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Effect of Alternate Food Sources on Predatory Mite *Amblyseius finlandicus* (Oudeman) (Acari: Phytoseiidae)

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A B S T R A C T

The effect of various alternate food sources on the biological parameters of predatory mite, *Amblyseius finlandicus* (Oudeman) was evaluated under the laboratory condition. Among various alternate food sources the adult male and female longevity was maximum (7.80 and 12.60 days) when fed with mixture of castor pollen + yeast + honey, while in case of primary food sources maximum adult male and female longevity (18.00 and 26.20 days) was recorded when fed upon mixed stages of *T. urticae*. Fecundity of *A. finlandicus* was highest (9.60 eggs) when fed with mixture of castor pollens + yeast + honey. However, among primary food sources the fecundity of *A. alstoniae* was maximum *i.e.*27.10 eggs when fed mixed stages of *T. urticae*.

Introduction

The mites belonging to family Phytoseiidae are considered as generalist predator that plays a major role in keeping the population of phytophagous mites below economic threshold levels. Some *Phytoseiid* species can develop and reproduce on pollen as well as on tetranychids and eriophyoids (Helle and Sabelis, 1985). Pollen is a fundamental food source for generalist predatory mites (McMurtry, 1992; McMurtry and Croft, 1997) and leaves are excellent pollen traps (Eichhorn and Hoos, 1990; Duso *et al.*, 1997). It has been observed that the populations of predatory mites increase when pollen is abundant on grape leaves (Engel and Ohnesorge, 1994; Duso *et al.*, 1997, 2002, 2004). Plant pathogenic fungi can also be food sources for certain predatory mites (Pozzebon and Duso, 2008; Pozzebon *et al.*, 2009). The presence of grape downy mildew in vineyards increases the persistence of predatory mites (Duso *et al.*, 2003; Pozzebon *et al.*, 2010). Maintenance of laboratory stock culture of predatory mites is a pre-requisite to study their predatory potential against the target mite hosts and to conduct compatibility studies with recommended chemicals. The survival and fecundity of acarophagous predator are the important factors to be considered while rearing to assure the continuous supply of the bio-agents for the *in-vitro* studies. Predatory mites feed on a wide variety of non-prey foods like fungi, pollen, honeydew (Lundgren, 2009). In the present study, an attempt was made to explore the suitability of different alternate foods and natural hosts to rear *A. finlandicus* and their impact on the biology of predatory mite for the *in-vitro* rearing of *A. finlandicus* in the absence of its prey *i.e.* the plant mites.

Materials and Methods

The biological observation of phytoseiid mite, *A. finlandicus* was studied on different diet and their combinations to assess their usefulness in mass multiplication. The culture of predatory mite, *A. finlandicus* was maintained in the laboratory conditions on the leaves of French bean heavily infested by two spotted spider mite, *Tetranychus urticae* Koch. Castor pollen, honey and yeast were given as food singly and in different combinations were placed directly on the leaf surfaces. Food droplets were added daily. The experiment was carried out with eleven treatments and five repetitions in complete randomized design (CRD). The leaves were changed daily and mites were transferred from old leaves to new leaves. The various biological parameters *viz.*, longevity of adult male and female, fecundity, daily fecundity and mating period was recorded and compared.

Results and Discussion

In case of male the adult longevity during the year 2014-15 (Table 1 and Figure 1), the male longevity was 2.40, 3.40, 3.20, 4.20, 5.00, 5.40 and 7.60 days while consuming castor pollen, honey, yeast, castor pollen + honey, castor pollen + yeast, yeast + honey and castor pollen + yeast + honey, respectively. The adult male longevity was higher when they prey on mixed stages of their primary host. The adult male survived for 17.00 days when fed on mixed stages of *T. urticae*, 13.20 days on mixed stages of *O. indicus* and 13.40 days on mixed stages of *P. latus*. The longevity of male was lowest in starved (no food) condition *i.e.* 2.20 days.

