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Effect of Temperature and Aphid-Host Plant Variety on Performance and Thermal Requirments of *Coccinella undecimpunctata* L. and *Cheilomenes propinqua isis* (mulsant)

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ABSTRACT

In this study, the single and common effects of temperature (20, 25 and 30 ± 1˚C) and eggplant varieties (Classic, 0111, and Anan) on the developmental performance and heat requirements of *Coccinella undecimpunctata* L. and *Cheilomenes propinqua isis (*Mulsant) were examined. The predators were fed upon *Aphis gossypii* Glover that reared on the three eggplant *Solanum melongena* (L.) varieties. The two-way ANOVA showed that there was significant effects of temperature and host plant varieties on the total developmental times of both predators. However, the interaction between temperature and host plant variety interaction had only significant effect on the total developmental times of *C. undecimpunctata*. The results also revealed that the developmental times (DT) of both predators were decreased with increasing the temperature, whereas the developmental rates increased. Based on lower developmental threshold (T_0) values, the more tolerant stage for coldness was the pupal stage of both *C. undecimpunctata* and *C. propinqua isis* on the three eggplant varieties. On the contrary, the more sensitive stage for low temperature degrees differed for both species: the eggs stage for *C. undecimpunctata* and the larval stage for *C. propinqua isis*. The minimum (T_0) values for the entire development of both predators were recorded on Classic variety. The heat units (degree-days, DD's) estimated for each stage showed that aphids produced on Classic variety lowered the amount of heat required by both predator species to complete their development. Further, the larval stage of both predatory species required more heat units to develop at each aphid-host plant variety combination than other stages. These results suggest that eggplant var. Classic has to be considered, in mass rearing programs, to produce a high nutritional prey for both predator species. This might maximize the population of these predators. As well, 30 ˚C would multiply the population of both predators under the same rearing conditions, and thus has to be generalized.

keywords: *Aphis gossypii*, *Coccinella undecimpunctata, Cheilomenes propinqua isis* , degree-days, development, mass rearing

INTRODUCTION

One of the most notable preys of several species of Coccinellidae in Egypt is the cotton aphid, *Aphis gossypii* Glover. It is an economical pest of several plant species (Blackman and Eastop, 1984). Aphid populations exhibit 'boom and bust' dynamics in linked with host plant vegetation times. Thus, their populations are highly aggregated over time and space. Accordingly, their associated predators move to aggregate in the same patch as well, making conditions excellent to interactions (Bayoumy and Ramadan, 2018).

The family of Coccinellidae is an important predatory group that distributed in many economic crops worldwide. Some Coccinellidae may have an important part in the biological control (BC) of aphid species, other scale insects and whiteflies. In Egypt, *Coccinella undecimpunctata* L. and *Cheilomenes propinqua isis (*Mulsant) (= *Cydonia vicina isis*) are among the most effective predators in this family (Ghanim and El-Adl, 1987a, b; Darwish and Ali, 1991; El-Saadany *et al.,* 1999). The former one is a cosmopolitan species that prefers to prey on aphids among others (Raimundo and Alves, 1986; Hodek and Honek, 1996). However, it can also complete their development on other soft body insects and moth eggs (Bakhtawar *et al*., 2017). It is quickly declined the population of aphids after its introduction in Azores (Soares *et al*., 2003b). The latter species is, a polymorphic lady beetle species, widely distributed in Africa and the Arabian Peninsula and prefers aphids, as prey, as well (Sæthre *et al*., 2011).

Temperature controls the development rate of many insects which need a certain amount of heat to grow from stage to another one. This amount of heat is expressed as degree-days (dd's). Development of insects is highly associated with temperature. As the temperature decreases, developmental time decreases as well until the temperature reaches the inappropriate limit for development. This limit is known as the lower development threshold (T_0). It defines as the minimum temperature at which the organism can survive and develop, but down it the death happens. Numerous studies have paid attention to the importance of these aphidophagous predators. Several studies have been extensively dealt with feeding efficiency, prey preference, behavioural responses, seasonal abundance, and effect of insecticides of these predators (Smith, 1965; Ghanim and El-Adl, 1987a, b; Eraky and Nasser, 1993; Abdel-Salam, 1995; El-Hag and Zaitoon 1996; Nasser *et al*., 2000; Bayoumy *et al*., 2015, Bayoumy and Awadalla, 2018). Because these predatory species have high searching rates, they could be excellent candidates for BC of aphids in open fields or/and greenhouses. Thus, it is necessary to estimate the appropriate temperature that require for maximizing their efficiency prior to the release processes in the open field.

