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BIOLOGY OF MAJOR INSECT PESTS OF CARNATION

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ABSTRACT

Caranations are among the most popular commercial cut flowers. Among the insect pests attacking carnation, two spotted spider mite *Tetranychus urticae* Koch and bud borer *Helicoverpa armigera* (Hübner) were studied under laboratory conditions at the Department of Entomology, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India during 2021. Total developmental/ period of *T. urticae* lasted for 12.10 days. The growth parameters revealed that the gross reproductive rate, net reproductive rate (R_o), true generation time (T) and finite rate of natural increase (λ) was 91.24 eggs/ individual, 81.20 eggs/ individual, 18.73 days and 1.26 females/ day, respectively for *T. urticae*. The intrinsic rate of increase (r) was 0.23 females/ female/ day. Total developmental/ period for *H. armigera* was 32.12 days; its growth parameters revealed that the net reproductive rate (R_o) was 37.40 offsprings/ individual, intrinsic rate of increase (r) was 0.10 females/ female/ day and finite rate of natural increase (λ) was 1.10 females/ with generation time (T) being 37.94 days.

Key words: Carnations, *Tetranychus urticae*, *Helicoverpa armigera*, developmental biology, population growth parameters, male, female, egg, larva, pupa, protoymph, deutonymph

Carnations (*Dianthus caryophyllus* L.) are one of the most important cut flowers in the world being used in floral arrangements, corsages and boutonnieris. It is also known as the divine flower, clove pink, gilly flowers etc. The genus name *Dianthus* means flower of zeus or divine (Sandeepa et al., 2019). Carnation holds a prominent place among the cut flowers in India. It can be grown successfully under greenhouse conditions for ornament purposes, it is grown commercially in India in places having mild climate such as Solan, Shimla, Kalimpong, Kodaikanal, Mandi, Kullu, Srinagar, Ooty (Shiragur et al., 2004). The most common pests associated with carnation are *T. urticae*, *H. armigera*, thrips (*Thrips florum* and *Thrips hawaiiensis*) and aphids (*Rhopalosiphum maidis*) (Raj et al., 2019). *T. urticae* is a serious pest of greenhouse crops, including carnation (Jhansi and Mohan, 1997). Both nymphs and adult feed with chelicerate type mouth parts which pierce and suck the cell sap from epidermis of leaves. Heavy damage may cause carnation leaves turn yellow then bronze and the plant may be covered with webbing with stunted growth, resulting in reduced yield and quality of marketable flowers (Sandhu and Gupta, 1977). *H. armigera* is the most important pest causing serious damage to the flowers of carnation (Multani and Sohi, 2002). The moth lays eggs on the buds and the larvae feed on leaves, buds and flowers after hatching thereby it reduces the flower yield (Reddy et al., 2020). Though there are studies and reports on the biology of *T. urticae* and *H. armigera* on different vegetable and flower crops but there are not many studies on carnation under Solan conditions. In this background present study was carried out to study the developmental biology of *T. urticae* and *H. armigera* on carnation, keeping in view the economic importance of carnation in commercial floriculture and the magnitude of damage caused by insect and mite pests,

MATERIALS AND METHODS

Laboratory experiments were conducted in the department of entomology, Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh during 2021 to study the biology of *T. urticae* and *H. armigera* on carnation. For this purpose, both *T. urticae* and *H. armigera* were reared at room temprature under laboratory conditions. The carnation plants were sourced from 'Department of Floriculture and Landscape Architecture' of the University and raised in pots under laboratory conditions. *T. urticae* and *H. armigera* were collected from naturally infested plants

and reared on these laboratory-cultivated carnations and were used as stock culture to conduct biology studies. To study the biological parameters of *T. urticae*, eggs from same cohort were collected from the stock culture and transferred using fine camel hair brush onto detached leaves of carnation which were placed over wetted sponge in the plastic trays (30 x 24 cm). Leaves were replaced at regular intervals to ensure the continuous supply of food. A total of fifty eggs of *T. urticae* were transferred in total to five plastic trays with a set of 10 eggs in each plastic tray as a replicate and five replications were maintained. The total time period of life stages of mite was recorded. In addition, pre-oviposition and oviposition period were also recorded.

