INFLUENCE OF TEMPERATURE ON LIFE HISTORY CHARACTERISTICS OF XYLOCORIS FLAVIPES REARED ON ARTIFICIAL DIETS

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ABSTRACT

Xylocoris flavipes (Reuter) was reared at five constant temperatures (15-35°C) on Tribolium castaneum (Herbst) and T. confusum DuVal reared on artificial diets and its predatory activity against hosts were investigated. There was significant difference noticed in the mean oviposition period of X. flavipes feeding on two hosts ($P<0.001$, T. castaneum and $P<0.001$, T. confusum). The maximum oviposition period of the female X. flavipes reared on agar + flour on the above pests were 18.00±0.22 and 17.80±0.2 days at 30°C but minimum was 3.87±0.17 and 3.67±0.16 days reared only on flour. Mean number of eggs laid/female on T. castaneum reared on the same food was 39.80±0.17 at 25°C but minimum number of eggs/female 8.80±0.17 at 35°C. No eggs were laid at 15°C. When T. castaneum and T. confusum were reared on agar+flour the maximum and minimum hatchability of eggs of X. flavipes was 33.07±0.36, 32.47±0.24 and 7.80±0.17, 7.80±0.14 days at 25 and 35°C respectively. Highly significant ($P<0.001$) difference was noticed between temperature and development time. The minimum percentage mortality of immature stages of X. flavipes recorded on both the hosts reared on yeast+flour at 25°C but maximum at 35°C. In relation to foods the progeny production of the predator differed significantly ($P<0.001$, T. castaneum and $P<0.001$, T. confusum). Both hosts when reared on agar+flour, X. flavipes produced maximum number of progeny/female (28.73 and 28.60) at 20-30°C respectively.

INTRODUCTION

One of the most important factor that affects insect population in storage condition is the temperature (Flinn and Hagstrum 1990), which is strongly correlated with the relative humidity of the habitat.

Arbogast (1975) reported that temperature has a significant effect on the life history characteristic of the predator, Xylocoris flavipes. At low temperature, development of individual insects decreases and the rate of population growth becomes lower whereas temperature increases, the rate of developmental activity of individuals increases and the rate of population growth subsequently higher. All the species have an optimum temperature at which population growth is at it maximum level. Insects are poikilothermic and its rate of development varies with temperature (Anderwartha and Birch 1954, Kitching 1977).

To examine the effects of temperature on the life history and predation activity of the bug against T. castaneum and T. confusum (reared on artificial diets) in order to provide useful information on its potential use for IPM programs was undertaken. The experiment were to determine the reproductive potentials, development, mortality and sex ratio of emerging adults of X. flavipes reared on T. castaneum and T. confusum feeding on artificial diets over a range of temperature were assessed.

MATERIALS AND METHODS

Experimentation

Adults of both predator (X. flavipes) and hosts (T. castaneum and T. confusum) were collected from the rearing culture and kept separately in three beakers with different foods, Tribolium larvae for the predators and standard food for the beetles. Eggs of X. flavipes were collected and reared separately on the larvae of two hosts species until adult emergence. After emergence eight healthy and mated female X. flavipes were aspirated and kept in individual glass beaker (50 ml). These eight beakers were then grouped into two each group containing four beakers. In one of the four beakers of a group, 15 first instar larvae (2-3 d old) of T. castaneum reared on one of the artificial diet were introduced. So, that female predator of each of the beaker was supplied with host larva which were reared on one of the artificial diet and control food. The other group of four beakers were supplied similarly with 15 first instar larvae (2-3-day old) of T. confusum reared on different diets. Mouth of each beaker was covered with fine cloth and rubber band to inhibit moving out of the insects.

The experiments were kept in an incubator at 15°C for 24 h for allowing egg laying of the female predator. After 24 h the females were replaced in separate beakers with host larvae further egg laying and kept at same temperature. This procedure was maintained until the death of the female predator. Similar process were at 20, 25, 30 and 35°C in the incubator. For each host and each artificial diet at each temperature level, 15 replications were made. These experiments were carried out at 70% relative humidity.

