and combining the two predatory species did not enhance the reduction of *A. siro* population. Whereas,(El-Akhdar, 2009) [7]who studied the biology of *Acaropsellina notchi* on eggs of stored grain insect, *trogoderma granarium*.

The age-stage-specific survival rate (*lx*), probability that a newly hatched *B. dentriticus* mite will survive to age *x* and age specific fecundity (*mx*), (Figure 1) that shows the survivorship and stage differentiation, as well as the variable developmental rate. Total survival of *B. dentriticus* immature on three different diets was 0.93, 0.91 and 0.95;whilethe 50% mortality of adult female of the predatory mite, *B. dentriticus* was31, 36.5 and 39.7 days on different prey types.

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