Besides these, the longevity of male and female adults, sex ratio (proportion of males to female adults emerged) and total life cycle duration were also recorded. For *H. armigera* fifty freshly laid eggs from same cohort were collected and transferred to petri plates. Eggs were kept singly in petri plates (to prevent cannibalism in larval stage) with 10 petri plate/ replicate and five replications were maintained. Eggs transferred were observed daily for hatching. On hatching, the larvae were reared on the carnation flower buds until they reached the pupation stage. The duration of egg stage and different larval stages was recorded. Once larvae entered pupation, they were observed till adult emergence. The adults thus emerged were released into the oviposition cages. Cotton swabs drenched with honey solution (30%), protinex mixture (protinex, pollen, honey and yeast) and water were provided as diet to the adults. The data on age specific survival and fecundity were used to construct life-fertility tables using TWOSEX-MS chart (version 2021.21.06). The age stage specific survival rate (S_{xj}, where x= age in days and j=stage), age-stage specific fecundity (f_{xj}) (daily number of eggs produced/ female of age x), age-specific survival rate (l_x), and the age- specific fecundity (m_x) were calculated according to the age-stage, two-sex life table theory (Chi and Liu, 1985; Chi, 1988). The adult pre-oviposition/ period (APOP) and the total pre-oviposition/ period (TPOP) were calculated from the raw data. population parameters (r, λ, R_o and T) were calculated by using the TWOSEX-MS chart program. The variance and standard errors of the population parameters were estimated by using the bootstrap procedure (Wei et al., 2020).

RESULTS AND DISCUSSION

Development of *T. urticae* on carnation revealed that the duration of egg/ period lasted for 4.60± 0.20 days with a range of 4-6 days, whereas the larval stage lasted for 2-3 days with an average duration of 2.70± 0.14 days (Table 1). The duration of protonymph and deutonymph was 2.50± 0.21 and 2.30± 0.14 days, respectively. The mean duration of the total developmental period was 12.10± 0.28 days which varied from 9-18 days. The adult male survived for 9.50± 0.50 days with range value of 9-10 days, whereas, the female lived for 14.75± 0.97 days which varied for 10-18 days. Sex ratio was 1:2.5 (male: female). Rai et al. (1989) reported the duration of larval, nymphochrysalis, protonymphal, deutochrysalis, deutonymphal and teleochrysalis ranged from 1.0 to 3.0 (1.94± 0.63), 0.31 to 1.0 (0.82±0.31), 0.33 to 2.00 (0.91± 0.56), 0.66 to 1.00 (0.81± 0.17), 1.00 to 2.00 (1.38± 0.52) and 0.33 to 1.00 (0.78± 0.35) days in male and 1.00 to 5.00 (2.11±0.79), 0.33 to 3.00 (0.89± 0.36), 0.33 to 4.00 (1.21± 0.50), 0.33 to 2.00 (0.85± 0.32), 0.66 to 3.00 (1.56± 0.84) and 0.33 to 1.00 (0.91± 0.17) days in female, respectively. According to Singh and Singh (1993) *T. cinnabarinus* on lady's finger took 12.30± 1.35 and 9.20± 0.55 days as development period from egg to adult at 30°C and 35°C with relative humidity 75 and 55%, respectively. Patiladiti et al. (2016) reported that the total developmental/ period was 12.08± 1.77 days for male and 22.11± 2.43 days for female on marigold. Sandeepa et al. (2019) reported that the total life period occupied by *T. urticae* on carnation varied from 18.60 to 24.20 (21.65± 1.63) days in male and 24.33 to 29.80 (26.85± 1.15) days in female.

Duration of life stages of *H. armigera* revealed that the incubation period was 2.90±0.17 days with a range of 2-4. The larval stage lasted for 13-20 days and the duration of five larval instars was 2.80± 0.13, 2.90± 0.22, 3.00± 0.14, 3.78± 0.14, 4.44± 0.17 days, respectively (Table 1). The pupal stage lasted for 11-15 days with an average duration of 12.38± 0.50 days. The mean duration of the total developmental period was 32.12± 0.72 days with range value of 28-35 days, adult longevity was 6.25± 0.69 days which varied from 3-9 days. The adult male survived for 4.50± 0.64 days with range value of 3-9 days, whereas the female lived for 8.00± 0.40 days which varied for 7-9 days. Sex ratio was 1:1 i.e. 50% females and 50% males were emerged. Two individuals died during their immature stage, one after third larval instar and the other in pupal stage. The findings of the present study are in line with the observations made by Kaushal (1997) on the developmental biology of *H. armigera* on carnation. Egg, larval and pupal stages lasted for 3.7, 18.5 and 9.1 days on an average, respectively. Adult longevity for male was 3.2 days and for female, it lasted for about 5.5

