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Morpho-bioecological Accounts of the Phytophagous Coccinellid Beetle, *Henosepilachna vigintioctopunctata* (Fabricius, 1775) along with Botanical Pest Management from Eastern India

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ABSTRACT

Field and laboratory investigations were carried out during 2022-23 to study the bioecology and efficacy of plant extracts for the phytophagous coccinellid, *Henosepilachna vigintioctopunctata* (F.) for understanding them properly to devise ecology based management techniques. Besides damaging the brinjal a significant population of *H. vigintioctopunctata* beetle was recorded from the solanaceous weeds like *Solanum nigrum* and *Physalis* spp. Biology of *H. vigintioctopunctata* on *S. nigrum* under laboratory conditions was conducted and the results revealed that the beetle completed its life cycle in 23.1±3.5 days and the mean fecundity was 220 ± 33.0 revealing that the beetle can very successfully breed on this host plant. Morphological and taxonomical descriptions of the immature as well as adult stages of these beetles were studied and for proper identification the male genitalia was dissected. The population fluctuation of *H. vigintioctopunctata* in relation to weather parameters was also monitored under field conditions and was observed to have significant influence altogether on the pest population in brinjal but not in alternate hosts. The methanolic extracts of *Polygonum hydropiper* and tobacco decoction were found moderately effective in lowering the leaf damage by the beetle.

Keywords: Henosepilachna vigintioctopunctata, hosts, morphology, biology, seasonality, botanicals.

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INTRODUCTION

Beetles typically comes under the order coleoptera, which is the largest order in the class “Insecta”. The family Coccinellidae is one of the most well-known families of Coleoptera in terms of taxonomy due to their distinctive appearance, which includes numerous species with brilliant reddish colour and black spot. It is widely known for its abundance and diversity and has over 6000 described species worldwide (Vandenberg, 2002; Akhavan, Jafari, Vafai, & Afrogheh, 2013). Coccinellid beetles, often known as ladybirds, lady bugs, or lady beetles, are frequently regarded as a representation of joy, peace, and harmony. This family comprises a number of important bio-control agents. But, members of the tribe Epilachnini under the sub family Coccinellinae are phytophagous and serious crop pests. There are over 1100 species of lady beetles in the tribe Epilachnini Mulsant, which accounts nearly 20% of the Coccinellidae (Jadwiszczak & Wgrzynowicz, 2003; Szawaryn & Tomaszewska, 2013; Tomaszewska & Szawaryn, 2016). The 27 known genera of the Epilachnini have all been redefined by Tomaszewska & Szawaryn (2016). According to the global catalogue of Epilachninae published by Jadwiszczak & Wgrzynowicz (2003) and Poorani (2004) there are 114 species of Epilachnini from the Indian Subcontinent.

According to Shirai & Katakura (1999), Islam, Islam, & Ferdous (2011), Mathur & Srivastava (1964), Dhamdhere, Koshta, & Rawat (1990), Folcia, Rodriguez, & Russo (1996), the Hadda beetle, *H. vigintioctopunctata* is reported as the key pest of many cultivated and weed plants of Solanaceae and Cucurbitaceae crops. Most of the economically significant Epilachnini species found in India, including *Henosepilachna vigintioctopunctata* (F.), *H. pusillanima* (Mulsant), *H. septima* (Dieke), and *H. vigintioctomaculata* (Motschulsky), belong to the genus *Henosepilachna* (Li & Cook, 1961). The phytophagous ladybird beetle *Epilachna vigintioctopunctata* (Fabricius) is widespread in Asia and Australia, it is a serious pest of vegetables (Khan, Islam, Rahman, & Rahman, 2000).

Both adult beetles and grubs feed on the epidermal tissue of the leaves by scrapping on the leaf surface. This results in the leaves becoming dry and eventually shed. Sometimes it is called leaf scrapping Coccinellid beetle (Imura & Ninomiya, 1978). The growth and development of plants are greatly hampered and yield is markedly reduced by attack of Epilachna beetle. Rajagopal & Trivedi (1989) have reported that Epilachna beetle may damage up to 80% of plants depending on place and season. Similarly, Rao, Chitra, & Kameswara Rao (1990) reported the damage by the beetle going beyond 30-40 percent on leaves and also nearly 50 per cent on fruits.

In vegetable production, this pest is one of the limiting factors causing both qualitative as well as quantitative losses. To compensate this pest problem, many synthetic chemical insecticides have been largely used. But, the frequent and indiscriminate use of chemical insecticides may detrimentally affect the natural enemies of Epilachna beetle. Chemical management techniques used during the crop growing season may lower the beetle population in the field, but after certain period the population eventually rebuild from the alternate hosts to the primary crop.