RESULTS

Oviposition period

Mean oviposition period of X. flavipes feeding on T. castaneum and T. confusum were reared on different artificial food medium found to vary (Table 1 and Figures 1 and 2) and their relationship also varied. There was a significant effect observed in between different foods ($F=319.21$, $P<0.001$ T. castaneum; $F=398.06$, $P<0.001$ T. confusum) and at different temperatures ($F=3868.29$, $P<0.001$, T. castaneum; $F=4925.75$, $P<0.001$, T. confusum) (Tables 1). The maximum oviposition period of the female X. flavipes reared on agar + flour on T. castaneum was 18.00±0.22 at 30°C and minimum on T. castaneum reared on only flour as control was 3.87±0.17 at 35°C. Whereas, on agar + flour was 17.80±0.2 days at 30°C but minimum on T. confusum reared on only flour as control was 3.67±0.16 days at 35°C.

Fecundity

Mean total number of eggs laid by a single female of X. flavipes on different artificial foods at 15, 20, 25, 30 and 35°C temperature and their relationship are shown in Figures 3 and 4 respectively. The predator laid higher number eggs on artificial diets than in the control food. Maximum number of eggs laid/female on T. castaneum reared on agar + flour was 39.80±0.17 at 25°C but minimum (8.8±0.17) was found when T. castaneum raised on flour only at 35°C.

Hatchability

The maximum and minimum hatchability of X. flavipes eggs on T. castaneum was 33.07±0.36 reared on agar + flour and 7.80±0.17 when reared on only flour as control at 25 and 35°C respectively (Figures 5 and 6). The maximum and minimum hatchability of eggs produced by the predator on T. confusum was 32.47±0.24 when reared on agar+flour and 7.80±0.14 on control at 30 and 35°C respectively. Temperature and food also played significant role ($P<0.001$) (Table 1).

Developmental time

Mean development times increased at low temperature levels (Figures 7 and 8). The maximum developmental time was observed at 20°C on T. castaneum or T. confusum. The effect of temperature on the developmental time was highly significant (F=30000.00, P<0.001 T. castaneum, F=12000.00, P<0.001 T. confusum) (Table 1) which indicated that the developmental times of X. flavipes depended upon the temperatures.

Mortality among immature stage

Minimum mortality (%) of the predator was recorded on T. castaneum reared on yeast+flour at 25°C. Maximum mortality was recorded at 35°C when the predator was reared on T. castaneum fed on control food. Similarly, minimum mortality was recorded when the predators were reared on T. confusum fed on yeast+flour at 25°C, and maximum mortality (62.44%) was obtained when the host fed on control food at 35°C. Immature mortality (%) was significantly varied when the hosts were reared on different diets (Table 1).

Total progeny production

The progeny production was increased with the increase of temperature from 20-30°C, and then began to decrease at 35°C on both host species (Figures 11 and 12). The progeny production of the predator on two host beetles differed significantly in relation to different foods (F=1930.62, P<0.001, T. castaneum; F=1625.75, P<0.001, T. confusum) at different temperatures (F=9388.44, P<0.001, T. castaneum, F=8051.27, P<0.001, T. confusum) (Table 1).

Progeny production/female/day

Maximum number of progeny/female/day on T. castaneum reared on yeast+flour was 1.83±0.03 and on T. confusum when reared on same food was 1.81±0.05 at 25°C (Figures 13A and B). Significant differences (P<0.001) existed in progeny production/female/day at different levels of temperature and different artificial foods (Table 1).

Sex ratio

The sex ratio of the emerged predators differed at different temperature levels, in both hosts and host diets (Table 2). Host larvae reared on yeast + flour, when were fed to X. flavipes, sex of the emerged adults showed preference for more female production than male, at 20-30°C on T. castaneum and at 20 and 35°C on T. confusum. The immature X. flavipes feeding on T. castaneum larvae reared on the same food, produced more males than females (65.67%, χ^2=9.86) as 35°C, whereas, at same temperature and host diet, more females of the predator was produced (64.29%, χ^2 value 8.17) than males.

