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Studies on genetic variability of Diamondback moth, *Plutella xylostella* (Lepidoptera: Yponomeutidae) in Himachal Pradesh

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Abstract
Studies were carried out during 2015 and 2016 at Nauni, Solan, Himachal Pradesh to determine the genetic variability of *Plutella xylostella* (Lepidoptera: Yponomeutidae) in Cauliflower. The diamondback moth population collected from 4 locatitons viz. three from Himachal Pradesh and one from Punjab revealed significant variability existing among them. The life table analysis revealed that the female from Palampur laid maximum eggs (368.93eggs/female). The innate capacity for increase (r_c) was maximum in the Theog population (0.238) and Solan population had lowest r_c value (0.209). The intrinsic rate of natural increase (r_m) was estimated from r_c values for different populations. The Theog population had highest value of r_m value (0.242) followed by the Palampur (0.236) and Fatehgarh (0.221). The least value of r_c was observed in the Solan population (0.211). On comparing fertility parameters of *P. xylostella*, it was found that the Theog population was the most prolific among all the populations while the Solan population was the least prolific.

Keywords: *Plutella xylostella*, genetic variability, intrinsic rate

1. Introduction
The diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Yponomeutidae), is one of the most destructive pest of cultivated cruciferous vegetables throughout the world [1,2,3]. The main damage of this pest is associated with larvae of different age's damage leaves, buds, flowers, and seed-buds of cultivated cruciferous plants. Although the larvae are small, they can be very numerous and cause complete removal of foliar tissue except for the leaf veins. 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. In India, its infestation leads to 30-100% loss of the cole crops [4]. There is difference in the development of the *P. xylostella* fed on different host plants [5] under different temperatures and climates [6,7] and has different resistant levels to various insecticides [8]. But 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 [9]. Collecting this information will be helpful to understand the variations of population dynamics in different regions so that develop suitable management strategies [10]. The focus of this study was to compare the differences in life tables among three populations of *P. xylostella* from different geographical regions. Understanding the geographical variation of *P. xylostella* will allow us to develop better management and control strategies for the different regions.

2. Materials and Methods
2.1 Sampling
Larvae and pupae of *P. xylostella* were collected manually from four different localities of different altitudes (Table 1) from the cauliflower and cabbage fields at each location and were immediately placed in plastic jar (20 cm × 15 cm), 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 described under.

Table 1: Sampling localities of *Plutella xylostella*

Locality	Altitude (meter)
Nauni (Solan)	1,275
Palampur (Kangra)	1,472
Theog (Shimla)	1,965
Fatehgarh	260

2.2 Raising of laboratory culture

Plutella xylostella larvae and pupae so collected from four 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 adults thus emerged were fed with 10% sugar syrup in cotton swab 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±1ºC) throughout the period of study.

2.3 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. The intrinsic rate of increase (rm), mean generation time (T), finite rate increase (λ), doubling time (DT) and net reproductive rate (Ro) were calculated using method of Brich [11] and elaborated by Howe [12].

3. Results and Discussion

Life fertility parameters of different *P. xylostella* populations revealed that that there were observable differences in the different populations with respect to their life fertility parameters (Table 2). The gross reproductive rate (GRR) was highest in the Palampur population (198.65 female eggs per female) followed by Theog (165.10 female eggs per female), Solan 142.81 and minimum was for Fatehgarh 129.49. The Gross fecundity (M_x) was highest for Palampur population (368.93 eggs per female) followed by the Theog and Solan populations i.e. 294.82 and 272.64 eggs per female, respectively. The least M_x was observed in the Fatehgarh Sahib population i.e. 229.10 eggs per female. The net reproductive rate (R_o) followed almost similar trend as the Palampur population had highest value of R_o followed by Theog and Fatehgarh Sahib i.e. 94.24, 75.91 and 55.95 females produced per generation, respectively. The Solan population had the least R_o value (55.41 females produced per generation). The approximate generation time (T_c) varied from 18.17 days in Theog population to 19.97 days in Palampur population.