Food, as a biotic factor, and temperature, as an abiotic factor, are considered among the most influential factors affecting the biology, ecology, and physiology of insects and their natural enemies (Huffaker *et al*., 1999; Jervis *et al*., 2005). Recently, debates focused on a "Metabolic Theory of Ecology" since temperature and body weight are the fundamental determinants of the rates at which life's central processes occur (Brown *et al*., 2004). The thermal characteristics are differing between species, populations, developmental stages, and with other ecological factors such as food source (Gilbert and Raworth, 1996; Roy *et al*., 2003). Finding food that contains protein and carbohydrates in optimal ratios is an important challenge for many animals (Price *et al*., 2011; Simpson and Raubenheimer, 2012). Acquisition of food resources by herbivores differs highly from that by carnivorous because variations in nutritional values of dirty items are much higher for herbivores. Energy and nutrient content of vertebrate prey is compatible to body composition of vertebrate predators, i.e. high protein contact, variable lipid contact, and little or no carbohydrates (Robbins, 1993). Hence, the aphid-host plant variety could play a significant role in increasing the persistence of a species to lower degrees of temperatures, resulting in increasing the amount of heat (degree-days) requires for development. On the contrary, this hypothesized effect could be minimized in case of interacting with other abiotic factors like temperature. Therefore, this study aims to evaluate the single and common effects of temperature and aphid-host plant variety on development, reproduction, longevity and heat requirements of *C. undecimpunctata* and *C. propinqua isis*.

MATERIALS AND METHODS

I. Plant and aphid cultures

Seedlings of eggplant (*Solanum melongena* L.) varieties namely Classic, 0111 and Anan were sown in the greenhouse. The experimental area of the green house was 360 m^2 placed at the Experimental farm of Mansoura University. The cotton aphid, *Aphis gossypii* Glover was collected from heavily infested crops (green bean and cowpea) growing at the Experimental farm. Once the seedlings inside the greenhouse reached 10 cm in highest, the infestation was started using the first instars of A. gossypii that transferred to each host plant variety. These plants were watered and fertilized in the due time as required. After one month from plantation, these infestations were used either in rearing predators or in feeding experiments for predators.

2. Predator colonies:

The rearing of *C. undecimpunctata* and *C. propinqua isis* was carried out at 25.0 ± 1.0 °C, 60.0 ± 5% RH, and a 14:10 (L:D) day length. Adults and larvae of theses predatory species were kept, in isolation, in Petri-dishes (9.0 cm diam × 2.0 cm ht and 5.5 cm diam × 2.0 cm ht for oviposition and development, respectively). Colonies of *C. undecimpunctata* and *C. propinqua isis* were began from ca. 50 beetles per each species. These lady beetles were directly collected and transferred into plastic vials (6.0 cm diam × 10.0 cm ht) from green and white bean fields at the University farm. In the laboratory, adult ladybeetles were maintained in ventilated jars (15 cm diam. × 10 cm ht.) and stuffed with wax paper. Ten females of each species were kept in Petri-dishes in isolation, and provided with cotton aphids, *ad libitum*, on a piece of eggplant leaf. Aphids were daily offered and eggs were collected by transferring females to new dishes. Upon eclosion, sibling groups of five individuals of each coccinellid species were reared on a diet of *A. gossypii* supplied *ad libitum* every 48 h. To ensure mating, all emerged beetles of each coccinellid species were collected into ventilated plastic vials (9.0 cm diam × 20.0 cm ht) and were fed on ca. 15.0 mg of the Angoumois grain moth, *Sitotroga cerealella* Olivier (Lepidoptera: Gelechiidae), ca. 5.0 mg of pollen, and water on a cotton wick. Water and moth eggs were added every 48 h. Previous work has shown these conditions to be ideal for maintaining beetles in reproductive diapause for extended periods prior to breeding (Michaud and Qureshi, 2006). In each experiment, mated females were isolated in Petri-dishes and daily provided with aphids, *ad libitum*, to produce their eggs. These eggs were used in the experiments.

