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SPECIES DIVERSITY AND POPULATION DYNAMICS OF FLEA BEETLES ON MUSTARD AND RADISH

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ABSTRACT

The diversity of flea beetles and their population dynamics on mustard and radish was investigated during *rabi* 2009-10 at the Department of Entomology, Rajasthan College of Agriculture, MPUAT, Udiapur. The flea beetles collected from mustard and radish belonged to the two genera, *Phyllotreta* and *Chaetocnema*; of which, *Phyllotreta* dominated forming 86.48 and 82.77 per cent of the total on mustard and radish, respectively. The species, *Phyllotreta chotanica* Duvivier and *Chaetocnema basalis* Baly were the most frequent on these crops. The genus *Chaetocnema* was most speciose with four species, while *Phyllotreta* was represented by two species. Quantitative analysis showed that *Ph. chotanica* population peaked during the third and fourth weeks in February 2010 with a mean of 39.8 and 54.4 beetles per plant on mustard and radish, respectively. The mean atmospheric temperature and relative humidity had mild negative correlation (r = -0.012 & -0.404) with the beetle population on mustard, but a mild positive correlation (r = +0.293) with sunshine; whereas, the flea beetle population on radish showed a significant positive correlation with mean atmospheric temperature (r = +0.89), but a significant negative correlation with mean relative humidity (r = - 0.83).

Key words: Alticinae, flea beetles, mustard, radish, population dynamics

INTRODUCTION

The flea beetles (Alticinae) comprise the largest subfamily of Chrysomelidae with approximately 500 genera and more than 8000 species worldwide, and about 1388 species classified in 90 genera in the Palearctic Region (Konstantinov and Vandenberg, 1996; Gruev and Döberl, 2005). Adult flea beetles feed on various parts of the plants, including leaves and non-woody stems (Konstantinov and Tishechkin, 2004). Some of them are serious agricultural pests causing direct damage or transmitting viruses, although several species (including those of *Longitarsus* Berthold and *Altica* Müller) are beneficial as biological control agents of weeds (Booth *et al*., 1990; Jolivet and Verma, 2002). Alticinae constitute an important taxonomic group for comparative biodiversity studies and conservation activities, not only because of their close association and serious damage to host plants in both agricultural and forest areas, but also due to their huge population densities.

However, to our knowledge, there have been no comparative studies focused exclusively on Alticinae species diversity and composition patterns; therefore the present study on, "*Species diversity and population dynamics of flea beetles on mustard and radish*", the two most seriously damaged cruciferous crops, has been taken with a view to record the qualitative and quantitative abundance of flea beetles infesting mustard and radish; besides, establishing the effect of abiotic factors on their population dynamics.

MATERIALS AND METHODS

The investigation was carried out at the farm of College of Technology and Agricultural Engineering, MPUAT, Udaipur during *rabi* 2009. Geographically, Udaipur is located at 23.4°N longitude and 75°E latitude at an elevation of 579.5 MSL in the state of Rajasthan. As the crops were sown in *rabi* (Oct 2009 to March 2010), a pre-sowing irrigation was given for proper preparation of land. The experimental field was prepared by ploughing once followed by cross harrowing and planking. Required quantity of FYM (8 to 10 tones/ha) was mixed with soil. Inorganic fertilizers as half the recommended dose of nitrogenous fertilizer (15 kg/ha) and full dose of phosphatic fertilizer (15 kg P_2O_5/ha) were applied at the time of last ploughing.

Recommended varieties of radish and mustard were sown on 12th of October 2009 in plots of 4m × 3m (12 sq. m) maintaining 45cm row to row and 30cm plant-to-plant spacing. The seed rate used were 8 kg/ha for radish and 4 kg for mustard. As per recommendations, radish and mustard were irrigated as and when required and the other recommended agronomical practices like thinning,

weeding and hoeing were also followed to maintain the crop. Data on weather factors *viz.*, atmospheric temperature (minimum and maximum); relative humidity (morning and evening) and sunshine were obtained from the meteorological section of the Meteorological Observatory at the College of Technology and Agricultural Engineering, MPUAT, Udaipur.