Host feeding on agar + flour produced more females of X. flavipes at both 25 and 30°C on T. castaneum, and at all temperature levels on T. confusum. Irrespective of host diet and host species, temperature levels at 25 and 30°C, sex-ratio of X. flavipes was significantly deviated from normal 1:1 ratio.

Only flour (control) fed host larvae produced more male predators, otherwise, artificial host diets encouraged increased female percentage in X. flavipes at all temperature levels.

DISCUSSION

Temperature is one of the most important abiotic factors affecting the population dynamics of insects in different storage structures (Flinn and Hagstrum 1990). In the present experiment, the life history characteristics of the predator X. flavipes were found to be dependable on the temperature. The life history characteristics like egg laying period, egg production, fertility of eggs, total progeny production and egg-adult developmental time, were optimized at 30°C and at 70% rh irrespective of host species. At 15°C, the female predators failed to oviposit while feeding on either host species.

However, host diet played an important role in controlling development, survivability and reproductive potentiality of the predator. The host food containing agar and flour has been proved to be effective in encouraging population build up of X. flavipes feeding on larvae of both Tribolium and T. castaneum; and T. castaneum enhanced growth of the predator compared to T. confusum. Wackers (1998) reported that the parasitoids Anisopteromalus calandrae and Heterospilus prosopidis to establish on Callosobruchus species only without supplementing with honey. A number of available reports support the positive role of supplemental diets of hosts for increasing the parasitoid activities (Schmale et al. 2001, Wackers 2001), which are important raise then as biocontrol agents against the stored product insects.

At 30°C, the female predator laid around 39 egg, feeding on either of the hosts. Though the percentage of hatchability of the eggs was >50 feeding on larvae raised on all types of food, but it was higher in agar+flour supplement in control diet. From 20°C up to 30°C, development and reproductive potentials of X. flavipes were found to increase while reared on both host species and at all food sources; but at 35°C there is a sudden decrease in the values of all life history characteristics in all the mentioned factors. Arbogast et al. (1975) reported that X. flavipes females laid maximum number of eggs at 20 and 30°C, but the longest oviposition period was recorded at 20°C.

Herrera et al. (2005) reported that the developmental time for all three larval stages, decreased with increasing temperature between 20 and 35°C and maximum at 40°C in Diorhabda elongate. The egg-adult developmental time also decreased with increasing temperature between 20 and 35°C that are in accordance with the present result in all food medium. Russo et al. (2006) observed that the developmental time of Piophila casei from first instar to adult decreased with the increasing temperature of 32°C.

Temperature plays vital role in embryogenesis in all animals. Fertility of insect eggs positively related with the rearing temperature, and after the optimum level, the relation becomes increase. In other species of predators like D. elongate (Herrera et al. 2005), P. maculiventris (Legaspi and Legaspi 2005), P. casei (Russo et al. 2006) lowest hatching rate of eggs was recorded at temperatures ranged from 15-18°C. In the present study lowest hatching was recorded ranging from 14-28% (on T. castaneum) and 13-26% (on T. confusum) in X. flavipes at 20°C, where egg laying was totally inhibited at 15°C.

Mortality of the developmental stages of X. flavipes was maximum (>62%) at 35°C, when provided with host larvae raised on normal food. The supplement of yeast to hosts food increased the survivability of immature stages of the predator, which was minimum at 25°C.

In, X. flavipes, temperature also played a significant role in progeny production. Fecundity (total eggs laid) was adversely affected by lower and higher temperatures. At low temperature, production of egg was maximum at 25°C feeding on larvae of both host species, reared on all food medium. Arbogast (1975) reported that a single X. flavipes female laid on average 31.7 eggs in her life time; but in the present study the number was increased as 39.8 and 39.07 eggs by a single female X. flavipes feeding on T. castaneum and T. confusum at 30°C.