3. Development and thermal requirements

Development of each predator species was monitored at three constant temperatures (20 ± 1, 25 ± 1 and 30 ± 1 °C) with a relative humidity of 60.0 ± 5.0% and a photoperiod of 14:10 (L: D). The cotton aphid, *A. gossypii*, provided as a diet in each trial for each predator species was collected from the three eggplant verities (i.e., classic, 0111 and Anan) cultivated in the greenhouse. The second clutch of predator's eggs was collected from four females (predator colony) and incubated at 25.0 ± 1.0 °C, 60 ± 5% RH, and 14:10 (L:D) photoperiod. Upon eclosion, three groups of larvae, each consisted of 20 neonate larvae were isolated in Petri-dishes (each 5.5 cm in diam.) that provided with a filter paper on their bottom to offer a walking surface for the larvae. A fixed number of second and third instars *A. gossypii* were provided daily on a piece of each host plant leaf for each individual larva of predator species. As the predator's instar developed, the aphid amount was gradually increased. Larvae were monitored daily and all developmental transitions (i.e., larval molts, pupation and developmental times) were recorded until emergence of adults. The number of died immature individuals during the experiment was also recorded. Within 24 h of emergence, adults were sexed. The developmental rate (1/developmental time) of immature stages was estimated. Data of individuals that failed to complete their development were excluded from the analysis. Developmental times for each stage and total stages (egg – adult) were used to estimate the thermal requirements. The linear regression relationship between developmental rates (y) and temperatures (x) was calculated as y= a+bx; (Arnold, 1960; Campbell *et al.,* 1974). The lower developmental threshold (T_0) was estimated using the x- intercept point and slope of the relation (T_0= -a / b).

The degree-days (dd's), expressed as thermal units (K) accumulated above the T_0, that require for the partial or total development of a predator on each temperature were calculated according to equation of Fletcher (1981) and Obrycki and Tauber (1981), as below:

$$K = D\,(T - T_0)$$

Where: D is the development duration in days, and T is the temperature at which development examined.

4. Data analysis

A two-way ANOVA was performed to analyze the effect of temperature, aphid-host plant variety, as independent variables, and their interaction on developmental times of *C. undecimpunctata and C. propinqua isis*. In case of significant, one-way ANOVA was also performed for each effect and means were separated using Student- Newman-Keuls Test (Costat Software, 2004).

RESULTS

I. Development

Temperature, aphid-eggplant varieties and their interaction had significant effects on preimaginal developmental times of *C. undecimpunctata* ($F_{2,149}$ = 503.94, P < 0.001; $F_{2,149}$=34.93, P < 0.001; and $F_{4,149}$= 3.73, P < 0.01, respectively). There were significant effects of temperature ($F_{2,150}$ = 647.34, P < 0.001) and aphid eggplant varieties ($F_{2,150}$ =16.48, P < 0.001) on preimaginal developmental times of *C. propinqua isis,* whereas interaction temperature and eggplant variety was not ($F_{4,150}$= 0.97, P = 0.42) (Table 1).

Table 1. Effects of temperature and aphid-eggplant varieties on developmental times of *Coccinella undecimpunctata* and *Chilonemus propinqua isis* when provided *Aphis gossypii* from three host plant varieties and monitored t three constant temperatures.

Predator species	Variables	df	F	P
C. undecimpunctata	Temperatures	2	503.94	< 0.001
	Varieties	2	34.93	< 0.001
	Varieties X Temperatures	4	3.73	< 0.01
	χ^2		14.39	
C. propinqua isis	Temperatures	2	647.34	< 0.001
	Varieties	2	16.48	< 0.001
	Varieties X Temperatures	4	0.97	> 0.05
	χ^2		26.11	

As the temperature increased the entire development time (egg-adult) of *C. undecimpunctata* significantly decreased on the Classic ($F_{2,49}$=180.09, P < 0.001), 0111 ($F_{2,52}$=180.09, P < 0.001), and Anan ($F_{2,48}$= 261.07, P < 0.001) varieties. The lowest developmental times of *C. undecimpunctata* was recorded using aphids from Classic variety at the three constant temperatures. But, there were significant differences among aphid-host plant varieties in the entire developmental time of *C. undecimpunctata* only at 20 °C ($F_{2,48}$=39.13, P < 0.001) and 25 °C ($F_{2,51}$=9.38, P < 0.001) (Table 2).

Table 2. Developmental times (±SE) in days of *Coccinella undecimpunctata* fed upon *Aphis gossypii* that reared on three eggplant varieties and monitored at three different temperatures.

