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Studies on intra-specific variations in the diamondback moth, *Plutella xylostella* (Lepidoptera: Yponomeutidae) under different geographical regions

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Abstract: Studies on intraspecific variations in insect pests are an important tool for preparation of management strategy in different geographical regions. In this paper we tried to establish that these variations are also found in the diamondback moth (*P. xylostella*) populations under north Indian conditions with respect to reproductive biology. The pest populations were collected from five different geographical regions viz. Hisar (800feet), Kangra (2200feet), Solan (4200 feet), Theog (7500feet) and Kinnaur (9000feet) and then reared under laboratory conditions at 25±1^{o}C on cauliflower. The life table analysis revealed that the female from the Kangra population laid maximum eggs (332.16 eggs/female) whereas the number of eggs laid by the female from the Hisar, Solan, Theog and Kinnaur population was 189.53, 207, 252 and 270 eggs/female, respectively. The doubling time (DT) was observed to be the lowest for Kangra (3.12 days) and maximum for the Hisar (4.59 days) population, whereas weekly multiplication rate was minimum for the Solan (2.252) and maximum for the kangra (4.73) population. The true generation time was the lowest for the Kangra (18.54 days) and highest for the Hisar (24.38 days) population. The true intrinsic rate of increase (r_m) was found to be maximum (0.222 female progeny/female/day) for the Kangra whereas for the Kinnaur, Theog, Solan and Hisar population it was 0.203, 0.202, 0.182 and 0.151 female progeny/female/day thereby indicating that the Kangra population is more prolific as compared to the population from other geographical regions. The results are indicative of geographical variations among different populations of *P. xylostella.*

Keywords: Diamondback moth, Intraspecific variation, Reproductive biology

INTRODUCTION

The diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Yponomeutidae) is a pest of crucifer crops. It was reported for the first time in India by Fletcher (1914). Now it has been noticed all over India where plants belonging to family Brassicaceae are grown (Devi *et al.,* 2004). In India, its infestation leads to 30-100% loss of the cole crops (Ahmed *et al*., 2009). From Himachal Pradesh, Bhalla and Pawar (1977) reported this pest on cruciferous crops in temperate regions where cabbage and cauliflower are grown. Later on the pest was found as a regular and serious pest of cabbage and cauliflower (Anonymus, 1991 and Bharwal, 1997).The first instar larvae mine in the leaf and the subsequent instars feed on the leaf and skeletonize it ultimately affecting the plant growth and rendering it unfit for further use. Due to variations in various agroclimatic factors, this insect sometimes assumes the status of major pest and performs differently when fed on different host plants under different temperatures and climates and has different resistant levels to various insecticides. However, the variations of life-histories and life-table parameters of *P. xylostella* from different geographical regions when fed on the same host plant have not been well determined (Pan *et al*., 2014). The recognition of intra-specific variations, its nature and scope may aid our understanding of the pest and also to predict its spatial and temporal occurrence to devise effective management strategies and to characterize population responses to control measures (Khiban *et al*., 2010)

The aim of this study was to compare the differences in life tables among five populations of *P. xylostella* from different geographical regions in North India when reared on the same host plant (cauliflower) and at the same temperature. The findings will help to develop better management and control strategies against this pest.

MATERIALS AND METHODS

Sampling: Samples of *P. xylostella* were collected manually from farmers field from five different localities of different altitudes (Table 1). Each sample comprised of at least 40 larvae and 20 pupae. These were immediately placed in plastic jar (20cm x 15cm), the top of which was covered with muslin cloth with leaves of cauliflower inside the container as food to the developing larvae. These were further reared under laboratory conditions as per the method of rearing of the test insect as described below.

