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IDENTIFICATION AND TAXONOMIC CHARACTERIZATION OF BIOCONTROL AGENTS OF *LIPAPHIS ERYSIMI* (KALTENBACH, 1843) INFESTING MUSTARD IN ALIGARH DISTRICT OF UTTAR PRADESH, INDIA

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ABSTRACT

Present field experiment was carried out to record the diversity along with taxonomical features of the potential natural enemies associated with a major polyphagous pest of mustard i.e. *Lipaphis erysimi* (Kaltenbach, 1843) in field condition. The mustard aphid, *Lipaphis erysimi* (Kaltenbach, 1843), belonging to the family Aphididae and order Hemiptera, is regarded as one of the most notorious pest among the 24 major pests infesting the Mustard. That's why this field survey had conducted during Rabi season of 2024-25 at experimental fields of the Department of Plant Protection, Aligarh Muslim University, Aligarh, Uttar Pradesh, India, ranging between 27^0 54' North latitude to $78^0$05' East longitude with an elevation of 178 of above mean sea level to distinguish the taxonomically potential biocontrol agents and their life stages targeting the mustard aphid efficiently. There were three natural enemies observed to feed the *Lipaphis erysimi* (Kalt) effectively in field condition, belonging to three orders of the class Insecta: Coleoptera (Coccinellidae), Diptera (Syrphidae) and Hymenoptera (Braconidae). After collecting the specimens, a critical examination of the morphological features along with major dichotomous taxonomic keys had performed to identify the insects upto species level. In India, 47 species of Coccinellidae, 27 species of Syrphidae and 17 species of Braconidae family have already described or distributed among the 28 states or union territories. Among the predators, *Coccinella septempunctata* Linnaeus belongs to family: Coccinellidae and subfamily: Coccinellinae and second one *Eristalinus arvorum* (Fabricius) commonly referred as Syrphid fly comes under the family: Syrphidae and subfamily: Eristalinae were identified after reviewing the several taxonomic keys. *Diaeretiella rapae* MacIntosh, an endoparasitoid in the family Braconidae and subfamily Aphidiinae, parasitized the aphids and their nymphs effectively, were also clearly distinguished. After vigorous identification, the biological hirechary or taxonomic trees of each specimen were also formatted and the illustrations of most distinguishing key characters along their distribution and host association were manifested in this literature.

Key words : Taxonomy, Life cycle, Biocontrol agents, Morphology, Distribution and Diagnosis.

Introduction

Indian Mustard, *Brassica juncea* (L.) is India's most widely cultivated and commonly consumed rabi season oilseed crop. Among the seven major oilseed crops, notably, rapeseed-mustard *Brassica juncea* (L.) (commonly known as 'rai') (Warwick *et al.*, 2011) is primarily grown to meet the demand for vegetable oil, contributing to about 35% of oil production in India (Rai *et al*., 2022). Due to the diverse utilities and rich nutrient availability, this oilseed crop snatches a nationwide acceptance across the farmers. In India, except the *Brassica juncea*, three other Cruciferous species or ecotypes of *Brassica* are cultivated to some extent i.e. *B. campestris* viz. yellow sarson, *B. rapa* ssp. *Oleifera*, brown sarson and *B. nigra*. (Kumar, 2015). During the year of 2023-24 Indian mustard accounts for 33.24% of

the total oilseed production in the country, which is 13.56 million tonnes out of a nation's total of 39.59 million tonnes (Rai *et al*., 2022).

Though it's a high value crop, yet the yield and output of mustard and rapeseed are adversely affected by various biotic and abiotic stresses (Rawat *et al.*, 2024). Among the biotic stresses, devastating pests become the serious concern for the yield and oil quality of this crop, now days. Mustard aphid, *Lipaphis erysimi* (Kalt) is one of them, which significantly causing the both qualitative and quantitative losses in mustard during the whole crop season, from seedling stage upto podding. (Koirala, 2020 and Kumar *et al*., 2020). This particular sucking pest is belonging to the family: Aphididae, Order: Hemiptera, Suborder: Sternorrhyncha and Superfamily: Aphidoidea and considered the major key pest of *Brassica* species. (Tiwari *et al.*, 2024i and Rawat *et al.*, 2024). Due to the excessive desapping from the growing points, including leaf folds, tips, inflorescence, and developing pods, both nymphs and adults not only reduce the yield by one-fourth to one-fifth but also decrease the oil content upto 66.9% (Sahoo, 2012 and Thakur *et al*., 2024).

In order to manage such devastating pest in field condition, farmers are only focusing to spray target systemic insecticides, which possess their own adverse effect on crop ecosystem. However, the excessive use or misuse of certain chemicals poses some drawbacks to agroecology, including phytotoxicity, resurgence of secondary pest outbreaks and extinction of non-target organisms which ultimately disrupt the process of natural control (Singh *et al*., 2013). That's why to get rid of from this detrimental effect of synthetic pesticides, certain prophylactic or preventive measures should be taken sometimes to promote the holistic approach of pest management. Biological control, by involving the potential natural enemies of the particular pest is proved to be beneficial among the several preventive measures. A good no. of predators and parasitoids are well-known to be associated with mustard aphids, including *Episyrphus balteatus* (Wiedemann) (Syrphidae), *Coccinella septempunctata* Linnaeus (Coccinellidae), *Menochilus sexmaculatus* (Fabricius) (Coccinellidae), *Chrysoperla carnea* (Stephens) (Chrysopidae) and *Diaeretiella rapae* M'Intosh (Braconidae) (Landge *et al*., 2024). Seventy one species of insects belonging to 6 families and 4 orders: Coccinellidae (Coleoptera); Chamaemyiidae and Syrphidae (Diptera); Geocoridae (Hemiptera); and Chrysopidae and Hemerobiidae (Neuroptera) and Twenty two species of parasitoids belonging to three families, Aphelinidae, Braconidae and Pteromalidae are reported to be effective for controlling the *L. erysimi* (Kalt.). (Tiwari *et al.*, 2024i). In field condition, correct identification, features and the association of these particular biocontrol agents are most crucial for achieving optimal yields and managing pests in an eco-friendly manner (Geethanjali *et al*., 2024).

Keeping this context in mind, this scientific research aimed to establish the taxonomic description, distribution status and key characteristics of identifying the particular natural enemies associated with *L. erysimi* under laboratory condition to enhance the approach of natural control among the farmers.

Materials and Methods

This experiment had conducted during the *rabi* season of 2024-25 to investigate the diversity of the biocontrol agents associated with *L. erysimi* in field condition along with their taxonomical characterization under plant protection laboratory.

Experimental site

The specimens of natural enemies were assembled for the taxonomic review from the mustard fields of Department of Plant Protection, under the Faculty of Agricultural Sciences, Aligarh Muslim University, Aligarh, U.P., India. The research plot is located between 27.9223^0N to 78.0726^0E, 132 km south-east of New Delhi and its elevation is 178 meters above sea level.