Eggplant variety	Temperature (°C)	Egg stage	Larval instars 1st	2nd	3rd	4th	Total	Pupal Stage	Egg-Adult
	20	5.00±0.07 a^{A}	2.25±0.09 a^{C}	2.10±0.12 a^{B}	1.80±0.13 a^{B}	3.61±0.13 a^{B}	9.76±0.23 a^{B}	4.07±0.23 a^{A}	18.82±0.30 a^{B}
Classic	25	4.00±0.16 b^{A}	1.90±0.07 b^{A}	1.15±0.08 b^{A}	1.20±0.09 b^{A}	3.10±0.07 b^{B}	7.35±0.18 b^{B}	3.39±0.12 b^{A}	14.74±0.24 b^{B}
	30	2.50±0.16 c^{A}	1.20±0.22 c^{A}	1.10±0.16 b^{A}	1.16±0.05 b^{A}	2.30±0.13 c^{A}	5.74±1.35 c^{A}	2.٧0±0.12 c^{A}	10.94±0.24 c^{A}
	20	5.05±0.16 a^{A}	2.80±0.18 a^{B}	2.45±0.19 a^{AB}	2.10±0.07 a^{B}	4.71±0.11 a^{B}	12.06±0.26 a^{B}	4.20±0.10 a^{A}	21.31±0.33 a^{A}
0111	25	4.00±0.16 b^{A}	2.10±0.13 b^{A}	1.50±0.11 b^{A}	1.40±0.11 b^{A}	3.80±0.13 b^{A}	8.80±0.28 b^{A}	3.61±018 b^{A}	16.41±0.47 b^{A}
	30	2.50±0.16 c^{A}	1.50±0.16 c^{A}	1.20±0.16 b^{A}	1.30±0.16 b^{A}	2.70±0.32 c^{A}	6.70±0.28 c^{A}	3.10±0.16 c^{A}	11.90±0.34 c^{A}
	20	5.30±0.16 a^{A}	3.40±0.11 a^{A}	2.90±0.60 a^{A}	2.60±0.11 a^{A}	3.80±0.11 a^{B}	12.7±0.19 a^{A}	4.16±0.88 a^{A}	22.18±0.23 a^{A}
Anan	25	٤.20 ±0.09 b^{A}	٢.20±0.11 b^{A}	١.35±0.11 b^{A}	١.٥0±0.12 b^{A}	٣.70±0.14 a^{A}	٨.75±0.27 b^{A}	3.83±0.09 b^{A}	16.78±0.32 b^{A}
	30	2.70±0.11 c^{A}	1.30±0.11 c^{A}	1.20±0.09 b^{A}	1.22±0.10 b^{A}	2.69±0.19 b^{A}	6.٣١±0.37 c^{A}	٢.٨0±0.123 c^{A}	11.81±0.37 c^{A}

Values followed by the same lowercase small letters in a column among temperatures within each variety and the same uppercase capital letters among varieties in each temperature are not significantly different at the 5% probability level (ANOVA, Student- Newan-Keuls Test).

Similarly, with increasing temperature from 20 to 30 °C, the entire development time of *C. propinqua isis* declined dramatically on Classic variety ($F_{2,50}$= 297.94, P < 0.001), on 0111 variety ($F_{2,50}$ =23.77, df =2, P < 0.001) and on Anan variety ($F_{2,50}$=161.78, P < 0.001). There were significant differences among aphid-host plant varieties in the entire developmental time of *C. propinqua isis* at the three different temperatures ($F_{2,48}$= 3.34, P < 0.05; $F_{2,51}$= 7.687, P < 0.001; and $F_{2,52}$= 14.14, P < 0.001, respectively). The lowest development times of *C. undecimpunctata* was recorded on aphid-Classic variety at the three constant temperatures. On all tested varieties, egg, larval, pupal and egg-adult development of *C. undecimpunctata* required a much greater number of day-degrees than that of *C. propinqua isis* (Table 3).

Table 3. Developmental times (±SE) in days of *Chilonemus propinqua isis* fed upon *Aphis gossypii* that reared on three eggplant varieties and monitored at three different temperatures.