Table 1. Duration of life stages and growth paramteres of *T. urticae* and *H. armigera* on carnation

T. urticae Stage		Duration (days)	
		Mean (±SE)	Range (days)
Egg		4.60± 0.20	4-6
Larva		2.70± 0.14	2-3
Protonymph		2.50± 0.21	2-4
Deutonymph		2.30± 0.14	2-3
Total developmental/ period		12.10± 0.28	9-18
Adult	Male	9.50± 0.50	9-10
	Female	14.75± 0.97	10-18
APOP (Adult preoviposition/ period)		2.50± 0.23	2-3
TPOP (Total preoviposition period)		14.88± 0.38	13-16
Oviposition period		9.75± 0.98	5-13
Total longevity		25.80± 0.97	21-29

H. armigera Stage			Duration (days)	
			Mean (±SE)	Range (days)
Egg			2.90± 0.17	2-4
Larva	I instar		2.80± 0.13	2-3
	II instar		2.90± 0.22	2-4
	III instar		3.00± 0.14	2-4
	IV instar		3.78± 0.14	3-4
	V instar		4.44± 0.17	4-5
Pupal			12.38± 0.50	11-15
Total developmental period			32.12± 0.72	28-35
Adult longevity		Male	4.50± 0.64	3-6
		Female	8.00± 0.40	7-9
APOP (Adult preoviposition period)			2.25± 0.25	2-3
TPOP (Total preoviposition period)			35.50± 0.64	34-37
Oviposition/ period			4.75± 0.45	4-6
Total longevity			34.70± 2.60	15-43

Growth parameters	Mean± SE	
	T. urticae	*H. armigera*
Mean fecundity/female (F)	101.50± 21.21	93.50± 6.99
Gross reproductive rate (GRR) (eggs/individual)	91.24± 12.66	88.98± 15.33
Net reproductive rate (R_o) (eggs/individual)	81.20± 14.15	37.40± 14.16
Intrinsic rate of increase (r) (females/female/day)	0.23± 0.01	0.10± 0.01
True generation time (T) (days)	18.73±0.34	37.94±0.71
Finite rate of natural increase (λ) (females/day)	1.26±0.01	1.10±0.01
Doubling time (DT) (days)	2.95	7.26

days. Mean incubation period and larval period varied from 2.5 to 2.7 days and 14.9 to 15.3 days, respectively on different cultivars. Mean oviposition period varied from 3.2 to 3.4 days. Adult longevity in case of female varied from 8.6 to 9.2 days and from 4.6 to 5.5 days in male. Genç et al. (2017) observed several biological parameters of *H. armigera* on gladiolous. Incubation and larval period and the duration of pupal stadium was 3.50± 0.70 days, 16.75± 4.13 days and 14.25± 2.5 days, respectively at 23± 2°C, 65% RH and 16:8 h L:D under laboratory conditions.

Population growth parameters of *T. urticae* on carnation revealed that mean fecundity/ female (F) was 101.50± 21.21 days, the gross reproductive rate (GRR) of the species was 91.24± 12.66 eggs/ individual, whereas, the net reproductive rate (R_o) was 81.20± 14.15 eggs/ individual. Intrinsic rate of increase (r) was 0.23± 0.01 females/ female/ day and the finite rate of natural increase (λ) was 1.26± 0.01 females/ day, while the true generation time (T) was 18.72± 0.34 days. The doubling time (DT) of *T. urticae* was 2.95 days (Table 1). The present study finds support from the findings of Tello et al. (2009) who studied the fertility parameters of *Ts. cinnabarinus* on carnation and reported that the intrinsic rate of increase (r_m) was 0.183 female/ female/ day, whereas, the net reproductive rate and the mean generation time was 40.80 female eggs/ female and 20.24 days, respectively. Haque et al. (2011) reported that the value of the intrinsic rate of increase (r_m) of *T. urticae* on bean was 0.187 female/ female/ day, whereas, the finite rate of increase (λ) was 1.20 females/ day. Guljam (2018) reported that the gross reproductive rate (GRR) of *T. urticae* was 122.49 female eggs/ female whereas, the net reproductive rate (R_o) was 41.20 female eggs/ female (Fig. 3, 4). The approximate generation time (T_c) was 22.36 days and the innate capacity of natural increase (r_c) was 0.166 female/ female/ day. The finite rate of increase (λ) was 1.20 females/ day, while the true generation time (T) was 20.21 days. The doubling time (DT) and the weekly multiplication (WM) rate of the *T. urticae* on 'Pusa Narangi Gainda'