Insect Sampling and Identification methodologies

Insect specimens were collected through traditional aerial net or sweep net, aspirators and then they were killed with cotton swab dipped in ethyl acetate. During this visual exploration and sweeping the vegetation, collected immature stages were also reared in laboratory condition and taxonomically assessed.

The collected specimens were further pinned or stretched at mounting board, and labelled with the informations of host plants, locality, and date of collection. But comparatively smaller specimens e.g. Coccinellid beetles & endoparasitoids were card mounted on the edge of 10×5 mm triangular card by using a transparent or stain free adhesive. Few specimens and the immature stages were preserved in 70% ethanol for further morphological identification through ease dissection and study with taxonomic characters. In certain cases for Hymenopteran parasitoid, the field specimens i.e. mummified aphids were kept individually in a glass test tube of 12×75 mm and tied its mouth by a muslin cloth and reared in a BOD incubator at 25±5°C and 70 ± 5% RH for adult emergence. (Banshtu *et al*., 2022 and Soni *et al*., 2020). Within 3-4 days after the hatching of adult parasitoids, they were studied taxonomically.

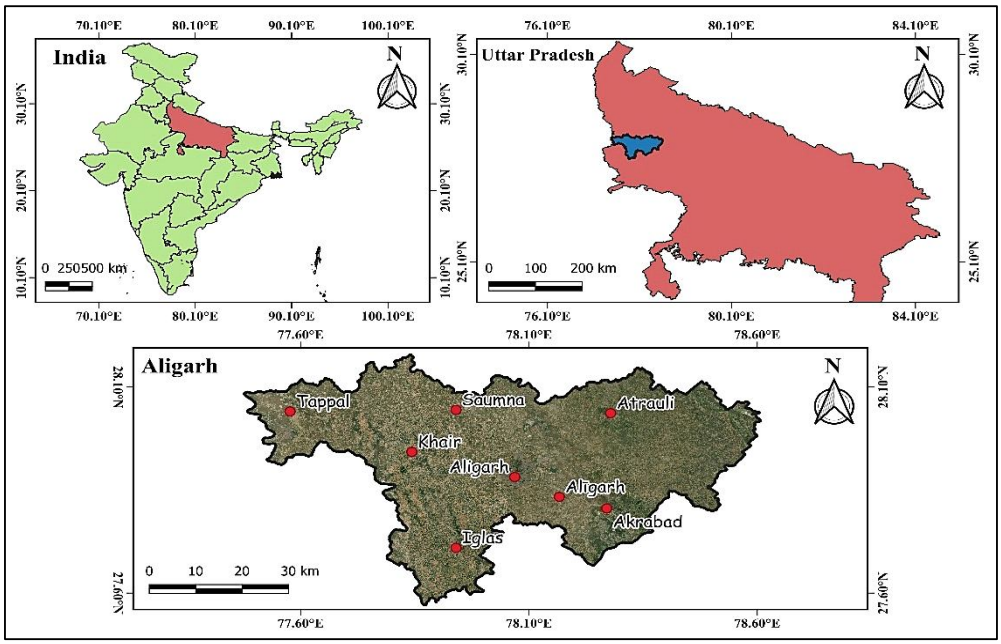

Fig. 1 : Study area map of the experiment (QGIS 3.44.5).

To study the external morphology of head, thorax and abdomen of the collected beetles, the entire specimen was soaked in 10% potassium hydroxide solution at room temperature for overnight to remove the extra chitinization and then further dissection of body parts had performed. For genitalia extraction, the abdomen was separated from the thoracic region by applying gentle pressure in the thorax-abdomen intersection through needles. In order to dissolve the extra body tissue, the separated abdomen was immersed overnight in a cavity block with freshly prepared 10% KOH at room temperature. Afterwards, the processed abdomen was placed on a glass slide with 2-3 drops of glycerin. The male and female genitalia were dissected carefully with a blunt needle while rinsing with distilled water repeatedly to enhance transparency. The permanent slides had prepared for those extracted genitalia by mounting into Canada balsam followed by a gentle dip on xylene to remove the air bubbles and further examined for identification. (Dhanapati *et al*., 2024 and Poorani, 2002). After mounting all the specimens gently, they were morphologically studied through Magnus Stereo Zoom microscope SZX7 up to species level with the reference of available dichotomous taxonomic keys of following literatures: Saeady El *et al*. (2020), Chowdhury *et al*. (2015), Poorani (2002), Che *et al*. (2021), Bieñkowski (2018), Ali *et al*. (2018), Iqbal *et al*. (2024), Maruthadurai (2023), Brunetti (1920), Rego *et al*. (2022), Cao *et al*. (2022), Sengupta *et al*. (2017), Thompson (1999), Akhtar *et al*. (2010), Goulet and Huber (1993), Rakhshani *et al*. (2006), Ferrer-Suay *et al*. (2025), Khalil *et al*. (2019), Van Achterberg (1993). Further their global distribution and host association were also classified.

Results and Discussion

During the present experiment, there were three biocontrol agents had identified and characterized under laboratory conditions by examining several proposed taxonomic dichotomous keys. After vigorous review and the survey, two predators named as *Coccinella septempunctata* Linnaeus and *Eristalinus arvorum* (Fabricius) and one endoparasitoid *Diaeretiella rapae* MacIntosh had been collected and identified from the mustard ecosystem in association with *L. erysimi* (Kalt). The important morphological features and detailed taxonomic hierarchy of the identified species were discussed:

***Coccinella septempunctata* Linnaeus**, 1758; Fig. 2 (a-k)

Materials examined: 4 ♂, 3 ♀, Aligarh (27.9223^{0}N, 78.0726^{0}E), UP, 15.ii.2025, Coll. Swastik.

Diagnosis: Adult body shape oval to nearly round, strong convex dorsum with hemispherical appearance; BL: 5.3-7.10 mm, BW: 4.0 ± 0.34 -5.8 ± 0.26 mm; Head black with white frontal spots at ocular margins on the frons; Antennae clavate, dark brownish and hairy with 11 flagellomeres; Mandible stout, bifurcated apically with basal teeth, terminal maxillary palpi hairy and securiform; Pronotum black with two pale yellow or white quadrate spots located anterolaterally; Scutellum triangular and black, small whitish patches on both edges; Elytra yellowish-orange to reddish in colour, punctate, without hairy, featuring with seven black spots arranged in: 1/2, 1, 1, 1 pattern- three lateral spots per elytron, with a

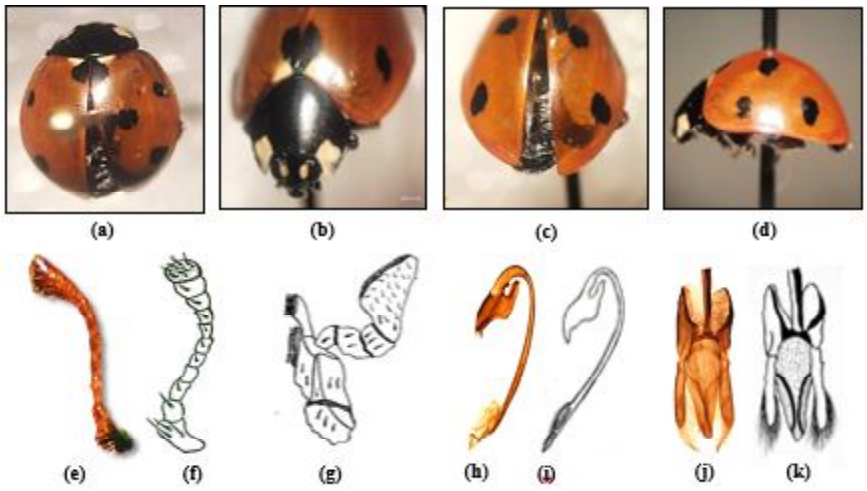

Fig. 2 : *Coccinella septempunctata* Linnaeus, 1758, (a) dorsal view; (b) frontal view; (c) ventral view; (d) lateral view; (e-f) antennae; (g) maxilla with securiform maxillary palpi; (h-i) sipho with sc and st; (j-k) tegmen anterior view.

