Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2016; 4(1): 279-283

Received: 28-11-2015
Accepted: 31-12-2015

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Effect of temperature variation on the developmental stages of *Tetranychus urticae* Koch and *Panonychus ulmi* Koch (Tetranychidae: Acarina) under laboratory conditions in Swat valley of Khyber Pakhtunkhwa, Pakistan

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Abstract
Two Spotted Spider Mite (TSSM), *Tetranychus urticae* Koch and European Red Mite (ERM), *Panonychus ulmi* Koch (Tetranychidae: Acarina) are major mite pests of apple orchards in Swat valley. For efficient control of pest mites on apple basic knowledge of developmental durations of pest is utmost important. In the present study developmental stages of TSSM and ERM were studied at two levels of temperature (24-26 °C) and (29-31 ºC) and constant level of relative humidity 65±5% under laboratory conditions at Agricultural Research Institute, Mingora, Swat during 2010. The test arthropods were reared on fresh apple leaves. Variation in temperature significantly affected the developmental stages of both the male and female of the mite species. The total developmental duration of *T. urticae* female was 12.4 days at 24-26 ºC and 10.0 days at 29-31 ºC while for male it was 10.8 days at 24-26 ºC and 8.3 days at 29-31 °C. The developmental duration of ERM female was 12.18 at 24-26 °C and 9.8 days at 29-31 ºC while for male it was 11.61 days at 24-26 °C and 9.35 days at 29-31 °C. The developmental duration of females of both the species were longer than its males and it was longer for females and males of TSSM than of ERM. The present findings might be used in devising integrated pest management of TSSM and ERM on apple orchards in the Swat valley.

Keywords: Apple, *T*etranychus *urticae*, *P*anonychus *ulmi*, Developmental duration, Temperature effect

1. Introduction
Apple is one of the most common crops in the world; worldwide, apple production reaches about 58 billion tons at each year [1]. Pakistan is one of the apple producing countries. In Pakistan, apples are mainly grown in temperate regions like some parts of Balochistan, South and North Waziristan, Northern areas (Gilgit, Baltistan) and Malakand division of Khyber Pakhtunkhwa [2]. So far twenty five species of apple have been reported, but still modern commercial apple production is dominated by only few cultivars [3].
A number of arthropod pests attack and cause economic damages to apple production all over the world. Among these spider mites encompass an important group of phytophagous mites dwelling fruit bearing plants. These arthropod pests most often infest apple and plum trees, less often they can be observed on pear-trees, sweet cherry, cherry and peach [4-7]. Population density of the spider mites on host plants is usually highly variable and mostly depends on the environmental conditions [6-8]. It was further stated that coexistence of European red spider mite (*Panonychus ulmi* Koch), almond brown mite (*Bryobia rubrioculus* Scheuten) and lately also two-spited spider mite (*Tetranychus urticae* Koch) was most often observed [6-8]. Pest mites cause economic losses to the apple growers and significantly reduce the photosynthetic rate of plants due to stomatal limitation Bueno *et al.* [9]. In Swat valley of Khyber Pakhtunkhwa, mites attack a diversified range of fruits as well as vegetables. As stated by Beers and Hull, 1990 [10] infestation by mites influences the blooming, fruiting and yielding of the infested apple trees. Mostly the apple growers rely on pesticides application for the control of the arthropod pests in Swat valley. Suppression of the natural enemies by pesticides has been causing spider mites outbreaks. The world is transitioning towards biological control to minimize health hazards and also to manage the resistance so developed by the arthropod pests to chemical pesticides. The disruptive effects of pesticides, especially due to development of resistance by pests, have led to greater reliance on natural enemies for their control in the Van region [11-13]. In recent years, population densities and economic importance of spider mites has

greatly increased in Van [14]. Tetranychid mites (Acarina: Tetranychidae) harm a wide range of crops and ornamental plants. In particular, *T. urticae* Koch (Acari: Tetranychidae), important phytophagous mites, feeds on more than 150 species of host plants, mainly vegetables and deciduous fruit trees [15-21].