variety were 3.77 days and 3.63 days, respectively.

According to Kasap (2002), the value of the true intrinsic rate of increase (r_m) of *T. urticae* on rose was 0.20 female/ female/ day, while the net reproductive rate was 47.8 female eggs/ female. These values are slightly higher than the values observed in the present studies. Silva et al. (2009) reported that the net reproductive rate (R_o) of the pest on gerbera was 24.6 female eggs/ female, whereas, the mean generation time was 18.6 days, which is not in agreement to the present studies. These variations could be attributed to the difference in host plant species on which mite was reared. It is well recognized that host plant quality can affect history traits of their herbivore insects thus affecting r_m value by impairing growth, increasing mortality and reducing the fecundity (Price et al., 1980). Moreover, host plant species and cultivars often differ in chemical profiles, thereby affecting herbivore physiology (Ode, 2006) and interactions between various organisms (Stout et al., 2006). Based on the findings, the age stage survival rate (S_{xj}) of *T. urticae* on carnation for adult stage was 20 % at pivotal age of 11 days and remained constant till to 19th day for male and for female it was 80 % at pivotal age between 13th to 22nd day (Fig. 1). The data on daily survival and fecundity of *T. urticae* on carnation were used to construct age-specific survivorship curves

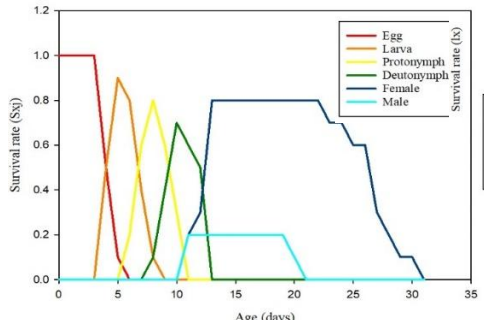

Fig. 1. Stage-specific survivorship (S_{xj}) of *T. urticae* on carnation

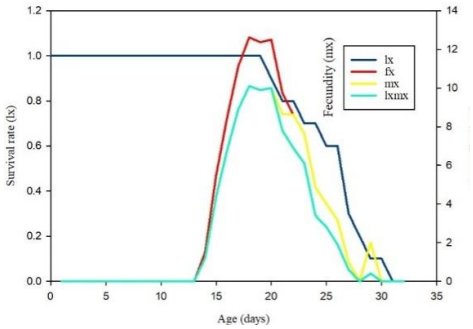

Fig. 2. Age-specific survivorship (l_x), age-stage specific fecundity (f_x), age-specific fecundity (m_x) and age specific maternity ($l_x m_x$) of *T. urticae* on carnation

(Fig. 2) which showed 100 % survival rate in the initial stages till the 20th day when it reached 90 %. After this the survival kept on decreasing and all the adults died by 31st day of pivotal age. The maximum m_x (female progeny/ female) was observed at pivotal age of 17th day wherein the values of f_x, m_x and $l_x m_x$ were 12.63, 10.10 and 10.10 eggs/ female. Afterwards a decline in m_x value was recorded, eventually stopping at 31st day of pivotal age.

