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RESEARCH

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The hymenopterous parasitoids of the diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae), on cruciferous vegetables in Delhi, India

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Abstract

Background The diamondback moth (DBM), *Plutella xylostella* (L.) (Lepidoptera: Plutellidae), is a serious and economically important pest of crucifers in Delhi, India. Larvae and pupae of the pest were collected from the cabbage, cauliflower and broccoli crops grown in vegetable fields at the farm of ICAR-Indian Agricultural Research Institute (ICAR-IARI), New Delhi-110012, from December 2021 to June 2022. The larvae and pupae of the pest were transferred to the laboratory and reared for emergence of parasitoids' adults at 25 ± 0.5 °C and RH 70 ± 5%.

Results Four parasitoid species were emerged, viz. *Apanteles mohandasi* Sumodan & Narendran 1990, *Cotesia vestalis* (Haliday, 1834), *Diadegma insulare* (Cresson, 1865) and *Diadromus collaris* (Gravenhorst, 1829). Among them, *A. mohandasi*, *C. vestalis* and *D. collaris* were reported for the first time in Delhi, whereas *D. insulare* (Hymenoptera: Ichneumonidae) is recorded here for the first time in India. Additionally, the first record of parasitism by *A. mohandasi* on *P. xylostella* from Delhi was established. The highest parasitism percentage was that of *C. vestalis* and *D. collaris*. Moreover, higher parasitism rate was recorded during May 2022 in organically cultivated fields. The parasitism percentage by *A. mohandasi*, *C. vestalis*, *D. insulare* and *D. collaris* was 7.5, 22.5, 12.5 and 15%, respectively. Conversely, in conventionally farmed fields, the parasitism rates were 3.57, 16.67, 10 and 13.33%, respectively.

Conclusion The use of biological control agents particularly the parasitoids in the IPM program of *P. xylostella* should be considered, thereby reducing reliance on insecticides and increasing the efficacy of hymenopteran parasitoids.

Keywords *Plutella xylostella*, Biological control, Conventional, *Cotesia*, Organic, *Diadegma*, Braconidae, Ichneumonidae, *Diadromus*, Delhi

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Background

The diamondback moth, *Plutella xylostella* (Linnaeus) (Lepidoptera: Plutellidae), is one of the most significant insect pests of cruciferous crops worldwide (Saini et al. 2019). It significantly affects several economically important crucifer crops such as cauliflower, cabbage, mustard, radish, mustard greens, broccoli, Brussels sprout, Chinese kale and Chinese cabbage. Specifically, it highly prefers cauliflower and cabbage due to their fleshy succulent leaves, which offer both olfactory and gustatory stimuli (Singh and Singh 1982). In India, it caused significant yield losses varying from 31 to 100% (Chaubey and Murthy 2018). Depending on the crop and the extent of infestation, *P. xylostella* causes significant economic yield losses of up to 92% in cabbage, 75% in broccoli and 30% in cauliflower (Farias et al. 2020). The pest's resistance to pesticides inclusive of *Bacillus thuringiensis* has been well established (Sarfraz and Keddie 2005). Pratissoli et al. (2008) observed that insecticides used in cabbage fields reduced the efficacy of *Cotesia vestalis* and *Diadegma insulare* in Malaysia. Since insecticides are toxic to both parasitoid species and human beings, using biocontrol agents, particularly parasitoids, offers a more environmentally friendly alternative for pest control.

Recently, much emphasis has been given to biocontrol agents, including parasitoids for keeping this pest below the economic injury level. Worldwide, *P. xylostella* has been associated with over than 90 nominal species of parasitoids (Azidah et al. 2000). Among them, *Diadromus collaris* (Grav.), *Diadegma semiclausum* (Hellen), *D. rapi* (Cameron), *D. mollipla* (Holmgren), *D. insulare* (Cresson), *D. fenestralis, Itoplectis* nr. *himalayensis* (Hymenoptera: Ichneumonidae), *Cotesia vestalis* (Haliday), *Apanteles* sp. (Hymenoptera: Braconidae) and *Oomyzus sokolowskii* (Kurdjumov) (Hymenoptera: Eulophidae) have been reported in various studies (Saini et al. 2019).

Syed et al. (2018) recorded six parasitoid species, acting as primary parasitoids of *P. xylostella* at different life stages. These included the larval parasitoid *Cotesia* sp., *C. vestalis* (Haliday) and *Diadegma* sp.; a larval–pupal parasitoid *Oomyzus sokolowski* (Kurdjumov); and a pupal parasitoid *Diadromus collaris* (Grav.) and *Brachymeria excarinata* Gahan.