Eggplant variety	Temperature (°C)	Egg stage	Larval instars 1st	2nd	3rd	4th	Total	Pupal Stage	Egg-Adult
	20	4.2±0.19 a^{A}	3.9±0.07 a^{B}	2.6±0.11 a^{A}	2.80±0.09 a^{A}	3.39±0.16 a^{A}	12.69±0.18 a^{B}	4.47±0.12 a^{A}	21.28±0.27 a^{B}
Classic	25	3.1±0.07 b^{A}	2.7±0.11 b^{A}	1.7±0.11 b^{B}	1.90±0.23 b^{B}	2.89±0.23 a^{A}	9.19±0.32 b^{B}	3.72±0.11 b^{A}	16.03±034 b^{B}
	30	2.5±0.11 c^{A}	2.2±0.09 c^{A}	1.1±0.07 c^{A}	1.20±0.09 c^{A}	1.39±0.12 b^{B}	5.89±0.23 c^{B}	2.89±0.11 c^{A}	11.28±0.24 c^{B}
	20	4.3±0.19 a^{A}	4.4±0.11 a^{A}	2.8±0.09 a^{A}	2.90±0.07 a^{A}	3.67±0.11 a^{A}	13.77±0.24 a^{A}	4.81±0.40 a^{A}	22.88±0.54 a^{AB}
0111	25	3.1±0.07 b^{A}	2.9±0.07 b^{A}	1.9±0.07 b^{AB}	2.10±0.07 b^{AB}	2.95±0.16 b^{A}	9.85±0.20 b^{AB}	3.83±0.09 b^{A}	16.78±0.26 b^{B}
	30	2.5±0.11 c^{A}	2.4±0.16 c^{A}	1.2±0.16 c^{A}	1.32±0.11 c^{A}	1.83±0.17 c^{A}	6.75±0.26 c^{A}	3.15±0.17 c^{A}	12.53±0.28 c^{A}
	20	4.3±0.32 a^{A}	4.5±0.32 a^{A}	2.9±0.16 a^{A}	2.90±0.16 a^{A}	3.83±0.17 a^{A}	14.13±0.17 a^{A}	4.87±0.34 a^{A}	23.30±0.17 a^{A}
Anan	25	3.3±0.11 b^{A}	2.9±0.07 b^{A}	2.0±0.07 b^{A}	2.30±0.11 b^{A}	3.10±0.18 b^{A}	10.30±0.23 b^{A}	3.94±0.18 b^{A}	17.54±0.34 b^{A}
	30	2.6±0.11 c^{A}	2.5±0.12 c^{A}	1.3±0.11 c^{A}	1.40±0.11 c^{A}	1.68±0.11 c^{A}	6.88±0.27 c^{A}	3.2±0.12 c^{A}	12.68±0.28 c^{A}

Values bearing the same lowercase small letters in a column among temperatures within each variety and the same uppercase capital letters among varieties in each temperature are not significantly different at the 5% probability level (ANOVA, Student- Newan-Keuls Test).

2.Lower developmental threshold and heat requirements

The developmental rates of all life stages of *C. undecimpunctata* and *C. propinqua isis*, when both provided *A. gossypii* from different eggplant varieties, increased as the temperature increased. The lower developmental threshold (T_0) showed that the pupal stage was the more tolerant stage at the three eggplant varieties. Whereas the egg stage of *C. undecimpunctata* and larval stage of *C. propinqua isis*, respectively, were the more sensitive stages for temperature among others on the three eggplant varieties. In addition, the minimum T_0 values for the entire development of both predators were recorded on Classic variety. The thermal units estimated for each stage of the predators revealed that aphids developed and produced on Classic variety lowered the amount of heat required by both predator species to complete their development. The larval stage required more heat units to develop at each aphid-host plant variety than other stages (Table 4).

Table 4. Lower developmental threshold (T_0) and heat requirements (Degree-days, DD's) for various developmental stages of *Coccinella undecimpunctata* and *Chilonemus propinqua isis* when supplied with aphid prey that reared on three eggplant varieties.

