Effect of Temperature on the Biology and Predatory Potential, of *Harmonia Dimidiata* (Fab.) (Coleoptera: Coccinellidae) Feeding on *Myzus Persicae* (Sulzer) (Hemiptera: Aphididae) Aphid

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***Abstract*— *The influence of five constant temperatures i.e 16±1°C, 20±1°C, 24±1°C, 28 ±1°C and 32 ±1 ˚C was investigated on the biology and predatory potential of Coccinellid beetle, Harmonia dimidiata (Fab.), (Coccinellidae: Coleoptera), feeding on Myzus persicae aphid. The results revealed that temperature has significant effect on the development time and with increasing temperature, the development time may significantly decrease. Maximum duration was observed at low temperatures and minimum at high temperature level for egg incubation period, larvae, pupa and egg to adult emergence. The number of eggs per female beetle was maximum (656.8±7.08) at 24 ± 1˚C and minimum (184.6±5.16) at 28 ± 1˚C. The results further indicate that at high temperature level 32 ± 1˚C the female could not produce eggs. The predatory potential of larvae, male and female beetle was maximum 827.7±13.39, 14183.0±543. 76 and 15375.0±549.98 aphids at 24 ± 1˚C. The results indicate that temperature has profound effect on fecundity and predatory potential as well as development of H. dimidiata. The optimum rearing temperature for this Coccinellid predator was found to be 24 ±1°C followed by 20 ±1°C. It has high potential against M. pericae and thus can be utilized as part of integrated pest management program for the management of this economically important aphid pest.*

***Keywords*— Harmonia dimidiata, biology, predatory potential, Myzus persicae aphid, temperature.**

I. INTRODUCTION

The green peach aphid, *Myzus persicae* Sulzer, (Hemiptera: Aphididae) is economically the most important crop pest worldwide [7]. A number of factors are involved in making this species a notorious pest, that include its capacity to disperse, host range, distribution, of damage mechanisms, life cycle and its resistance to insecticides. *M. persicae* is polyphagous with a host range of about 400 species in 40 plant families, including a number of economically important crops. It also has the ability to adapt to new host plants. It causes damage by feeding directly on the host causing the transmission of important plant viruses. Its economic importance depends upon the crop plant but the primary reason is its capability of transmitting more than 100 different plant viruses [15].

The control of *M. persicae* has usually relied on the use of chemical insecticides but their intensive use has led to the development of multiple forms of resistance [6]. Regarding the resistance problems with this pest specie, biological control agents are receiving great attention, especially, the ladybird beetles are considered as important aphid predators in agricultural crops due to some of their unique characteristics, such as: wide host range of prey, voracious feeders and show a rapid response [8]; [2]. These characteristics make them a useful natural enemy for the purpose of biological control program against economically important aphid species.

The beneficial status of ladybeetles has a rich history that has long been recognized by the general public and by entomologists involved in the development of biological control programs [11]. Ladybeetles have been recorded from a wide range of habitats feeding on many different prey types and both monophagous and polyphagous species are known [8].

Harmonia dimidiata (F.) sub tropical lady bird beetle commonly known as fifteen spotted lady bird beetle occurs in China, Vietnam, India, Nepal, Pakistan and other countries of South-East Asia. Under natural conditions, *H. dimidiata* develop on many aphid species affecting field crops and horticultural plants like *M. persicae, S. graminum, A. gossiphy, A. fabae and A. pisum* [17]. In Pakistan it was reported from Malakand, Swat, Murree, Peshawer, Islamabad and Rawlakoat areas. This species exists in two polymorphic forms [12]. Both adults and larvae of *H. dimidiata* are highly voracious predators of aphids. Kuznetsove and Pang [17] reported a daily predation rate of more than 200 *A. gossypii* for *H. dimidiata* (F.).