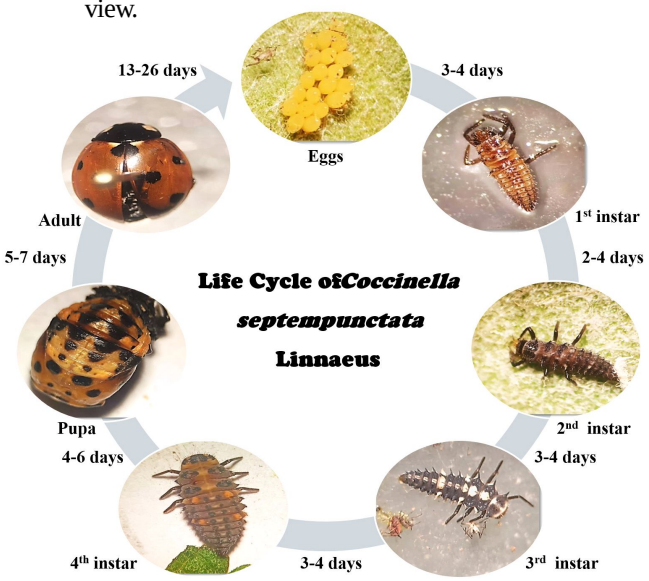

Fig. 3 : Life cycle of *C. septempunctata.*

common scutellar spot positioned at mid-dorsal line, elytral suture not darkened; Legs black, middle and hind tibiae bear apical spur; Six abdominal sternites, black in colour, posterior margin of sixth sternum convex in female, blunt or truncate in male; Male genitalia having a long chitinized semicircular siphonal tube (st), where a dilated sac like structure present at distal end, apex of siphonal tube flattened, distorted at three points, Siphonal capsule (sc) asymmetrical, T- shaped; Tegmen containing curved, flattened, short trabe, apically pointed, median lobe broad at its base, gradually tapered towards apex forming cone-shaped with a trilateral aperture or blunt apically, parameres thick, oblong, shorter than the median lobe, with dense setae on the anterior dorsal surface rather than its broad base.

Morphology of Immature stages (Fig. 3)

Eggs oval-elliptical, cylindrical in shape, measuring 1-1.30 mm in length, yellowish to orange in colour; Larvae campodeiform, dorsoventrally compressed, elongated, 1.4 ± 0.26 -7.0 ± 1.2 mm body length varying according to instars, dorsal body surface highly segmented with numerous short spines and orange splotches; Head prognathous; 3 pairs thoracic legs well developed; Anal cerci present at 8th abdominal segment;

Pupae obtect, slate grey to black with variegated white or orange markings

Host association: Among the tribe Coccinellini, *C.*

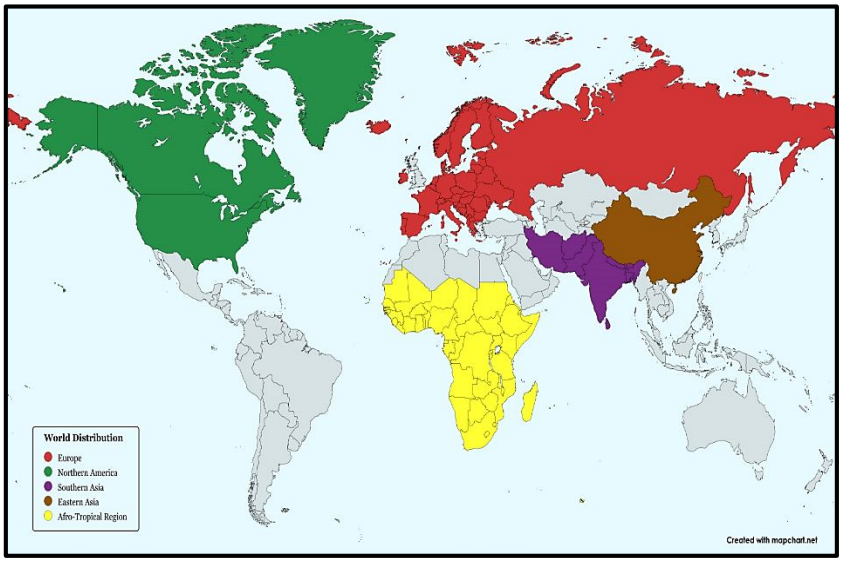

Fig. 4 : World distribution of *C. septempunctata.*

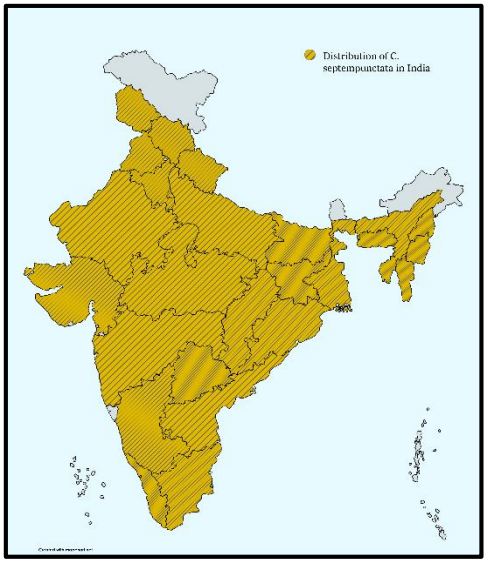

Fig. 5 : Indian distribution.

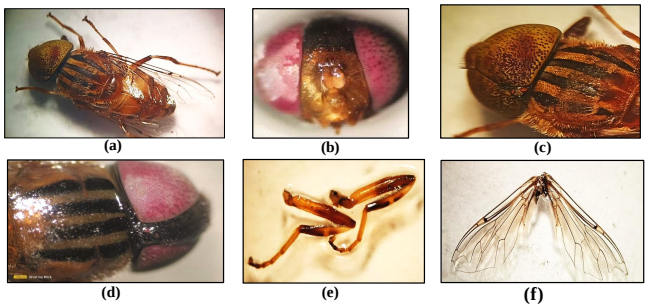

Fig. 6 : *Eristalinus arvorum* (Fabricius), 1787, (a) adult fly; (b) bare arista; (c) spotted compound eye; (d) mesonotum; (e) hind leg; (f) wing.

