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Damage Pattern of Cabbage Flea Beetle, *Phyllotreta cruciferae* (Goeze) (Coleoptera: Chrysomelidae) and its Associated Hosts of Crops and Weeds

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Abstract: Among the insect pests of Brassicaceae crops flea beetle, *Phyllotreta cruciferae* (Coleoptera: Chrysomelidae) has been emerged as a serious pest in Jaffna district of Sri Lanka and inflicted severe damage in the seedling stage of cabbage. The damage incurred by adult *P. cruciferae* was significantly high (71. 4%) in the seedlings of cabbage. However, other Brassicaceae crops also prone to the damage of flea beetle. The extent of damage in cauliflower, radish, mustard and leafy cabbage was 52. 6, 62. 5, 60. 7 and 35. 6%, respectively. The flea beetles have a wider host range extended to the families Brassicaceae, Capparidaceae, Amaranthaceae, Asteraceae, Convulvulaceae, Chenopodiaceae, Solanaceae, Fabaceae and Euphorbiaceae, of which Capparidaceae was the most preferred alternate host next to Brassicaceae. Monocot weeds were not preferred over dicots by the adult beetles of *P. cruciferae*. However, it was extended in dicot weeds. *Gynandropis pentaphylla* and *Cleome viscosa,* dicot weeds of Capparidaceae, served as a food source for the beetles in fields. *G. pentaphylla* provided a unique breeding site for the beetles, thus favouring the survival and development of *P. cruciferae* in fields. Non-*Brassica* crops such as *Beta vulgaris*, *Alternanthera sessilis*, *Ipomoea aquatic, Amaranthus sp.* and *Crotalaria juncia* were also preferred by the beetles. *Crotalaria juncia* (Fabaceae) had a role in the establishment of beetles and favoured the beetle's survival in the field. Weeds played a key role in the development of *P. cruciferae*. Hence, it is advisable for better and timely management of weeds for the sustainable crop cultivation.

Key words: *Phyllotreta sp.* · Cabbage · Damage · Alternate host

INTRODUCTION

Cabbage has been cultivated for at least 4000 years and grown as a popular vegetable. It is a cool season crop which prefers cool moist climate with a monthly average temperature of 15 to 22°C.

Cabbage cultivation is under the threat of pest infestation throughout its cropping period. Among the pests, insects have close association with the phenology of crop from the seedling stage to head harvesting. Being a leafy vegetable, cabbage receives frequent application of pesticides to prevent the damage of defoliating caterpillars in the head. However, flea beetle, *Phyllotreta cruciferae* (Goeze) has been emerged as a serious insect pest in Jaffna district and it damages the seedling of cabbage. The seedling phase of cabbage is more prone to the attack of adult beetles, *P. cruciferae* than other growth stages. The extent of damage often resulted to the loss of crop at the early stage.

The flea beetle, *P. cruciferae* (coleoptera: chrysomelidae) is the most common and destructive pest of Brassicaceae crops. It was first introduced into North America in the 1920s and is now distributed all over the world [1]. *P. cruciferae* is an early season pest commonly found on cabbage and other Brassicaceae crops including horse radish. Adults of *P. cruciferae* over-winter primarily in leaf litter and shelter belts and consequently injure crop seedlings [2].

Adults feed on the foliage of host plant and produce small round holes. The cuticular holes give the plant a "shot-hole" appearance. Heavy feeding on young plants may reduce yields or even kill plants in severe cases.

Current control options for adult *P. cruciferae* consist primarily of foliage application of broad-spectrum insecticides which may create several environmental as well as health hazards. Keeping these facts in view, this research was initiated with the following objectives to:

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- Study the damage pattern and severity of damage by *P. cruciferae*.
- Identify the alternate hosts range.

MATERIALS AND METHODS

The investigations were carried out both in the laboratory of Department of Agricultural Biology, Faculty of Agriculture, University of Jaffna and in the cabbage fields at Thirunalvely, Jaffna district. The details of materials used and methodology adopted during the investigation are described below.

Assessment of Foliage Damage by *P. cruciferae*: The adult flea beetles made feeding holes on the leaves of cabbage in a characteristic manner. Hence the pattern of infestation was assessed based on a visual rating method. The rating was performed by counting the feeding holes created in leaves of host plant. Host plants such as *Brassica oleracea* var. *capitata, Brassica oleracea* var. *botrytis*, *Brassica juncea, Brassica oleracea*, *Raphanus sativus, Gynandropis pentaphylla, Cleome viscosa* and *Amaranthus viridis* were evaluated for damage assessment. Host plants with 3-4 leaves stage were placed in individual screened cages with clear and well ventilated tops. Three even aged adult beetles were released into each cages and left to feed for 48 hours at 28. 3°C ± 1 °C. The plants were then removed from the cages and the damage percentage was assessed using the following equations.

