Pak. J. Agri. Sci., Vol. 54(1), 83-89; 2017
ISSN (Print) 0552-9034, ISSN (Online) 2076-0906
DOI: 10.21162/PAKJAS/17.4611
http://www.pakjas.com.pk

TEMPERATURE DEPENDENT LIFE PARAMETERS AND PREDATORY POTENTIAL OF A STIGMAEID MITE, *Agistemus buntex*, CHAUDHRI AGAINST TWO SPOTTED SPIDER MITE, *Tetranychus urticae*, DUFOUR

Bilal Saeed Khan[1], Muhammad Farooq[2,*], Faisal Hafeez[2], Hafiz Azhar Ali Khan[3], Muneer Abbas[2] and Abdul Ghaffar[2]

[1]Department of Agri. Entomology, University of Agriculture, Faisalabad, Pakistan; [2]Entomological Research Institute, Faisalabad, Pakistan; [3]Institute of Agricultural Sciences, Punjab University, Lahore, Pakistan.
***Corresponding author's e-mail: farooqentomol@gmail.com**

Studies were conducted to evaluate the life history parameters and predatory potential of a stigmaeid mite *Agistemus buntex* Chaudhri against *Tetranychus urticae* Dufour at three constant temperatures viz., 20, 25 and 30°C. At 25°C, egg, larvae, protonymph, deutonymph and egg to adult stages were completed in 7.36, 3.00 2.44, 2.34 and 15.14 days, respectively for male, and 8.48, 3.98, 3.69, 3.52 and 19.67 days, respectively for the female. The development time was longer at other two temperatures. Daily fecundity, total fecundity and sex ratio was much greater at 25°C compared to 20 and 30°C. The lower development threshold was found to be 6.65 and 8.35°C for *A. buntex* female and male, respectively. Degree day requirements (DD) for *A. buntex* were 346.02 DD for female and 250 DD for the male. The intrinsic rate of natural increase (r_m) of *A. buntex* was recorded as 0.11 at 25°C. Finite rate of increase (λ) values for *A. buntex* were found to be 1.07, 1.12 and 1.11 at 20, 25 and 30°C respectively. From obtained results, it can be concluded that *A. buntex* can become a strong candidate for biological control of *T. urticae* in Pakistan and elsewhere along-with other control strategies. The findings will serve as baseline information to better understand the biology of the pest, which can be utilized in an effective management program.
Keywords: *Agistemus buntex*, *Tetranychus urticae*, Stigmaeidae, Tetranychidae, predatory potential.

INTRODUCTION

Stigmaeid mites are found on number of field, forest and cash crops that can predate on a wide variety of harmful insects (soft bodied and slow moving) and mites (Nelson *et al.*, 1973). The most important predators of family Stigmaeidae include genera *Agistemus* Summers and *Zet-zellia* Oudemans against spider mites (Santos and Laing, 1985; Croft, 1994). Of these genera, *Agistemus exsertus*, *Agistemus buntex, Agistemus pallinii, Agistemus longisetus, Agistemus floridanus* are widely diverse species (Khan *et al*., 2010*;* Fouly *et al.,* 2011).

Agistemus buntex is the most abundant stigmaeid mite species found in the Punjab, Pakistan that consumes different stages of *Panonychus citri* (McGregor) and *Tetranychus urticae* (Chaudhri and Akbar, 1985). Temperature affects the development rate of poikilothermic animals as illustrated by (Sohrabi and Shishehbor, 2008; Latifi *et al.,* 2010). Determination of temperature dependent development characteristics is critical for population prediction, development time, survivorship, migration and dormancy of the predatory organisms (Aghdam, 2008). A study by Khan and Afzal (2005) indicated that development time of *A. buntex* immature stages was lowest on *T. urticae* followed by *P. citri* and *Eutetranychus orientalis.* However, development time for the adult was recorded as 32 days on *T. urticae* in contrast to 20.8 and 20.5 days when provided with *E. orientalis* and *P. citri*, respectively. On the other hand, *T. urticae* being major pest attacks field crops and ornamental plants thus reducing chlorophyll content and vigor of the plant.

Earlier investigations elaborated the importance of phytoseiid mites as a biological control agent but few studies explicit the life history and feeding potency of stigmaeid mites as predators. Current study was designed to explore the influence of temperature regimes on life cycle parameters and feeding potential of the *A. buntex* against *T. urticae*. *A. buntex* along with another indigenous stigmaeid mite species, *A. exertus*, is an emerging candidate of IPM program adopted against *T. urticae* in Pakistan and elsewhere.