The interactions of *H. vigintioctopunctata* with different alternative host plants and prevailing abiotic factors should be studied and understood in detail for devising a sustainable pest management strategy with an aim to reduce the residual effect of chemicals, it can be replaced by safer and bio-degradable plant products like botanicals as pesticides. So, the present investigation was carried out to identify the life stages of the pest correctly, to determine the alternate hosts of the Hadda beetle and their seasonal fluctuation as well as to know the effect of some plant materials against *H. vigintioctopunctata* beetle under laboratory conditions.

MATERIALS AND METHODS

Study site

The survey was conducted in the campus area of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India during 2022-2023. The experiments on morphological identification, life cycle, morphometrics and management studies of *H. vigintioctopunctata* were conducted at the Entomology laboratory of the Directorate of Research, Regional Research Station (Terai Zone), UBKV, Pundibari, Cooch Behar, West Bengal from November, 2022 to June, 2023.

Collection and identification of *H. vigintioctopunctata*

The eggs, grubs and adults of *H. vigintioctopunctata* were collected randomly by sweep net and hand collection method at weekly interval during the whole survey period. The beetles were collected from different solanaceous crops and some related weeds. Occurrence and diversity of these beetles were assessed by taking observation at weekly interval. The adult beetles were then carried to the laboratory and maintained at room conditions. They were placed in Boro silicate glass vials (6.3 x 2.3 cm diameter) with cotton plugs soaked in ethyl acetate for killing purpose. Larvae collected were reared in petri dishes (9 cm diameter) on respective host plant leaves till adults emerged. The collected specimens were studied in detail and identified using available literature (Chakraborty, Bhowmik, & Biswas,1996; Tomaszewska & Szawaryn, 2016).

External morphology and genitalia structure

Morphology and morphometric studies

The measurement and morphological features of the different developmental stages of Hadda beetle were observed under laboratory conditions. Measurements of length and width of eggs(n=10), various instars of grub (n=10), pupa (n=10) and adult male and female beetles (n=10) were recorded. The specimens were killed using ethyl acetate in killing bottles, then dried in a hot air oven at 45-50ºC for 4-6 hours. The beetles were identified based on the shape of elytra and spot variation with the help of ZEISS Stemi 508 stereo zoom microscope (8:1 zoom) fitted with ZEISS Axiocam 105 color camera and Carl Zeiss Zen 2.5 lite (blue edition) imaging software.

Dissection of male genitalia structures

The male phytophagous coccinellid beetles were separated from females based on the size (generally males are smaller than females) and dissected under a microscope to confirm the sexes. The specimens were positioned dorsally on a dissection slide and elytra removed. After removing elytra, the beetles were turned and kept ventral side upward. The abdomen was detached from the thorax using micro needles under the microscope. With the help of camel hair brush, internal content of the abdomen was removed and kept in 10% KOH solution for 24 hours to dissolve the soft fatty tissue. The abdomen was carefully withdrawn from the KOH solution and placed in a glass hollow dish containing distilled water and added one to two drops of glycerol for genitalia dissection to make the entire abdomen fully transparent and enable for genitalia examination under the stereo zoom microscope and photographed following Roy, Uma Maheswari, Sridevi, & Raghavender (2021).

Biological studies

The field collected gravid female laid eggs in the petri dish (9 cm diameter) and the eggs were reared till adult emergence on the respective host plant leaves under laboratory conditions. Emerged adults were sexed and transferred to new petri dishes (9 cm diameter). In the Laboratory, clean petri dishes were taken and eggs collected from the laboratory reared generation was kept singly on moist filter paper along with tender leaves (*Solanum nigrum*). Twelve such replicates were maintained and observations on incubation period and hatchability were recorded. Daily morning, the food was changed. To prevent desiccation and maintain the freshness, leaves' tip was covered with water-soaked cotton swab. The petri dishes were observed daily till adult emergence. The grubs were examined under microscope for the sign of moulting. In this way, the duration of different instars., 1st,2nd,3rd and 4thinstar grubs were recorded and also pupal period, total developmental period, adult longevity and fecundity was observed.

Ecological studies

The ecological activity of the Epilachna beetles, *H. vigintioctopunctata* was monitored in a brinjal field during November, 2022 – March, 2023 and afterwards on different solanaceous plants growing within the campus area of Uttar Banga Krishi Viswavidyalaya (UBKV) till June, 2023. In the brinjal field the observations were recorded from five randomly selected plots distributed over the whole field. Again, from each plot data were recorded from ten plants selected at random. During off season the *H. vigintioctopunctata* population was monitored on different solanaceous weed hosts which serve as alternate hosts for the beetles and data were recorded on per plant basis. The meteorological data was obtained from the meteorology unit of UBKV.