Damage percentage of individual leaf = a/b * 100

Where,
a – Total area of feeding holes present in leaf
b – Total leaf area assessed

$$\text{Average damage percentage} = \frac{\sum \text{damage percentage of individual leaf}}{\text{Number of plants evaluated}}$$

Identification of Alternate Hosts of *P. cruciferae*: Host plant preferences were determined in the laboratory using different crops and weeds belong to the family Brassicaceae with emphasis on those crops most commonly cultivated in Jaffna. This information would in turn help to detect the host range of adult *P. cruciferae* in field. Experiments were conducted in screened cages. Plants used in these tests were sufficiently wetted to avoid drying. 50 even aged adult beetles were introduced into the cage and left to feed for 24 hours. The plants were then removed from the cage and number of feeding holes and area of leaves fed were assessed to determine the colonization pattern and feeding preference of flea beetles in crops.

Feeding Preference of *P. cruciferae* in Weed Hosts: Two weed hosts such as *Gynandropis pentaphylla* and *Amaranthus viridis* were selected to evaluate feeding preference. Newly emerged 25 beetles of *P. cruciferae* were starved for 24 hours and were released into 15x15x15 cm^3 screened plastic cages. Undamaged leaves from these two hosts were selected and placed inside the cages. The cages were kept closed after the introduction of beetles. This experiment was replicated five times. After 24 hours, the damaged leaves were removed from the cages and percentage of damage was assessed by counting of feeding holes in leaves.

RESULTS

The cabbage flea beetle, *Phyllotreta cruciferae* is primarily a pest of Brassicaceae plants. However, cabbage was mainly affected by adult beetles at its seedling phase. This causes a heavy loss in the crop stand. In order to mange the pest effectively and economically, it is vital to understand the damage pattern, severity of damage and alternate hosts of *P. cruciferae*. The results are presented below.

Laboratory Assessment of Foliage Damage by *P. cruciferae*: In order to quantify the degree of flea beetle feeding damage on different Brassicaceae plants and weeds, a test was conducted in the laboratory and the results are described in Table 1.

The foliage damage by *P. cruciferae* was different among the plants tested in the laboratory. Adult beetles fed on the foliage of host plant resulted in a characteristic

Table 1: Mean foliage damage percentage on different host plants by adult *P. cruciferae*

Host plant	Foliage damage (%)
Brassica oleracea var. *capitata*	71. 4
Brassica oleracea var. *botrytis*	56. 6
Raphanus sativus	62. 5
Brassica juncea	60. 7
Brassica oleracea	35. 6
Gynandropis pentaphylla	59. 2
Amaranthus viridis	42. 4
Cleome viscose	55. 9

(a) *Gynandropis pentaphylla* (b) *Amaranthus viridis*

Plate 1: Damage caused by adult *Phyllotreta cruciferae* beetles on weed hosts

shot-hole appearance. The number of feeding holes produced by *P. cruciferae* was significantly high in *Brassica oleracea* var. *capitata* and the mean foliage damage was 71. 4%.

Flea beetles also attacked other Brassica crops such as *Brassica oleracea* var. *botrytis*, *Raphanus sativus*, *Brassica juncea* and *Brassica oleracea*. The mean foliage damage on *B. oleracea* var. *botrytis*, *R. sativus*, *B. juncea* and *Brassica oleracea* was 56. 6, 62. 5, 60. 7 and 35. 6%, respectively. Among the Brassicaceae crops tested, the damage on *B. olaraceae* var. *botrytis* was less than *B. olaraceae* var. *capitata* (71. 4%). *Brassica oleracea* had the lowest feeding damage when compared to other brassica crops.

The percentage of damage on weed hosts such as *Gynandropis pentaphylla*, *Amaranthus viridis* and *Cleome viscosa* were 59. 2, 42. 4 and 55. 9, respectively. The number of flea beetle feeding holes was significantly high in *G. pentaphylla* when compared to the weed host, *A. viridis* (Plate 1). This revealed that weeds play a crucial role in favouring the survival and subsequent development of *P. cruciferae* in the field during off-cabbage cultivation.