In the year 2015-16, the survival of male *A. finlandicus* was also reared on alternate food sources and it was found that the adult male longevity was 2.80 days when fed on castor pollen, 3.60 days when consumed honey, 3.00 days when fed on yeast, 4.20 days when fed on castor pollen + honey it was 5.00 days when fed on castor pollen + yeast, 5.60 days when consumed yeast + honey and 8.00 days when consumed castor pollen + yeast + honey. In case of primary hosts the adult male survived for longer period. The adult male longevity was 19.00 days while preying on mixed stages of *T. urticae*, 11.60 days when preying upon mixed stages of *O. indicus* and 11.20 days when fed upon mixed stages of *P. latus*. Male longevity was shortest in the treatment with no food (starved) (1.80 days).

The pooled analysis over two years revealed that in case of alternate food the adult male longevity was 2.60, 3.50, 3.10, 4.20, 5.00, 5.50 and 7.80 days when fed on castor pollen, honey, yeast, castor pollen + honey, castor pollen + yeast, yeast + honey and castor pollen + yeast + honey, respectively. While in case of primary food sources the adult male longevity was much higher and it was 18.00 days when fed on mixed stages of *T. urticae*, 12.40 days when fed on mixed stages of *O. indicus* and 12.30 days when fed on mixed stages of *P. latus*. Interaction (Y x T) between year of observation (Y) and treatment (T) was found to be non significant exhibiting similar response of the treatments in their effectiveness in two different years. However, the order of preference of food as reflected by duration of longevity of male *A. finlandicus* was mixed stages of *T. urticae*> mixed stages of *O. indicus*> mixed stages of *P. latus*> castor pollens + yeast + honey >castor pollens + yeast > yeast + honey > castor pollens + honey > honey > yeast > castor pollens. Neelam Kumari (1981) from Ludhiana, Punjab reported the survival of male *A. finlandicus* was less on castor pollens and other artificial food sources *viz*., yeast, honey alone as compared to their combinations. This was closely support the present findings. Further, Abou-Elella *et al.,* (2014) reported that the survival of male *Euseius finlandicus* was less on different pollen grains like *Ricinus communis* L., *Phoenix dactylifera* and *Helianthus annus* as compared to mite hosts *viz*., eriophyid mites and spider mites. These findings are more or less closely support the present findings.

The effect of alternate food sources and primary food sources were also recorded in case of adult female longevity of *A. finlandicus*. In the year 2014-15, it was found that among the alternate food sources the adult female longevity was maximum when fed upon mixture of castor pollen + yeast + honey (12.80 days) and was followed by the treatments comprised of castor pollen + yeast (10.20 days), honey (10.00 days), yeast (10.00 days), yeast + honey (9.80 days), castor pollens + honey (9.60 days) and castor pollens alone (6.60 days). However, in case of primary hosts having mixed stages of *T. urticae* the female longevity was maximum, (25.40 days) followed by mixed stages of *O. indicus* (15.20 days) and mixed stages of *P. latus* (13.40 days). Adult female survived for least period in no food (starved) condition (1.80 days).