Statistical analysis

The analysis of data pertaining to biological parameters and morphometrics were accomplished with the help of range and mean analysis with standard deviation and was performed using Microsoft Excel (2010) software in PC. The seasonal fluctuation

of the beetle was assessed by considering population counts per plant and the data was plotted in graphical presentations. The grub and adult population was correlated with prevailing weather parameters and correlation coefficients (r) were derived using Microsoft Excel (2010). The significance level of the correlation coefficients at 1% and 5% of were judged by comparing the tabulated value with the help of Gomez and Gomez (1984).The influence of weather parameters like average maximum (X_1) and minimum temperature (X_2), maximum (X_3) and minimum relative humidity (X_4) and total rainfall (X_5) on the grub and adult population of *H. vigintioctopunctata* was studied by deriving the linear multiple regression models on a date of observation and average maximum and minimum temperature, maximum and minimum relative humidity and total rainfall during last 7 days from that date of observation. The multiple linear regression model was denoted as follows:

$$Y= a +b_1X_1+ b_2X_2+b_3X_3+b_4X_4+b_5X_5$$

Where, Y = Response or dependent variable i.e., pest population

a = Constant or Y intercept which signifies the value of Y when all value of all predictor variables is zero, b_1- b_5 = Regression coefficients for each predictor variable like X_1 = average maximum temperature, X_2 = average minimum temperature, X_3 = average maximum relative humidity, X_4 = average minimum relative humidity, X_5 = total rainfall.

The 'F' test and student 't' test were applied to test the significance at 5 and 1% level. The Microsoft Excel and OPSTAT statistical package was used for the correlation and regression analysis.

Efficacy of plant extract against *H. vigintioctopunctata*

Extract from whole plant parts viz., flowers, leaves and stem of Biskattali (*Polygonum hydropiper*) and cured Tobacco leaves were tested against the grubs of *H. vigintioctopunctata* under laboratory conditions.

Preparation of botanicals

For this experiment, seven different treatments such as methanolic polygonum extract, aqueous polygonum leaf extract, tobacco decoction, blank methanol solution (to judge the effect of this solvent) and control (water) were used. The Biskattali plants were collected from the campus area of UBKV. The plant material was shade dried for 15-20 days and coarsely grounded in a mixer. The powdered material was extracted with methanol as solvent in Soxhlet apparatus for 3 hours and the resultant semiliquid form of extract was collected in a glass beaker and kept on a water bath at atmospheric pressure to evaporate the excessive amount of solvent. The semi-solid crude extract was collected and stored in refrigerator for further use. From the stock, three concentrations of methanolic extracts of Biskattali (4%, 2% and 1%) were prepared with distilled water (i.e., 4g, 2g and 1g/ 100ml distilled water). For the preparation of aqueous polygonum extract and tobacco decoction, fresh leaf of polygonum and cured tobacco leaf were grounded and soaked (20 g in 100 ml and 25 g in 200 ml distilled water, respectively) overnight. The extract was collected by filtering with the help of filter paper.

Application method

The experimental insect, *H. vigintioctopunctata* was taken from the stock culture being maintained at the Entomology laboratory. Each treatment had 3 replications, so in total 21 petri dishes were maintained for the experiment. In each petridish 10 uniform sized 3rd instar grubs which were starved for 4 hours were released. Along with that set of petridishes 3 more petridishes without grubs were maintained to know the natural loss of leaf weight due to evaporation. The experiment was laid out in a Complete Randomized Design (CRD) with 7 treatments and 3 replications.

Evaluation of leaf protection by the application of different plant extract

Pre-weighed *Solanum nigrum* leaves of uniform size were selected and treated with different treatments and then airdried for 10 minutes. Then these treated leaves were given to the pre-starved grubs for feeding. After 48 hrs. of exposure, the uneaten portions of the leaves were taken out, cleaned and weighed to estimate the quantity of leaves consumed by the grubs.

The percentage of leaf protected by the treatment was estimated by following Lily (1995) as,

$$\frac{A-B}{A} X100$$

where,
A = weight of leaf consumed in control and
B = weight of leaf consumed in treatment

RESULTS

Host plants

The Hadda beetle, *H. vigintioctopunctata* were recorded on brinjal, *Solanum melongena* as well as on some solanaceous weed plants like *Solanum nigrum*, *Physalis* spp. and some cucurbits related weeds belonging to the family Cucurbitaceae (Fig. 1a-d). Due to its wide host range, it was recorded throughout the study period.