Semyanove [18] reared *Leis dimidiata* on nine aphid species *i.e Myzus persicae* Sulzer, *Aphis frangulae gossypii* Glover, *A. craccivora* Koch, *A. glycines* Matsumura, *A. fabae* Scopli, *Macrosiphum eupharbiae* Thomas, *Schizaphis graminum* Rondani, *Macrosiphum rosae* Linnaeus and *Acyrthosiphon pisum* Harris. Most effective breeding was found to be on *Myzus persicae* Sulzer and *Schizaphis graminum*. A single female laid up to 3000 eggs during her life time with the mean fecundity of 1892 eggs per female. The most favorable temperature for species development was 20-25˚C. One generation from egg to imago took 22 days at 25˚C and 35 days at 20˚C. Yu *et al*., [9], reported the life history and predatory potential of *Harmonia dimidiata* at 15, 20 and 25˚C, reared on *Aphis gossypii* Glover. Depending upon the age of both sexes, the net reproductive rate was 147.4, 98.7 and 62.5 off springs at three constant temperatures. The net predation rates were 10963, 13050 and 7492 aphids per beetle respectively.

The influence of a key abiotic external factor i.e temperature on insect development has been studied extensively; improving our knowledge about the effects of temperature on insect development will be helpful in the mass rearing of insect and their application as natural predators of pests. Previous workers [4]; [9]; [17]; [18] reported that the most favorable temperature for culturing *Harmonia dimidiata* was 20-25˚C. Temperature is one of the most important environmental factors that influence the developmental rate of a particular insect species and affect its reproductive and predatory performance [10]. Therefore it is very important to study the relationship between temperature and development for any economically important species.

Keeping in view the importance of *H. dimidiata* (Fab.), the present study was conducted with the objective to identify the most suitable temperature for mass rearing and to evaluate their predatory potential as bio control agents against *Myzus persicae* aphid.

II. MATERIALS AND METHODS

The study was conducted on the biological parameters and predatory potential of lady bird beetle *Harmonia dimidiata* Fab. reared on *Myzus persicae* aphid (Fig. I) at Insect Pest Management program, National Agricultural Research Centre Islamabad during winter 2012. The experiments were conducted at five constant temperatures, 16 ±1˚C, 20 ±1˚C, 24 ±1˚C and 28 ±1˚C with 65 ±5% relative humidity and 16:8 light dark photoperiod in growth chamber. The following experiments were conducted.

2.1 Developmental duration and predatory potential of immature stages

Experiments were conducted to check the effect of five constant temperatures on the developmental durations of immature stages. A total of 100 freshly laid eggs of *H. dimidiata* were collected from stock culture in different batches. The eggs were kept in plastic petridishes (8 ×2 cm) for hatching at each constant temperature in growth chamber separately. The experiments were repeated five times for each required temperature. The eggs were observed daily in each petri dish for hatching. The incubation period was recorded. Upon hatching, 40 newly emerged grubs were separated and kept in plastic vials (6×4 cm) separately at each required temperature. A known number of aphid's nymphal instars (2nd–4th) were provided on cabbage leaves for feeding. Initially the first instar grubs were provided 40 aphids/ vials and with the passage of time the number of aphids increased as the grubs entered into next instars. The 4th instar grubs were provided up to 400 aphids per day and the process continued till all the grubs entered in to pupal stages. The insects were observed for molting daily in the vials and the exuava found was considered as a sign that the insect has entered in to the next instar. The insect passed through four larval instars before entering in to pupal condition.

2.2 Biological parameters and reproductive potential of adult beetles

To study the effect of five constant temperature levels on the adult biology and reproductive potential of *H. dimidiata*, a total of 20 newly emerged male and female beetles were paired and kept in adults rearing jars (20 ×10 cm) in growth chamber. Aphids were provided inside the rearing jars on cabbage leaves in excess daily. The rearing jars were also provided with tissue paper and fresh wheat leaves for

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oviposition. The old infested leaves and the dead aphids were removed daily. The eggs laid in batches were counted and replaced daily in each rearing jar. The pre ovipostion period (first egg laid) by each pair was recorded as well as the mean number of eggs per female per day and the longevity of both male and female beetles were also recorded after the individuals died at each temperature. During the longevity experiment, the first and last egg-laying in each pair was also checked for the determination of pre-oviposition, oviposition and post-oviposition periods.