The damage was primarily produced by the adult stage. However, the grub feeding on the roots of host plants caused little appreciable damage. It was estimated as less than 5%. No major effects from grub root feeding have been reported [3].

Among the brassica crops, the adult flea beetles highly preferred *B. olaraceae* var. *capitata*, *R. sativus* and *B. juncea*. The feeding preference of adult flea beetles with respect to various brassica species have been investigated by Haddock [4] and Tahvanainen [5].

Table 2: Host range of *Phyllotreta cruciferae* beetles

Host	Family	Feeding preference
Brassica oleracea var. *capitata*	Brassicaceae	+
Brassica oleracea var. *botrytis*	Brassicaceae	+
Brassica juncea	Brassicaceae	+
Raphanus sativus	Brassicaceae	+
Brassica oleracea	Brassicaceae	+
Alternanthera sessilis	Amaranthaceae	+
Amaranthus sp.	Amaranthaceae	+
Beta vulgaris	Chenopodiaceae	+
Ipomoea aquatica	Convolvulaceae	+
Crotalaria juncea	Fabaceae	+

+: denotes Damage found - : denotes Damage not found

Table 3: Weed hosts of *P. cruciferae* beetles in cabbage fields

Host	Family	Feeding preference
Acalypha indica	Euphorbiaceae	-
Aerva lanata	Amaranthaceae	+
Ageratum conizoides	Asteraceae	+
Amaranthus viridis	Amaranthaceae	+
Cenchrus echinatus	Poaceae	-
Cleome viscosa	Capparidaceae	+
Cyanodon dactylon	Poaceae	-
Cyperus rotundus	Poaceae	-
Eragrostis tenella	Poaceae	-
Euphorbia garcini	Euphorbiaceae	+
Gynandropis pentaphylla	Capparidaceae	+
Parthenium histerophorous	Asteraceae	-
Physalis minima	Solanaceae	+
Tridex procumbens	Asteraceae	+
Vernonia cenaria	Asteraceae	+

+: denotes Damage found - : denotes Damage not found

In case of weed hosts, the feeding preference was found to be high in *G. pentaphylla* followed by *C. viscosa* (Plate 3). The damage was very high in younger leaves compared with older leaves. *A. viridis* also susceptible to flea beetle attack but not preferred over *G. pentaphylla*.

Identification of Alternate Hosts of Adult *P. cruciferae*: The adult *P. cruciferae* fed on different Brassicacea crops (Table 2) and weeds (Table 3). Highly preferred hosts of

P. cruciferae were *Brassica oleracea* var. *capitata*, *Raphanus sativus*, *Brassica juncea, Brassica oleracea* var. *botrytis*, *Gynandropis pentaphylla*, *Amaranthus viridis* and *Cleome viscosa.* Weeds belong to Capparidaceae and Amaranthaceae were highly preferred hosts next to Brassicaceae by adult beetles.

In contrast, the adult flea beetles were occasionally found to feed on non-brassica vegetable crops such as *Beta* vulgaris, *Alternanthera sessilis* and *Ipomoea aquatica*. The Fabaceae crop, *Crotalaria junceawas* also preferred by the adult beetles.

Among the weeds, *G. pentaphylla* was served an identical breeding site and thus attracting the beetles in the field. This would in turn facilitate the survival of flea beetles throughout the year. Similarly, *A. viridis* was also highly preferred when compared to other weed hosts.

Weeds belongs to Poaceae were not preferred by the flea beetles. Thus, the monocot weeds were said to be insignificant in favouring the beetle population in field when compared to the dicot weeds. The reason was unknown and it has to be investigated whether these plants have any chemical compounds to repel the flea beetles.

Feeding Preference of *P. cruciferae* in Weed Hosts: Two weed hosts namely *Gynandropis pentaphylla* and *Amaranthus viridis* were tested for the feeding preference. The average area of damage on the leaf of *G. pentaphylla* and *A. viridis* after 24 hours of feeding was estimated as 8. 67 cm^2 and 6. 53 cm^2, respectively. The feeding of *P. cruciferae* was significantly higher in *G. pentaphylla* than *A. viridis. G. pentaphylla* served as a source of food for the growth and survival of adult *P. cruciferae* as it was highly preferred than *A. viridis.* In addition, *G. pentaphylla* served as a unique breeding site for the multiplication of *P. cruciferae* in the field.