To record the population density of flea beetles infesting radish and mustard, observations were recorded by random sampling using the sight count technique for estimating the population of flea beetles. The total numbers of flea beetles present on the entire tagged plants were counted without disturbing the plant. Records on the flea beetle incidence were made four weeks after germination; thereafter; weekly observations were recorded from the tagged plants. The mean density and relative density of the flea beetle population on both crops were estimated and subjected to Chi-square analysis to establish the food preference. The formulae used were:

Table 1. Population abundance of flea beetles on mustard during 2009-10

Dates of sampling	Total per five plants	Flea beetle genera collected			
		Chaetocnena Stephens		*Phyllotreta* Foudras	
		Numbers per five plants	Abundance (%)	Numbers per five plants	Abundance (%)
02.11.09	75	8	10.66 (19.05)	67	89.34 (70.94)
09.11.09	93	9	9.67 (18.12)	84	90.33 (71.88)
16.11.09	102	10	9.83 (18.27)	92	90.17 (71.73)
23.11.09	142	12	8.45 (16.90)	130	91.55 (73.10)
30.11.09	30	6	20.00 (26.57)	24	80.00 (63.43)
07.12.09 to 28.12.09	No adult beetles were recorded during this period and has not been accounted for in the analysis				
04.01.10	84	6	7.14 (15.50)	78	92.86 (74.50)
11.01.10	138	11	7.97 (16.40)	127	92.03 (73.60)
18.01.10	168	17	10.11 (18.54)	151	89.89 (71.46)
25.01.10	222	28	12.61 (20.80)	194	87.39 (69.20)
01.02.10	324	56	17.28 (24.56)	268	82.72 (65.44)
08.02.10	431	73	16.93 (24.30)	358	83.07 (65.70)
15.02.10	597	141	23.61 (29.07)	456	76.39 (60.93)
22.02.101	522	149	28.54 (32.30)	373	71.46 (57.71)
Seasonal values	2928	526	21.90 (27.90)	2402	78.10 (62.09)
Mean	225.23	40.46	13.51 (21.567)	184.77	86.48 (68.43)
S.D.	184.73	50.76	5.30	136.43	5.30
S.E. ±	51.24	14.08	1.47	37.84	1.47

Mean Density: *Chaetocnema* – 8.09/plant; *Phyllotreta* – 36.95/plant; Relative Density (%): *Chaetocnema* – 17.96; *Phyllotreta* – 82.03; * Figures in parentheses are arc sine values.

(i) Mean Density: $Mean\ Density = \frac{\Sigma Xi}{n}$

Where,

Xi = Number of beetles in i^{th} sample

n = Total number of plants sampled

(ii) Relative Density (%):

$$Relative\ Density\ (\%) = \frac{Number\ of\ individuals\ of\ one\ species}{Number\ of\ individuals\ of\ all\ species}$$

The pest population (numbers of beetles per plant) was correlated to the prevailing mean abiotic environmental factors (atmospheric temperature, relative humidity and sunshine). The following formula was used to determine the correlation coefficient (r) between the pest population and the abiotic factors:

$$Correlation\ coefficient\ (r) = \frac{\Sigma xy}{\sqrt{\Sigma[xx]X[yy]}}$$

Where:

r = Correlation coefficient

x = Independent variable (the key abiotic factors)

y = Dependent variable (the pest population)

N = number of observations recorded

$$\Sigma xy = \Sigma xy - \frac{\Sigma x}{\Sigma y};\ \Sigma yy = \Sigma y^2 - \frac{(\Sigma y)^2}{N}$$

$$\Sigma xx = \Sigma x^2 - \frac{(\Sigma x)^2}{N}$$

In order to record the species diversity of flea beetles, adults were collected using the sweep net and transferred into polythene bags containing cotton swabs with ethyl