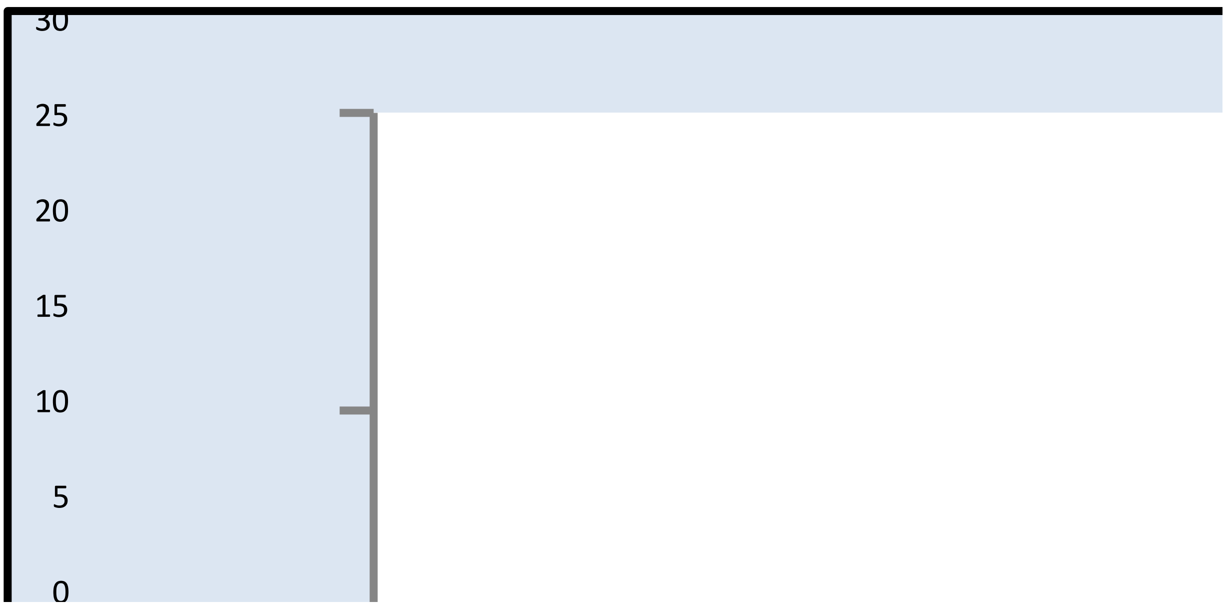
While in the year 2015-16, it was found that among alternate food sources maximum female longevity was recorded in treatment comprising castor pollen + yeast + honey (12.40 days) followed by yeast (10.80 days), honey (10.40 days), castor pollen + yeast (9.80 days) castor pollen + honey (9.80 days), castor pollen + honey (9.20 days), and castor pollens alone (6.60 days). Adult female lived for longer period when they fed on primary host. Adult female longevity was highest when they offered mixed stages of *T. urticae* (27.00 days) followed by mixed stages of *O. indicus* (13.80 days) and *P. latus* (13.00 days).

Pooled data of two years revealed that among different alternate food sources maximum female longevity was recorded in treatment consisting castor pollens + yeast + honey (12.60 days) followed by yeast (10.40 days), honey (10.20 days), castor pollens + yeast (10.00 days), yeast + honey (9.80 days), castor pollen + honey (9.40 days) and castor pollens alone (6.60 days). In case of primary host maximum female longevity was recorded when female fed on mixed stages of *T. urticae* (26.20 days) followed by mixed stages of *O. indicus* (14.50 days) and mixed stages of *P. latus* (13.20 days). Shortest longevity of female was recorded in starved (no food) condition. Interaction (Y x T) between year of observation (Y) and treatment (T) was found to be non significant exhibiting similar response of the treatments in their effectiveness in two different years. However, the order of preference of food as reflected by duration of longevity of female *A. finlandicus* was mixed stages of *T. urticae*> mixed stages of *O. indicus*> mixed stages of *P. latus*> castor pollens + yeast + honey > castor pollens + honey > yeast + honey > honey > castor pollens + yeast > yeast > castor pollens. Neelam Kumari (1981) reported less survival of female *A. finlandicus* as compared to other food substances *viz*., yeast, honey and their combinations. Further, Abou-Elella *et al.,* (2014) also reported the poor survival of female *E. finlandicus* on various pollen grains *viz*., *R. communis*, *P. dactylifera* and *H. annus* as compared to the primary host like *T. urticae*, *Aceria olive* (Zaher and Abou-Awad) and *A. dioscoridis* (Soloman and Abou-Awad) and *Cisaberoptus kenyae* (Keifer).