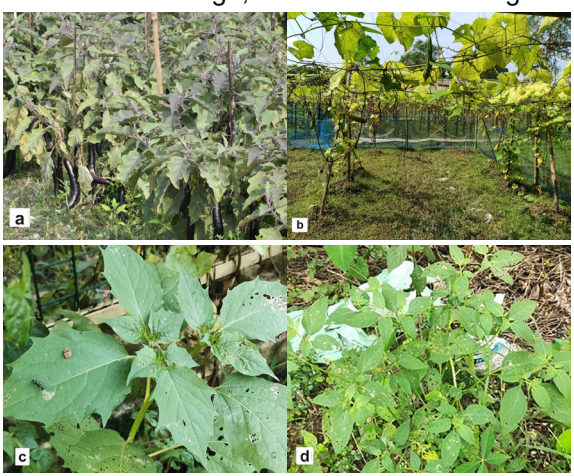

Figure 1. Host plants of *H. vigintioctopunctata*; a) brinjal, b) ridge gourd, c) *Physalis* sp., d) *Solanum nigrum*

External morphology and male genitalia

Eggs: Creamy yellow in colour, slender and elongate-oval in shape with slight round ring like mark on the apex (Fig. 2a).

Grub: Neonate grub was glossy yellow or sometimes light blackish in colour. Second and third instar grubs were shiny yellow in colour with six rows of spine and more or less similar in appearance except body size. The fully matured grubs of *H. vigintioctopunctata* had a black band at the base of the spine. Spines were whitish in colour (Fig. 2b).

Pupa: The pupa of *H. vigintioctopunctata* was creamy white in colour and it had 2 round-shaped black spots in the anterior region and while the posterior margin had white colour spine (Fig. 2c).

Adult: The adult of *H. vigintioctopunctata* was copperish brown in colour with the variation of 7-14 spots on each elytron and it had roundish elytral tip (Fig. 2d).

Male genitalia: The genitalia structure of male *H. vigintioctopunctata* had median lobes with two rows of hairs and a basal knife edge. The base of siphon was long and broad and it had a gentle curve, then the siphonal tube was straight with pointed siphonal tip at the end (Fig. 2e).

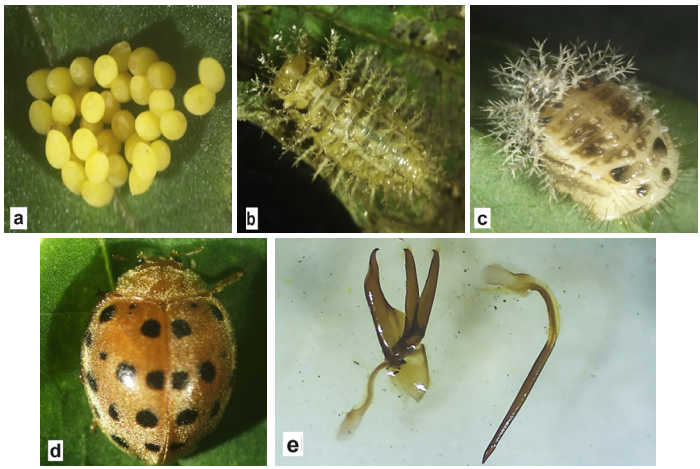

Figure 2. External morphology and male genitalia of *H. vigintioctopunctata*; a) egg, b) grub, c) pupa, d) adult, e) male genitalia.

Life cycle and morphometric studies

Eggs were laid as small clusters on the under surface of the leaves. Freshly laid eggs were light yellow in colour but after hatching it turn into white. After hatching of the eggs, the insect passed through four larval instars followed by a pupal stage and finally adult (Fig. 3a-j).

Figure 3. Life cycle of *H. vigintioctopunctata*; a) egg, b) 1st instar larva, c) 2nd instar larva, d) 3rd instar larva, e) 4th instar larva, f) newly formed pupa, g) pupa after 2 days, h) newly emerged adult, i) male adult, j) female adult.

Newly emerged first instar grubs fed gregariously. The larvae scrapped the lower epidermal surface of the leaves and adults fed on upper surface. The incubation period of Hadda beetle ranged from 3 to 5 days with an average of 3.6±0.8 days (Table 1) and the mean length and breadth of egg was 1.33±0.21 and 0.43±0.07 mm, respectively (Table 2). The duration of 1st instar grub was 2-7 days with a mean of 3.8±1.9 days. The average duration of 2nd instar grub was 2-5 days with an average of 3.5±1.1 days. The 3rd instar duration ranged from 2-7 days with a mean of 3.6±1.4 days. The fully grown 4th instar grub required 3-5 days for development with an average of 4.1 ± 0.7 days. The total larval period was 13 – 20 days with an average of 15±2.5 days. The body length and breadth of 1st, 2nd, 3rd and 4th instar larvae was 2.03±0.13 and 1.22±0.15 mm, 2.98±0.11 and 1.47±0.13 mm, 4.07±0.15 and 2.08±0.20 mm & 4.89±0.53 and 2.97±0.43 mm, respectively. The pupal period lasted for 3-5 days with an average of 4.5±1.1 days and the average body length and breadth of pupa was 5.03±0.30 and 3.92±0.16 mm, respectively. The life cycle of *H. vigintioctopunctata* was 20-31 days with a range of 23.1±3.5 days. Generally, the females were bigger in size than the males.