MATERIALS AND METHODS

Mites culture: Predatory as well as phytophagous mites were collected from cotton, tomato and brinjal leaves and brought to the Acarology Research Laboratory, Department of Entomology, University of Agriculture, Faisalabad (31° 26' 0" N; 73° 6' 0 E). *T. urticae* was transferred to water soaked cotton arena whereas *A. buntex* to leaf arena as per (Chaudhri and Akbar, 1985). The arenas were kept in the growth chamber at 25±2°C, 70±5% RH and under 16:8 (L:D) conditions for the purpose to get enough numbers of *T.*

urticae to use in the experiments.

***Determination of development time*:** Duration of *A. buntex* male and female development was observed at 20, 25 and 30°C. Ovipositing females were kept on *Azadirachta indica* (Meliaceae) leaf arenas having different *T. urticae* life stages. The same procedure was followed to rear the emerging immature stages. Data was recorded after 12 hour interval till the adult emergence. A sufficient quantity of *T. urticae* was maintained in the leaf arena. Only females were further processed for fecundity studies while males obtained were kept separately for longevity study. The fecundity of *A. buntex* female was determined under similar laboratory conditions. It was kept in mind that the adult male mated once with the female and then removed. Thereafter, pre-oviposition data was recorded (every 12 hours) until oviposition started. Fecundity was noted on daily basis and the total number of eggs laid was calculated. Furthermore, the eggs were transferred to new arenas for adult emergence as per method of Canlas *et al.* (2006). The experiment was replicated five times for each treatment.

***Life table parameters*:** Adult females after emergence were kept under observation for the construction of life table by age specific fecundity and survivorship. Mean generation time, net reproductive rate, intrinsic rate of increase, finite rate of increase and doubling time were assessed from daily fecundity data following equations proposed by Birch (1948). Development rate (1/development time) for egg, larva, protonymph, deutonymph and egg to the adult stage of both male and female were regressed with temperature. From regression equation obtained, lower developmental threshold (K) and degree days were estimated following Campbell *et al.* (1974).

***Evaluation of predatory potential*:** The predatory potential of *A. buntex* nymph and adult was observed against immature as well as adult *T. urticae* at different densities i.e. larva (n=20), nymph (n=30) and adult (n=40) per arena having five replications for each treatment at same temperature levels. The prey density was maintained by adding new live specimens and eggs laid by adult females were removed from the arenas on daily basis to reduce the risk of population multiplication. Total prey consumption was recorded by counting live specimens in 12 hour interval.

***Statistical analyses*:** Data recorded under the different constant temperatures were analyzed using ANOVA (SAS, Institute 2001). Means were compared by the Tukey's HSD method using windows based statistical software Statistix 8.1 (Analytical Software, 2005). Data was then subjected to simple regression analysis using Minitab 17.0 to precisely access the importance of temperature in explaining the variation of different developmental stages of *A. buntex* (Steel and Torrie, 1980).

RESULTS

Table 1 shows development time of immature stages of *A. buntex* male with respect to temperature variation. Analysis of variance depicted significant differences among all stages and constant temperatures. Results revealed that eggs were hatched after 8.10 days at 20°C which is statistically at par with 25°C at which egg stage lasted for 7.36 days. The hatching time was reduced significantly at higher temperature (F=41.21, P<0.01) and eggs were hatched after 5.48 days at 30°C. The juveniles of *A. buntex* male i.e, larva, protonymph and deutonymph took more time to complete (4.16, 4.42 and 4.64 days) respectively at 20°C while these stages were completed in 2.21, 1.99 and 1.83 days, respectively at 30°C. Egg to adult duration was recorded as 21.31, 15.14 and 11.50 days at 20, 25 and 30°C, respectively. Statistical significant differences were observed among all constant temperatures for male longevity and total life span of *A. buntex* male (F=1881, P<0.01 for male longevity, F=1295, P<0.01 for life span). The total life span of *A. buntex* male was found to be 52.86 days at 20°C followed by 35.38 days and 26.34 days at 25 and 30°C, respectively.

Temperature also exerted significant impact on the development time of immature stages of *A. buntex* female. The egg stage of *A. buntex* female took a little bit more time to complete as compared with *A. buntex* male and eggs were hatched after 9.07 days at 20°C. The development time of eggs hatching started to decrease at increasing temperature and lasted for 8.48 and 6.53 days at 25 and 30°C, respectively (Table 2). Juveniles of *A. buntex* female, larva, protonymph and deutonymph completed their development in 5.16, 5.54 and 5.45 days, respectively at 20°C which differ significantly

Table 1. Development time (days±SE) of immature stages of *Agistemus buntex* male at three constant temperatures.