2.3 Predatory potential of adult male and female beetle's

To study the predatory potential of adult male and female *H. dimidiate* beetles, a total of newly emerged 10 male and 10 female adult beetles were kept in plastic rearing jars separately at each required temperatures levels in a growth chamber. Counted numbers of aphids 250-300 (from first to fourth nymphal instars) were provided inside the rearing jars on cabbage leaves daily. The jars were covered with muslin cloth at the top. After 24 hours the dead, consumed and unconsumed aphids were counted and replaced with fresh diet daily. The process was continued till all adults (male and female) beetles died in each rearing jar.

The data was recorded on the developmental duration and predatory potential of each larval instar. The data was statistically analyzed by using one-way ANOVA and means were compared using LSD test at 1% level of significance.

III. RESULTS AND DISCUSSION

3.1 Effect of temperature on the development time of immature stages

The mean development time of immature stages at five constant temperatures is presented in Table 1. The results indicate that maximum mean incubation period (Fig. B) was 9.08 ±.0996 days at 16 ±1˚C and minimum 3.11±0.1126 days at 32±1˚C. The grub duration (Fig. F) was maximum 22.96±0.0932 days and minimum 11.34±0.0704 days at 32 ±1˚C. The pupal (Fig. G) and total duration from egg to adult emergence was minimum 9.37±0.0899 and maximum 43.030±0.1776 days at low temperature, while at high temperature level it was minimum 4.0±0.0917 and maximum 19.42±.2873 days. These results are significantly different from each other and with increasing temperature, the development time of immature stages significantly decreased. These results are in accordance with the previous studies carried out on the biology of *H. dimidiata* under different temperature levels. Yu *et al*., [9] observed that the development time from egg to adult emergence was 38.8 ±0.3, 27.5 ±0.1 and 18.4 ±0.1 days at 15, 20 and 25˚C. Kunznestov *et al*., [17] reported that the developmental duration from egg to adult emergence was 35 and 22 days at 20˚C and 25˚C. The grub duration was 22 and 12 days. Similarly, Castro *et al*., [5] recorded longer developmental times at low temperatures for *Harmonia axyridis* (Pallas). The maximum duration from egg to adult emergence was 43.1, 30.8 and 22.3 days at 15˚C, 20˚C and 25˚C. Semyanov [18] studied the biology of *L. dimidiata* (F.) feeding on *M. persicae* aphid at different temperature levels. The developmental duration of egg, larvae and pupae was 12.5, 60 and 20 days at 15°C and at 25°C it was 5, 22 and 8 days, while at 30° C it was 2, 10 and 3.5 days respectively. The results of the present study and that of the past workers indicate that temperature has significant effect on the developmental duration of immature stages of *H. dimidiata* (Fab.)

3.2 Effect of temperature on the development time and reproductive potential of adult beetles

The results revealed that temperature has significant effect on the adult's (Fig. A) biology and reproductive potential. The pre oviposition, oviposition and post oviposition period was maximum 21.0±0.7154, 53.8±1.1124 and 12.0±0.1664 days at 16±1˚C. Minimum duration was 6.0±0.2814, 25.40±0.5572 and 5.2C±0.2889 days at 28 ±1˚C (Table 2). Semyanov [17] conducted studies on the maturation of female *Lies dimidiata* at different temperature and photoperiod levels. At 20˚C and at photoperiod of 18:6, 16:8 and 6:18 (dark:light) the female reached maturity in 30.4, 31.8 and 28.0 days. Similarly at 25 and 30˚C with 16:8 and 6:18 hours photoperiod, the female reached maturity in 16.4, 15.5 and 15.3 and 15.1 days respectively. The adult male and female longevity was maximum 86.6±1.2869 and 81.8±1.0307 days at low temperature and only 28.8±0.6514 and 31.7±0.5387 days at 32 ±1˚C followed by 38.2 ± 0.9853 and 39.6 ± 0.7980 days at 28±1˚C. The results indicate that the development duration was significantly different at all tested temperatures and with increasing temperature the duration significantly reduced. Yu *et al*., [9] reported that adult male and female longevity was 98.9, 57.6, 63.5 and 91.4, 54.3 and 59.6 days at 15˚C, 20˚C and 25˚C.