The mean total fecundity/female P. casei was higher at 25°C and lower at 15 and 19°C, and the best performance was recorded at 32°C (Russo et al. 2006). Legaspi and Legaspi (2005) observed the life table analysis of Podisus maculiventris immatures and female adults under four constant temperatures (18, 22, 26 and 30°C) and reported the total number of eggs laid/female ranged from 429.4 at 18°C to 755.4 at 26°C. These findings are in accordance with the relationship of temperature and fecundity of X. flavipes.

Arbogast (1975) reported that mortality among the immature stages of X. flavipes was highest at 35°C which complies with the present results.

Production of higher percentage of female predators in usually preferable for potential biocontrol of pests. In the present experiment at 25 and 30°C, T. castaneum larvae feeding on any diet including the control diet, increased the production of female X. flavipes. However, T. confusum also showed similar effect on the sex differentiation of the predator at the same temperature and other diets except yeast + flour.

To enhance predation potentiality of X. flavipes food plays as a regulating factor which is also related with the rearing temperature. Food of the host larvae directly affected the life history characteristics of X. flavipes. At 15°C enriched food even failed to produce eggs by the female predator. Addition of agar in host's food irrespective of host species, increased potentiality of X. flavipes, which was maximum at 25-30°C. An increase of temperature level beyond 30°C produced negative effect on developmental period and reproductive potentials of the predator, irrespective of host species and their diets. Lack of such information on predators of stored product insects make it difficult to compare the present data.

Table 1. Analysis of variance on the effect of temperature and artificial diets on the life history of X. flavipes reared on T. castaneum and T. confusum

Life history characteristics	Factors	F-values (level of significance)	
		T. castaneum	T. confusum
	Artificial Diet	319.21 (p<0.001)	398.06 (p<0.001)
Oviposition period	Temperature	3868.29 (p<0.001)	4925.75 (p<0.001)
	Diet x Temperature	60.34 (p< 0.001)	78.72 (p<0.001)
	Artificial Diet	1775.92 (p<0.001)	921.49 (p<0.001)
Fecundity	Temperature	2300.00 (p<0.001)	9588.38 (p<0.001)
	Diet x Temperature	249.39 (p<0.001)	144.04 (p<0.001)
	Artificial Diet	818.71 (p<0.001)	242.52 (p<0.001)
Hatchability	Temperature	1600.00 (p<0.001)	4376.32 (p<0.001)

	Diet x Temperature	195.60 (p<0.001)	68.73 (p<0.001)
	Artificial Diet	292.10 (p<0.001)	136.58 (p<0.001)
Dev. Time	Temperature	3000.00 (p<0.001)	1200.00 (p<0.001)
	Diet x Temperature	37.38 (p<0.001)	15.82 (p<0.001)
	Artificial Diet	229.45 (p<0.001)	120.18 (p<0.001)
Mortality of Immature stage (%)	Temperature	769.56 (p<0.001)	357.58 (p<0.001)
	Diet x Temperature	72.36 (p<0.001)	55.63 (p<0.001)
	Artificial Diet	1930.62 (p<0.001)	1625.75 (p<0.001)
Total progeny production	Temperature	9388.44 (p<0.001)	8051.27 (p<0.001)
	Diet x Temperature	265.23 (p<0.001)	219.15 (p<0.001)
	Artificial Diet	100.39 (p<0.001)	96.84 (p<0.001)
Progeny Prod/day	Temperature	976.28 (p<0.001)	907.39 (p<0.001)
	Diet x Temperature	10.73 (p<0.001)	11.85 (p<0.001)

Table 2. Effect of artificial foods on T. castaneum and T. confusum on the sex ratio (%) of X. flavipes at different temperature.

