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THE MUSTARD APHID *LIPAPHIS ERYSIMI* (KALTENBACH) AND ITS NATURAL ENEMIES IN TRIPURA: A REVIEW

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ABSTRACT: The mustard aphid, *Lipaphis erysimi* (Kaltenbach), commonly found in the cultivated fields of Tripura attacks the several agricultural crops, transmit plant viruses and cause leaf deformation. There are a number of its natural enemies (parasitoids/predators) that kill them. These natural enemies are component (bioagent) of biocontrol which is especially important for reducing the number of pest insects without polluting the environment. The principal aim of this review is to put together useful information about the mustard aphids and their natural enemies published from studies done in the State of Tripura, north-east India. This will serve as the latest point reference for the incidence pattern and biological control of this pest insect species. Possibility cannot be ruled out that there may be some more species of predators and parasitoids of *Lipaphis erysimi* in Tripura.

Keywords: Mustard aphid, Predators, Parasitoids, Biocontrol, Natural enemies.

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1. INTRODUCTION

Aphids, belong to the insect order Hemiptera, feed on plant sap, tapping the phloem tubes by inserting their piercing mouthparts deep into the plant. Approximately, 5100 aphid species are described worldwide out of which about 250 species infest agricultural and horticultural crops [1]. From India, 794 species under 208 genera are known [2]. Several aphid species are highly polyphagous but few are highly host specific and only feed on one or a few closely related plant species. *Lipaphis erysimi* (Kaltenbach) (Hemiptera: Aphididae) is one of them. It infests 52 species of plants belonging to 18 families, out of which 23 plants belong to the family Brassicaceae [3].

Brassica is important group of crops having vegetables (e.g., broccoli, brussels sprouts, cabbage, cauliflower, collard greens, kale, radish, turnips etc.) as well as oilseed crops (e.g., rapeseed-mustard) which have great economic importance all over the world [4, 5]. *Brassica juncea* (L.) Czern., commonly called *rai* or brown mustard, is the chief oil yielding crop widely produced in Tripura. Different species and varieties of *Brassica* show differential responses to the infestation by *Lipaphis erysimi* [6, 7]. A number of studies were conducted to evaluate the varietal resistance and susceptibility of different varieties and genotypes of *Brassica* species against the mustard aphid [8, 9, 10, 11, 12]. In general, *rai* varieties were found to be less susceptible to aphid attack than yellow and brown mustard varieties [13, 14, 15, 16, 17]. Delayed sowing considerably enhances the risk of heavy infestation irrespective of the susceptible *Brassica* genotypes used [18, 19]. In India, 55 species of insect species belonging to 9 orders have been recognised affecting the mustard crop in terms of economic yield [20, 21, 22]. Of these, 16 species have been recognised as the major pests and rest of the other are considered as minor pests of the mustard and other brassica crops. In north eastern part of India, five major pest species are recognised: mustard aphid, *Lipaphis erysimi*; pentatomid bug, *Bagrada hilaris* (Burmeister) (=*Bagrada cruciferarum* Kirkaldy) (Hemiptera: Pentatomidae); Bihar hairy caterpillar, *Spilosoma obliqua* (Walker) (=*Diacrisia obliqua* Walker) (Lepidoptera: Noctuoidea: Erebidae; mustard flea beetle, *Phyllotreta cruciferae* (Goeze) (Coleoptera: Chrysomelidae); and cabbage butterfly, *Pieris rapae* (Linn.) (Lepidoptera: Pieridae). Among them, the mustard aphid, *Lipaphis erysimi* is a serious threat to cultivation of oilseed brassicas in India and infest the crop right from seedling stage to maturity stage [23, 24, 25, 26]. It is widely considered to be the principal pest species of mustard crop in the tropic and subtropics in India [27] and other parts of the oriental region [28]. A number of studies have estimated the yield loss in different parts of the country. The yield losses due to *Lipaphis erysimi* vary from 11-96 per cent under different agro-climatic regions [6, 16, 26, 29, 30]. The species attained population peak in the moderate age of the crop and infests leaves, stems and flowering twigs of mustard [31, 32, 33, 34]. Effective biocontrol agents are being successfully used in the integrated pest management (IPM) of some key pest species belonging to insect orders Lepidoptera, Hemiptera, Coleoptera and Hymenoptera. In most of the case, the natural enemies of pest insects manage their population under check [35].

2. NATURAL ENEMIES OF *LIPAPHIS ERYSIMI*

Aphid colonies are visited by a number of insect species for variety of purposes. A large group come to feed on the honeydew which is sticky fluid, periodically ejected as droplets from the anus of a feeding aphid. It consists of excess sugars from the plant sap imbibed by the aphid and some waste products from its digestive system. Many flies, bees, ants and wasps visit aphids for this sugary solution. Other visitors are parasitoids and predators.