Raising of laboratory culture: *Plutella xylostella* larvae and pupae so collected from five different localities were reared in cages of size of 36×34×24 cm with glass pan on three sides. Fresh leaves of cauliflower with their petiole dipped in glass vials (7cm x 1.5cm) were kept inside these cages. The adult thus emerged were fed with 10% sugar syrup and were provided with fresh cauliflower leaves for egg laying. The eggs thus obtained were used for the further studies. The culture of the test insect collected from each locality was maintained under laboratory conditions at room temperature (25±1^{o}C) throughout the period of study.

Geographical variations: Studies on variations among population of the diamondback moth collected from different geographical regions were carried out by studying the life fertility tables as per the details given below.

Reproduction and population growth: Eggs of the diamondback moth obtained after rearing the larvae and pupae of each locality under laboratory conditions were used for studying the life tables. The life tables were prepared as per the observations recorded on the duration of pre-oviposition period, post-oviposition periods adult longevity and age specific fecundity. The intrinsic rate of increase (r_m), mean generation time (T), finite rate increase (λ), doubling time (DT) and net reproductive rate (R_o) were calculated using method of Brich (1948) and elaborated by Howe (1953) and Carey (1993).

RESULTS AND DISCUSSION

Oviposition activity reveals differences among the population collected from different localities. The oviposition period was found to be significantly higher (13.30) in case of the Hisar population whereas it was the lowest (8.20) for the Theog population. The fecundity was observed maximum (332.16 eggs/female) in case of females from the Kangra ecotype and the minimum (189.53 eggs/female) fecundity was recorded for the Hisar population (Table 2).

These findings revealed that there were marked variations in the fecundity of the diamondback moth collected from different geographic regions. Various other workers have found such dissimilarities between different geographical populations of *P. xylostella*. Arvanitakis *et al.* (2002) found the difference in the fecundity of *P. xylostella* from seven different geographical regions of Africa of which five averaged a fecundity of 210 eggs per female wheareas, two poppultions showed lesser fecundity of 115 and 170 eggs per female. Variations in oviposition period of *P. xylostella* was also observed by Pichon *et al*.(2004) from different geographical regions of the world and obserevd the longest oviposition period in Uzbekistan (30 days) as compared to other populations where it varied from 15-20 days. Mahaparta *et al*. (2006) also reported similar results from three states in India. He observed higher fecundity from Tamilnadu (305 eggs per female) wheras, it was least for New Delhi population (268.5 eggs per female). Pan *et al*. (2014) investigated variations in biology of *P. xylostella* from five geographical regions of China. The oviposition period ranged from 10.47 to 17.18 days whereas, fecundity varied from 337.18- 411.47 eggs per female.

Fertility tables: Fertility table summarizes the information on the biological performance of a species. The net reproductive rate for the Hisar, Kangra, Solan, Theog and Kinnaur populations of the diamondback moth was 39.74, 90.22, 35.76, 44.30 and 43.13, respectively at 25^{o}C on cauliflower. The true generation time (the mean period from birth of the parents to the birth of offspring) for the respective geographical regions was found to be 24.38, 20.09, 19.65, 18.76 and 18.54 days whereas the value of r_m for the diamondback moth collected from these localities was 0.151, 0.222, 0.182, 0.202 and 0.203 (female progeny/female/day), while the finite rate of increase (λ) was 1.16, 1.25, 1.19, 1.22 and 1.22, respectively indicating a marked variations in the intrinsic

Table1. Sampling localities of *P. xylostella*.

Locality	State	Altitude (feet)
Hisar (Haryana)	Haryana	800
Jaach (Kangra)	Himachal Pradesh	2200
Chambaghat (Solan)	Himachal Pradesh	4200
Theog (Shimla)	Himachal Pradesh	7500
Kalpa (Kinnaur)	Himachal Pradesh	9000

Table 2. Comparative analysis of biological parameters of *P. xylostella* collected from five different geographical regions.