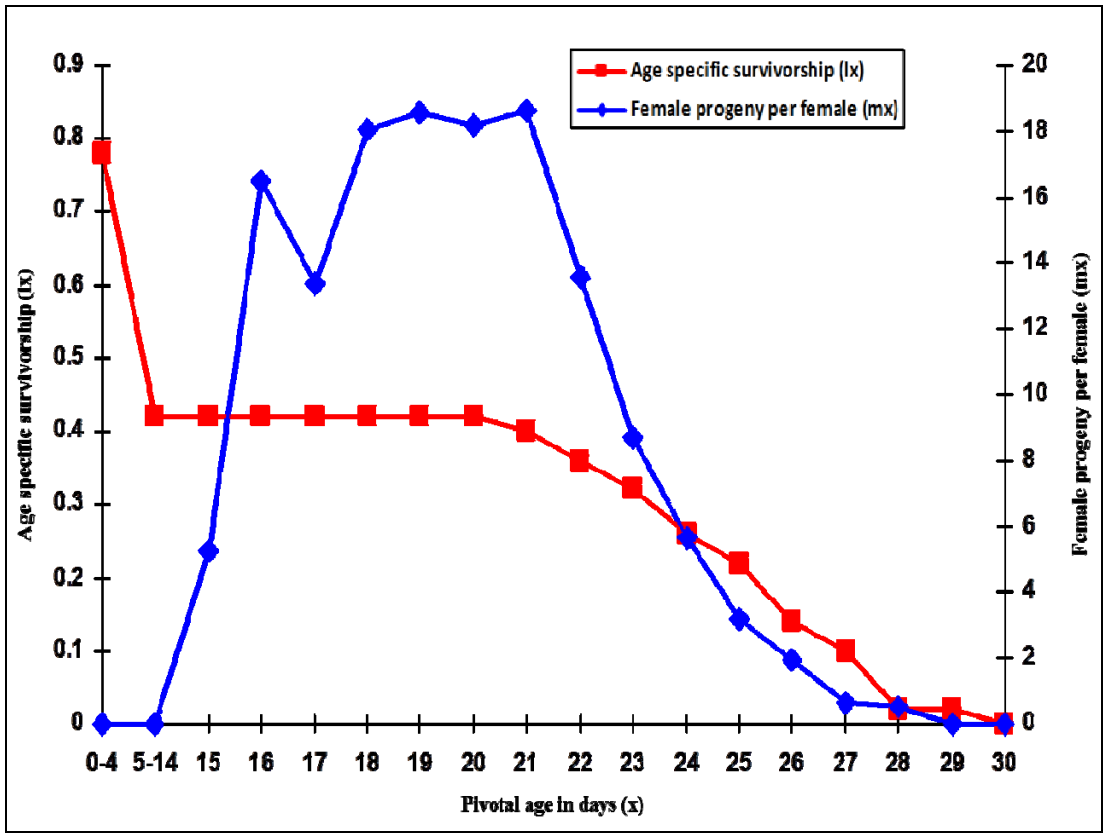
The innate capacity for increase (r_c) was highest in the Theog population (0.238) followed by the Palampur (0.228) and Fatehgarh (0.220) populations. The Solan population had lowest r_c value (0.209). The intrinsic rate of natural increase (r_m) was estimated from r_c values for different populations. The highest value of r_m value was observed in the Theog population (0.242) followed by the Palampur (0.236) and Fatehgarh Sahib (0.221).The least value of r_m was observed in the solan population (0.211). On comparing fertility parameters of *P. xylostella* collected from different geographical regions, it was found that the Theog population was the most prolific among all the populations while the Solan population was the least prolific as revealed by the minimum value of the true intrinsic rate of increase amongst all the populations. The true generation time (T) and Doubling time (DT) were minimum for Theog population (17.89 days and 2.86 days, respectively) and maximum true generation time (T) for Palampur population (19.26 days) and maximum doubling time (DT) 3.29 days for Solan population. Weekly multiplication rate (WM) was observed to be the highest for the Theog population (5.44 days) and least for Solan population (4.38 days). These variations may be due to the different geographical latitudes, where insects lived, and the insects may be adjusting to different lengths of seasons with favorable temperatures [13]. The adult reproductive parameters varied between the populations because of latitudinal variation and the length of the adult activity period [14].