2.1 Parasitoids

The parasitoid is an insect whose larva develops parasitically on or inside the body of its host insect. Unlike a true parasite, a parasitoid normally consumes and kills the host. Aphid parasitoids include wasps belonging to Hymenoptera (Braconidae, Aphidiinae; Aphelinidae); and midges belonging to Diptera (Cecidomyiidae) [35]. Usually host-specificity is found in aphid parasitoid relationship but there are a number of polyphagism noticed in some species of parasitoids, e.g. *Diaeretiella rapae* (McIntosh) which parasitises about 98 species of the aphids infesting more than 180 plant species belonging to 43 plant families distributed in 87 countries throughout the world [36] and was evaluated as bioagent against the mustard aphid in India [37, 38]. So far 125 species belonging to 22 genera of Aphidiinae have been recorded from India up to 2211 [39, 40] and 400 species about under 60 genera in the world [41, 42]. From North east India alone 87 species under 18 genera of aphid parasitoids have been recorded [43].

2.2 Predators

Aphid predators are of two types, (1) obligatory or aphid specific predators, viz. ladybird beetles (Coccinellidae: Coleoptera), many hover flies (Syrphidae: Diptera), aphid midges (Cecidomyiidae: Diptera), lacewings (Chrysopidae: Neuroptera), and few other insects, and (2) facultative or polyphagous (feeding on many different types of food) predators in which aphids are just part of much wider diet, v.z. ground beetles, social wasps, birds, earwigs and various groups of predatory flies [44]. The coccinellid fauna of India consists of about 400 species belonging to 79 genera [45, 46] and syrphid fauna consists of 312 species under 71 genera out of which at least 25 per cent are predacious chiefly on aphids [47, 48]. A number of aphid parasitoids and predators have been studied for their effectiveness and used in the fields for their biocontrol [35, 49, 50]. A number of empirical studies have been also made on the predators of Lipaaphis erysimi but the information that has been available are found to be inadequate from the view point of their biological control [51, 52]. A total of 42 species of insect predators and 11 species of insect parasitoids have been recorded in association of *Lipaphis erysimi* from India [46, 53]. However, in Tripura, we observed only 12 species of predators and 2 species of parasitoids out of which 4 species belong to Coccinellidae, 6 species of Syrphidae and 1 species each of Chrysopidae and Hemerobidae during the last two years, i.e. 2017 and 2018. Only 2 species of parasitoids were also found in Tripura during the study period (Table 1). Population census was carried out and was based on the active stages of all the predatory species encountered in the aphid population 100 plant twigs of 10 cm length chosen at random. In population sampling predators were not discriminated for their species but distinguished at group level like syrphids and coccinellids. Population census of parasitoids was also based on counting the mummified aphids in the population sample. Number of predators and parasitoids that are recorded been enumerated as number/100 aphids/week in the study.

Table 1. Number of species of predators and parasitoids recorded in association of *Lipaphis erysimi* from India and in the state of Tripura.

Natural enemies	Number of species		Species recorded in Tripura
	India	Tripura	
PREDATORS			
Order: Hemiptera			
Anthocoridae	1	0	-
Coleoptera			
Coccinellidae	16	4	*Coccinella septempunctata* (Linn.)
			Coccinella transversalis Fabricius
			Micraspis discolour Fabricius
			C*heilomenes sexmaculata* (Fabricius)
Order: Diptera			
Syrphidae	23	6	*Episyrphus balteatus* DeGeer
			Episyrphus alternans (Macquart)
			Betasyrphus serarius Wiedemann
			Ischiodon scutellaris (Fabricius)
			Macrosyrphus confrator (Wiedemann)
			Allograpta javana (Wiedemann)
Order: Neuroptera			
Chrysopidae	1	1	*Chrysopa* sp.
Hemerobidae	1	1	*Micromus timidus* Hagen
Total	**42**	**12**	
PARASITOIDS			
Order: Hymenoptera			
Braconidae	10	2	*Aphididus matricariae* (Haliday)
			Diaeretiella repae (McIntosh)
Aphilinidae	1	0	-
Total	**11**	**02**	

Following species were more common in the experimental field and in the particular cropping season. Coccinellidae: *Coccinella septampunctata*, *Coccinella transversalis,* C*heilomenes sexmaculata.* Syrphidae: *Episyrphus balteatus*, *Ischiodon scutellaris*, *Macrosyrphus confrator.* Parasitoids: *Aphidius matricariae*. No Neuropteran predators were found in the field during this observation.

3. ACTIVITIES OF PREDATORS AND PARASITOIDS IN TRIPURA

Coccinellid predators arrived early in the crop and maintained higher incidence in the vegetative stage. Adults of *Micraspis discolor* occurred in the late inflorescence and fruiting stages, but its larvae or eggs were never observed in the field. During the observations for the last two years first incidence of syrphid predators was noticed in the third week of crop sampling. These predators continued to dominate the predatory complex of *Lipaphis erysimi* throughout the population sampling until the last week when the crop was harvested (Table 2). Earlier, it was reported that syrphids attained maximum population in 6th sowing week which is coincide with the maximum population of aphids and then gradually decreased [54, 55]. Our findings are closely related with others regarding the activity of syrphid larvae that started during 4th sowing week and lasted up to the 9th sowing week [34, 56]. In contrast incidence of the parasitoids was limited to 3-4 weeks during the inflorescence and flowering stages of mustard crop when aphid incidence was much higher.