The observed longevity of the male and female was 24-58 and 36-67 days with a mean of 43.3±10.8 and 48.8±9.3 days, respectively (Table 1). The observed mean body length and breadth of male and female was 5.83 ±0.29 and 4.91 ±0.39 & 6.86±0.51 and 5.65±0.48 mm, respectively (Table 2). The fecundity of female beetle on *S. nigrum* was found in the range of 142-257 with an average of 220.1±33.0.

Table 1. Duration of various life stages of *Henosepilachna vigintioctopunctata*.

Stages	Range (days)	Mean ± SD (days)
Egg	3 – 5	3.6 ± 0.8
1st Instar	2 – 7	3.8 ± 1.9
2nd Instar	2 – 5	3.5 ± 1.1
3rd Instar	2 – 7	3.6 ± 1.4
4th Instar	3 – 5	4.1 ± 0.7
Total larval period	13 - 20	15 ± 2.5
Pupa	3 – 6	4.5 ± 1.1
Total Life cycle	20 - 31	23.1± 3.5
Adult longevity		
Male	24 – 58	43.3 ± 10.8
Female	36 – 67	48.8 ± 9.3
Fecundity*	142 – 257	220 ± 33.0

Average of 10 observations.
*Average no. of eggs laid by single female.

Table 2. Morphometrics of different developmental stages of *Henosepilachna vigintioctopunctata.*

Stages	Length (mm) Mean ± SD	Breadth (mm) Mean ± SD
Egg	1.33 ± 0.21	0.43 ± 0.07
1st Instar	2.03 ± 0.13	1.22 ± 0.15
2nd Instar	2.98 ±0.11	1.47 ±0.13
3rd Instar	4.07 ±0.15	2.08 ±0.20
4th instar	4.86 ±0.53	2.97 ±0.43
Pupa	5.10 ±0.37	3.92 ±0.16
Adult		
Male	5.83 ±0.29	4.91 ±0.39
Female	6.86 ±0.51	5.65 ±0.48

Average of 10 observations.

Seasonal incidence

Brinjal

The activity of beetle population was observed from the 3rd week of November, 2022 to the second week of March, 2023 during rabi season in brinjal crop (Fig. 4). The population of grubs and adults of *H. vigintioctopunctata* fluctuated throughout the crop period in the field till maturity. But more population was observed during the vegetative and early fruiting stage of brinjal. Correlation coefficient between grub population and weather parameters revealed that max. temp. (r=-0.535*) showed low level of significant negative association and min. temp. (r=-0.106), max. RH(r=0.448) and min RH (r=0.176) had non-significant association. The adult population had highly significant negative correlation with min. temp.(r=-0.665**) and non-significant correlation with max. temp.(r=-0.428), max. RH (r=0.453) and min RH (r=0.272) (Table 3).

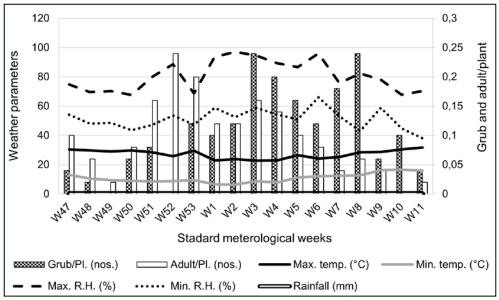

Figure 4. Population of *H. vigintioctopunctata* and mean abiotic factors for preceeding week (Brinjal)

Table 3. Correlation coefficients between *H. vigintioctopunctata* in brinjal and weather parameters.

Stages	Max. temp. °C	Min. temp. °C	Max. RH %	Min. RH %	Total Rainfall (mm)
Grub	-0.535*	-0.106	0.448	0.176	-
Adult	-0.428	-0.665**	0.453	0.272	-

*Significant at 5% level of significance.

** Significant at 1% level of significance.

Multiple linear regression: Together, all the abiotic factors were responsible for 29.98% variation in the larval population and 26.07% variation in the adult population of *H. vigintioctopunctata* (Table 4) and the combined effect of all the meteorological parameters was statistically significant at 5% significance level for grubs (F-calculated = 3.93) and adults (F-calculated = 3.39) (Table 5).

Table 4. Multiple linear regression equation of *H. vigintioctopunctata* in brinjal with weather parameters.

Life stages	Regression equation	Coefficient of determination (R2)
Grub	Y= 1.362-0.036X1*+0.013X2*-0.001X3-0.007X4*	0.2998
Adult	Y=-0.393+0.012X1-0.015X2*+0.003X3+0.002X4	0.2607

X1 = Max. temp, X2 = Min. temp, X3 = Maximum RH, X4 = Minimum RH.
*Significant at 5% level of significance.
** Significant at 1% level of significance.

Table 5. Parameters of larval and adult population of *H. vigintioctopunctata* as affected by weather parameters in brinjal.