Table 2: Comparative life fertility parameters of different populations of *P. xylostella*

Fertility parameters	Unit	Palampur	Solan	Theog	Fatehgarh
GRR	Female progeny/female	198.65	142.81	165.10	129.49
Ro	Female progeny/female	94.24	55.40	75.90	55.95
Tc	Days	19.97	19.25	18.17	18.31
Rc	Female/female/day	0.228	0.209	0.238	0.220
Rm	Female/female/day	0.239	0.216	0.246	0.226
T	Days	19.02	18.58	17.60	17.81
λ	Female/day	1.27	1.24	1.28	1.25
DT	Days	2.90	3.21	2.89	3.07
WM	Folds	5.33	4.54	5.60	4.86
Mx	Number of eggs	368.93	272.64	294.82	229.10

The difference of the values influenced by of multiple factors, including differences in average temperature and the local environment characteristic. Environmental conditions are important factors for local adaptation among differnent regions, and biological divergence has been found along latitudinal gradients [15]. The intrinsic rate of natural increase (r_m) is a good indicator of temperature at which the growth of a population is most favourable, because it reflects the overall effect of temperature on the development, reproduction and survival characteristics of a population. The true intrinsic rate of increase (r_m) would reflect many factors such as fecundity, survival rate, and generation time. These values would adequately summarize the physiological qualities of a species in relation to its capacity to increase. So, it would be a most appropriate index to evaluate the performance of an insect [16, 17]. Our results find the support from the findings of Pan *et al.* [9], who investigated local adaptation, measured the variation of the biology, life-histories and life-table parameters of *P. xylostella* populations from five widely ranging geographical regions in China, Beijing (BJ), Shandong (SD), Shaanxi (SX), Yunnan (YN), and Guangdong (GD). The true intrinsic rate of increase (rm), which was recorded highest for Beijing population (0.2888) whereas it was the lowest for Shandong population (0.2165). Similar results were observed for *P.*

xylostella by Ram *et al* [10], who reported difference in r_m value in the five populations of diamondback moth collected from different regions Hisar (800feet), Kangra (2200feet), Solan (4200 feet), Theog (7500feet) and Kinnaur (9000feet). 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. Schluter [18] attributed that this variation due to adaptation of the different populations to their ecological niche. Variation among different populations of insects may also be attributed to geographical barriers between their habitats [19]. Migration of populations from different locations over long distances (>3000 km) may be the regions of these variations [20].