Foods	Temp	T. castaneum			T. confusum		
		Male	Female	Chi-square	Male	Female	Chi-square
	15	0.0	0.0	0.0	0.0	0.0	0.0
	20	38.46	61.54	5.33 (p<0.05)	38.46	61.54	5.33 (p<0.05)
Yeast + Flour	25	40.0	60.0	4.0 (p<0.05)	44.0	56.0	1.44
	30	40.0	60.0	4.0 (p<0.05)	44.0	56.0	1.44
	35	65.67	34.3	9.86 (p<0.05)	35.71	64.29	8.17 (p<0.05)
	15	0.0	0.0	0.0	0.0	0.0	0.0
	20	46.67	53.33	0.44	35.71	64.29	8.17 (p<0.05)
Agar + flour	25	35.71	64.29	8.17 (p<0.05)	37.93	62.07	5.83 (p<0.05)
	30	35.71	64.29	8.17 (p<0.05)	37.64	62.96	6.72 (p<0.05)
	35	50.0	50.0	0.0	40.0	60.0	4.0 (p<0.05)
	15	0.0	0.0	0.0	0.0	0.0	0.0
	20	37.5	62.5	6.25 (p<0.05)	42.86	57.14	2.04
Folic acid + Flour	25	33.33	66.67	11.12 (p<0.01)	35.71	64.29	8.17 (p<0.05)
	30	33.33	66.67	11.12 (p<0.01)	34.3	65.67	9.82 (p<0.05)
	35	50.0	50.0	0.0	44.0	56.02	1.45
	15	0.0	0.0	0.0	0.0	0.0	0.0
	20	50.0	50.0	0.0	50.0	50.0	0.0
Control	25	60.0	40.0	4.0 (p<0.05)	61.54	38.46	5.33 (p<0.05)

	30	60.0	40.0	4.0 (p<0.05)	64.29	35.71	8.17 (p<0.05)
	35	50.0	50.0	0.0	60.0	40.0	4.0 (p<0.05)

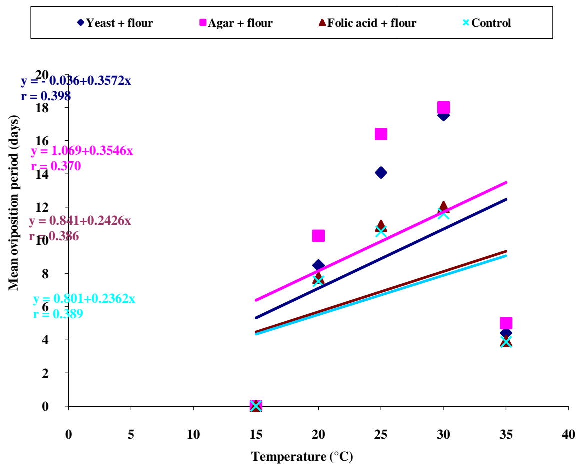

Figure 1 Oviposition period of X. flavipes feeding on T. castaneum at different temperatures (°C).

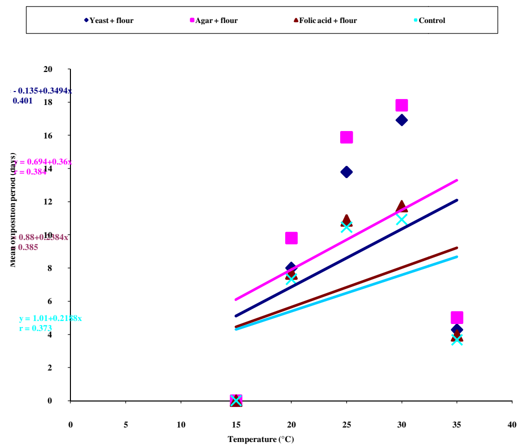

Figure 2 Oviposition period of X. flavipes feeding on T. confusum at different temperatures (°C).

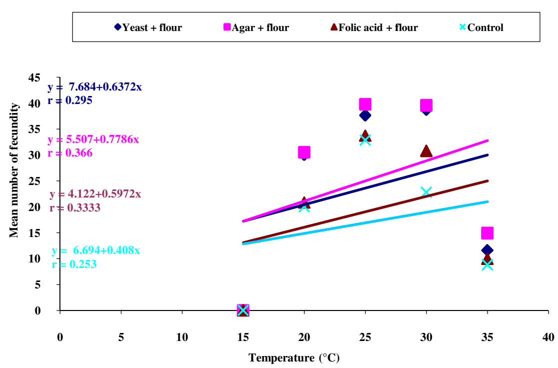

Figure 3 Fecundity of X. flavipes feeding on T. castaneum at different temperatures (°C).