The effect of alternate food sources on fecundity, daily fecundity and mating period was also studied in the experiment. Result on effect of alternate diet on fecundity of *A. finlandicus* presented in table 2 and figure 2 revealed that during the year 2014-15 among alternate food sources maximum fecundity of *A. finlandicus* was recorded with treatment comprising castor pollens + yeast + honey (9.60 eggs) followed by yeast + honey (8.00 eggs), pollens + yeast (6.60 eggs), honey alone (6.40 eggs), castor pollen + honey (5.60 eggs), pollens (5.60 eggs) and yeast (5.00 eggs). Among primary host maximum fecundity was obtained when *A. finlandicus* fed upon mixed stages of *T. urticae* (25.40 eggs) followed by mixed stages of *O. indicus* (13.20 eggs) and mixed stages of *P. latus* (12.20 eggs). Very low egg laying was observed when female remain starved (1.60 eggs). During the year 2015-16, among different alternate food sources maximum fecundity of *A. finlandicus* female was recorded in treatment comprising mixture of castor pollens + yeast + honey (9.60 eggs), followed by yeast + honey (7.80 eggs), castor pollen + yeast (6.80 eggs), honey (6.60 eggs), castor pollen alone (5.80 eggs), castor pollen + honey (5.60 eggs) and yeast (4.80 eggs). Fecundity of *A. finlandicus* was maximum on primary food as compared to alternate food sources. Maximum fecundity was recorded when female fed on mixed stages of *T. urticae* (28.80 eggs) followed by mixed stages of *O. indicus* (14.40 eggs) and treatment having mixed stages of *P. latus* (14.20 eggs). Lowest fecundity was recorded when female kept starved (1.20 eggs). Pooled data of two years on *A. finlandicus* fecundity revealed that among various alternate food sources treatment comprising castor pollens + yeast + honey recorded maximum fecundity (9.60 eggs) which was followed by treatments comprising yeast + honey (7.90 eggs), castor pollens + yeast (6.70 eggs), honey (6.50 eggs), castor pollen alone (5.70 eggs), castor pollens + honey (5.60 eggs), and yeast alone (4.90 eggs). Among different preys treatment with mixed stages of *T. urticae* recorded maximum fecundity of *A. finlandicus* (27.10 eggs) which was followed by mixed stages of *O. indicus* (13.80 eggs) and mixed stages of *P. latus* (13.20 eggs). Lowest fecundity was recorded when female kept starved (1.40 eggs). Interaction (Y x T) between year of observation (Y) and treatment (T) was found to be non significant exhibiting similar response of the treatments in their effectiveness in two different years. However, the order of preference of food as reflected by number of eggs laid by female *A. finlandicus* was mixed stages of *T. urticae*> mixed stages of *O. indicus*> mixed stages of *P. latus*> castor pollens + yeast + honey > yeast + honey > castor pollens + yeast > honey > castor pollens > castor pollens + honey >yeast.