Localities	Reproductive phases			
	Pre-oviposition period (days)	Oviposition period (days)	Post-oviposition period (days)	Total no. of eggs/ female
Hisar	3.20±0.25^{a}	13.30±0.64^{a}	0.50±0.44^{ab}	189.53 ± 1.31^{d}
Kangra	1.60±0.15^{c}	9.80±0.61^{b}	1.20±0.37^{a}	332.16 ± 4.34^{a}
Solan	2.40±0.33^{b}	9.20±0.55^{bc}	0.40±0.22^{b}	207.00 ± 2.88^{cd}
Theog	1.20±0.13^{cd}	8.20±0.31^{c}	0.30±0.15^{b}	252.19±4.54^{bc}
Kinnaur	1.00^{d}	8.3±0.51^{c}	0.50±0.21^{ab}	270.00±4.45^{b}

Figures followed by same alphabet are significantly at par with each other

Table 3. Comparative fertility analysis of five different *P. xylostella* populations.

Fertility parameters	Localities				
	Hisar	**Kangra**	**Solan**	**Theog**	**Kinnaur**
Gross reproductive rate :($\sum(m_x)$)	98.54	189.33	107.58	136.18	151.23
Gross fecundity: ($\sum(M_x)$)	189.5	332.15	206.90	252.19	270.07
Net reproductive rate(female eggs/female) (R_o): ($\sum$ ($l_x m_x$))	39.74	90.22	35.76	44.30	43.13
Approximate generation time (T_c): ($\sum(xl_x m_x)/(R_0)$ (days)	25.00	20.43	20.05	18.78	18.87
The innate capacity for increase (r_c): ($\log_e R_o/T_c$)	0.147	0.220	0.178	0.201	0.200
Doubling time (DT):($\log_e 2/ r_m$) (days)	4.59	3.12	3.80	3.430	3.41
Intrinsic rate of natural increase (female/female/day) (r_m)	0.151	0.222	0.182	0.202	0.203
Weekly multiplication rate: ($_e7\ r_m$)	2.87	4.73	2.25	4.11	4.14
Finite rate of increase (λ): (Antilog $_e\ r_m$)	1.16	1.25	1.19	1.22	1.22
Mean age gross fecundity (days): ($\sum x\ M_x/M_x$)	25.30	20.37	19.59	19.03	19.94
Mean age net fecundity: ($\sum xL_x\ M_x/\sum L_x\ M_x$)	24.99	20.12	19.79	18.80	18.60
Eggs/female/day: ($\sum L_x\ M_x/\ \sum L_x$)	10.77	27.66	15.20	24.34	22.26
True generation time(T): ($\log\ R_o/ r_m$) (days)	24.38	20.09	19.65	18.76	18.54

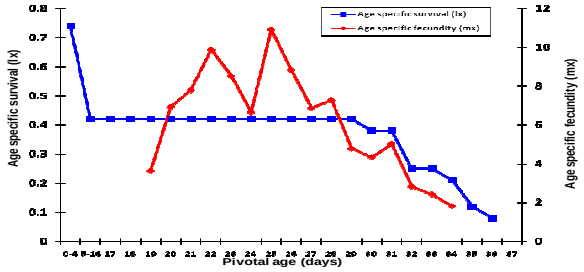

Fig .1. *Daily age specific survival and age specific fecundity of P. xylostella for Hisar population.*

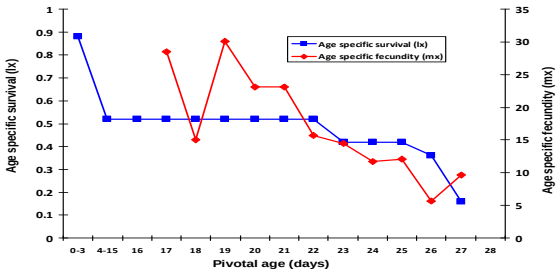

Fig. 2. *Daily age specific survival and age specific fecundity of P. xylostella for Kangara population .*