Variables	Regression Coefficients		Standard Error		t-value		Significance		F-calculated	
	Grub	Adult	Grub	Adult	Grub	Adult	Grub	Adult	Grub	Adult
Max. temp.	-0.036*	0.012	0.013	0.011	-2.869*	1.079	0.011	0.296	3.93*	3.39*
Min. temp.	0.013*	-0.015*	0.006	0.005	2.199*	-2.802*	0.042	0.012		
Maximum RH	-0.001	0.003	0.003	0.003	-0.185	1.086	0.855	0.293		
Minimum RH	-0.007*	0.002	0.003	0.003	-2.298*	0.627	0.035	0.539		
Constant	1.362	0.393	-	-	-	-	-	-		

*Significant at 5% level of significance

Solanaceous weed hosts

The population of *H. vigintioctopunctata* on solanaceous weeds during off season was first observed in the 3rd week of April, 2023. The population of grubs and adults of *H. vigintioctopunctata* fluctuated throughout the study period, but a greater number of beetle population were observed than the main host. The highest adult population was observed on 18th SMW (2 adult/pl), likewise maximum grub population was recorded

on 24th SMW (0.8 grub/pl) (Fig. 5). The correlation coefficients between the beetle population (both grub and adult) and weather parameters were non-significant. But the beetle population showed positive correlation with maximum (r=0.274 & 0.152) and minimum relative humidity (r=0.174 & 0.253) and rainfall (r= 0.617 & 0.137), and negative correlation with minimum temperature (r= -0.037 & -0.386). The maximum temperature (r= 0.072 & -0.463) acted differently in grub and adult, in case of grub, it showed positive correlation and in adult, it showed negative correlation (Table 6).

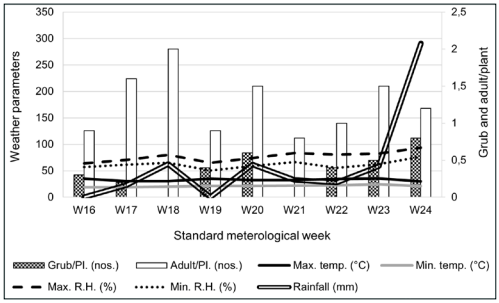

Figure 5. Population of *H. vigintioctopunctata* and mean abiotic factors for preceeding week (Solanaceous weeds).

Table 6. Correlation coefficients between *H. vigintioctopunctata* in solanaceous weed and weather parameters.

Stages	Max. temp. °C	Min. temp. °C	Max. RH %	Min. RH %	Total Rainfall (mm)
Grub	0.072NS	-0.037 NS	0.274 NS	0.174 NS	0.617 NS
Adult	-0.463 NS	-0.386 NS	0.152 NS	0.253 NS	0.137 NS

NS – non-significant.

Multiple linear regression: It revealed that together all the abiotic factors were responsible for 73.31% variation in the larval population and 8.49 % variation in the adult population of *H. vigintioctopunctata* (Table 7). From the Table 8, it is evident that beetle population showed non-significant regression coefficients as indicated by the t-test statistics values.

Life stages	Regression equation	Coefficient of determination (R2)
Grub	Y=-0.358+0.075X1-0.006X2-0.012X3- 0.016X4+0.005X5NS	0.7331
Adult	Y=2.975-0.050X1-0.016X2-0.014X3+0.023X4-0.001X5NS	0.0849

NS – non-significant.

Table 8. Parameters of larval and adult population of *H. vigintioctopunctata* as affected by weather parameters in solanaceous weeds.

Variables	Regression Coefficients		Standard Error		t-value		Significance		F-calculated	
	Grub	Adult	Grub	Adult	Grub	Adult	Grub	Adult	Grub	Adult
Max. temp.	0.075	-0.050	0.064	0.218	1.1750	-0.228	-1.789	0.372	3.5743NS	0.2468NS
Min. temp.	-0.006	-0.016	0.011	0.036	-0.514	-0.425	-0.379	-0.152		
Maximum RH	-0.012	-0.014	0.019	0.064	-0.646	-0.219	-0.702	0.398		
Minimum RH	-0.016	0.023	0.029	0.099	-0.548	0.236	-0.463	0.350		
Rainfall	0.005	-0.001	0.001	0.004	3.893	-0.238	-3.308	0.345		
Constant	-0.358	2.975	-	-	-	-	-	-		

NS – non-significant

Efficacy of plant extracts against *H. vigintioctopunctata*

The present study revealed that there was variation in leaf protection by different treatments (Fig. 6). But among the treatments, 4 % methanolic Polygonum extract gave the highest mean percentage of leaf protection (68.13%) followed by 2% methanolic Polygonum extract (57.08%) and 1% extract (48.04%). The aqueous Polygonum extract resulted in 37% leaf protection over control, which was higher than the Tobacco decoction (18.56%). The mean percent of leaf protection by a blanket solvent (methanol) application was 13.6%.