Daily fecundity of *A. finlandicus* was also altered differently by different alternate food sources (Table 2 and Figure 2). During the year 2014-15 among different alternate food sources castor pollens alone recorded maximum daily fecundity of *A. finlandicus* (0.88 eggs/day), followed by treatments which comprised yeast + honey (0.84 eggs/day), castor pollens + yeast + honey (0.75egg/day), castor pollen + yeast (0.67 eggs/day), honey (0.64 eggs/day), pollens + honey (0.59 eggs/day) and yeast (0.52 eggs/day). However, of all primary food sources maximum daily fecundity was recorded with treatment consisting mixed stages of *T. urticae* (1.00 eggs/day) followed by mixed stages of *O. indicus* (0.91 eggs/day) and mixed stages of *P. latus* (0.87 eggs/day). *A. finlandicus* female laid eggs also in starved conditions (0.52 eggs/day). During the year 2015-16 when female *A. finlandicus* fed on different alternate food source, the maximum daily fecundity was recorded in treatment comprising castor pollens alone (0.88 eggs/day), followed by the treatments which comprised yeast + honey (0.80 eggs/day), castor pollens + yeast + honey (0.78egg/day), castor pollen + yeast (0.70 eggs/day), honey (0.64 eggs/day), pollens + honey (0.62 eggs/day) and yeast (0.45 eggs/day). However, among different primary host treatment with mixed stages of *T. urticae* recorded maximum daily fecundity (1.10 eggs/day) followed by mixed stages of *O. indicus* (1.07 eggs/day) and mixed stages of *P. latus* (1.05 eggs/day). Egg laying was also recorded (0.45 eggs/day) when female kept starved. Pooled data over two years revealed that treatment with castor pollens alone recorded maximum daily fecundity (0.88 eggs/day) among all alternate food sources which was followed by treatments having yeast + honey (0.82 eggs/day), castor pollens + yeast + honey (0.76egg/day), castor pollen + yeast (0.69eggs/day), honey (0.64 eggs/day), pollens + honey (0.60 eggs/day) and yeast (0.48 eggs/day) while among primary hosts *A. finlandicus* recorded maximum daily fecundity when fed on mixed stages of *T. urticae* (1.03 eggs/day) followed by mixed stages of *O. indicus* (1.00 eggs/day) and mixed stages of *P. latus* (0.96eggs/day). Female also laid eggs when kept starved (0.48eggs/day). Interaction (Y x T) between year of observation (Y) and treatment (T) was found to be non significant exhibiting similar response of the treatments in their effectiveness in two different years. However, the order of preference of food as reflected by number of eggs laid per day by female *A. finlandicus* was mixed stages of *T. urticae*> mixed stages of *O. indicus*> mixed stages of *P. latus*> castor pollens > yeast + honey > castor pollens + yeast + honey > castor pollens + yeast > honey > castor pollens + honey >yeast. The effect of various alternate food substances on fecundity of different species of predatory mites were studied by various workers. Kolokytha *et al.,* (2011) reared *T. athenas* on nine different pollens and found highest fecundity when female predator fed on bee hive pollens followed by almond pollens while lowest in castor pollens, while Nguyen *et al.,* (2015) in their laboratory trail concluded that the fecundity of *N. californicus, N. cucumeris* and *A. limonocus* female given spider mites or pollens was significantly higher than that of females presented artificial diet with sucrose, yeast, honey etc., whereas no differences among diets were observed in *A. andersoni.* However, when *N. californicus* females were fed on the artificial diet, none of their offsprings succeeded in reaching adulthood. These earlier reports more or less closely support the present finds.

The effect of alternate food sources on mating period of *A. finlandicus* was also studied and the results are summarized in table 2 and figure 2. During the year 2014-15 among different alternate food sources no mating was recorded on any of the treatment studied. However, when *A. finlandicus* fed on primary food sources mating was recorded in all of three primary food source treatments studied. Longest mating period was recorded in treatment comprising mixed stages of *T. urticae* (13.40min.) followed by mixed stages of *O. indicus* (6.20min.) and mixed stages of *P. latus* (6.20min.). During the year 2015-16 also same effect of alternate food sources on mating period was observed however among different primary food source treatment with mixed stages of *T. urticae* recorded longer mating period (14.00 min) followed by mixed stages of *O. indicus* (6.80 min) and *P. latus* (6.00 min). Pooled data over two years revealed that no mating of *A. finlandicus* was observed in treatments having alternate food source. However, among primary food sources treatment with mixed stages of *T. urticae* recorded longer mating period (13.70min) followed by mixed stages of *O. indicus* (6.50min) and mixed stages of *P. latus* (6.10min). Interaction (Y x T) between year of observation (Y) and treatment (T) was found to be non significant exhibiting similar response of the treatments in their effectiveness in two different years. However, the order of preference of food as reflected by duration of mating of *A. finlandicus* was mixed stages of *T. urticae*> mixed stages of *O. indicus*> mixed stages of *P. latus*. The present findings are more or less in accordance with the earlier work of Neelam Kumari (1981).