Temperature is the main abiotic factor influencing the temporal and spatial distribution of insects and mites in the field [22-23]. Population growth rates largely determine the pest status of spider mites [24] and temperature strongly affects population growth [25-28]). Therefore, knowing the temperature requirements of the different stages of mite pests can be used to forecast their potential distribution and abundance.

2. Materials and Methods

Biology of spider mites TSSM and ERM was studied at the Agricultural Research Institute Mingora, Swat during 2010 at two levels T_1 (24-26 ºC) and T_2 (29-31 ºC) of temperature. Fresh leaves of Red Delicious apple variety were collected from the apple orchard. The leaves were washed with distilled water and cut in to pieces of 3 cm^2 and put upside down on the water saturated foam in the petri dishes (100×15 mm diameter) to maintain the vitality of the leaf discs. Ten mature female spider mites each of TSSM and ERM were collected from the apple orchard and released for egg laying singly on the leaf discs for 24 hours. After the mentioned time the adult females were detached from the petri dishes and eggs of the same age group were counted in each petri dish with the help of stereo-microscope.

The leaf discs were regularly observed at 12 hours intervals for any development in the immature stages with the passage of time. Leaf discs were replaced on detecting any deterioration and all the developmental stages of male and female specimens were recorded for variable temperature levels and constant 65±5% relative humidity on daily basis.

The duration recorded for the developmental stages of the target mite species at two different levels of temperature (24-26 ºC) and (29-31 ºC) and constant relative humidity 65±5% were analyzed statistically using Statistix 8.1 program with one way ANOVA and the means were separated by LSD at 5% level of probability.

3. Results and Discussion

3.1. Biology of Tetranychus urticae and Panonychus ulmi at two levels of temperature

3.1.1 *Tetranychus urticae* Koch

During the present studies the two levels of temperature significantly affected all the developmental stages of male and female of TSSM, presented in figures 1 and 2. According to our findings total developmental period was shorter, 10 days for female and 8.3 days for male of TSSM at highest level 29-31 °C while the period recorded at low level of temperature 24-26 ºC was longer 12.4 days for female and 10.8 days for male, respectively. Developmental time for male was 8.3 days at 29-31 ºC and 10.8 days were recorded at 24-26 °C, respectively. Slow development of all stages of female of *T. urticae* was 4.6 days for egg hatching, 2.3 for larva, 2.2 for protonymph and 2.0 days for deutonymph of female at low level of 24-26 ºC while significantly shorter time of 4.1 days for egg hatching, 2.0 for larva and 1.9 days each for protonymph and deutonymph were recorded at high 29-31 °C level of temperature. While studying the developmental stages of male, egg hatching took shorter time of 2.7 days, larval stage took 1.9 days, protonymph and deutonymph took1.8 days for its development at high 29-31 °C level of temperature. The time noted for all the above stages of male of the TSSM was 4.2, 2.2, 2.1 and 1.9 days at low level 24-26 °C of temperature, respectively. In our findings, the time for development stages decreased as the temperature level increased, which may be due to difference in host plant. Similar studies were conducted by Riahi *et al*., [29] with a slight difference that beyond 27 °C to 31 °C the time for development of all stages took longer time and compared to temperature range in between 17 to 27 ^{0}C. Riahi *et al.* [29] stated that development, reproduction and life table parameters of TSSM were determined on leaves of peach (G. H. Hale cultivar) at different temperatures, ranging from 13 to 33 °C under laboratory conditions. No development was observed at 13 °C. Egg-to-adult developmental time decreased gradually from 17 to 27 °C and increased at higher temperatures (27 to 33 °C). The results suggested that TSSM was able to develop and reproduce within a wide range of temperatures, and that temperatures from 27-30 °C are the most suitable conditions for the development, survivorship and reproduction of the mite. So the results of Riahi *et al.* [29], confirm the findings of our studies with little difference of host plants. Same method was used by Kasap [19] at 20 °C who reported 15.5 and 14.5 days for female and male, respectively, as duration of development on apple but our findings are lower than those reported by Kasap [19] may be due to high levels of temperature.