The present study aimed to assess the parasitism rate of the parasitoids associated with the diamondback moth, *P. xylostella* in both organic and conventional fields (cabbage, cauliflower and broccoli) in Delhi.

Methods

This study was conducted over three consecutive seasons (winter, spring and summer) between December 2021 and June 2022 to investigate and evaluate the potential of parasitoid species associated with *P. xylostella* in both organic and conventional vegetable fields at ICAR-IARI, New Delhi-110012.

Working sites

The organic field received farmyard manure (10 t h^{-1}), vermicompost (10 t h^{-1}), bone meal (100 kg h^{-1}) and neem cake (200 kg h^{-1}). In contrast, the inorganic fertilizers such as urea (46%), di-ammonium phosphate (DAP 18%) and muriate of potash (MOP 60%) at rates equivalent to 160 kg N ha^{-1}, 80 kg P_2O_5 ha^{-1} and 60 kg K_2O ha^{-1} were used in the conventional field. Additionally, insecticides, viz. Confidor 17% SL, Indoxacarb 14.5% SC and Boadshah 20% SE, were applied to control pests.

Meteorological data during the study period including rainfall, minimum and maximum temperatures, and relative humidity were recorded from an agrometeorological observatory, Division of Agricultural Physics, ICAR-IARI, New Delhi, and are provided in (Additional file 1: Fig. S1).

Sampling

Larvae and pupae of *P. xylostella* were collected weekly from 20 randomly selected plants (cabbage, cauliflower and broccoli) in each field (organic and conventional) during the period extending from December 2021 to June 2022. Each field was divided into four quarters, and five plants per quarter were randomly sampled. The live samples were transferred to the laboratory and reared in transparent/glass-rearing jars for adults' emergence of parasitoids under laboratory conditions of 25 ± 0.5 °C, 70 ± 5% RH and a photoperiod of 12 light:12 dark hrs. Larvae were fed on fresh leaves of cabbage and cauliflower during the rearing period.

Emerged parasitoids' adults were preserved in 70% alcohol and card mounted for taxonomic identification, and the parasitism percentage during each month was calculated according to the following equation:

$$\textbf{Parasitism}(\%) = \frac{\text{Total parasitoids emerged from larvae or pupae}}{\text{Total No.of larvae or pupae collected from field}} \times 100$$

Wasps were identified with the help of Nixon (1974), Azidah et al. (2000), Rousse and Villemant (2012), and Rousse et al. (2013). The morphological studies were carried out using Leica S8AP0 stereomicroscope and LEICA M205 C stereozoom automountage microscope. Multi-focused montage images were taken using LEICA MC190 HD digital camera attached to the LEICA M205 C stereozoom automountage microscope. The morphological terminology is based on (Goulet and Huber 1993; Wahl and Sharkey 1993). Additionally, most morphological terms were also defined on the HAO website (http://portal.hymao.org/projects/32/public/ontology/). The wing venation taxonomy followed (Gauld 1991; Gauld and Bolton 1996; Whitfield et al. 2009). All the specimens were deposited in the National Pusa Collection (NPC), ICAR-IARI, New Delhi, India.

Results

Taxonomic account

In this study, the main diagnostic characteristics of all species of parasitic wasps found were highlighted, along with their material examined, host records and distribution details.