Temp.	Egg	Larvae	Protonymph	Deutonymph	Egg to Adult	Male Longevity	Life Span	HSD	P-value
20°C	8.10±0.31aA	4.16±0.08 bA	4.42±0.13bA	4.64 ±0.10bA	21.31±0.33A	31.55±0.28A	52.86±0.52A	0.7280	<0.01
25°C	7.36±0.06aA	3.00±0.07bB	2.44±0.05cB	2.34±0.08cB	15.14± 0.18B	20.24±0.21B	35.38±0.35B	0.2628	<0.01
30°C	5.48±0.19aB	2.21±0.05 bC	1.99±0.05 bC	1.83±0.03bC	11.50±0.12C	14.84±0.12C	26.34±0.15C	0.4077	<0.01
HSgD	0.7951	0.2537	0.3319	0.2916	0.8652	0.8114	1.4173	-	-
F	41.2	214	216	377	470	1581	1295	-	-
P-Value	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-

Means followed by same lowercase letters in the same column were not significantly different at P=0.05.
Means followed by different uppercase letters in the same row were significantly different at P=0.05.

Table 2. Development time (days±SE) of immature stages of *Agistemus buntex* female at three constant temperatures.

Temp.	Egg	Larvae	Protonymph	Deutonymph	Egg to Adult	HSD	P-value
20°C	9.07±0.13aA	5.16±0.08bA	5.54±0.11bA	5.45±0.26bA	25.22±0.22A	0.6552	<0.01
25°C	8.48±0.16aA	3.98±0.04bB	3.69±0.18bB	3.52±0.17bB	19.67±0.40B	0.6055	<0.01
30°C	6.53±0.22aB	3.21±0.05bC	2.58±0.14cC	2.27±0.04cC	14.59±0.16C	0.5457	<0.01
HSD	0.6563	0.2303	0.5670	0.6850	1.0602	-	-
F	58.8	261	99.5	78.2	360	-	-
P-Value	<0.01	<0.01	<0.01	<0.01	<0.01	-	-

Means followed by same lowercase letters in the same column were not significantly different at P=0.05. Means followed by different uppercase letters in the same row were significantly different at P=0.05.

Table 3. Duration and rate of reproduction of *A. buntex* female at three constant temperatures.

Temp.	Pre-oviposition	Oviposition	Post oviposition	Adult Longevity	Life Span	Total Fecundity	Daily Fecundity	Sex Ratio (M:F)	HSD	P-Value
20°C	4.44±0.13bA	26.75±0.35aA	5.13±0.07bA	36.33±0.35A	61.54±0.37A	36.01±0.81	1.33±0.03	1:2.33	0.8282	<0.01
25°C	2.34±0.08cB	19.36±0.40aB	3.54±0.11bB	25.25±0.43B	44.91±0.82B	51.65 ±0.77	2.59±0.04	1:4.75	0.9192	<0.01
30°C	2.04±0.02bB	13.44±0.50aC	1.95±0.05bC	17.43±0.53C	32.02±0.60C	22.01±0.76	1.57±0.05	1:3.33	1.1076	<0.01
HSD	0.3404	1.5959	0.3078	1.6782	2.3563				-	-
F-value	212	250	380	458	565				-	-
P-Value	<0.01	<0.01	<0.01	<0.01	<0.01				-	-

Means followed by same lowercase letters in the same column were not significantly different at P=0.05.
Means followed by different uppercase letters in the same row were significantly different at P=0.05.

Table 4. Development rates (1/development time) regressed on constant temperature(*x*) of *A. buntex*.

Sex/Stage	Regression Equation	R^2 (%)	Lower Developmental Threshold (To, °C)	Thermal Constant (K, Degree days, DD)
Female				
Egg	$y= 0.0198 + 0.00430x$	87.86	4.60	232.56
Larvae	$y= -0.04255 + 0.011792x$	99.98	3.61	84.80
Protonymph	$y= -0.2368 + 0.02066x$	99.52	11.46	48.40
Deutonymph	$y= -0.3398 + 0.02570x$	98.43	13.22	38.91
Egg to Adult	$y= -0.01922 + 0.002890x$	98.33	6.65	346.02
Male				
Egg	$y= -0.0002 + 0.00590x$	89.84	0.03	169.49
Larvae	$y= -0.1892 + 0.02125x$	99.44	8.90	47.06
Protonymph	$y= -0.311 + 0.02761x$	96.53	11.26	36.22
Deutonymph	$y= -0.432 + 0.03314x$	97.42	13.04	30.18
Egg to Adult	$y= -0.0333 + 0.004x$	98.33	8.32	250.00

Where, *y*= life stage, *x*= temperature

from other constant temperatures. At 25°C, development time of juveniles of *A. buntex* female was recorded as 3.98, 3.69 and 3.52 days followed by 3.21, 2.58 and 2.27 days at 30°C. Egg to adult duration of *A. buntex* female also presented significant variation (F=360, P<0.01) at three constant temperatures. Egg to adult duration was completed in much lower time (14.59 days) only at 30°C as compared to 25.22 days at 20°C.