At 25 °C, the total duration of development of the TSSM was 13.75 days [30] fed by lima beans. Similar results were reported by Riahi *et al*. [29] but the host plant was peach. At the same temperature level but the different host plants the time taken for total development was 11.7days [31], 9.38 days [32], 12.36 and 10.7 days for female and male, respectively [33] and 10.0 and 9.3 days [19]. The results of our research work are close to those of RajaKumar *et al.* [33] and Shih *et al.* [34] who reported that immature stages of TSSM required about 7.5 days to reach adulthood at 27 °C, which was markedly lower than the time we recorded for all immature stages of the target mite.

The developmental time reported by Sedaratian *et al.* [35] on different soybean genotypes varied from 7.6 to 8.8 days for female and from 7.1 to 8.4 days for male, which were shorter than the values obtained in the present study. At 30 °C, our findings are considerably higher than those found in other studies Inglinski and Rainwater [36]; Kasap [19]; Parslika and Huszar [37]; Forghani *et al*., [38]. Many factors like host plants, mite strains, as well as, experimental conditions may provide explanation for longer and lower development times [29].

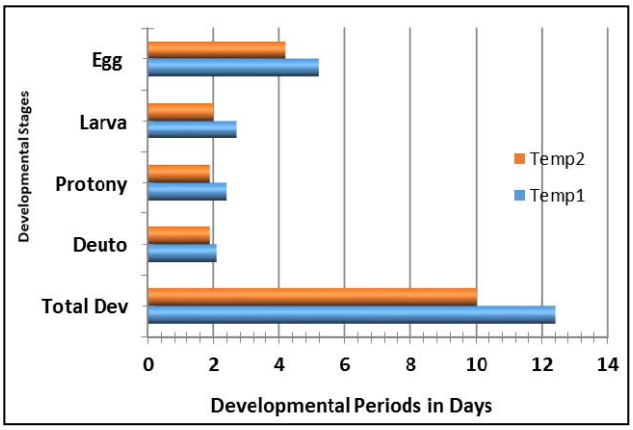

Fig 1: Duration of immature stages of TSSM female

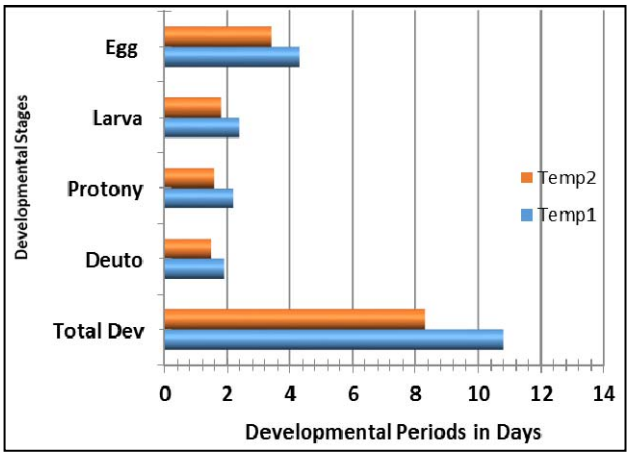

Fig 2: Duration of immature stages of TSSM male

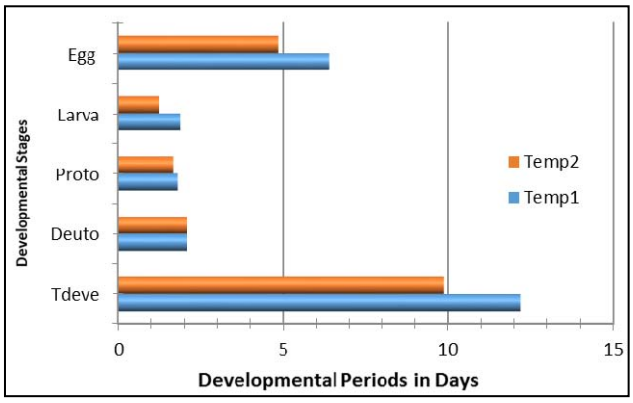

Fig 3: Duration of immature stages of ERM female

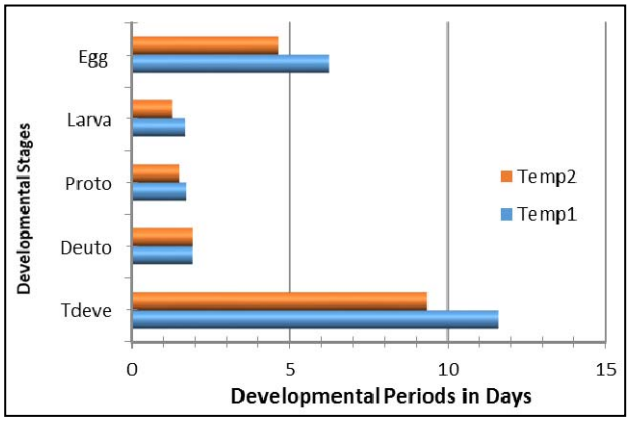

Fig 4: Duration of immature stages of ERM male

3.1.2 *Panonychus ulmi* Koch

The present studies revealed that the two levels of temperature T_1 (24-26 ºC) and T_2 (29-31 ºC) also affected the developmental stages of ERM of both females and males under laboratory conditions, fed on apple fresh leaves. The findings represented in fig 3 and 4 showed that high temperature level T_2 (29-31 ºC) shorten all the developmental stages of female and male of red mite as 9.88 and 9.33 days respectively, while the total developmental time at lower temperature level T_1 (24 to 26 ºC) was 12.18 and 11.61 days for female and male of spider mites, respectively. Similarly the time recorded for egg hatching was female was 6.5 days, for larval stage it was 1.8 days, for protonymph it was 1.7 days and for deutonymph it was 2.0 days respectively at low level of temperature. The same stages of female completed in 4.9, 1.1, 1.6 and 2.0 days respectively at high level of temperature. The time recorded for the development of egg hatching for male was 6.2 days, for larva it was 1.7 days, for protonymph it was 1.8 