DISCUSSION

The host spectra of flea beetles varied greatly in the laboratory than in the field. It might be due to the microclimatic, temporal and physical habitat characteristics of the herbaceous plants that may greatly restrict the utilization of plant species [6]. Since temperature plays a key role in the flight activity of flea beetles in field [3], being a Cole crop it also a deciding factor of the growth of cabbage in Jaffna

It was found that the seedling phase of cabbage was highly affected by adult beetles resulting in stunting of plant growth. Under severe feeding pressure, flea beetles have been recorded attacking the growing point and ultimately killing the plants [7]. Among the brassicaceae crops tested, *Brassica oleracea* var. *capitata* had the highest mean foliage damage whilst, *Brassica oleracea* (leafy cabbage) had the lowest feeding damage when compared to other brassica crops.

Hines and Hutchison [8] reported that flea beetles hibernate in leaf litter, wind breaks, shelter belts and wooded areas. The over-wintered adult beetles emerge and feed on volunteer Brassicas and weeds. Depending on the temperature, it may take up to three weeks for the adults to leave their over-wintering sites [3].

The number of flea beetle feeding holes was significantly high in *G. pentaphylla* when compared to the weed host, *A. viridis.* In case of weed hosts, the feeding preference was found to be high in *G. pentaphylla* followed by *C. viscosa.* The damage was very high in younger leaves compared with older leaves. *A. viridis* also susceptible to flea beetle attack but not preferred over *G. pentaphylla.*

The feeding preference of adult flea beetles with respect to various brassica species have been investigated by Haddock [4] and Tahvanainen [5]. The adult flea beetles had a wider host range extended to the families Brassicaceae, Amaranthaceae, Asteraceae, Capparidaceae, Euphorbiaceae, Solanaceae, Chenopodiaceae, Convolvulaceae and Fabaceae.

Family Capparidaceae was significantly preferred over other families. The dicot weed, *G. pentaphylla* provided a unique breeding site for the adult beetles in the field. In contrast, feeding of these beetles is confined to plant species that contain glucosinolates as secondary plant compounds, which impart a desirable pungent odor and taste to attract the flea beetles towards the feeding site in field [9].

CONCLUSION

Investigations on cabbage flea beetle, *Phyllotreta cruciferae*, were carried out at the Department of Agricultural Biology, University of Jaffna and in the field at Thirunalvely, Jaffna, Sri Lanka.

The flea beetle, *P. cruciferae*, was a small, oval-shaped and shiny blackish beetle. The damage by the adult beetles was much pronounced in the seedling phase of cabbage. At severe feeding pressure the seedlings get ultimately died and produced dramatic yield losses to the farmers. Flea beetle out breaks can cause considerable stand losses [10]. Adult beetles feed on young seedlings resulting in reduced crop stand and plant growth and eventually lower yield [11, 12]. Plants recover from flea beetle injury often have reduced biomass [13, 14].

The damage incurred by adult beetles was assessed in the laboratory using a damage rating method. The damage was significantly high (71. 4%) in *Brassica oleraceae* var. *capitata*. The lowest flea beetle damage (35. 6%) was found in *Brassica oleraceae*. The beetles highly preferred weed hosts such as *Gynandropis pentaphylla*, *Amaranthus viridis* and *Cleome viscosa*. The flea beetle damage was also found in some non-brassica crops including *Beta vulgaris*, *Alternanthera sessilis*, *Ipomoea aquatica* and *Crotalaria juncia*.

The flea beetles have a wider host range. The host spectra of flea beetles varied greatly in the laboratory than in the field. It might be due to the microclimatic, temporal and physical habitat characteristics of the herbaceous plants that may greatly restrict the utilization of plant species [5].

Plant families such as Brassicaceae, Capparidaceae, Amaranthaceae, Asteraceae, Solanaceae, Chenopodiaceae, Convolvulaceae, Fabaceae and Euphorbiaceae were preferred by adult *P. cruciferae*. Capparidaceae was the most preferred host next to Brassicaceae. Weeds of monocots were not affected by adult *P. cruciferae*. The dicot weed of Capparidaceae, *Gynandropis pentaphylla* served an identical breeding site to the beetles there by favouring the development and survival of *P. cruciferae* in field. Monocot weeds were not preferred by the adult beetles of *P. cruciferae*.

It is vital to initiate appropriate weed management at proper time of plant establishment in the field to avoid the seedling damage and thereby the whole crop. Once it escapes the damage from its seedling phase then it can withstand. Since the adult beetles prefer younger leaves when compared to older leaves to feed.

Hence, better and timely weed management is essential for the sustainable crop cultivation in the future.

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