An inverse trend was observed between temperature and pre-oviposition, oviposition and post-oviposition period of *A. buntex* female across the full investigated temperature range (Table 3). ANOVA indicated that temperature significantly affected pre-oviposition (F=212, P<0.01), oviposition (F=250, P<0.01) and post-oviposition (F=380, P<0.01) period. As described in the Table 3, pre-oviposition period of *A. buntex* female lasted for 4.44 days at 20°C and reduced significantly (2.34 days) at 25°C which is statistically at par with that of 30°C (2.04 days). Total fecundity of *A. buntex* female recorded was 36.01, 51.65 and 22.01 eggs with an average oviposition period of 26.75, 19.36 and 13.44 days at 20, 25 and 30°C, respectively. Post oviposition period also differed significantly across all temperature range investigated (5.13, 3.54 and 1.95 days) at 20, 25 and 30°C respectively. Daily mean fecundity per female was highest (2.59 eggs) at 25°C as compared to lower daily fecundity of 1.33 and 1.57 eggs at 20 and 30°C respectively. Female

Table 5. Life table parameters of *A. buntex* at three constant temperatures.

Temperature (°C)	Mean generation time (T, days)	Net reproductive rate (R_o)	Intrinsic rate of natural increase (r_m /day)	Finite rate of increase (λ)	Doubling Time (DT)
20°C (n=14)	41.14±0.87	13.73±0.35	0.06	1.07	10.88±0.15
25°C (n=25)	28.90±0.77	23.91±0.11	0.11	1.12	6.31±0.07
30°C (n=14)	21.91±0.56	9.11±0.06	0.10	1.11	6.87±0.07

n=number of samples.

Table 6. Predatory potential of nymph and adults of *A. buntex* against different stages of *T. urticae* at three constant temperatures.

Predator Stages	Temp.	Prey Stages				
		Larvae	Nymph	Adult	HSD	P-Value
Nymph	20°C	23.92±0.60bA	13.82±0.86bB	8.85±0.80bC	2.3429	<0.01
	25°C	26.24±0.52aA	18.62±1.36aB	11.16±0.06aC	2.5991	<0.01
	30°C	21.24±0.86cA	16.28±0.85abB	12.82±0.85aC	2.6369	<0.01
	HSD	2.0851	3.2396	2.0868	-	-
	P-value	0.0008	0.0235	0.0047	-	-
Adult	20°C	29.24±0.72bA	18.86±0.86cB	10.61±0.43cC	2.1354	<0.01
	25°C	34.23±1.90aA	26.63±1.07aB	16.84±0.87bC	4.1729	<0.01
	30°C	30.64±0.99abA	23.63±0.94bB	20.63±0.93aC	2.9428	<0.01
	HSD	4.0174	2.9582	2.3964	-	-
	P-value	<0.01	<0.01	<0.01	-	-

Means followed by same lowercase letters in the same column were not significantly different at P=0.05.
Means followed by different uppercase letters in the same row were significantly different at P=0.05.

longevity exhibited a negative trend with respect to temperature range and continued to decrease with each level of increasing temperature. Similar behavior was noticed for total life span of the adult female. An adult female lived for 61.54 days at 20°C with shortened life span of 44.91 and 32.02 days at 25 and 30°C respectively. Male to female ratio was highest (1:4.75) at 25°C while the lowest sex ratio (1:2.33) was observed at 20°C.

Development rates (1/developmental time) of *A. buntex* female were regressed against temperature (Table 4). Results revealed that temperature contributed 87.86, 99.98, 99.52, 98.43 and 98.33% variation in development of egg, larva, protonymph, deutonymph and egg to the adult stage respectively for *A. buntex* female. Almost similar contribution was observed for male life stages. The lower developmental threshold of *A. buntex* female for egg, larva, protonymph, deutonymph and egg to adult stage was recorded as 4.60, 3.61, 11.46, 13.22 and 6.65°C respectively whereas these values were 0.03, 8.90, 11.26, 13.04 and 8.35 for male respectively. Concerning thermal constant (K), 346.02 DD were required for *A. buntex* female to complete egg to adult stage whereas male required 250.00 DD when reared on *T. urticae*.