Predator species	Eggplant variety	Egg stage		Larval instars										Pupal Stage		Egg-Adult	
				1st		2nd		3rd		4th		Total					
		T_0	DD's	T_0	DD's	T_0	DD's	T_0	DD's	T_0	DD's	T_0	DD's	T_0	DD's	T_0	DD's
	Classic	10.84	50.13	9.53	25.73	7.63	23.52	0.65	32.73	3.14	63.47	7.00	130.40	0.64	80.22	6.34	263.63
C.undecimpunctata	0111	11.04	49.49	8.83	32.32	10.04	23.59	2.71	34.33	7.08	63.56	7.67	150.30	2.69	75.66	6.56	292.06
	Anan	10.47	54.75	14.30	20.99	11.89	20.98	10.67	23.12	0.07	81.85	10.5	123.01	2.25	79.54	7.58	277.46
	Classic	5.28	62.50	6.8١	50.5١	13.05	19.08	12.98	21.01	14.3	23.58	11.9	109.89	2.16	81.97	9.07	238.1
C. propinqua isis	0111	6.00	59.70	7.60	52.88	13.00	20.96	12.25	24.24	10.9	36.61	10.7	132.96	1.06	91.30	8.11	276.56
	Anan	4.83	65.75	6.86	56.53	12.33	23.51	11.54	27.11	13.3	30.15	10.9	134.70	1.00	93.30	8.42	278.14

DISCUSSION

The developmental times of both predators preyed aphids from the three eggplant varieties are decreased with increasing the temperature, whereas the developmental rates increased with the higher rates at 30 °C. These results in consistent with those of Ghanim and El-Adl (1987a), Kontodimas (2004 a,b), Katsarou *et al*. (2005), Bayoumy *et al*. (2015), Saleh *et al.* (2017), and Zhou *et al.* (2017). The development time of *C. undecimpunctata* ranged from 10.94 to 22.18 d and ranged from 11.28 to 23.30 day for *C. propinqua isis* on various host plant varieties. Katsarou *et al*. (2005) and Zarpas *et al*. (2007) observed a closed developmental time at 23 °C (22.2 and 23.4 days, respectively) than that observed by Skouras *et al*. (2015) which was 30.2 days for *Coccinella septempunctata* L. However, the current results of T_0 and dd's values are inconsistent with those estimated by Jalali *et al*. (2014). In their study, the T_0 estimated for the entire development (egg - adult) of *Coccinella undecimpunctata aegyptica* (Reiche) was 14 ˚C and dd's were 166.67. The difference between both studies may be due to the different prey species, prey-host plant, and range of tested temperatures (Skouras *et al.* 2015). In addition, the estimates of the current study are lower than those by Bayoumy *et al.* (2015) for *C. undecimpunctata*. This is likely because the aphid prey (*Sitobion avenae* F.) is poorer in nutrients than *A. gossypii*. On the contrary, the lower developmental thresholds for *C. undecimpunctata* at various host plant varieties are almost closed to those estimated by Xia *et al.* (1999) for *C. septempunctata* fed upon *A. gossypii* at a range of 15-35 ˚C.

The thermal requirements of of *C. propinqua isis* ranged from 238 to 278 dd's. These amounts are relatively close to those of Skouras *et al.* (2015) for *Coccinella undecimnotata* Schneider preyed the tobacco aphid, *Myzus persicae nicotianae* Blackman. In another study of Honek and Kocourek (1988), the T_0 and dd's values were 10.9 °C and 44.5 dd's for eggs and 11.1°C and 69.4 dd's for pupae of *C. undecimnotata*. The values for egg stage are closed to those estimated in this study, but not for pupal stage. The differences between the current values and those reported by Honek and Kocourek (1988) are probably because the different prey and host plant varieties used by these authors. This could be confirmed by the pupal stage, in which the accumulated nutrients from different aphid-eggplant variety combinations increased the tolerance for lower temperatures, whereas this is not true for egg stage. In respect to *C. propinqua isis*, our estimation is different from that by El-Batran *et al*. (2015) for larval and pupal stages, but is closed to that of egg stage, using *Aphis nerii* Boyer reared on oleander leaves at range of 20-28 °C. This is an additional confirmation of the effect on host plant on the quality of prey, resulting in low amount of heat required by pupal stage of predator, as the store of converted accumulated nutrients by larval stage.

The minimum T_0 values and the corresponding dd's for the entire development of both predators were recorded on Classic variety. In other word, Classic variety lowered the amount of heat required by both predator species to complete their development. This may give an evidence that eggplant var. Classic contains protein and carbohydrates in optimal ratios than other varieties which transfer to feeding prey (unpublished data). Energy and nutrient content of vertebrate prey is compatible to body composition of vertebrate predators, i.e. high protein contact, variable lipid contact, and little or no carbohydrates (Robbins, 1993).