Table 2. Population abundance of flea beetles on radish during 2009-10

Dates of sampling	Total per five plants	Flea beetle genera collected			
		Chaetocnena Stephens		*Phyllotreta* Foudras	
		Numbers per five plants	Abundance (%)	Numbers per five plants	Abundance (%)
02.01.10	96	9	9.37 (17.82)	87	90.63 (72.17)
09.01.10	180	18	10.00 (18.43)	162	90.00 (71.56)
16.01.10	219	21	9.58 (18.03)	198	90.42 (71.97)
23.10.10	360	45	12.05 (20.70)	315	87.50 (69.30)
30.01.10	504	81	16.07 (23.63)	423	83.93 (66.37)
06.02.10	666	153	22.97 (28.64)	513	77.03 (61.36)
13.02.10	735	184	25.03 (30.02)	551	74.97 (60.00)
20.12.10	747	207	27.71 (31.76)	540	72.29 (58.24)
27.02.10	816	224	27.45 (31.60)	592	72.55 (58.40)
Seasonal values	4323	942	27.86 (31.86)	3381	72.14 (58.14)
Mean	480.33	104.67	17.21 (24.51)	375.67	82.77 (65.48)
S.D.	274.85	87.411	6.013	190.35	6.008
S.E.±	91.62	29.14	2.004	63.45	2.002

Mean Density: *Chaetocnema* – 20.96/plant; *Phyllotreta* – 75.13/plant; Relative Density (%): *Chaetocnema* – 21.79; *Phyllotreta* – 78.21; *Figures in parentheses are transformed arc sine values.

acetate for instant killing. Later, the specimens were brought to the laboratory, segregated genus-wise under the binoculars and wet preserved after processing through 30, 60 and 90 percent alcohol for identification of the species. The flea beetles were identified in the biosystematics laboratory of Department of Entomology, Rajasthan College of Agriculture, Udaipur, using the keys provided in the Fauna of British India (Chrysomelidae: Alticinae) by Maulik (1926); later, our identifications were confirmed and validated by Dr. K.D. Pratapan, Insect Taxonomist (Chrysomelidae) at the Department of Entomology, Kerala Agricultural University, Vellayani, Trivandrum.

RESULTS AND DISCUSSION

During the present investigation flea beetles collected from mustard and radish belonged to the two genera *Phyllotreta* and *Chaetocnema*, with the former dominating, forming 86.48 and 82.77 per cent of the total in mustard and radish, respectively. The frequently found species were *Phyllotreta chotanica* Duvivier and *Chaetocneama basalis* Baly; besides, the genus *Chaetocnema* was relatively more speciose with three species to record: *Chaetocnema* sp. nr. *minuta*, *Chaetocnema* sp. nr. *belli* and *Chaetocnema* sp. nr. *kanika*; while the genus *Phyllotreta* had one dominating species *Ph. chotanica* and the rare species, *Ph. oncera*. In the present study few males could be collected due to which validation of the species of *Chaetocnema* could not be obtained.

The flea beetles infest crops and cultivated plants and the more common genera infesting cruciferous crops include: *Haltica*, *Phyllotreta* and *Psylloides*. Besides, crucifer feeding species included *Haltica oleraceae* L.; *Phyllotreta pusilla* Horn, *Ph. sinuata* Stephans, *Ph. vittata* F., *Ph. atra* F., *Ph. schreineri* Jakobson, *Ph. cruciferae* Goeze, *Ph. nigripes* F., *Ph. undulata* Kutsch, and *Ph. armoraciae* Koch; *Psylloides chrysocephala* L. and *P. napi* F. However, there are no reports of *Chaetocnema* infesting cruciferous crops, as noted in our findings; but, earlier reports do indicate the genus to be common on grain crops, sudan grass, beet and vegetables like spinach, tomato, potato, and sweet potato (Maulik, 1926).