Temperature had a great influence on the recorded life table parameters i.e. mean generation time (T), net reproductive rate (R_o), intrinsic rate of natural increase (r_m), finite rate of increase (λ) and doubling time (DT) of *A. buntex*. Mean generation time (T) of 41.14 days was recorded at 20°C and reduced at increasing temperatures. The net reproductive rate (R_o) was found to be 13.73, 23.91 and 9.11 female offspring per female at 20, 25 and 30ºC, respectively. *A. buntex* required 10.88 days to double the population at 20°C, then decreased suddenly at higher temperatures (6.31 days at 25°C). The intrinsic rate of natural increase (r_m) and finite rate of increase (λ) were higher at 25 and 30°C but much lower at 20°C which shows that lower temperature does not favor fast development and oviposition as compared to higher temperatures (Table 5).

Figure 1 depicts age specific survival (l_x) and age specific fecundity (m_x) curves for the full range of temperature investigated. It is evident from the figure that low mortality was observed at each specific life stage (x). Female progeny of 1.45 was recorded after 13th day of oviposition followed by 1.36 females after 5th day at 20°C. Maximum female progeny / female / day at 25°C and 30°C were recorded after 12th (4.56) and 5th day (1.49) oviposition, respectively.

The predatory potential of *A. buntex* nymphs and adults was also carried out against juveniles and adults of *T. urticae* at same constant temperatures (Table 6). Consumption by nymph and adult *A. buntex* differed significantly among all prey stages. As described in Table 6, *A. buntex* nymph preferred more larvae of *T. urticae* followed by nymphs and adults. Prey consumption by *A. buntex* nymph ranged from 21.24 larvae at 30°C to 26.24 larvae at 25°C against *T. urticae* larvae. Nymph against nymph consumption was highest at 25°C (18.62 nymphs) followed by 16.28 and 13.82 nymphs at 30°C and 20°C respectively. Adult *T. urticae* were less preferred by *A. buntex* nymph. Maximum consumption of

12.82 adults was observed at 30°C which is statistically at par with 11.16 adults at 25°C. *A. buntex* adult fed more voraciously than nymph against all prey stages offered at three constant temperatures. ANOVA indicated significant variations against larva (P=0.049), nymph (P<0.01) and adult (P<0.01) stage of *T. urticae* at all temperatures tested. Adult consumption against *T. urticae* larvae averaged at 29.24, 34.23 and 30.63 larvae at 20, 25 and 30°C respectively. Consumption by *A. buntex* adult against *T. urticae* nymph exhibited similar behavior of predation while adult *T. urticae* were less favored by *A. buntex* adult. Only 10.61, 16.84 and 20.63 *T. urticae* adults were consumed at 20, 25 and 30°C by *A. buntex* adult.