The population growth parameters of *H. armigera* on carnation revealed that mean fecundity/ female (F) was 93.50± 6.99 days, the gross reproductive rate (GRR) was 88.98± 15.33 offspring/ individual, whereas, the net reproductive rate (R_o) was 37.40±14.16 offspring/ individual. Intrinsic rate of increase (r) was 0.10± 0.01 females/ female/ day, finite rate of natural increase (λ) on the other hand was 1.10± 0.01 female/ day. True generation time (T) was 37.94±0.71 days and the doubling time (DT) was 7.26 days. The present studies find support from those of Jha et al. (2012) who reported that the intrinsic rate of increase (r), finite rate (λ) and mean generation time (T), net reproductive rate (R_o), and gross reproductive rate (GRR) of *H. armigera* was 0.1029 $days^{-1}$, 1.1083 $days^{-1}$, 36.7 days, 40.2 offspring and 68.6 offspring, respectively. According to Jha et al. (2014), the intrinsic rate of increase (r), finite rate of increase (λ), net reproductive rate (R_o), and mean generation time (T) were estimated by the jackknife technique, the values of which were found to be 0.0780 day^{-1}, 1.0811 day^{-1}, 67.4 offspring, and 54.8 days, respectively, while those estimated by the bootstrap technique were 0.0752 day^{-1}, 1.0781 day^{-1}, 68.0 offspring, and 55.3 days, respectively.

The net reproductive rate (R_0) was 95.49 females/ female, the mean generation time (T) 37.53, and the instantaneous rate of population increase "r" 0.12. The population doubling time (DT) was 5.70 days, and the

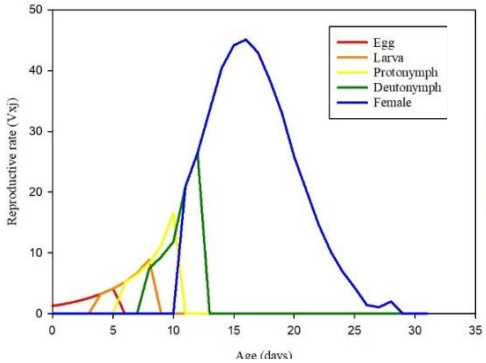

Fig. 3. Age-stage reproductive rate (V_{xj}) of *T. urticae* on carnation

daily finite rate of increase (λ) 1.13. The maximum rate of population growth occurred in the day 33. Fecundity had two peaks: at days 35 and 37. Gross and net fecundity rate, and the average number of eggs laid/ female/ day were 565.87, 496.07, and 18.76, respectively (Herrero et al., 2018). The age-stage survival rate (S_{xj}) of *H. armigera* for adults was maximum (40 %) on pivotal age of 35 days and remained constant till 38th day, whereas, for male it was maximum between pivotal age of 33-35 days (30%) (Fig. 5). It was noted that there was 100% survival upto 14th day of pivotal age and further the survival rate decreased to 70 and 30% on 31st and 39th day of pivotal age, respectively (Fig. 6). On the pivotal age of 38 days, the maximum number of female progeny/ female (m_x) was recorded as 16.5 eggs/ female, followed by a reduction until oviposition totally by the 43rd day. The age stage reproductive value (V_{xj}) ranged from 1.10 to 1.46, 9.07 to 63.13 and 4.54 to 69.45 for egg, pupal and female adult respectively (Fig .7). The age-stage life expectancy (E_{xj}) at adult emergence was 10.25 and 3 days for female and male, respectively (Fig. 8).