In the present study, the female fecundity was maximum 656.8A±7.0740 and 473.2B±7.7755 eggs per female at 24±1˚C and 20±1˚C (Table 2). The number of eggs per female decreased at 28 ±1˚C and at 32 ±1˚C the female could not produce any eggs. These observations demonstrate that *H. dimidiata* is adapted very well to mild temperatures. Yu *et al*., [9] also reported that *H. dimidiata* could not reproduce at higher temperature (30˚C). He observed maximum 18.04±0.1406 eggs per female per day at 24±1˚C followed by 10.60±0.1163, 7.26±0.1141 and 6.44±0.1289 eggs at 20±1˚C, 28±1˚C and 16±1˚C (Table 2).

These results indicate that the mean fecundity of female was significantly different at four constant temperature levels. Yu *et al*., [9] reported that the female *H. dimdiata* beetle laid 409.5 ±67.4, 229.4 ±63.1 and 312.3 ±46.0 eggs per female at 15, 20 and 25˚C respectively. Semyanove [18] found out that the most favorable temperature for species development was 20-25˚C. The results of the present study also indicate that the most favorable temperature for mass breeding of *H. dimidiata* was 24 ±1˚C and 20 ±1˚C. Gillani *et al*., [18] reported mean fecundity of 422.31 eggs per female reared on *B. brassicae* at 25 ±2˚C. Debnath [13] reported that the fecundity of *H. (Leis) dimidiata* (Fabricius) was 631.4 eggs at 20.0 ± 2˚C with daily oviposition rate ranging from 0 to 45 eggs per female. The results of the present and that of the past workers indicate some differences among number of eggs per female *H. dimidiata*. These differences may be due to the differences in the environmental conditions, the host insect they used and also due to the different strain of *H. dimidiata* used during the experiments.

Similar works on other Coccinellid beetles in the past were also reported by different workers like Castro *et al*., [5], Aksit *et al*., [1], Asrar *et al*., [3] and Hemchandra *et al*., [14]. They all reported that temperature has significant effect on the biology of Coccinellid beetles and with increasing temperature; the developmental duration may significantly decrease in all species.

3.3 Effect of temperature on the predatory potential of *Harmonia dimidiata* larvae, adult male and female beetles

Studies were conducted on the predatory potential of different larval instars and adult male and female beetles at five constant temperatures feeding on *M. persicae* aphid. The results are presented in (Fig 1 and 2) which revealed that temperature has significant effect on the predatory potential of each larval/grub instar as well as adult male and female beetles. The maximum predatory potential of first, second, third, fourth instar and total grub was 52.6±0.8550, 70.5±0.8934, 178.2±1.8324, 526.0±10.677 and 827.7±13.399 nymphal instars (2nd-4th) of *M. persicae* aphids at 24 ±1˚C and minimum potential was 23.8±0.3694, 44.0±1.1024, 76.0±1.4919, 232.8±1.7375 and 376.6E±5.4329 aphids at 32 ±1˚C**.** The results indicate that 4th instar grub was highly voracious stage and consumed more aphids than other three larval instars collectively. The results further indicate that at high and very low temperature, the predatory potential was significantly low as compared to mild temperature levels. Previous workers also indicate significant variation in predatory potential of *H. dimidiata* larval instars feeding on different species of aphids. Yu *et al*., [9] reported that the total number of aphids (*Aphis gossypii*) killed by the *H. dimidiata* grubs were 2877.3, 3081.9, and 1722.4 aphids per larva at 15, 20 and 25˚C. Kuznetsov and Pang Hond [17] reported that larva/grub predatory potential was 940 adults of *M. persicae* aphid. Chakrabarti *et al*., [16] reported the larval predatory potential of *H. (lies) dimidiata* feeding on woolly apple aphid, *Eriosoma lanigerum* was 853.7 and 710.7 at 24.0±0.5˚C and 17.6±1.8˚C respectively. The results of the present study and that of the past workers showed differences in the predatory potential and these differences may be due to differences in host insects and host insect stage or may be different strains of *H. dimidiata* on which they conducted experiments.