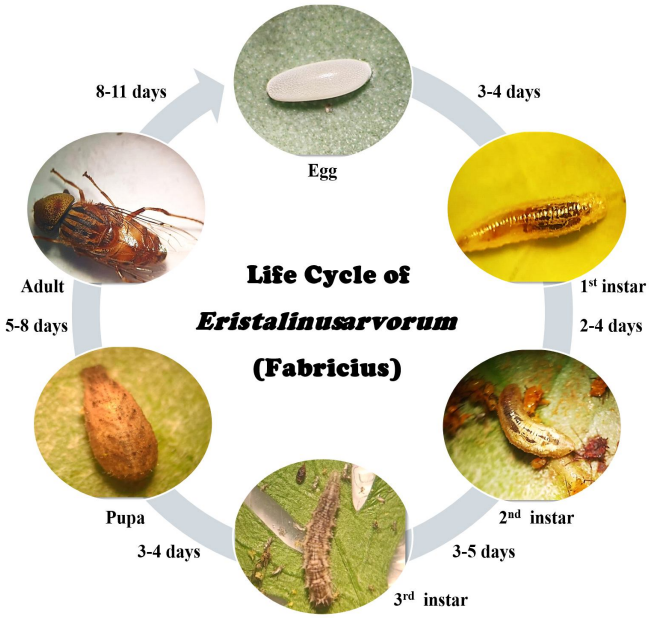

Fig. 7 : Life cycle of *E. arvorum*

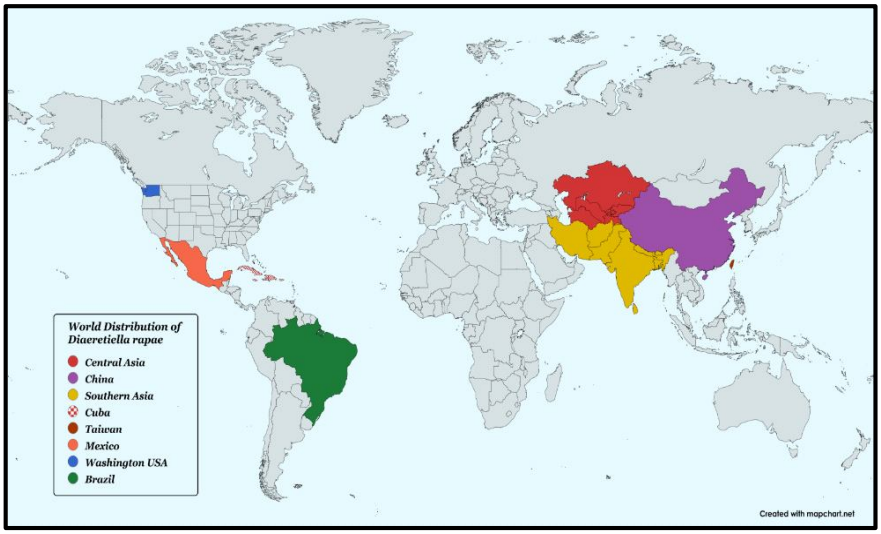

Fig. 8: World distribution of *E. arvorum*.

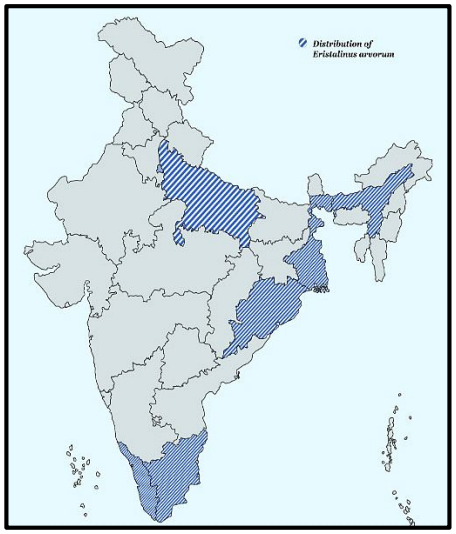

Fig. 9: Indian distribution.

septempunctata has a diverse range of host-prey associations, that's why the species entitled as cosmopolitan in distribution. During the course of study, this species mostly remains abundant on subsequent aphid species e.g. *Lipaphis erysimi* (Kalt.), *Brevicoryne brassicae* (L.), *Myzus persicae* (S)., *Aphis gossypii* G., *Aphis nerii* F., *Rhopalosiphum padi* (L.) etc. associated with *Brassica juncea* (L.), *B. oleracea var. capitata* L., *B. oleracea var. botrytis* L, *Raphanus sativus* L, *Calotropis gigantea* (L.), *Triticum aestivum* L., host plants. According to Maqbool *et al*. (2020), *C. septempunctata* had a wide distribution and feeding on *A. pomi*; *L. erysimi*; *M. persicae*; *B. brassicae* aphid morphs. Ahmed *et al*. (2017) also justified that not only the different aphid morphs, but other soft-bodied insects e.g. scale insects, mealy bugs, white flies are also included in host range of *C. septempunctata*. Vasista *et al*. (2020) reported that *C. septempunctata* also able to prey on the *A. craccivora, Aproaerema modicella* and white flies infesting groundnut crop. *C. septempunctata* also found to be feeding on *Aphis gossypii* G associated with a weed (*Convolvulus arvensis* L.) (Manoj *et al*., 2024). Due to tolerant to wide range of insecticides, coccinellids act as most preferred bio-control agents in field condition. (Sarker *et al*., 2019).

Local Distribution: Atrauli, Khair, Iglas, Saumna, Akarabad and Tappal blocks of Aligarh district.

Taxonomic hierarchy of *Coccinella septempunctata* Linnaeus

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Sub-Class: Pterygota

Division: Exopterygota

Order: Coleoptera

Suborder: Polyphaga

Superfamily: Coccinelloidea

Family: Coccinellidae

Subfamily: Coccinellinae

Genus: *Coccinella*

Species: *septempunctata* Linnaeus

***Eristalinus arvorum* (Fabricius), 1787;** Fig. 6 (a-f)

Materials examined: 5♂, 3♀, Aligarh, (27.9117^{0}N, 78.0732^{0}E), UP, 23.ii.2025, Coll. Swastik.

Diagnosis: Adult body robust, elongated, 9.1 ± 1.06 – 12.2 ± 2.6 mm, without metallic lustre; Head black, globular with varied colouration, greenish to brownish; Compound eyes spotted with irregular blackish to dark brown markings, holoptic distribution in male (♂) and dichoptic in female (♀); Frons short, slightly convex, covered with yellowish fluff intermixed with long black hairs; Arista bare, slender, and bright orange; Mesonotum yellowish fluff with a characteristic four narrow black longitudinal stripes extending from anterior to margin of scutellum; Scutellum pale yellow or having metallic gloss, with numerous short yellow hairs along the lateral edges; Forewings membranous with prominent false or spurious vein, R5 vein closed, Cu_{1a} cell open, r-m cross vein crosses between R4+5 and R5 vein, R4+5 vein sinuate towards apex; Femora of all three pairs of legs orange to brownish orange, hind tibiae black at distal end, brownish-orange at proximal; Oval, oblong diamond-shaped black spots arranged medially in 3rd abdominal uromer.