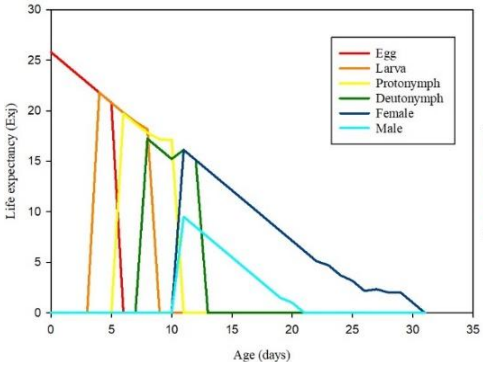

Fig. 4. Stage-specific life expectancy (E_{xj}) of *T. urticae* on carnation

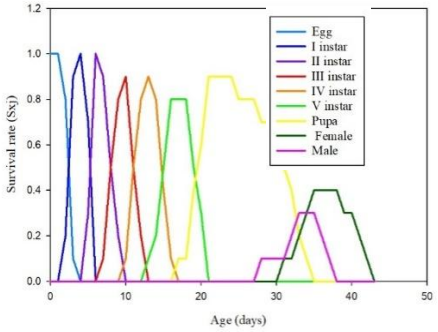

Fig. 5. Stage-specific survivorship (S_{xj}) of *H. armigera*

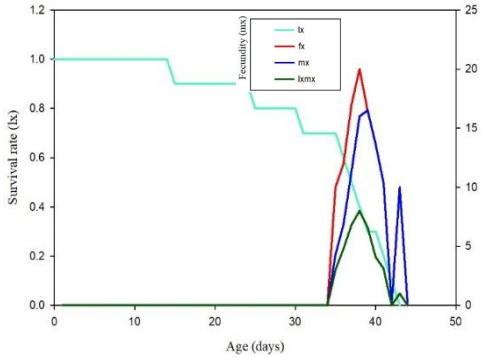

Fig. 6. Age-specific survivorship curves (l_x), age-stage specific fecundity (f_x), age-specific fecundity (m_x) and age specific maternity ($l_x m_x$) of *H. armigera* on carnation

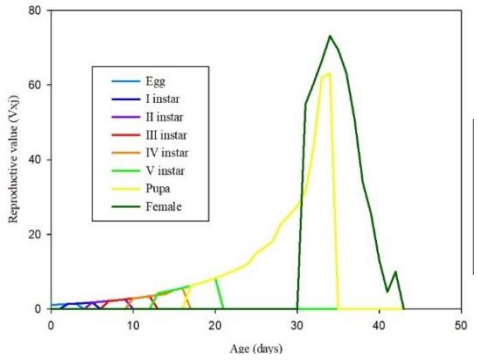

Fig. 7. Age-stage reproductive rate (Vxj) of carnation bud borer, *H. armigera* on carnation

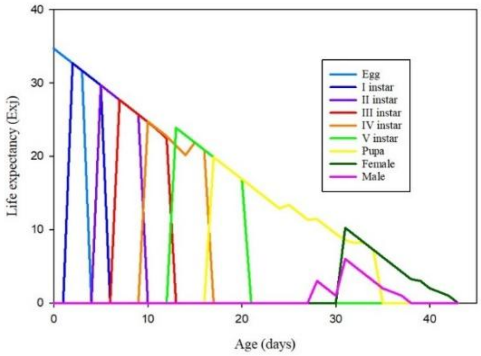

Fig. 8. Stage-specific life expectancy (Exj) of *H. armigera* on carnation

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AUTHOR CONTRIBUTION STATEMENT

AS and PLS conceived and designed the experiment, ST conducted the experiment, analysed data and wrote the manuscript.

CONFLICT OF INTERESRT

No conflict of interest.

REFERENCES

Chi H, Liu H. 1985. Two new methods for the study of insect population ecology. Bulletin of the *Institute of Zoology Academia Sinica* 24: 225-40.

Chi H. 1988. Life-table analysis incorporating both sexes and variable development rates among individuals. Environmental Entomology 17: 26-34.

Genç H, Yücel S, Akçal A. 2017. Observation of *Helicoverpa armigera* Hübner (Lepidoptera: Noctuide) Infestation on *Gladiolus grandiflorus* (Iridaceae) in Çanakkale. Canakkale Onsekiz Mart University Journal of Agriculture Faculty 5: 105-114.

Guljam C. 2018. Studies on the insect pests of ornamental plants in mid hills of Himachal Pradesh. M.Sc. Thesis. Dr Yashwant Singh Parmar University of Horticulture and Forestry. pp. 29.

Haque M, Islam T, Nahar N, Haque MM. 2011. Seasonal abundance of spider mite *Tetranychus urticae* Koch on vegetable and ornamental plants in Rajshahi. University Journal of Zoology 30: 37-40.

Herrero M I, Dami L C, Fogliata S V, Casmuz A S, Gómez D R S, Gastaminza G A, Murúa M G. 2018. Fertility Life Table, Population Parameters and Biotic Potential of *Helicoverpa gelotopoeon* (Dyar) (Lepidoptera: Noctuidae). Annals of the Brazilian Academy of Sciences 90: 3831-3838.

Jhansi R B, Mohan N J. 1997. Pest management in ornamental crops in progressive floriculture. Yadav J S, Chaudhary M L (eds.) House of Sarpan Bengalore 26: 169-181.

Jha R K, Chi H, Tang L C. 2012. A comparison of artificial diet and hybrid sweet corn for the rearing of *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) based on life-table characteristics. Environmental Entomology 41: 30-39. doi: 10.1603/EN11206.