Table 2. Population census of predators based on the number of larvae and adults/100 aphids of *Lipaphis erysimi* recorded in the year 2017-2018 in the study area.

Mustard crop stages	Weeks	Aphid density (Nymphs + Adults)	Number/100 Aphids					
			Syrphids		Coccinellids		Parasitoids	
			2017	2018	2017	2018	2017	2018
Seedling	1	Low	0	0	12.58	8.42	0	0
	2	Low	0	0	4.85	4.21	0	0
Early vegetative	3	Moderate	0.23	71	2.12	1.00	0	0
	4	Moderate	0.73	83	0.62	0.33	0	0
Vegetative	5	High	0.28	0.90	0.21	0.26	0	0
	6	High	0.52`	1.43	0.21	0.55	0	0
Inflorescence	7	High	0.71	1.48	0.14	1.41	2	16
	8	High	0.42	3.28	81	1.48	1	19
Flowering	9	High	0.32	1.00	56	66	0	0
	10	High	1.05	1.74	0.19	0.48	1	0
Fruiting	11	Moderate	2.12	3.18	0	1.64	0	0
	12	Moderate	0	5.60	0	5.26	0	0

Despite the synchronisation of the predatory complex with the population of *Lipaphis. erysimi*, the aphid population is potentially capable of reaching economic injury level in the vegetative stage and maximum threshold level in inflorescence stage. This is possible because females of predators which arrive in the early stage of aphid population build up engage themselves in searching suitable oviposition sites at low aphid density in the early vegetative stage of the crop. The foraging and

reproductive strategy of predators is adapted to exploiting the prey population when the later has achieved a minimum threshold [57]. It takes about two weeks for the first generation progeny of predators to become active after the eggs are laid. This time lag results in aphid population to attain higher growth rate in absence of any significant mortality factor. Aphids, being parthenogenetic viviparous insects, outnumber the reproductive and feeding potential of predators and, therefore, are able to cause direct and indirect damages to the host plants under natural conditions. In present study, coccinellids were the predominant natural enemies. It is clear that the population dynamics of coccinellid beetles indicated that its population increased gradually with the increase of aphid population and decreased gradually with the decrease in aphid population. Similar results were observed by other workers [51, 58, 59] who reported that *Coccinella septempunctata* populations in wheat had a strong positive and significant correlation with the aphid numbers in the field. Coccinellids have been reported as the key species in a natural enemy guild in organic brassica fields in Canada and cabbage aphid, *Brevicoryne brassicae* [60]. However, a number of studies on populations of *Lipaphis erysimi* have shown overwhelming parasitization and a very low incidence of predators in the northern plains of India [37, 38, 61, 62]. There were changes in the abundance of natural enemies within a year. There may be different causes like climate [63, 64, 65], prey density on different cultivars [63, 66], quality of host plants [66], host plant age [67] and adjacent habitats [68, 69]. In India, techniques for laboratory rearing of aphidophagous coccinellids, viz., *Coccinella septempunctata, Cheilomenes sexmaculata*, and *Harmonia octomaculata* (Fabricius) have been standardized [70, 71, 72, 73]. Parasitoids and predators have been successfully used in reducing the incidence of aphid pests in India and abroad [35]. In India the introduction of *Aphelinus mali* gave limited control of the wooly aphid *Eriosoma lanigerum* (Hausmann) on apple orchards [74]. Successful control of *Aphis craccivora* Koch on pigeon pea [75] and *Aphis gossypii* (Glover) on cucurbits [76] was achieved by the indigenous parasitoid, *Binodoxys indicus* (Subba Rao and Sharma).

2. CONCLUSION

At the outset of this study the intention was to undertake observations of population dynamics of both predators and parasitoids of the mustard aphid. But during the course of study it was found that the incidence of parasitoids was extremely low. The lone species of parasitoid, *Aphidius matricariae* was poorly represented. The definite reason for such a low incidence of parasitoids is difficult to assign at this stage. One of the reasons for this could lie in the fact that the observations for natural enemies of *Lipaphis erysimi* in the present study was restricted to experimental plots and only occasional observations were made in non-experimental plots in and around Udaipur, Tripura. Therefore, possibility is not ruled out that there are some more species of predators and parasitoids of *Lipaphis erysimi* are available in the area of present study and other parts than actually recorded in this or other studies. During this review work, it has been found that little information regarding

natural enemies of mustard aphids in Tripura are available. It may be due to less number of works were made in this regards. So, attempt will be made more and more to work on searching the number and activities of different natural enemies of mustard aphid, *Lipaphis erysimi* in Tripura state.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

No Animals/Humans were used for studies that are base of this research.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

The author confirms that the data supporting the findings of this research are available within the article.

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CONFLICT OF INTEREST

The author declares that there is no conflict of interest regarding the publication of the present paper.

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