On summer rape cultivar Mascot, Hiiessar *et al*. (2003) observed 6 species of flea beetles: *Phyllotreta undulata* Kutsch., *Ph. nemorum* L., *Ph. vittata* (*Ph. striolata*), *Ph. nigripes* F. *Ph. atra* and *Ph. vittula*. Kaplin and Antonov (2006) observed that *Chaetocnema aridula* Gill dominated among all the species of *Chaetocnema* found in cereal crops. Toth *et al*. (2007) observed that the crucifer flea beetle species spectrum included: *Phyllotreta cruciferae, Ph. vittula, Ph. undulata, Ph. nigripes, Ph. nodicornis, Ph. balcanica, Ph. atra, Ph. procera, Ph. ochripes, Ph. diademata* and *Psylliodes chrysocephalus*; and a great portion of the catch (30 to 98%) was *Ph. cruciferae*, irrespective of the plant culture. The second most abundant species present at most sites was *Ph. vittula*. Similarly, Toshova *et al*. (2009) recorded six species of flea beetles infesting cabbage and horseradish crops from Bulgaria. The most abundant species in the traps being *Ph. cruciferae* (92-96%) followed by *Ph. vittula*, *Ph. undulata* and *Ph. nigripes*. Mayoori and Mikunathan (2009) reported that flea beetles have a wider host range extended to the families Brassicaceae (Cruciferae), Capparidaceae, Amranthaceae, Asteraceae, Convovulaceae, Chenopodiaceae, Solanaceae, Fabaceae and Euphorbiaceae, of which Capparidaceae was the most preferred followed by Brassicaceae.

From the Tables 1 and 2 it can be observed that the flea beetle abundance recorded on mustard had a mean density of 8.09 beetles per plant for *Chaetocnema*, while 36.95 beetles per plant for *Phyllotreta*; the corresponding relative density values were 17.96 and 82.03 per cent, respectively. Likewise on radish, the mean density for *Chaetocnema* was 20.96 beetles per plant, while 75.13 beetles per plant for *Phyllotreta*; and the corresponding relative density values were 21.79 and 78.21 per cent, respectively.

Observations on the population dynamics of the flea beetles evinced that the incidence of flea beetles began in the first week of November 2009 on mustard that lasted up to the last week; while on radish the incidence began in the last week of December 2009 that also lasted up to last week of February (Tables 3 & 4). Quantitatively, flea beetles were more during the second period of their incidence during early January through February 2010 rather than in November/December, as the atmospheric temperature and relative humidity conditions were favourable. During the last week of February, species of the genus *Chaetocnema* formed 28.54 per cent of the total registering a peak of 149 beetles per 5-plants; while during the third week of February, *Phyllotreta chotanica* Duviv formed 76.39 per cent on mustard registering 456 beetles per 5-plants though *Ph. chotanica* appeared early in January in larger numbers (78 beetles/5-plants) than *Chaetocnema* spp. (6 beetles/ 5-plants). Similarly on radish, species of the genus *Chaetocnema* formed 27.45 per cent of the total with 224 beetles per 5-plants and *Ph. chotanica* formed 72.55 per cent of the total with 592 beetles per 5-plants. This indicated a very similar ratio of occurrence of the two genera on both cruciferous crops collected during last week of February 2010 (*Chaetocnema*: *Phyllotreta* as 1: 2.69 on mustard and 1: 2.64 on radish). The flea beetle populations had a significant positive correlation ($r = +0.89$) with mean

Table 3. Seasonal incidence of *Ph. chotanica* on mustard during 2009-10

Dates of observation	Mean abiotic factors			Mean flea beetle population (No./Plant)
	Atm. Temp. (°C)	Rel. Hum. (%)	Sunshine (hrs)	
02.11.09	23.95	36.15	8.7	5.0
09.11.09	23.20	45.80	7.8	6.2
16.11.09	19.85	68.65	4.8	6.8
23.11.09	18.25	50.30	8.4	7.4
30.11.09	19.45	50.45	8.5	2.0
07.12.09	19.50	55.60	8.4	0
14.12.09	20.50	58.15	7.2	0
21.12.09	18.35	65.60	5.4	0
28.12.09	17.10	53.25	7.3	0
04.01.10	18.05	62.50	3.7	5.6
11.01.10	14.60	64.50	8.1	9.2
18.01.10	15.50	53.30	8.8	11.2
25.01.10	18.55	49.15	8.9	14.8
01.02.10	18.90	48.3	8.2	21.6
08.02.10	19.70	45.85	7.2	29.4
15.02.10	18.45	49.85	8.1	39.8
22.02.10	20.55	43.65	9.1	34.8
Correlation coefficient values (r):	– 0.012	– 0.40	+ 0.293	