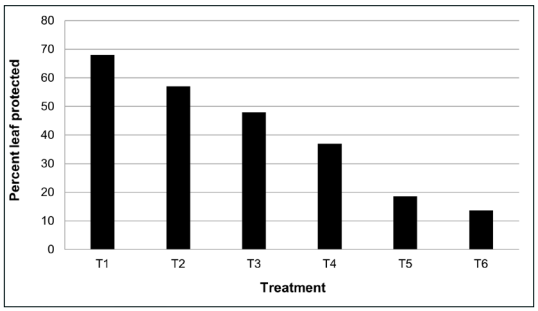

Figure 6. Percent leaf protected by different treatments.

DISCUSSION

The species *Henosepilachna vigintioctopunctata* under the tribe Epilachnini, is the most serious and widespread pest of Solanaceous vegetables and also occur on some related weed plants. Poorani *et al.* (2021) reported that, *H. vigintioctopunctata* and *H. septima* were the most widely distributed and economically important plant feeding coccinellids in India. Similarly, many works have been conducted on the host plants of phytophagous coccinellids. Naz, Inayatullah, Rafi, Ashfaque, & Ali (2012) recorded the host plants of *H. vigintioctopunctata* such as *Solanum melongena*, *S. nigrum*, *S. surretanses*, *Withania somnifera*, Datura, *Lycopersicum esculantum* and *Physalis* spp. In 1988, Anand, Gupta, & Ghai reported *H. vigintioctopunctata* from various crops such as *S. melongena, S. nigrum, S. surretanses, S. tuberosum, S, carolinense, S. xanthocarpum, S. indicum, S. khasianum, S. pubescent, S. evieulaare, S. torvum, S. megacarpum, Datura fastuosa, D. stramonium, Luffa cylendrica, W. somnifera, Momordica charantia, L. esculantum* and *P. maxima,* pumpkin, gourds, zucchini, mamours and cucurbits, *Cucurbita moschata*, cotton, melon, rock melons, cucumber, squash, *Luffa aegytiaca, Lagenaria* sp., *Vigna ungiculata* (cowpea), *Arachis hypogaea* (groundnut), alfalfa, *Phaseolus mungo*, *Hibiscus esculentum*, *Musa* sp. (banana); *Raphanus sativus* and *Zea mays* from India. Due to its polyphagous nature, it had higher chances of survival rate.

Generally, species of phytophagous coccinellid beetles are distinguished based on the elytral spots, colour and shape of the elytra. But elytral spots cannot be considered as full proof confirmation for species identification as the spots tend to vary as found

by earlier workers like Dharmaretham (2002). Elytral spots variation is influenced by genetic as well as environmental factors like ambient temperature. For further confirmation genitalia dissection of male beetles has to be done. Naz et al. (2012) described the Epilachna beetle, *Epilachna vigintioctopunctata* based on the external morphology and genital structure. The collected specimens were ground colour pale brown or reddish brown, elytral apex angled. Spots on the elytra varied between 12 and 28 but mostly with 26 spots and 7 pronotal spots. Saeed et al. (2016) collected two species *H. vigintioctopunctata* and *H. septima* during the study of morphological characteristics of ladybird beetles in Pakistan. The body shape of *H. vigintioctopunctata* was rounded with elytral apex also rounded, but the elytral spots varied, whereas, in *H. septima* the elytral apex was angular. Elytral spot pattern was found variable. Dharmaretham (2002) distinguished two species viz., *H. vigintioctopunctata* and *H. septima* based on genital structure. In the male genitalia of *H. septima*, the apex of the sipho was sharply narrowed on one side and pointed. In *H. vigintioctopunctata*, the median lobe of male genitalia was with basal knife edge and two rows of hairs. The siphon was gently curved near the base, then straight, ending in a curved point.

The biology of *H. vigintioctopunctata* has earlier been studied by several authors, Qamar, Masarrat, & Sharma (2009) and Kaur & Mavi (2005) recorded the incubation period of Epilachna beetle as 4 days and 5.20 ± 0.87 days on brinjal. Our results were confirmed with the findings reported by Kaur & Mavi (2005), the duration of first, second, third, and fourth instar larvae were 3–4, 2–4, 2–4, and 2–5 days, respectively with an average of 2.20 ± 0.40, 3.60 ± 0.66, 5.70 ± 0.46, and 4.10 ± 0.54 days on brinjal. In 2009, Hossain, Khan, Haque, Mannan, & Dash reported that the duration of 1st, 2nd, 3rd and 4th grub instars were 2.25 ± 0.13, 3.25 ± 0.08, 2.55 ± 0.15 and 3.25 ± 0.12 days, respectively. Tayde & Simon (2013), recorded the pupal period of Hadda beetle to be in the range of 3- 5 days with an average of 4.4 ± 0.89 days and the average longevity of male and female was 51.4 and 64.8 days, respectively. The life cycle of Hadda beetle was similar with the findings observed by Chowdhuri (1965), Ghosh & Senapati (2001), *H. vigintioctopunctata* required 22-30 days for its development and also, they stated that the life cycle duration might be varied depending upon the species of host plants on which it feeds and prevailing climatic conditions.