Morphology of Immature stages: (Fig. 7)

Eggs creamy white in colour, elongated-ovoid with rounded ends, with 1.1 ± 0.26 mm length, certain continuous parallel elevated stipes present throughout the egg chorion.

Fig. 7: Life cycle of *E. arvorum*

Larvae called as Apodous & Acephalous maggot, body shape cylindrical to sub-cylindrical, length varied according to instars from 1.73 ± 0.36 upto 12.34 ± 0.29, cuticle appears translucent, milky white in early instars, later it turns into gray-brown, prominent, dark-coloured cephalopharyngeal skeleton located anteriorly as piercing organ, two visible spiracles are present on a groove at the tapered posterior abdominal segment.

Pupae brownish yellow with dark bands, tear- drop shaped, oblong, termed as obtect puparium, length varies from 1.36 ± 0.32 to 3.43 ± 0.31, posterior spiracles at the caudal end, eversible bladder-like ptilinum at head region for adult emergence.

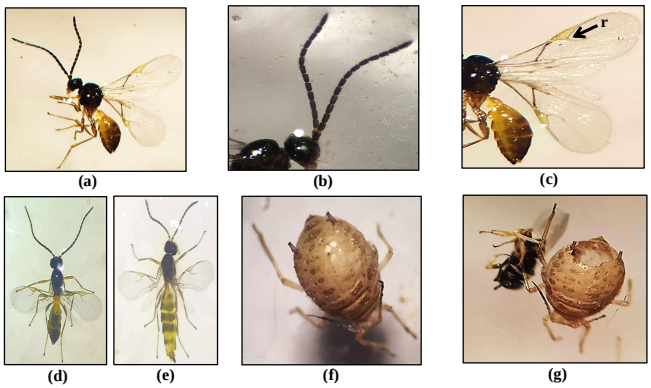

Fig. 10 : *Diaeretiella rapae* (MacIntosh), 1855, (a) adult wasp; (b) filiform antenna; (c) FW with radial vein; (d-e) male & female wasp; (f) mummified aphid; (g) emergence hole.

Host association: The main predatory stage i.e. larvae of *E. arvorum* was mostly collected from the field of cruciferous vegetables including mustard, cabbage, cauliflower associated with the following aphid hosts: *Lipaphis erysimi* (Kalt.) and *Brevicoryne brassicae* (L.). The adult fly frequently encountered to the mustard field for nectar feeding. Sengupta *et al*. (2016) justified that the insectivorous larvae mostly prey on soft-bodied Hemipteran pests (aphids, psyllids, woolly aphids) and also some Thysanopterans. According to Joshi *et al*. (2013), mostly 2nd and 3rd instar maggots act as active predators upon *M. persicae* (S), *L. erysimi* (Kalt.) and *B. brassicae* (L.). Besides that, Roy *et al*. (2024) and Sankar *et al*. (2024) reported that the larvae of Eristalinae subfamily act as potential biocontrol agents of soft-bodied hemipterans due to their wide range of host distribution. Moreover, Heo *et al*. (2020) recorded that certain species of the tribe Eristalini have the capacity for saprophagy in addition to the biological control agent.

Local Distribution: Atrauli, Iglas and Akarabad blocks of Aligarh district.

Taxonomic hierarchy of *Eristalinus arvorum* **(Fabricius)**

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Sub-Class: Pterygota

Division: Exopterygota

Order: Diptera

Suborder: Cyclorrhapha

Superfamily: Syrphoidea

Family: Syrphidae

Subfamily: Eristalinae

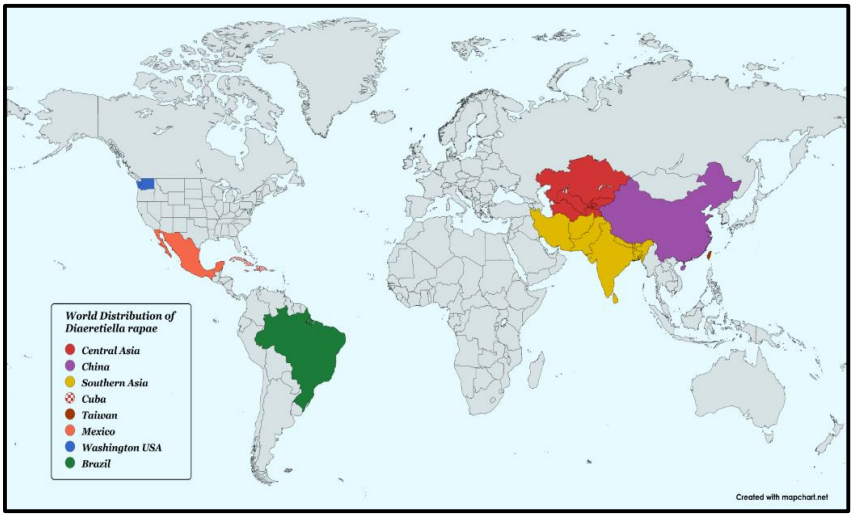

Fig. 11 : World distribution of *D. rapae*.

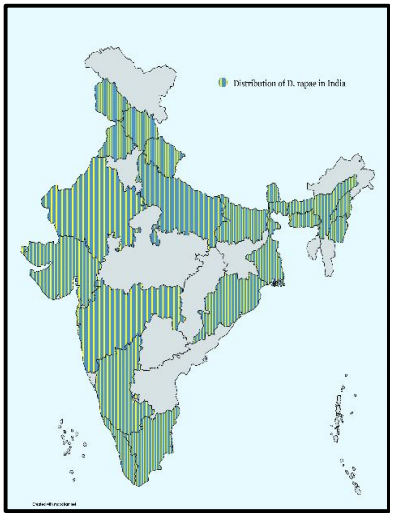

Fig. 12 : Indian distribution.

Table 1 : List of biocontrol agents solemnly associated with *L. erysimi* in north-eastern part of UP.