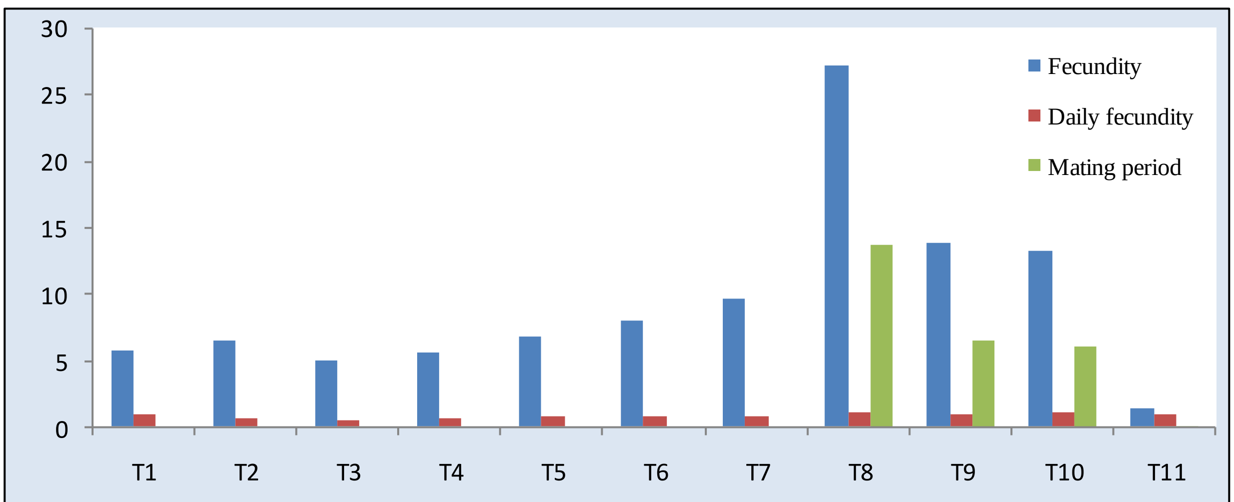


Figure.2 Effect of alternate food sources on fecundity daily fecundity and mating period of *A. finlandicus*.

Table.1 Effect of alternate diet on adult longevity (Days) of *A. finlandicus*

Treatment		2014-15		2015-16		Pooled	
		Male	**Female**	**Male**	**Female**	**Male**	**Female**
T_1: Castor Castor pollens		2.40(1.57)	6.60(2.81)	2.80(1.65)	6.60(2.82)	2.60(1.61)	6.60(2.82)
T_2: Honey		3.40(1.81)	10.00(3.36)	3.60(2.06)	10.40(3.28)	3.50(1.93)	10.20(3.32)
T_3: Yeast		3.20(1.86)	10.00(3.13)	3.00(1.92)	10.80(3.14)	3.10(1.89)	10.40(3.13)
T_4: Castor Castor pollens + Honey		4.20(2.21)	9.60(3.35)	4.20(2.45)	9.20(3.35)	4.20(2.33)	9.40(3.35)
T_5: Castor Castor pollens + Yeast		5.00(2.29)	10.20(3.23)	5.00(2.44)	9.80(3.29)	5.00(2.36)	10.00(3.26)
T_6: Yeast + Honey		5.40(2.30)	9.80(3.36)	5.60(2.39)	9.80(3.31)	5.50(2.34)	9.80(3.33)
T_7: Castor Castor pollens + Yeast + Honey		7.60(2.77)	12.80(3.88)	8.00(2.74)	12.40(3.77)	7.80(2.75)	12.60(3.83)
T_8: Mixed stages of *T. urticae*		17.00(3.96)	25.40(5.30)	19.00(4.27)	27.00(5.27)	18.00(4.12)	26.20(5.28)
T_9: Mixed stages of *O. indicus*		13.20(3.75)	15.20(4.46)	11.60(3.49)	13.80(4.42)	12.40(3.62)	14.50(4.44)
T_{10}: Mixed stages of *P. latus*		13.40(3.30)	13.40(4.30)	11.20(3.35)	13.00(4.50)	12.30(3.33)	13.20(4.40)
T_{11}: Starved (No food)		2.20(1.51)	1.80(2.02)	1.80(1.58)	1.20(2.34)	2.00(1.55)	1.50(2.18)
Treatment	**SEm±**	**0.08**	**0.08**	**0.08**	**0.09**	**0.05**	**0.06**
	C.D. 5%	**0.23**	**0.24**	**0.22**	**0.27**	**0.16**	**0.17**
Year	**SEm±**					**0.02**	**0.02**
	C.D. 5%					**0.06**	**0.07**
Y x T	**SEm±**					**0.08**	**0.08**
	C.D. 5%					**NS**	**NS**
C.V. (%)		**7.44**	**5.27**	**6.72**	**5.87**	**7.08**	**5.58**

Figures in the parentheses are arc sin transformed values while those outside are original value.