According to Kaur & Mavi (2005), newly laid eggs length and breadth was 1.09±0.04 mm and 0.32±0.03 mm, respectively. Verma & Anandhi (2008) reported that an egg's average length and breadth was 1.13 ± 0.10 mm and 0.41 ± 0.07 mm. Tayde & Simon (2013), recorded the average length and breadth of 1st, 2nd, 3rd and 4th instars were 2.09 ± 0.02 mm and 1.12 ± 0.26 mm, 2.99 ± 0.32 mm and 1.43 ± 0.16 mm, 4.16 ± 0.17 and 1.92 ± 0.31 & 6.18 ± 0.37 and 3.02 ± 0.34 mm, respectively. Our findings draw support from the results earlier obtained by Tayde & Simon (2013), who reported the average pupal length and breadth as 6.15 ± 0.24 mm and 3.73 ± 0.38 mm, respectively. The average body length of male was 6.08 ± 0.25 mm and breadth was 4.71 ± 0.43 mm. Whereas, in female length was 7.13 ± 0.49 mm and breadth was 5.41 ± 0.58 mm, respectively.

The present study results revealed that the population dynamics of *H. vigintioctopunctata* was influenced by environmental conditions either significantly or non-significantly. During Rabi season, the beetle population was started increasing from January month. Similarly, Haseeb, Qamar, & Sharma (2009) noted the initial incidence of the *H. vigintioctopunctata* on third week of January, 2009 in Aligarh, Uttar Pradesh. In 1999, Raghurajnan and Veeravel reported that the *H. vigintioctopunctata* population was highest in February and March in brinjal. In Solanaceous weeds, the highest beetle population was observed on 18th, 20th and 24th standard meterological week. Similarly, Qamar & Haseeb (2019) observed the peak grub and adult beetle population during 20th and 23rd SMW on tomato. They also concluded that *Henosepilachna* spp. can adopt to a vast range of temperature (27 to 35ºC), relative humidity (24 to 83%) and rainfall (0.80 to 70 mm). But the adoption of these climatic conditions by *Henosepilachna* spp. depends on the crop season and crop type, which enable the beetle to thrive well.

Different plant parts of *Polygonum hydropier* was extracted with a solvent and bioassay of various concentration of methanolic polygonum extract, polygonum aqueous and Tobacco decoction were tested against 3rd instar grub of *H. vigintioctopunctata*. These two are most commonly and easily available plant materials for the Terai region of West Bengal (India). Polygonum has been used as the main plant extract i.e., different treatments and tobacco was used as a botanical check, well known for its efficacy under this zone. In this study, the antifeedant activity of different treatments against *H. vigintioctopunctata* was estimated based on their leaves consumption rate. The result revealed that 4% methanolic polygonum extract showed better result followed by other treatments. Similarly, Podder, Uddin, & Adnan (2013), assessed the effectiveness of four botanicals, Neem Oil, Mehagony Oil, Bishkatali Leaf Extract, Pithraj seed extract and one insecticide Diazinon 60 EC against Epilachna beetle. Results revealed that, the aqueous extract of all the four botanicals were effective in beetle population reduction. Among the botanicals neem oil was found to be more toxic ranging next to Diazinon 60 EC. The Biskattali leaf extract showed better result compared to control. The past couple of decades have seen encouraging progress in the control of Epilachna beetles that infest several economic crops. While *H. vigintioctopunctata* infesting brinjal, Sreedevi, Chitra, & Rao (1993) and Mehta, Vaidya, & Kashyap (1995) observed the effectiveness of some plant extracts against *H. vigintioctopunctata* infesting brinjal. Under laboratory condition, Hussain (1995) observed some toxic effect of Bishkattali (*P. hydropiper*) leaf powder and extract on the *Tribolium castaneum* larvae.

CONCLUSION

The plant feeding coccinellid, *H. vigintioctopunctata* persists in the agroecosystem of sub-Himalayan eastern India almost throughout the year by changing their feeding habitat between cultivated crops and wild host plants. The duration of various life stages of *H. vigintioctopunctata* on the *S. nigrum* is quite comparable with other

cultivated crops. So, this plant can be used as a potential trap crop for the management of this pest. The plant *Polygonum hydropiper* which the farmers can access very easily in and around their farm lands can be utilized successfully coinciding initial pest infestation to check the population attaining the economically damaging level.

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