S. no.	Order	Family	Scientific Name	Reference
1.	**Coleoptera**	**Coccinellidae**	*Adalia bipunctata* (Linnaeus, 1758)	Tiwari *et al.* (2024ii)
			Cheilomenes sexmaculata (Fabricius, 1781)	Shukla and Kumar (2024); Tiwari *et al.* (2024ii)
			Coccinella septempunctata Linnaeus, 1758	Singh (2013); Tiwari *et al.* (2024ii)
			Coccinella transversalis Fabricus, 1781	Kishor *et al.* (2023); Tiwari *et al.* (2024ii)
			Coccinella repanda Thunberg, 1781	Kishor *et al.* (2023); Tiwari *et al.* (2024ii)
			Chilocorus nigritus (Fabricius, 1798)	Omkar and Bind (1995)
			Micraspis allardi (Mulsant, 1866)	Omkar and Pervez (1999); Singh (2009)
			Micraspis vincta (Gorham, 1895)	Singh (2009); Omkar and Pervez (2000)
			Anegleis cardoni (Weise, 1892)	Singh (2009), Omkar *et al.* (2009)
			Scymnus fuscatus Boheman, 1859	Omkar and Pervez (2000)
2.	**Diptera**	**Syrphidae**	*Episyrphus balteatus* (De Geer, 1776)	Singh (2013); Tiwari *et al.* (2024ii)
			Eupeodes confrater (Wiedemann, 1830)	Singh (2013)
			Ischiodon scutellaris (Fabricius, 1805)	Ali *et al.* (2009); Singh (2013)
			Eristalinus arvorum (Fabricius) 1787	Maruthadurai (2023)
3.	**Neuroptera**	**Chrysopidae**	*Chrysoperla carnea* Stephens	Tiwari *et al.* (2024ii)
4.	**Hymenoptera**	**Braconidae**	*Aphidius colemani* Viereck, 1912	Rafi *et al.* (2010)
			Diaeretiella rapae (McIntosh, 1855)	Halder *et al.* (2014)
			Binodoxys eutrichosiphi (Stary, 1975)	Ahmad and Singh (1995)
			Binodoxys indicus (Subba Rao and Sharma, 1958)	Ahmad and Singh (1995)
			Lipolexis gracilis Forster, 1862	Rafi *et al.* (2010)
		Aphelinidae	*Aphelinus asychis* Walker, 1839	Hayat, 1998

Genus: *Eristalinus*

Species: *arvorum* (F)

***Diaeretiella rapae* (MacIntosh), 1855** Fig. 10 (a-g)

Materials examined: 2 ♂, 5 ♀, Aligarh, (27.9223^{0}N, 78.0726^{0}E), UP 09.ii.2025, Coll. Swastik.

Diagnosis: Head shiny black, subquadrate; Frons entirely black; Occiput dark brown with prominent occipital crania; Antennae filiform, black to dark brown with 14 flagellomeres, F_1 and F_2 almost equal in length, scape and pedicel yellow in colour; Mandible basally broad and apically tapered, sharp; Propodeum rectangular, with narrow central areola; FW and HW hyaline with brown reduced wing venation, with numerous short spines along costal vein, triangular pterostigma prominent, radial vein well developed, FW with incomplete venation, Rs+M absent, marginal cell open, m-cu and r-m cross-veins also absent HW with SC+R arrangement of vein; Abdomen medially dilated and tapered apically, varied colouration from yellow to black; Legs slender, ochreous with dark brown variegation, femoras yellowish; Ovipositor sheath varied in shape, blunt, curved upwards, sub ovoid with a upcurved and pointed tip ovipositor.

Host association: *D. rapae* mostly act as a solitary, polyphagous endo-parasitoid of a diverse range of aphid taxa, attacking several agricultural & horticultural crops (Akhtar *et al*., 2010 and Talebi *et al*., 2023). During the experiment, mostly the mummified aphids were collected from *L. erysimi* (Kalt.) and *B. brassicae* (L.) aphid hosts associated with mustard field. Banshtu *et al*. (2022) reported that this koinobiont parasitoid *D. rapae* is a potential biocontrol agent of about 98 species of aphids and exhibiting about 31.69% parasitism rate only on *L. erysimi* (Pradhan *et al*., 2022). According to Gauraha *et al*. (2021), *D. rapae* has a wide host range such as *Myzus persicae*, *Diuraphis noxia*, *Rhopalosiphum padi* and *Schizaphis graminum*, *Aphis gossypii*, *Aphis craccivora*, *R. maidis*, *Hyalopterus pruni*, *Aphis nerii*, that's why this species is regarded as cosmopolitan parasitoid. Becoming a a polyphagous parasitic wasp yet *D. rapae* is considered an efficient natural enemy of *M. persicae*, *L. erysimi* (Kalt.) and *B. brassicae* (L.) on brassica crops. (Singh *et al*., 2015 and Soni *et al*., 2022).

Distribution: Atrauli, Khair, Iglas and Saumna blocks of Aligarh district.

Taxonomic hierarchy of *Diaeretiella rapae* (MacIntosh)

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Sub-Class: Pterygota

Division: Exopterygota

Order: Hymenoptera

Suborder: Apocrita

Superfamily: Ichneumonoidea

Family: Braconidae

Subfamily: Aphidiinae

Genus: *Diaeretiella* .

Species: *rapae* MacIntosh

According to the checklist of aphidophagous predators & parasitoids, maximum diversity along with the highest no. of prey-predator-host i.e. tritrophic associations, can be recorded only from the state of Uttar Pradesh. Among 299 models of total tritrophic associations, 98 triplets of predator population and 11 triplets of hymenopteran parasitoids were only recorded from western UP (Singh *et al*., 2024). According to Tiwari *et al.* (2024ii), 41% of newly reported tritrophic interactions were solely recorded from the north-eastern part of UP.

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References

Ahmed, K.S., Majeed M.Z., Rafi M.A., Sellami F. and Afzal M. (2017). Biodiversity and species distribution of Coccinellids (Coccinellidae: Coleoptera) in District Sargodha (Punjab), Pakistan. *Pak. J. Zool*., **49(5)**, 5-12.

Ahmad, M.E. and Singh R. (1995). Records of Macrosiphini of Northeastern Uttar Pradesh and its relationship with food plants and natural enemies. *J. Aphidology*, **9 (1–2)**, 80–86.

Akhtar, M.S., Dey D. and Usmani M.K. (2010). Redescription Of *Diaeretiella rapae* (M ' Intosh) (Hymenoptera : Braconidae : Aphidiinae) with Morphological Variability of Several Populations from India. *Munis Entomol. Zool*., **6**, 194-203.

Ali, M., Raza G., Ali S., Anjum, Syed I. and Hussain I. (2018). The Tribe Coccinellini Weise (Coleoptera: Coccinellidae) in Sindh, Pakistan. *The Coleopterists Bulletin*, **72(3)**, 629-638.

Ali, A., Rizvi P.Q. and Khan F.R. (2009). On the predation of aphids by *Ischiodon scutellaris* (Diptera: Syrphidae) under natural environment. *Bionotes*, **11(3)**, 95–96.

Banshtu, T., Verma S.C., Sharma P.L., Chandel R.S., Katoch S., Sharma N. and Sharma P. (2022). Biology and Demographic Parameters of *Diaeretiella Rapae* (McIntosh) against

Brevicoryne Brassicae (L.). *Acta Scientific Agriculture*, **6(11)**, 03-14.

Bieñkowski, A. (2018). Key for identification of the ladybirds (Coleoptera: Coccinellidae) of European Russia and the Russian Caucasus (native and alien species). *Zootaxa*, **4472 (2)**, 233-260.

Brunetti, E. (1920). *Fauna of British India*, including Ceylon and Burma. London: Taylor and Francis, Ltd.