The maximum predatory potential of adult male and female beetles was 14183.0±543.76 and 15375.0±549.98 nymphal instar (2nd to 4th) of aphids at 24±1˚C followed by 12301.0±533.42 and 11990.0±375.48 aphids at 20±1˚C respectively. Minimum potential of male and female beetles was 3167.4±128.46 and 3864.8±114.04 aphids at 32±1˚C. Yu *et al*., [9] reported the male and female predatory potential was 19690 and 18355 aphids at 25˚C. Gillani *et al*., [19] reported that *H. dimidiata* consumed 152.18 aphids/day and the total potential was 11555.0±1031.71 during the whole life time at 25 ±2˚C.

IV. CONCLUSION

The results of the present study and that of the past workers indicate that *Harmonia dimidiata* (Fab.) (Coleotrea: Cpccinellidae) is highly voracious predator of aphids including *Myzus persicae.* The results further indicate that temperature has significant effect on the biology and predatory potential of *H. dimidiata* and with increasing temperature, the duration of different stages significantly decreased. The most suitable temperature for mass rearing of the predator was 24 ±1 C˚ followed by 20 ±1 ˚C. The feeding potential is fairly high, therefore this species is suitable for the management of aphids in mild temperatures and this can be propagated in the hilly areas in summer and released in the plains in winter.

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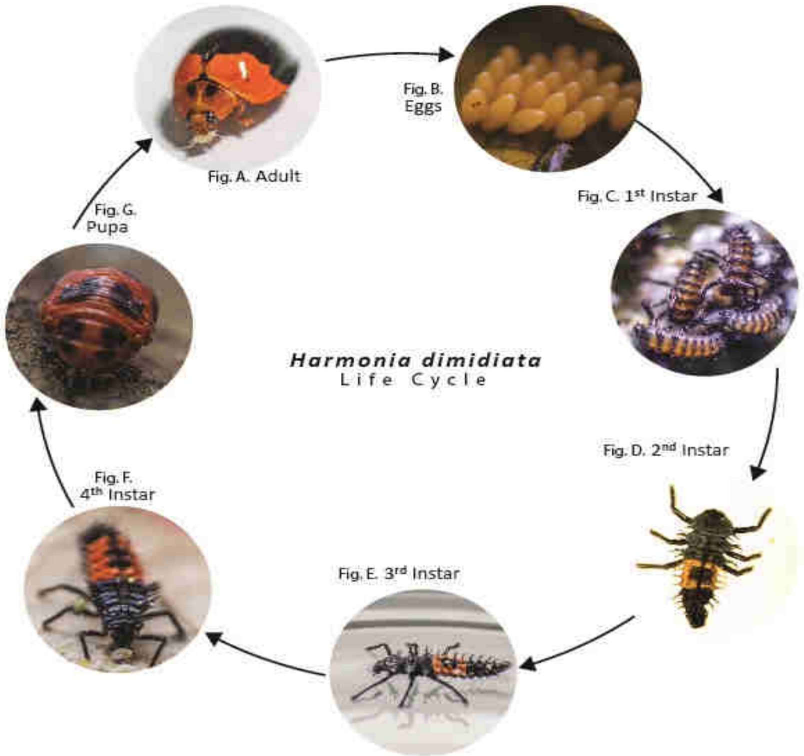

Fig. H. Insectary at NARC.