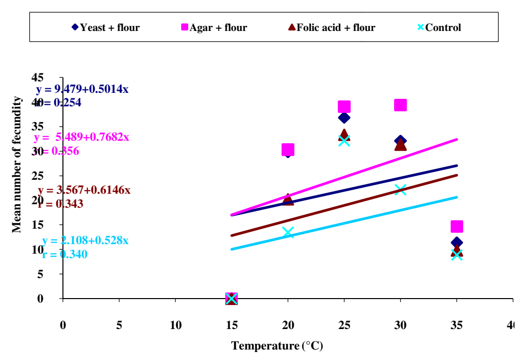

Figure 4 Fecundity of X. flavipes feeding on T. confusum at different temperatures (°C).

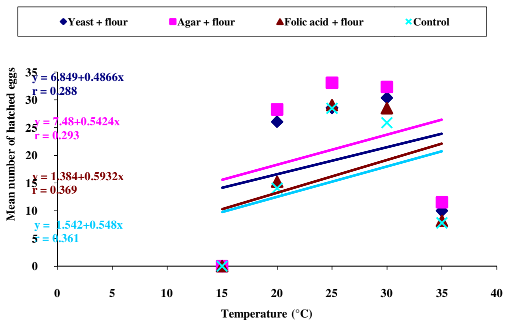

Figure 5 Hatchability of X. flavipes feeding on T. castaneum at different temperatures (°C)

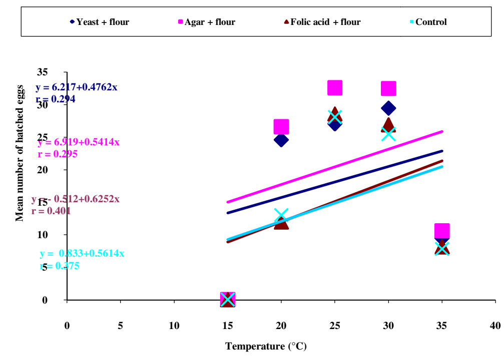

Figure 6 Hatchability of X. flavipes feeding on T. confusum different temperatures (°C).

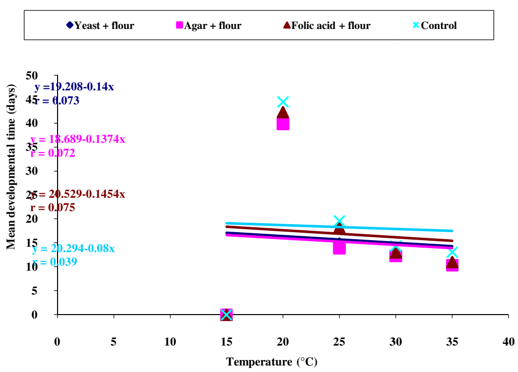

Figure 7 Mean developmental time (day) of X. flavipes feeding on T. castaneum at different temperatures (°C).

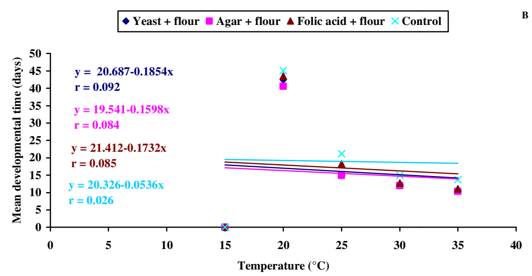

Figure 8 Mean developmental time (day) of X. flavipes on T. confusum at different temperatures (°C).

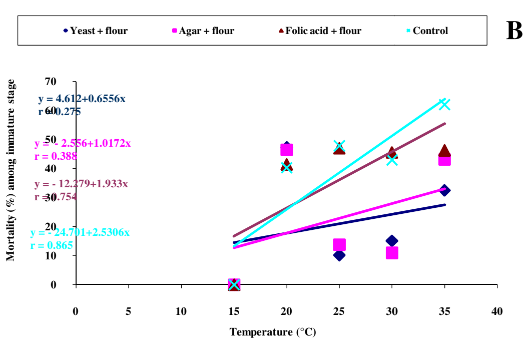

Figure 9Mortality (%) among immature stage of X. flavipes feeding on T. castaneum at different temperatures (°C).