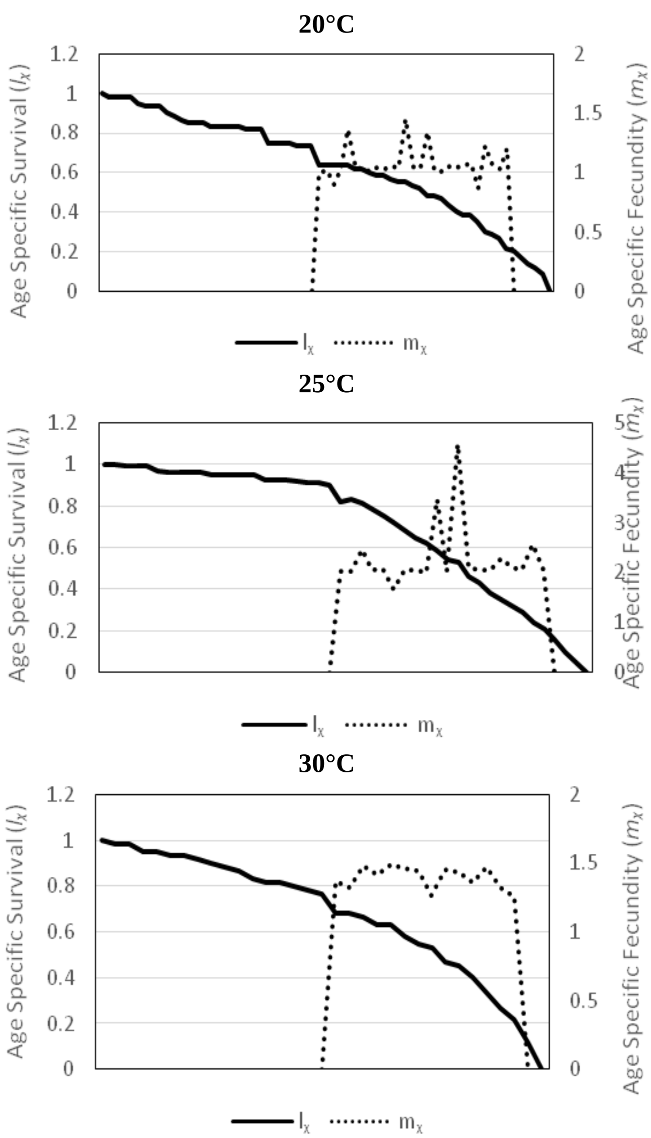

Figure 1. Age-specific survival (l_x) (straight line) and age-specific fecundity (m_x) (dotted line) of *A. buntex* females at three constant temperatures.

DISCUSSION

Our results revealed that variations in temperature levels attributed to the change in development time of immature stages of *A. buntex* when fed on *T. urticae.* Egg, larvae, protonymph, deutonymph and egg to adult stages were completed in 7.36, 3.00 2.44, 2.34 and 15.14 days respectively at 25°C for male and 8.48, 3.98, 3.69, 3.52 and 19.67 days, respectively for the female which are shorter than at 20 and 30°C. Maximum development time was recorded for the egg stage of the female at 20°C while male deutonymph took minimum time (1.83 days) to complete at 30°C. These results may be compared with the findings of Canlas *et al.* (2006) who found that egg to deutonymph development time of *Neoseiulus californicus (McGregor)* were completed in 1.42, 0.77, 1.07 and 1.35 days, respectively at 25°C which was shorter than development rates of these stages at 15, 20, 30, and 35°C. This difference in development rate may be due to the difference in food supply changes in interval levels. The similar trend of temperature with life stages was also reported by Shih and Shieh (1979) and Kim *et al.* (1996) who found that development of *Amblyseius womersleyi* (Schicha) changed when fed with different life stages such as *Tetranychus kanzawai* eggs and nymphs (Lo, 1984). Current findings are also contradictory to the Bolland *et al.* (1998) who reported that *Neoseiulus fallacis* development period of juveniles depends on temperature and completed in 3.5 and 12.3 days at 26.4°C and 13.3°C, respectively. Zhang *et al.* (1999) found that egg, larvae and nymph stages of *Typhlodromus bambusae* lasted for 1.7, 1.0 and 0.8 days respectively at room temperature. This contradiction might be due to the difference in temperature variation.

It should be noted that daily fecundity of *A. buntex* female on *T. urticae* in the present study was 2.59 eggs per day at 25°C. Furthermore, the *N. californicus* female fecundity was 0.83 and 1.17 eggs/day when fed with *T. urticae* male and female, respectively (Canlas *et al.,* 2006). The difference in development time was found when compared with the results of Khodayari *et al*. (2008) who recorded the life table parameters of *Zetzellia mali* against *T. urticae* eggs as: Female longevity, 10±0.73 days; preoviposition period, 1.81±0.2 days; oviposition period, 5.4±0.6 days and post oviposition period, 1.3±0.4 days. This slight difference may be attributed to the change of prey stage.

The lower development threshold observed was 6.65 and 8.35°C for *A. buntex* female and male respectively, which is much lower than *Phytoseius plumifer* female (13.22°C) but quite like that of *A. exsertus* female (5.29°C) (Rasmy *et al*., 2011). Degree day requirements for *A. buntex* were 346.02 DD for female and 250 DD for male. The highest value for intrinsic rate of natural (r_m) of *A. buntex* was found to be 0.11 females/female/day at 25°C, which is like *A. exsertus* (Rasmy *et al.,* 2011). Finite rate of increase (λ) values for *A. buntex* were found to be 1.07, 1.12 and 1.11 at 20, 25 and 30°C, respectively. Similar findings have been reported by (Nour El-din, 2006) who reported that *P. plumifer* λ values averaged 1.04, 1.13 and 1.16 at 20, 25 and 30°C, respectively. But λ values of some predatory mites shifted to 1.24 when kept at 27°C (El-Laithy, 1998).