Fig. I.Myzus persicae aphid

Fig. J.Myzus persicae on cabbage leaves

Table 1: Developmental duration of immature stages of H. dimidiata feeding on M. persicae aphid at five constant temperatures with 16:8 photoperiods

Temp. (˚C)	Incubation period (days) ± SE	1st Instar duration (days)± SE	2nd instar duration (days)± SE	3rd instar duration (days)± SE	4th instar duration (days) ± SE	Total larvae duration(days) ± SE	Pre-pupal duration (days) ±SE	Pupal duration (days)± SE	Duration from egg to adult emergence (days)± SE
16±1˚C	9.08A±0.0996	4.02A±0.0919	3.05A±0.1072	4.93A±0.0917	10.92A±0.0951	22.96A±0.0932	1.61±0.0290	9.37A±0.0899	43.03A±0.1776
20±1˚C	6.0B±0.2347	3.70B±0.1154	2.91A±0.0898	4.78AB±0.0898	8.56B±0.2645	19.95B±0.3644	1.31B±0.0237	6.91B±0.1594	34.17B±0.5616
24±1˚C	5.0C±0.0959	2.77C±0.0713	2.8AB±0.0690	4.48B±0.0589	7.02C±0.0638	17.07C±0.0818	1.04C±0.0356	6.50C±0.0639	29.61C±0.1411

28±1˚C	4.03C±0.1060	2.0C±0.0768	2.53BC ±0.0722	3.69C±0.1569	5.0D±0.1406	13.22D±0.2480	1.0C±0.0375	5.0D±0.0917	23.22D±0.2693
32±1˚C	3.11D±0.1126	2.0D±0.0587	2.34C±0.0647	3.0D±0.1051	4.0E±0.0699	11.34D±0.0704	0.9700C±0.0381	4.00D±0.1043	19.42D±.2873
LSD (0.01)	0.5153	0.3129	0.3021	0.3879	0.5400	0.7621	0.1178	0.3923	0.9648

Means in columns followed by the same letter are not significantly different at p ≤ o.o1

Table 2: Biological parameters of adult H. dimidiata feeding on M. persicae aphid at five constant temperature under 16:8 (L:D) photoperiod

Means in columns followed by the same letter are not significantly different at p ≤ o.o1

Temp.	**Pre ovi. Period**	**Ovi Position period**	**Post ovi.**	**Adult longevity**		**Total eggs per female**	**Eggs per fem./day**
				Female	**Male**		
16±1 ˚C	21.0A±0.7145	53.80A±1.1124	12.0A±0.1664	81.8A±1.0307	86.6A±1.2869	346.9C±7.1448	6.44±D0.1289
20±1 ˚C	10.6B±0.2753	44.60B±1.1275	10.2B±0.1225	65.2B±1.0989	68.4B±1.3795	473.2B±7.7755	10.60B±0.1163
24±1 ˚C	9.0BC±0.2786	36.40C±1.0118	8.0B±0.1225	52.6C±1.2758	54.8C±1.3386	656.8A±7.0740	18.04A±0.1406
28±1 ˚C	8.0C±0.2814	25.40D±0.5572	6.2C±0.2889	39.6D±0.7980	38.2D±0.9853	184.6D±5.1591	7.26C±0.1141
32±1 ˚C	----------	-------------	------------	23.7E±0.5387	22.8E±0.6514	-----------	-----------
LSD (0.01)	1.6105	3.6624	0.7019	3.6516	4.3179	25.627	0.4686