On all aphid-eggplant varieties, egg, larval, pupal and egg-adult development of *C. undecimpunctata* required a much higher number of dd's than that of *C. propinqua isis*. This is due to the differences between melanic (black, i.e. *C. propinqua isis*) and non-melanic (red, i.e. *C. undecimpunctata*) morphs. The thermal melanism theory suggests that the melanic morphs are a benefit under conditions of low temperature and a limited radiative regime, because a dark ectothermic insect will heat up faster and reach a higher equilibrium temperature when insolated, resulting in higher levels of activity and reproductions (Lusis, 1961). Several reports support the process of thermal melanism in the two-spot ladybird in which adverse relation was detected between levels of sunshine and relative frequencies of melanic morphs (e.g., Benham et al., 1974; Muggleton *et al.,* 1975; Brakefield, 1984; Jong *et al.,* 1996). This could also explain the absence of significance for the interaction between temperature and host plant varieties on the developmental rates of *C. propinqua isis* only, although each of these independent variables had significant effect on development rates. This means that the trend of interaction between both factors is not in parallel, but in reverse directions.

Based on lower developmental threshold (T_0) values, the more tolerant stage for coldness was the pupal stage of both *C. undecimpunctata* and *C. propinqua isis* on the three eggplant varieties. This is true because most of energy, i.e. protein, carbohydrates, and lipids, stores in this stage, resulting in growth and survival under lower values of T_0. On the contrary, the more sensitive stages for lower temperatures were the egg and larval stages of *C.*

undecimpunctata and *C. propinqua isis*, respectively. This is hard to explain, however the free water in these stages may be higher than others.

The results of this study suggest that eggplant var. Classic has to be considered in mass rearing programs to produce a high nutritional prey for both predator species. This might maximize the population of these predators. As well, 30 °C would multiply the population of both predators under the same rearing conditions, and thus it has to be generalized.

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تأثير أصناف البأذنجان ودرجات الحرارة على النمو فى حشرتى أبو العيد ١١ نقطة وأبو العيد الأسود

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فى هذا البحث تم دراسة تأثير ثلاثة درجات حرارة (٢٠ و ٢٥ و ٣٠ مo) على ثلاثة أصناف من البادنجان (كلاسيك و ٠١١١ و عنان) على كفاءة النمو والأحتياجات الحرارية لمفترسى أبو العيد إحدى عشر نقطة وأبو العيد الأسود. تم تغذية المفترسين على منّ القطن الذى تم تربيته على أصناف الباذنجان. أشار التحليل الأحصائى (2-way ANOVA) أنه يوجد تأثير معنوى لدرجة الحرارة والنبات العائل على الوقت الكلى لنمو للمفترسين. ولكن بالنسبة لتأثير التداخل بين درجة الحرارة والصنف النباتى كان يوجد تأثير معنوى على مفترس أبو العيد ١١ نقطة فقط. وأوضحت النتائج أنه بزيادة درجة الحرارة، فإن الوقت الكلى للنمو يقل، كما أنه معدل النمو يزيد للمفترسين. وبناءً على قيم أقل درجات حرارة للنمو (T0)، أظهرت النتائج أن طور العذراء هو أكثر طور تحملاً لدرجات الحرارة المنخفضة فى كلا المفترسين على أصناف الباذنجان المختلفة. كما أشارة النتائج أن أكثر الأطوار حساسية لدرجات الحرارة المنخفضة هم: طور البيض فى مفترس أبو العيد ١١ والطور اليرقى فى مفترس أبو العيد الأسود. كما أظهرت النتائج المسجلة أن أقل قيم للـ T0 كانت على صنف كلاسيك. وعندما تم حساب الوحدات الحرارية اللازمة لكل مرحلة من مراحل نمو كل مفترس، وجد أن المنً الذى تم تربيته على صنف الكلاسيك يُخفض قيمة الوحدات الحرارية المطلوبة لنمو كلا المفترسين. بالأضافة إلى ذلك، يحتاج الطور اليرقى فى كلا المفترسين إلى وحدات حرارية أكثر من أى أطوار أخرى. تقترح النتائج التى تم الحصول عليها أن صنف كلاسيك من الأصناف الجيدة للأنتاج الكمى للحصول على فريسة ذات قيمة غذائية عالية لزيادة أعداد كلا المفترسين. كما أن درجة حرارة ٣٠ مo من أفضل الدرجات التى تعمل على مضاعفة أعداد المفترسات فى نفس ظروف التربية.