All life stages of *T. urticae* effectively consumed by nymphs and adults of *A. buntex.* Both nymphal as well as adult stages of the predator prefer immature stages of prey mites than the adult stage (Hull *et al.*, 1977; Ragkou *et al*., 2004; Tanigoshi and McMurtry, 1977). On average, *A. buntex* adult consumed maximum of 34.23 larvae of *T. urticae* at 25°C. Our results confirmed that *A. buntex* fed on *T. urticae* 26.63 nymphs almost twice more than *A. swirskii* which consumed 4-6 nymphs within a 12 h period (Xu and Enkegaard, 2010; El-Laithy and Fouly, 1992) which presumably reflects difference in temperature (27°C) and a starvation period used by the latter authors. The predation rate of *A. buntex* was found slightly more than *N. californicus* (Canlas *et al.,* 2006). Khajuria (2009) observed that *A. fallacies* fed 2.0 and *S. punctilum* 12-18 mites per day which is far below the consumption rate of *A. buntex*. Our results are in confliction with Kazak (2008) who reported that mean daily consumption of adult *Phytoseiulus persimilis* females was 11.85, 20.64, and 15.41 while *P. persimilis* males consumed 2.41, 2.60, and 3.25 *T. cinnabarinus* larvae at 20, 25, and 30°C, respectively.

***Conclusions*:** Life table parameters of *A. Buntex* are considerably affected by temperature variation. *A. buntex* seems to be better adapted even at higher temperatures and might be successively used as an effective tool against spider mites especially *T. urticae* in hot and humid climatic conditions of Pakistan due to its short generation time, high fecundity, comparable sex ratio and high rate of predation.

***Acknowledgements*:** Author(s) are highly obliged to Dr. Eddi Ueckermann, Dr. Fan, Dr. Salih Dogan, Dr. Hans Klopmen and Dr. Shamshad Akbar for their help in stigmaeid mite literature.

REFERENCES

Analytical software. 2005. Statistix 8.1 for Windows. Analytical Software, Tallahassee, Florida.

Aghdam, H.R. 2008. Temperature-dependent development of Phytoseius plumifer (Acari: Phytoseiidae) on *Tetranychus urticae* (Acari: Tetranychidae). Syst. Appl. Acarol. 13:172-181.

Birch, L.C. 1948. The intrinsic rate of natural increase of an insect population. J. Anim. Ecol. 17:15-26.

Bolland, H.R., J. Gutierrez and C.H. Flecthmann. 1998. World catalogue of the spider mite family (Acari: Tetranychidae). Bull. Pub. Leiden, p.392.

Campbell, A., B. Frazer, N. Gilbert, A. Guitierrez and M. Mackauer. 1974. Temperature requirements of some aphids and their parasites. J. Appl. Ecol. 11:431–438.

Canlas, L.J., H. Amano, N.O. Chiai and M. Takeda. 2006. Biology and predation of the Japanese strain of *Neoseiulus californicus* (McGregor) (Acari: Phytoseiidae). Sys. Appl. Acarol. 11:141–157.

Chaudhri, W.M. and S. Akbar. 1985. Studies on biosystemstics and control of mites of field crops, vegetables and fruit plants in Pakistan. U.A.F. Tech. Bull. No.3, p.314.

Croft, B.A. 1994. Biological control of apple mites by a phytoseiid mite complex and *Zetzellia mali* (Acari: Stigmaeidae): long-term effects and impact of azin-phosmethyl on colonization by *Amblyseius andersoni* (Acari: Phytoseiidae). Environ. Ento. 23:1317–1325.

El-Laithy, A. Y. M. and A. H. Fouly. 1992. Life table parameters of the two phytoseiid predators *Amblyseius scutalis* (Athias-Henriot) and *A. swirskii* A–H (Acari, Phytoseiidae) in Egypt. J. Appl. Entomol. 113:8-12.

El-Laithy, A.Y.M. 1998. Laboratory studies on growth parameters of three predatory mitesassociated with eriophyid mites in olive nurseries. Zeitschr Pflanzenkrankh Pflanzensch 105:78–83.

Fouly, A., M. Al-Deghairi and N.A. Baky. 2011. Biological aspects and life tables of *Typhlodromips swirskii* (Acari: Phytoseiidae) fed *Bemisia tabaci* (Hemiptera: Aleyrodidae). J. Entomol. 8:52-62.

Hull, L.A., D. Asquith and P.D. Mowery. 1977. The mite searching ability of *Stethorus punctum* within an apple orchard. Environ. Entomol. 6:684-688.

Kazak, C. 2008. The development, predation and reproduction of *Phytoseiulus persimilis* Athias-Henriot (Acari: Phytoseiidae) from Hatay fed *Tetranychus cinnabarinus* Boisduval (Acari : Tetranychidae) larvae and protonymphs at different temperatures. Turk. J. Zool. 32:407-413.

Khajuria, D.R. 2009. Predatory complex of phytophagous mites and their role in integrated pest management in apple orchard. J. Biopestic. 2:141-144.

Khan, B.S. and M. Afzal. 2005. Comparison of life cycle of stigmaeid mite, *Agistemus buntex* on three host Tetranychid species. Pak. Entomol. 27:9-11.