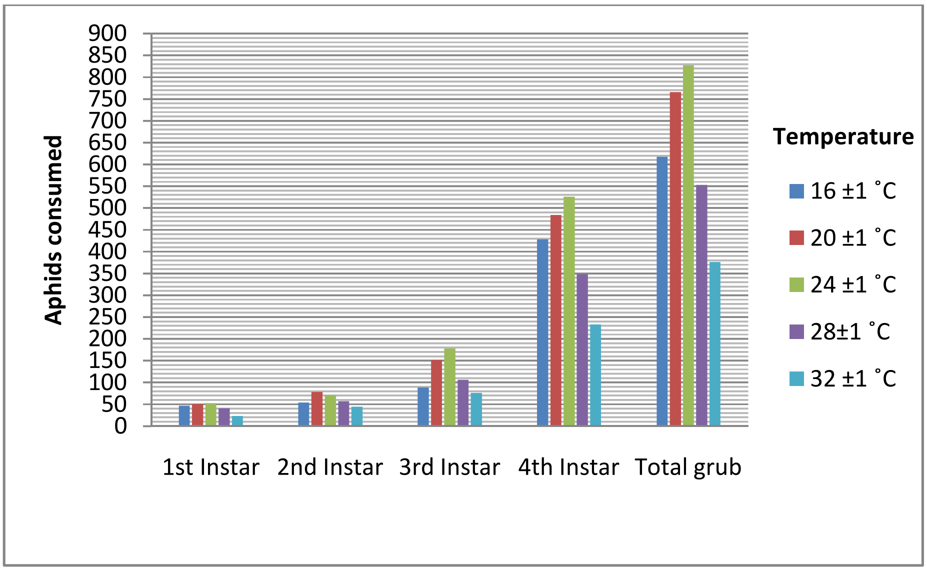

Fig.1:Predatory potential of immature stages of H. dimidiata at five constant temperatures feeding on M. persicae aphid

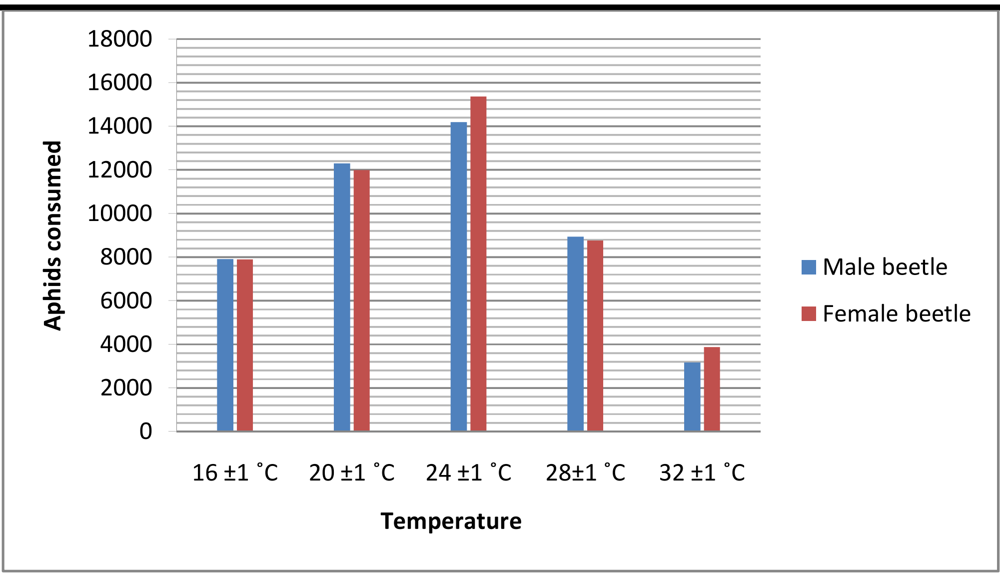

Fig.2: Predatory potential of adult male and female beetles of H. dimidiata at five constant temperatures feeding on M. persicae aphid

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