Cao, L., Zeng Q., Ren Q., Zeng A. and Zhang Y. (2022). Morphological characteristics and biological cycle of the hoverfly *Eristalinus arvorum* (Fabricius, 1787) (Diptera, Syrphidae). *Frontiers in Sustainable Food Systems*, **6**, 1052908.

Che, L., Zhang P., Deng S., Escalona H., Wang X., Li Y., Pang H., Vandenberg N., Œlipiñski A., Tomaszewska W. and Liang D. (2021). New insights into the phylogeny and evolution of lady beetles (Coleoptera: Coccinellidae) by extensive sampling of genes and species. *Molecular Phylogenetics and Evolution*, **156**, 107045

Chowdhury, S., Sontakke P.P., Boopathi T., Bhattacharjee J., Bhattacharjee D. and Malasawmzuali (2015). Taxonomic studies on predatory cocccinellid beetles and their species composition in rice ecosystem of Indo-Bangladesh border. *BioScan*, **10(1)**, 229-242.

Dhanapati, G.K., Pal S. and Rani K.S. (2024). Exploring the diversity of coccinellid species: A comprehensive study on polymorphism and species-specific male genitalia identification. *ENTOMON*, **49(3)**, 435–444.

Ferrer-Suay, M., Barreda M., Rakhshani E., Rodrigo E., Selfa J. and Polaszek A. (2025). A Review of Aphid Parasitoids, with an Identification Key to the Genera of Economic Importance. *Insects*, **16(7)**, 648-667.

Gauraha, R. and Ganguli J. (2021). Biology of aphid mummy (*Diaeretiella rapae*) (Mclntosh) and testing of its host preference among different species of aphids under laboratory conditions at Raipur, Chhattisgarh. *The Pharma Innov. J.*; **10(11S)**, 215-218.

Geethanjali, L., Singh B. and Tiwari A. (2024). A Comprehensive Review on Holistic Approaches for Managing Mustard Aphid, *Lipaphis erysimi* (Kalt.). *Plant Archives*, **24(2)**, 925-930.

Goulet, H. and Huber J.T. (1993). *Hymenoptera of the world: An identification guide to families*. Agric. Can. Ottawa, Ontario. p. 680.

Heo, C.C., Rahimi R., Mengual X., Sahirul M., Zainal S., Khofar P.N. and Nazni W.A. (2020). *Eristalinus arvorum* (Fabricius, 1787) (Diptera: Syrphidae) in Human Skull: A New Fly Species of Forensic Importance. *J. Forensic Sci.*, **65**, 276-282.

Hayat, M. (1998). Aphelinidae of India (Hymenoptera: Chalcidoidea): a taxonomic revision. *Memoirs on Entomology International*, **13**, 1–416.

Halder, J., Rai A.B. and Kodandarm M.H. (2014). Parasitization preference of *Diaeretiella rapae* (Hymenoptera: Braconidae) among different aphids in vegetable ecosystem. *Indian J. Agricult. Sci.*, **84 (11)**, 1431–1433.

Iqbal, Z., Azad R., Jin X., Hassan M.A., Abbas M., Nasir M., Bodlah I., Ali M., Szawaryn K. and Nie R.-E. (2024). The review of the genus Coccinella (Coleoptera, Coccinellidae) from Pakistan. *Biodiver. Data J.*, **12**, 1-32.

Joshi, S. and Ballal C.R. (2013). Syrphid predators for biological control of aphids. *J. Biological Control*, **27(3)**, 151-170.

Khalil, H., Afzal M., Aqueel M.A., Raza A.B.M., Khalil M.S., Khalil F. and Shurjeel H.K. (2019). Seasonal biodiversity of braconidae (Hymenoptera) in citrus orchards of Sargodha, Pakistan. *Sarhad J. Agricult.*, **35(2)**, 476-490.

Koirala, S. (2020). Mustard aphid and crop production. *Int. J. Appl. Sci. Biotechnol.*, **8(3)**, 310-317.

Kumar, H., Singh S. and Yadav S.P. (2020). Biology of mustard aphid, *Lipaphis erysimi* on *Brassica juncea* genotype RH 725 in semi-arid zone of Haryana, India. *Crop Research*, **55(5)**, 281-286.

Kumar, S. (2015). Relative Abundance of Turnip Aphid and the Associated Natural Enemies on Oilseed Brassica Genotypes. *J. Agricult. Sci. Technol.*, **17**, 1209-1222.

Kishor, R., Malik Y.P., Sirajuddin, Mishra P.K., Kushwaha D. and Verma S.K. (2023). Correlation between the seasonal incidence of aphids and coccinellids on the Indian mustard in different varieties and sowing dates. *Int. J. Environ. Clim. Change*, **13 (11)**, 1452–1466.

Landge, A., Dwivedi S.A. and Landge S.A. (2024). A review on application of integrated pest management tactics for aphid complex on crop ecosystem. *Int. J. Adv. Biochem. Res.*, **8**, 458-468.

Manoj, V., Vidya V., Ramesha B. and Sreekumar K.M.. (2024). Taxonomic Studies of the Tribe Coccinellini (Coleoptera: Coccinellidae) of Kerala. *Indian J. Entomol.*, 1-9.

Maqbool, A., Rather S.U. and Akbar S.A. (2020). Preliminary Survey of Ladybird Beetle Composition (Coleoptera: Coccinellidae) in Unmanaged Apple Orchard Ecosystems of Kashmir Himalayas. *Proc Zool Soc.*, **73**, 160–174.

Maruthadurai, R. (2023). *Biodiversity of Hoverflies* (Insecta: Diptera: Syrphidae) of the Protected Areas of Goa.

Omkar and Bind R.B. (1995). Records of aphids natural enemies complex of Uttar Pradesh. IV. The coccinellids. *J. Advanced Zool.*, **16 (2)**, 67–71.

Omkar and Pervez A. (1999). New record of coccinellids from Uttar Pradesh I. *J. Advanced Zool.*, **20(2)**, 106–112.

Omkar and Pervez A. (2000). New record of coccinellids from Uttar Pradesh II. *J. Advanced Zool.*, **21(1)**, 43–47.

Omkar, Kumar G. and Sahu J. (2009). Performance of a predatory ladybird beetle, *Anegleis cardoni* on three aphid species. *Europ. J. Entomol.*, **106**, 565–572.

Poorani, J. (2002). An annotated checklist of the Coccinellidae (Coleoptera) (excluding Epilachninae) of the Indian Subregion. *Oriental Insects*, **36**, 307-383.

Pradhan, P.P., Borkakti R.N. and Saikia D.K. (2020). Insect Pests of Mustard and their natural enemies in Assam. *Int. J. Microbiol. Appl. Sci.*, **9(7)**, 2785-2790.

Rai, P.K., Yadav P., Kumar A., Sharma A., Kumar V. and Rai P. (2022). *Brassica juncea*: A crop for food and health. In : *The Brassica juncea Genome*, 1-13.