Table 4. Seasonal incidence of *Ph. chotanica* on radish during 2009-10

Dates of observation	Mean abiotic factors			Mean flea beetle population (No./Plant)
	Atm. Temp. (°C)	Rel. Hum. (%)	Sunshine (hrs)	
26.12.09	17.10	53.25	7.3	2.2
02.01.10	15.55	54.00	8.6	6.4
09.01.10	15.80	57.50	8.8	12.0
16.01.10	16.00	53.30	8.8	14.6
23.01.10	18.55	49.15	8.9	24.0
30.01.10	18.90	48.30	8.2	33.6
06.02.10	19.80	43.65	9.1	44.4
13.02.10	19.55	49.85	8.1	49.0
20.02.10	20.55	43.65	9.1	49.3
27.02.10	23.60	40.70	9.1	54.4
Correlation coefficient values (r):	+ 0.89	– 0.83*	+ 0.45	

* Shows t-values being significant at 5 per cent

Table 5. Chi-square test for association of flea beetle genera on two host crops

Flea beetle genera / Crops	*Chaetocnema*			*Phyllotreta*				
Radish	(a)	104.67	O	(b)	271.00	O	(a+b)	375.67
		97.28	E		278.39	E		
Mustard	(c)	40.46	O	(d)	144.31	O	(c+d)	184.77
		47.85	E		136.92	E		
	(a+c)	145.13		(b+d)	415.31		(a+b+c+d)	560.44
		0.4879			0.2236			
		1.301			0.3467			

Estimated Chi-square (χ^2) at 1 d. f. = 2.36 NS

atmospheric temperature, but a significant negative correlation (r = -0.83) with relative humidity in radish; while the abiotic factors did not show significant correlations with flea beetle population on mustard indicating little influence of the environment. Since temperature plays an important role in the flight activity of the flea beetles damaging cole crops (Cruciferae), the seedling stage (October-November) and near harvest stage (February-March) are seriously affected under our climatic conditions in the *rabi* season (October to March). Based on the numerical abundance of the flea beetles, the Chi-square analysis (Table 5) evinced that there was no significant difference between the flea beetle genera for their preference of either mustard or radish; though quantitatively, *Phyllotreta* was more abundant than *Chaetocnema* on both crops.

Similar studies from the temperate zones indicate a significant variation in the flea beetle population depending on the climatic factors like temperature and relative humidity. Kaplin and Antonov (2006) observed that *Chaetocnema aridula* Gill developed mainly on winter wheat, and, to a lesser extent, on spring wheat and barley. In autumn, adult beetles aggregated on millet for pre-hibernation feeding. The highest population density of *Ch. aridula* was observed in the humid and warm year and the lowest one, in the extremely dry year. Reporting on the population dynamics of the flea beetles *Chaetocnema tibialis* and *Phyllotreta vittula,* associated with *Amaranthus retroflexus* (wild species) and *Amaranthus caudatus* (cultivated species), Cagan *et al* (2006) observed that the number of *C. tibialis* adults was usually very low until the beginning of July. During July the number of *C. tibialis* increased, but sooner on cultivated amaranth. An increased number of *C. tibialis* adults were observed on both amaranth species until the middle of September. The results showed that amaranth plants are a very important reservoir of *C. tibialis* during summer. *P. vittula* was a common flea beetle on amaranth during the whole summer, but its numbers never exceeded more than 10 adults per 25 plants. Low temperatures in winter had a negative effect on populations of *C. tibialis* on both amaranth species and also on populations of *P. vittula* on *A. retroflexus*. The lower the precipitation was in July, the higher were the populations of *C. tibialis* on both amaranth species and the populations of *P. vittula* on *A. retroflexus*.

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