Table.2 Effect of alternate diet on fecundity, daily fecundity and mating period *A. finlandicus*

Treatments		**Fecundity (N0. of eggs)**			**Daily fecundity (N0. of eggs)**			**Mating period (Minutes)**		
		2014-15	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**
T_1: Castor pollens		5.60(1.66)	5.80(1.64)	5.70(1.65)	0.88(0.90)	0.88(0.89)	0.88(0.90)	0.00(0.71)	0.00(0.71)	0.00(0.71)
T_2: Honey		6.40(2.02)	6.60(2.06)	6.50(2.04)	0.64(0.91)	0.64(0.93)	0.64(0.92)	0.00(0.71)	0.00(0.71)	0.00(0.71)
T_3: Yeast		5.00(1.44)	4.80(1.22)	4.90(1.33)	0.52(0.82)	0.45(0.78)	0.48(0.80)	0.00(0.71)	0.00(0.71)	0.00(0.71)
$T_{4:}$ Castor pollens + Honey		5.60(1.75)	5.60(1.73)	5.60(1.74)	0.59(0.87)	0.62(0.86)	0.60(0.86)	0.00(0.71)	0.00(0.71)	0.00(0.71)
T_5: Castor pollens + Yeast		6.60(1.91)	6.80(2.06)	6.70(1.99)	0.67(0.91)	0.70(0.94)	0.69(0.92)	0.00(0.71)	0.00(0.71)	0.00(0.71)
T_6: Yeast + Honey		8.00(2.30)	7.80(2.49)	7.90(2.40)	0.84(0.97)	0.80(1.03)	0.82(1.00)	0.00(0.71)	0.00(0.71)	0.00(0.71)
T_7: Castor pollens + Yeast + Honey		9.60(2.43)	9.60(2.54)	9.60(2.48)	0.75(0.93)	0.78(0.97)	0.76(0.95)	0.00(0.71)	0.00(0.71)	0.00(0.71)
T_8: Mixed stages of *T. urticae*		25.40(5.92)	28.80(6.28)	27.10(6.10)	1.00(1.32)	1.10(1.39)	1.03(1.36)	13.40(3.73)	14.00(3.77)	13.70(3.75)
T_9: Mixed stages of *O. indicus*		13.20(4.13)	14.40(4.12)	13.80(4.13)	0.91(1.16)	1.07(1.17)	1.00(1.17)	6.20(2.59)	6.80(2.69)	6.50(2.64)
T_{10}: Mixed stages of *P. latus*		12.20(3.96)	14.20(3.94)	13.20(3.95)	0.87(1.16)	1.05(1.12)	0.96(1.14)	6.20(2.58)	6.00(2.55)	6.10(2.57)
T_{11}: Starved (No food)		1.60(1.30)	1.20(1.49)	1.40(1.39)	0.52(0.82)	0.45(0.78)	0.48(0.80)	0.00(0.71)	0.00(0.71)	0.00(0.71)
Treatment	**SEm±**	**0.09**	**0.08**	**0.05**	**0.02**	**0.02**	**0.01**	**0.03**	**0.03**	**0.02**
	C.D. 5%	**0.25**	**0.22**	**0.16**	**0.07**	**0.05**	**0.04**	**0.08**	**0.09**	**0.05**
Year	**SEm±**			**0.02**			**0.006**			**0.008**
	C.D. 5%			**0.07**			**0.01**			**0.02**
Y x T	**SEm±**			**0.08**			**0.02**			**0.02**
	C.D. 5%			**NS**			**NS**			**NS**
C.V. (%)		**7.55**	**6.43**	**7.00**	**5.49**	**4.19**	**4.87**	**4.52**	**5.13**	**4.83**

Figures in the parentheses are arc sin transformed values while those outside are original value.

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