and for deutonymph it was 1.9 days respectively at low level of temperature. At highest level of temperature the time recorded for egg hatching was 4.7 days, for larva it was 1.2 days, for protonymph it was 1.5 days and for deutonymph it was 1.9 days, respectively. Yin *et al*., [39] studied the effect of four apple varieties at constant temperature, 23±1 °C, 75±5% R.H. and a photoperiod of 16:8 (L:D) h, on the developmental stages of ERM. They reported that total development time of immature females was shorter on Fuji than the other varieties, and this was because of its shorter egg duration. Immature survival of ERM was 74.51-78.00% among four apple varieties, and no significant differences were found. These results exceed the time of our findings may be due to low temperature level, as the host was the same.

Mazid *et al*., [40] reported their findings on development of Red Spider Mite (*Oligonychus Coffeae* Nietner) with a host plant, tea, at different levels of temperature. According to their findings the mean total development period irrespective of male and female, was 14.47, 13.2, 10.9, 8.29, 6.8 and 7.92 days at 22.7, 25.50, 29.10, 31.25, 32.00 and 31.90 °C, respectively, which is close and confirm our findings although the hosts and mite species are different.

Yin *et al*., [41] conducted studies on the effect of apple varieties on the total development time of *P. ulmi* population at 23±1 °C, 75%±5% relative humidity and a photoperiod of 16L:8L under laboratory condition and reported that the total developmental duration of ERM on *Malus sieversii* subsp. *kirghisorum* and *M. domestica* Golden Delicious were 12.60 d and 12.54 d for females, and 11.40 d and 11.67 d for males, respectively which support our present findings and confirm the results we have achieved. The temperature and relative humidity has a major effect on the population of European red mite. There was an increase in both the population of both the motile and eggs of spider mite *with* the increase in temperature from 13-21 °C and the relative humidity ranges from 55-85% or above [42]. These results also support the present findings that with the increase of temperature level up to limited level may decrease the total developmental time and hence help the population to build soon.

4. Conclusion

High level of temperature decreased the time of development of all life stages of the target pest mites, as compared to the

lower level. So, it is concluded that high the temperature level, shorter will be the life span of the apple pest mites, and the damage will also be more, proportionately.

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