Jha R K, Tuan S J, Chi H, Tang L C. 2014. Life-table and consumption capacity of corn earworm, *Helicoverpa armigera*, fed asparagus, *Asparagus officinalis*. Journal of Insect Science 14: 34. doi: 10.1093/jis/14.1.34

Kasap I. 2002. Biology and life tables of the two spotted mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) on three different host plants in laboratory conditions. Turkish Journal of Entomology 26: 113-122.

Kaushal P. 1997. Studies on *Helicoverpa armigera* (Hübner) on carnation and its chemical control. M.Sc. Thesis. Department of Entomology, Dr Yashwant Singh Parmar University of Horticulture and Forestry. 46 pp.

Multani J S, Sohi A S. 2002. *Helicoverpa armigera* (Hübner) on carnation, *Dianthus caryophyllus* Linn. in Punjab. Insect Environment 8: 82.

Ode P J. 2006. Plant chemistry and natural enemy fitness: Effects on herbivore and natural enemy interactions. Annual Review of Entomology 51: 163-185.

Patiladiti D, Ghetiya L V, Shukla A. 2016. Bionomics of spider mite (*Tetranychus urticae* Koch.) on marigold (*Tagetes* spp.). Journal of Applied Biosciences 42: 23-29.

Price P W, Bouton C E, Gross P, McPheron B A, Thompson J N, Weis A E. 1980. Interactions among three trophic levels: Influence of plants on interactions between insect herbivores and natural enemies. Annual Review of Ecology and Systematics 11: 41-65

Rai A B, Shah A H, Patel R N. 1989. Biology of *Oligonychus indicus* (Acarina: Tetranychidae) infesting sorghum in south Gujarat. Gujrat Agricultural University Research Journal 15: 47-52.

Raj P V, Abu M, Ahmad M J, Nazki I T, Bhat Z A, Khan I, Magray M. 2019. Seasonal incidence of major insect pests and mite on carnation under protected conditions in Kashmir. Journal of Experimental Zoology, India 22: 1197-1202.

Reddy S G E, Rana S, Rana A, Kumar R. 2020. Seasonal incidence and monitoring of *Helicoverpa armigera* Hübner on damask rose (*Rosa × damascena* Herrm.) by sex pheromone traps in western Himalaya (India). Journal of Applied Research on Medical and Aromatic Plants https://doi.org/10.1016/j.jarmap.2020.100270.

Sandeepa A R, Pradeep S, Thara K T, Sridhara S. 2019. Biology of *Tetranychus urticae* Koch (Acarina: Tetranychidae) on carnation under laboratory condition. Journal of Entomology and Zoology Studies 7: 1394-1398.

Sandhu G S, Gupta S K. 1977. Mites as pests of vegetables. Punjab Vegetable Grower 12: 9-12.

Shiragur M, Shirol A M. Reddy B S and Kulkarni B S 2004. Performance of standard carnation (*Dianthus caryophyllus* L.) cultivars under protected cultivation for vegetative characters. Journal of Ornamental Horticulture 7: 212-216.

Silva E A, Reis P R, Carvalho T M B, Altoe B F. 2009. *Tetranychus urticae* (Acari: Tetranychidae) on *Gerbera jamesonii* Bolus and Hook (Asteraceae). Brazilian Journal of Biology 69: 1121-1125.

Singh R N and Singh J. 1993. Biology of *Tetranychus cinnabarinus* (Boisd.) a serious pest of lady's finger (*Abelmoschus esculentum* (L.) Monech.). Pestology 17: 19-22.

Stout M J, Thaler J S, Thomma B P H J. 2006. Plant-mediated interactions between pathogenic microorganisms and herbivorous arthropods. Annual Review of Entomology 51: 663-689.

Tello V M, Vargas R M, Araya C J. 2009. Life history parameters of *Tetranychus cinnabarinus* (Acari: Tetranychidae) on leaves of carnation, *Dianthus caryophyllus*. Revista Colombiana de Entomología 35: 47-51.

Wei M F, Chi H, Guo Y F, Li X W, Zhao L L, Ma R Y. 2020. Demography of *Cacopsylla chinensis* (Hemiptera: Psyllidae) reared on four cultivars of *Pyrus bretschneideri* and *P. communis* (Rosales: Rosaceae) pears with estimations of confidence intervals of specific life table statistics. Journal of Economic Entomology.

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