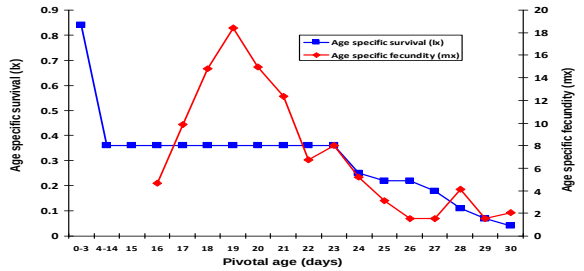

Fig. 3. *daily age specific survival and age specific fecundity of P. xylostella Solan population.*

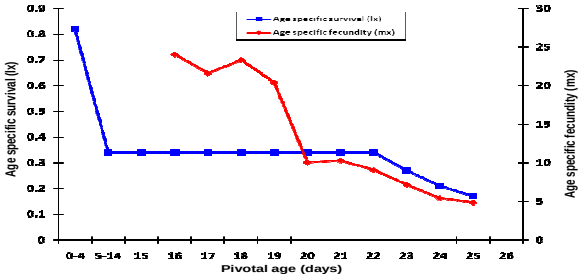

Fig. 4. *Daily age specific survival and ag specific fecundity of plutella for Theog population.*

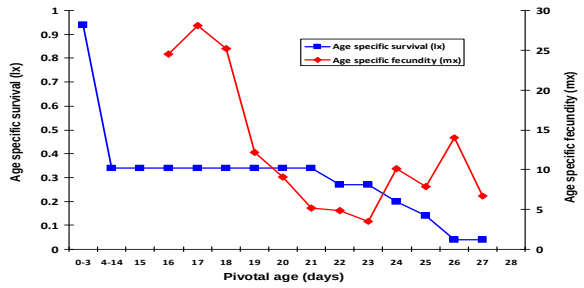

Fig. 5. *daily age specific survival and age specific fecundity of P. xylostella Kinnau population.*

rate of natural increase (Table 3). Since intrinsic rate of increase (r_m) reflects many factors (such as fecundity, survival rate, and generation time) so these values would adequately summarize the physiological qualities of a species in relation to its capacity to increase. thus, it would be the most appropriate index to evaluate the performance of an insect from different regions (Southwood and Henderson 2009).

Our results support the studies carried out by Liu *et al.* (1985) who recorded differences in the intrinsic rate of increase (r_m) in the population of the *P. xylostella* col-

lected from three localities in Taiwan as 0.228, 0.188 and 0.151 females per day. Similar findings were observed by Sheng *et al.* (2002) for *Diadromus collaris* a parasitoid of the diamondback moth collected from two different localities in China. Pan *et al.* (2014) found variations in r_m value of *P. xylostella* in China which were recorded the highest for Beijing population (0.2888) whereas it was the lowest for Shandong population (0.2165).

The present studies thus revealed variations among population from different geographical regions with respect to reproductive biology. Environmental variables are also important factors for local adaptation among allopatric regions, and biological divergence has been found along latitudinal gradients (Lee and Mitchell-Olds 2011). Variations among different populations of insects may also be attributed to geographical barriers between their habitats. Sometime distance alone can also function as a barrier to genetic exchange among populations (Ruggiero *et al*., 2004). As reported by Chu (1986) such variations might be due to migration of populations from different locations over long distances (>3000 km). Mayr and Ashlock (1991) reported the population differences due to geographic barriers that are defined as any terrain that prevents gene flow between populations. Schluter (2001) attributed that this variation due to adaptation of the different populations to their ecological niche.

Conclusion

On the basis of present studies it is concluded that there were significant variations with respect to reproductive biology among the populations of *P. xylostella* from different geographical regions. Besides, the difference in the true intrinsic rate of natural increase (r_m) among the population collected from different geographical regions was also found, It was the highest for the Kangra population, indicating thereby that the diamondback moth for this geographical region is more prolific as compared to the population from other geographical regions

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