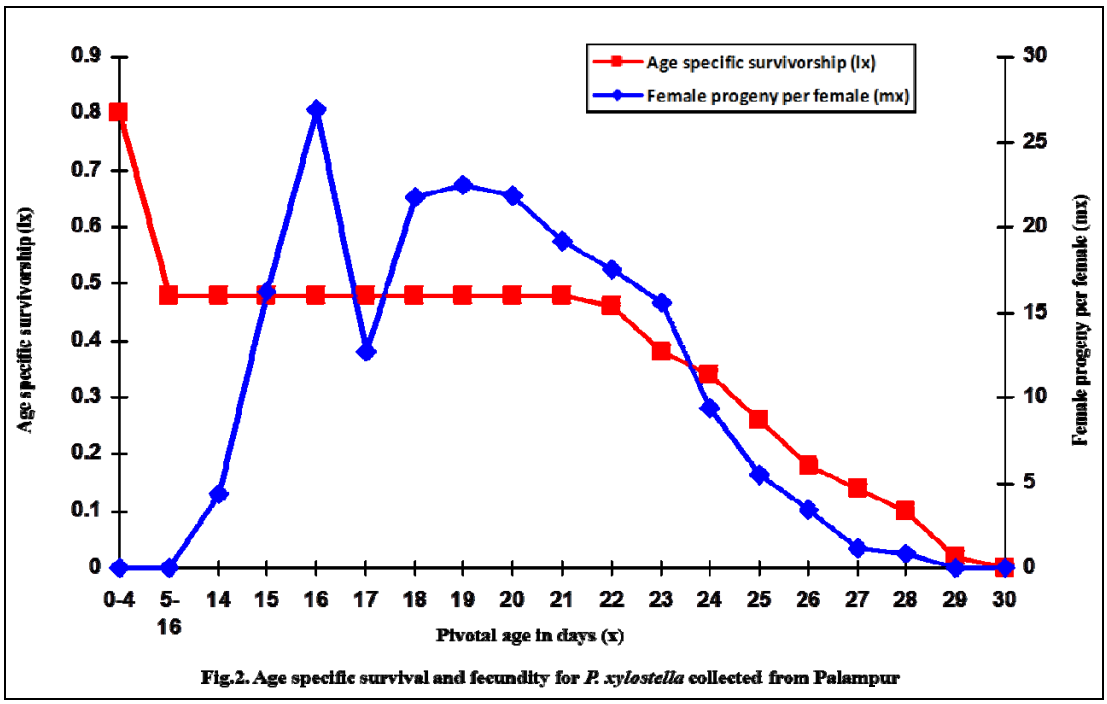


Fig.2. Age specific survival and fecundity for *P. xylostella* collected from Palampur