Rafi, U., Usmani M.K. and Akhtar M.S. (2010). Aphids of ornamental plants and winter vegetables and their aphidiine parasitoids (Hymenoptera: Braconidae) in Aligarh region, Uttar Pradesh. J. *Threatened Taxa*, **2(9)**, 1162–1164.

Rakhshani, E., Talebi A.A., Manzari S., Rezwani A. and Rakhshani H. (2006). An investigation on alfalfa aphids and their parasitoids in different parts of Iran, with a key to the parasitoids (Hemiptera: Aphididae; Hymenoptera: Braconidae: Aphidiinae). *J. Entomological Soc. Iran*, **25(2)**, 1-14.

Rawat, B.A. and Kunwar R. (2024). Mustard aphid: identification and control strategies. *J. Oilseed Brassica*, **15(1)**, 26-32.

Rego, C., Smit J., Aguiar A.F., Cravo D., Penado A. and Boieiro M. (2022). A pictorial key for identification of the hoverflies (Diptera: Syrphidae) of the *Madeira archipelago*. *Biodiversity Data J.*, **10**.

Roy, B., Sengupta J., Naskar A., Mandal G. and Banerjee D. (2023). Characterisation and Morphologically Identification of Scavenger Syrphid (Insecta: Diptera) pupae using Scanning Electron Microscopy (SEM) study. *Records of the Zoological Survey of India*, **123(i2S)**, 235-244.

Saeady, El, Hakam A., Sherif, Hafez F., Abied M. and Bedewy M. (2020). Taxonomical Revision of The Tribe Coccinellini (Coleoptera: Coccinellidae) in Egypt. *Egyptian Acad. J. Biological Sci.*, **13**, 23-47.

Sahoo, S.K. (2012). Incidence and management of mustard aphid (*Lipaphis erysimi* Kaltenbach) in West Bengal. *The J. Plant Prot. Sci.*, 4(1): 20-26.

Sankar, A.C., Bijoy C. and Shaji E.M. (2024). A checklist of hover flies (Diptera, Syrphidae) of Kerala, India. *ENTOMON*, **49**, 65-74.

Sarker, S., Howlader A.J., Rain F.F. and Aslam A.F.M. (2019). Predator performance of *Coccinella transversalis* and its molecular identification. *Bangladesh J. Zool.*, **47(2)**, 229-241.

Sengupta, J., Naskar A., Maity A., Hazra S., Sarkar N. and Banerjee D. (2017). Hover Flies (Diptera: Syrphidae) from Darjeeling Himalaya—A Part of Indo-Burmese Hotspot. *Indian J. Entomol.*, **79**, 336-353.

Sengupta, J., Naskar A., Maity A., Hazra S., Mukhopadhyay E., Banerjee D. and Ghosh S. (2016). An Updated Distributional Account of Indian Hover flies (Insecta: Diptera: Syrphidae). *J. Entomol. Zool. Stud.*, **4(6)**, 381-396.

Singh, R. and Singh G. (2015). Systematics, distribution and host range of *Diaeretiella rapae* (Mcintosh) (Hymenoptera: Braconidae, Aphidiinae). *Int. J. Res. Stud. Biosci.*, **3**, 1-36.

Singh, K. and Singh N. (2013). Preying Capacity of Different Established Predators of the Aphid *Lipaphis erysimi* (Kalt.) Infesting Rapeseed-Mustard Crop in Laboratory Conditions. *Plant Prot. Sci.*, **49(2)**, 84-88.

Singh, R. (2024). Checklist of natural enemies of *Lipaphis erysimi* (Kaltenbach, 1843) and *Lipaphis pseudobrassicae* (Davis, 1914) (Hemiptera: Aphididae) and their host plant associations in India. *J. Anim. Diver.*, **6 (3)**, 1–25.

Singh, Y.P., Meghwal H.P. and Singh S.P. (2009). Evaluation of some bioagents against mustard aphid (*Lipaphis erysimi* (Kaltenbach)) (Hemiptera: Aphididae) on single plant in field condition. *J. Biological Control*, **23(1)**, 95–97.

Soni, S. and Kumar S. (2020). Biological and behavioural characteristics of *Diaeretiella rapae* (McIntosh), a parasitoid of *Lipaphis erysimi* (Kaltenbach) infesting oilseed brassicas in India. *Biocontrol Science and Technology*, **31(4)**, 400–417.

Soni, S., Kumar S., Singh R., Badiyala A. and Chandel R.S. (2022). Aphid parasitoid, *Diaeretiella rapae* (McIntosh) (Hymenoptera: Braconidae): opportunities for its use in integrated management of aphids infesting rapeseed-mustard in north-western Indian Himalayas. *Crop Protection*, **151**, 105819.

Shukla, A. and Kumar A. (2024). Population dynamics of mustard aphid Lipaphis erysimi (Kalt) and its coccinellid predators. *Indian J. Entomol.*, No. **e24553**, 1–3.

Talebi, A.A., Kazemi M., Rezaei M., Mirhosseini and Mohammad A. (2023). Temperature-Dependent Demographic Parameters of *Diaeretiella rapae* (M'Intosh, 1855) (Hymenoptera: Braconidae) on *Schizaphis graminum* (Rondani, 1852) (Hemiptera: Aphididae). *J. Entomological Res. Soc.*, **25**, 31-43.

Thakur, D., Kumar S., Kumar A., Parmar K., Vishwakarma S.D. and Chadar N. (2024). Introduction and Management of Mustard Aphid [*Lipaphis erysimi* Kaltenbach (Homoptera: Aphididae)]: A Review. *J. Scientific Research and Reports*, **30(8)**, 477–484.

Thompson, F.C. (1999). A key to the genera of the flower flies (Diptera: Syrphidae) of the neotropical region including descriptions of new genera and species and a glossary of taxonomic terms. *Contributions Entomol. Int.*, **3**, 319 378.

Tiwari, K.M., Singh R. and Tripathi P.N. (2024i). Biosystematics, economic importance, natural enemies and food plants of *Lipaphis erysimi* (Kaltenbach, 1843) (Hemiptera: Aphididae) in India. *Munis Entomology & Zoology*, **19 (2)**, 615-635.

Tiwari, K.M., Tripathi P.N. and Singh R. (2024ii). Biodiversity of aphidophagous predators in Ayodhya district, Uttar Pradesh. *Arthropods*, **13 (3)**, 120 –156.

Van Achterberg C. (1993). Illustrated key to the subfamilies of the Braconidae (Hymenoptera: Ichneumonoidea). *Zool. Verh.*, **283**, 1–89.

Vasista, T., Chalam M.S.V., Hariprasad K.V. and Mohan N.G. (2020). Biodiversity of coccinellid fauna associated with groundnut crop-ecosystem from Rayalaseema region of Andhra Pradesh. *J. Entomol. Zool. Stud.*, **8(4)**, 1313-1319.

Warwick, S. and Sauder C. (2011). Phylogeny of tribe Brassiceae (Brassicaceae) based on chloroplast restriction site polymorphisms and nuclear ribosomal internal transcribed spacer (ITS) and chloroplast trnL intron sequences. *Canadian J. Botany*, **83(5)**, 467-483.