Khan, B.S., M.H. Bashir, M. Farooq and N.A. Khan. 2010. A new predatory mite species of the genus *Agistemus* (Stigmaeidae: Acari) from Punjab, Pakistan. Pak. Entomol. 32: 24-28.

Khodayari, S., K. Kamali and Y. Fathipour. 2008. Biology, life table and predation of *Zetzellia mali* (Acari: Stigmaeidae) on *Tetranychus urticae* (Acari: Tetranychidae). Acarina 16:191-196.

Kim, D.I., S.C. Lee and S.S. Kim. 1996. Biological characteristics of *Amblyseius womersleyi* Schica

(Acarina: Phytoseiidae) as a predator of *Tetranychus kanzawai* Kishida (Acari: Tetranychidae). Kor. J. Appl. Entomol. 35:38–44.

Latifi, M., P. Azmayeshfard, A. Khazaipakdel, A.R. Saboory and H. Alahyari. 2010. Effect of three constant temperatures on life table parameters of *Tetranychus turkestani* Ugarov and Nikolski (Prostigmata: Tetranychidae). Iranian J. Pl. Prot. Sci. 41:51-59.

Lo, K.C. 1984. The role of native phytoseiid mite *Amblyseius longispinosus* (Evans) in the biological control of twospotted spider mites on strawberry in Taiwan. pp.703-709. In: D.A. Griffiths and C.E. Bowman (eds.), Acarology VI Vol. 2. Wiley, New York.

Nelson, E.E., B.A. Croft, A.J. Howitt and A.L. Jones. 1973. Toxicity of apple orchard pesticides to *Agistemus fleschneri*. Environ. Entomol. 2:219–222.

Nour El-Din, N.A. 2006. Biological and ecological studies of certain predaceous mites. MSc diss., Faculty of Agric., Mans. Uni.

Ragkou, V.S., C.G. Athanasseiou, N.G. Kavallierator and Z. Tomanovic. 2004. Daily consumption and predation rate of different *Stethorus puntillum* instars feeding on *Tetranychus urticae*. Phytoparasitica 32:154-159.

Rasmy, A.H., M.A. Osman and G.M. Abou-Elella. 2011. Temperature influence on biology, thermal requirement and life table of the predatory mites *Agistemus exsertus* Gonzalez and *Phytoseius plumifer* (Can. & Fanz.) reared on *Tetranychus urticae* Koch. Arch. Phytopathol. Pl. Prot. 44:85-96.

Santos, M.A. and J.E. Laing. 1985. Other predaceous mites and spiders 2.2.1. Stigmaeidae predators, pp.197-302. In: W. Helle and M.W. Sabelis (eds.), Spider mites their biology, natural enemies and control. World Crop Pets 1B. Elsevier, Amsterdam.

SAS, Institute. 2001. PROC user's manual, version 6th ed. SAS Institute, Cary, NC.

Shih, C.I.T. and J.N. Shieh. 1979. Biology, life table, predation potential and intrinsic rate of increase of *Amblyseius longispinosus* (Evans). Pl. Prot. Bull. Taiwan. 21:175–183.

Sohrabi, F. and P. Shishehbor. 2008. Effects of host plant and temperature on growth and reproduction of the strawberry spider mite, *Tetranychus turkestani* Ugarov and Nikolski (Acari: Tetranychidae). Syst. Appl. Acarol. 13:26-32.

Steel, R.J. and J.H. Torrie. 1980. Principles and Procedures of Statistics: A biometrical approach, 2nd Ed. McGraw-Hill New York.

Tanigoshi, L.K. and J.A. McMurtry. 1977. The dynamic of predation of *Stethorus picipes* (Coleoptera, Coccinellidae) and *Typhlodromus floridanus* on the prey *Oligonychus punicae* (Acarina: Phytoseiidae, Tetranychidae). Part I. Comparative life history and life table studies, Part II. Effects of initial prey–predatory ratio and prey distribution. Univ. California, Division of Agricultural Science Pub. Hilgardia 47:237-288.

Xu, X. and A. Enkegaard. 2010. Prey preference of the predatory mite, *Amblyseius swirskii* between first instar western flower thrips *Frankliniella occidentalis* and nymphs of the two spotted spider mite *Tetranychus urticae*. J. Ins. Sci. 10: 1-11.

Zhang, Y., Z.Q. Zhang, Q. Liu and J. Lin. 1999. Biology of *Typhlodromus bambusae* (Acari: Phytoseiidae), a predator of *Schizotetranychus nanjingensis* (Acari: Tetranychidae) injurious to bamboo in Fujian, China. Syst. and Appl. Acarol. 4:57-62.