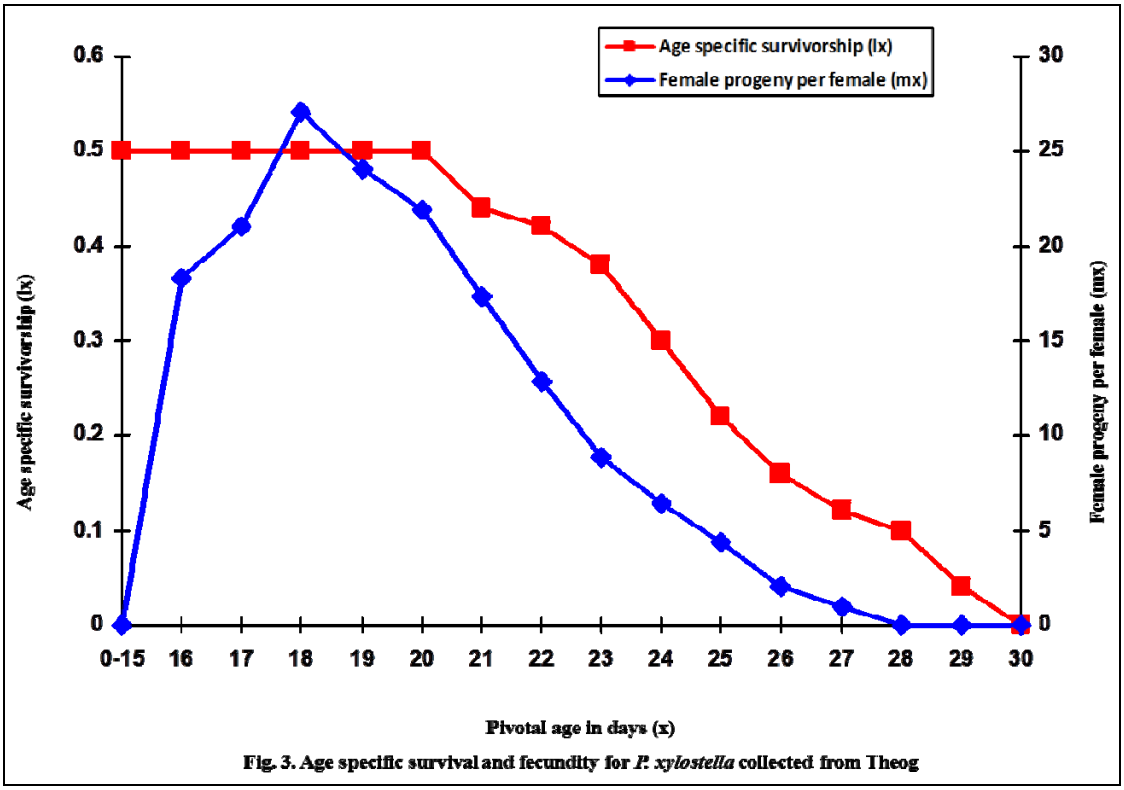


Fig. 3. Age specific survival and fecundity for *P. xylostella* collected from Theog

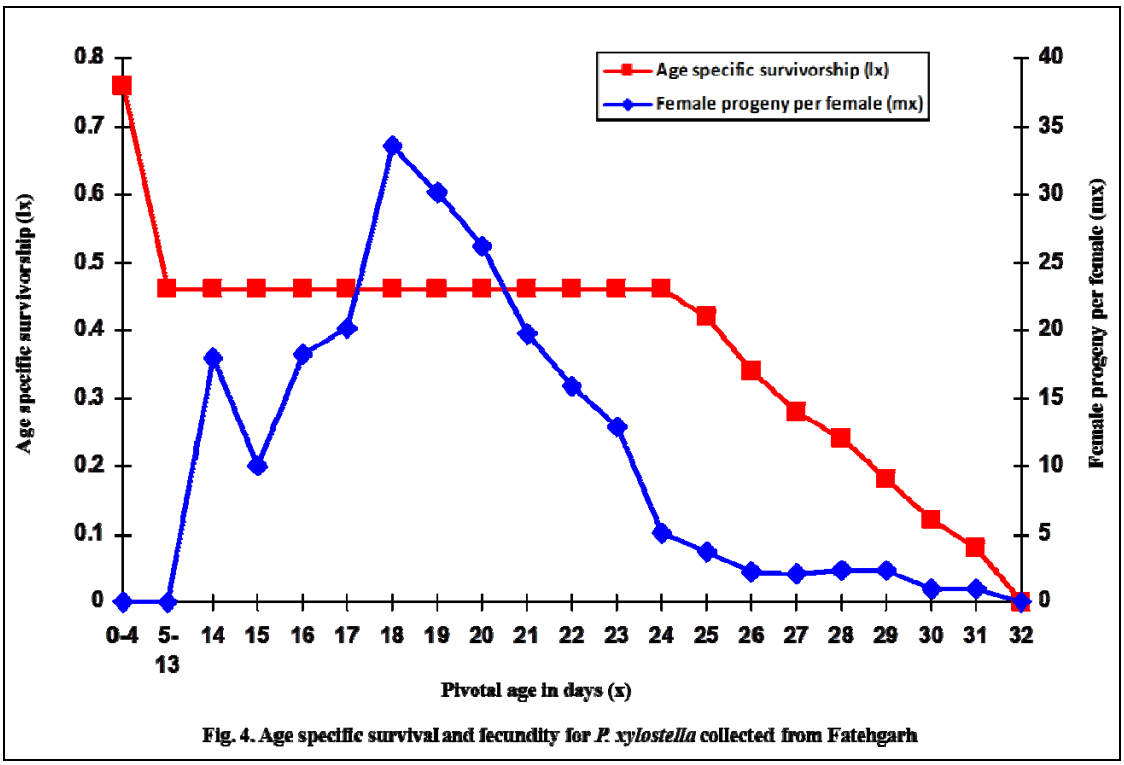


Fig. 4. Age specific survival and fecundity for *P. xylostella* collected from Fatehgarh

4. Conclusion

On the basis of present study it was concluded that there was significant variability among the population of different geographical regions. The Theog population was found to be very prolific as compared to other populations.

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