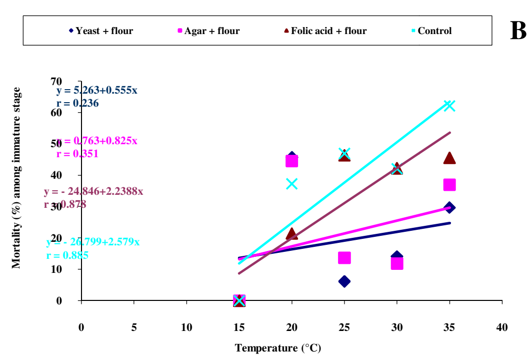

Figure 10 Mortality (%) among immature stage of X. flavipes feeding on T. confusum at

different temperatures (°C).

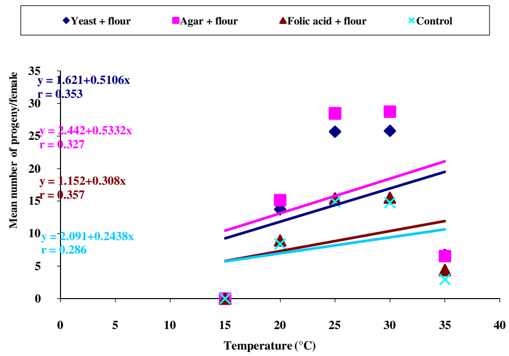

Figure 11 Mean number of total progeny/female of X. flavipes feeding on T. castaneum at different temperatures (°C).

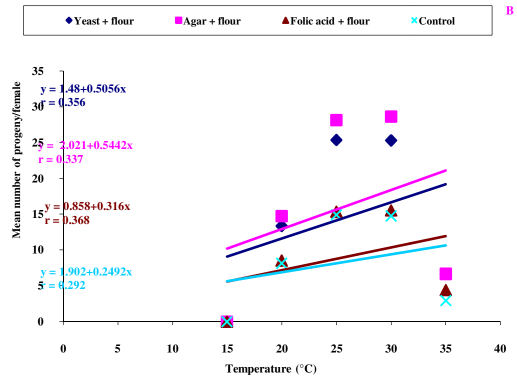

Figure 12 Mean number of total progeny/female of X. flavipes feeding on T. confusum at different temperatures (°C).

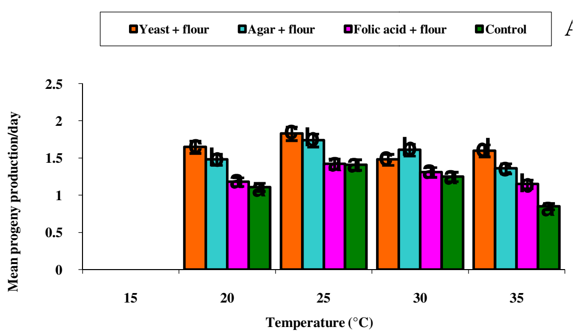

Figure 13 A Mean number of progeny production/day/female X. flavipes on T. castaneum (reared on different artificial food) at different temperatures (°C)

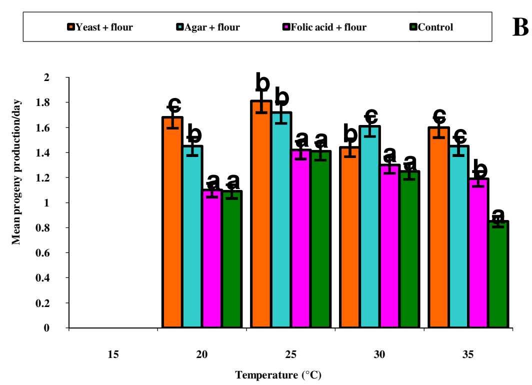

Figure 13 B Mean number of mean progeny production/day/female of X. flavipes on T. confusum (reared on different artificial food) at different temperatures (°C)

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