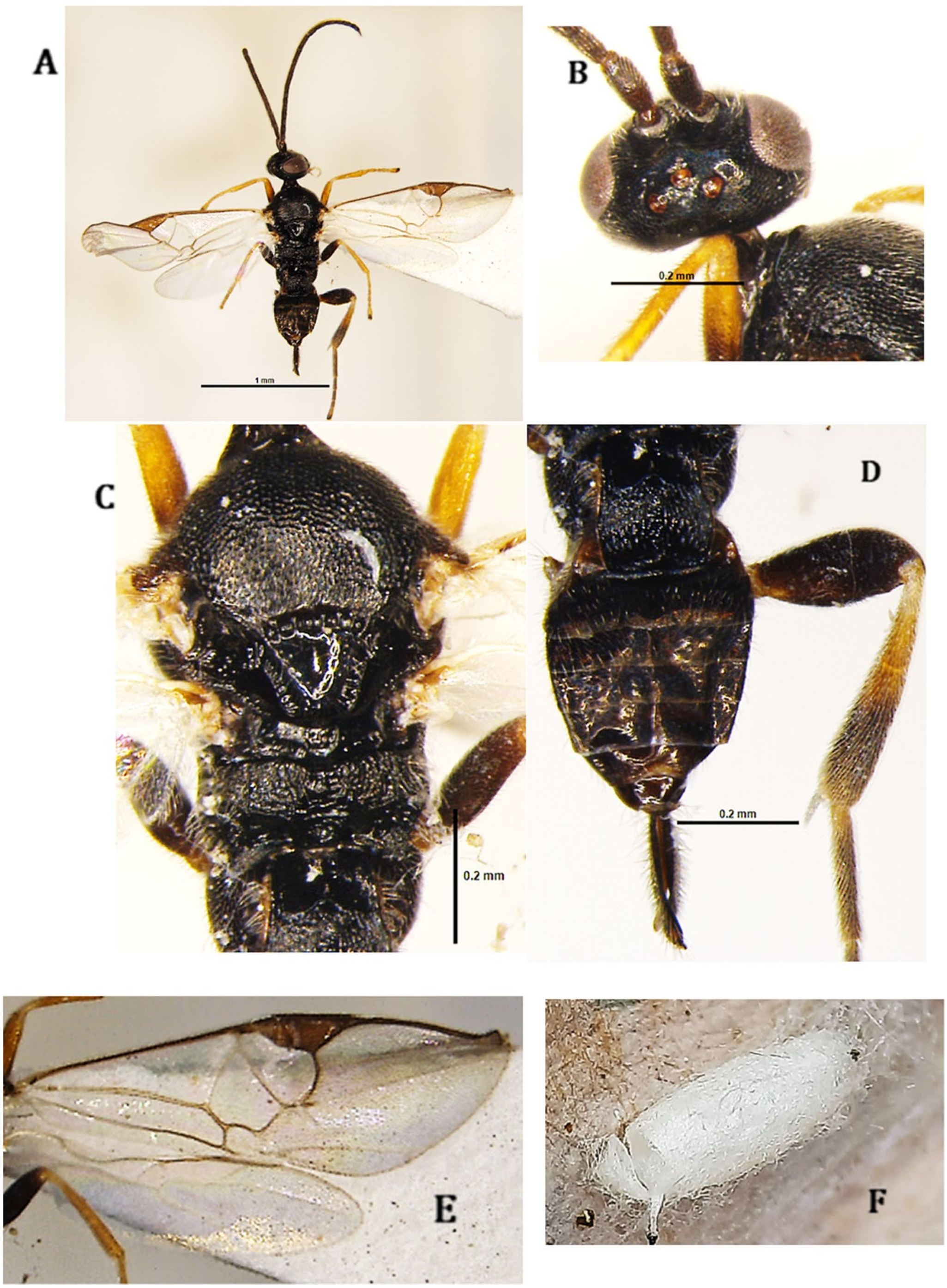

Fig. 1 *Apanteles mohandasi* Sumodan & Narendran, 1990 (female:**A**–**E**); **A**. dorsal habitus, **B**. dorsal view of head, **C**. dorsal view of mesosoma, **D**. dorsal view of metasoma, **E**. forewing and hind wing and **F**. pupa of parasite

***Apanteles mohandasi* (Sumodan & Narendran 1990) (Hymenoptera: Braconidae) (Fig. 1A–E)**

*Diagnosis*Female body length 2.0–2.4 mm. Body black, antennae dark brown to black, ocelli light brown (Fig. 1B), scape, all coxae and trochanters dark brown to black. Apex of fore femora, apical half of mid-femora, fore and mid-tarsi, and basal half of hind femora with yellow coloration. Apical half of fore and hind tibia with brown infuscation. Vertex rugose, frons and face with fine sculpture and minute punctuations. Mesoscutum distinctly punctate and densely setose. Scutellum smooth (Fig. 1C), impunctate, both the lateral edges with long pale white setae. Propodeum with distinct areola and costulae (Fig. 1C), setose on the apical half on both sides of areola; spiracles rounded. Metasoma shorter than combined length of head and mesosoma (Fig. 1D). T1 coarsely rugose, slightly wider at apex than extreme base. T2 with finely rugose. Rest of the tergites smooth and shiny. Ovipositor sheath very stout and uniformly curved apically with long white setae throughout its length (Fig. 1D), shorter than metasoma and hind tibia.

Material examined 1♀ March; 3♀ April; 5♀ May; 2♀ June.2022 emerged from larvae and 1♀ March; 3♀ May.2022 cabbage yellow pan trap, ICAR-IARI, New Delhi (HC).

Host records Pammene critica (Tortricidae) (Gupta et al. 2011; Gupta and Fernandez-Triana 2014).

Distribution India, Uttar Pradesh and Kerala (Gupta et al. 2011).

Remarks This species can be easily confused with the closely allied species *A. taragamae*, and the last can be easily distinguished by the following characteristics: Ovipositor sheaths not unusually stout and as long as metasoma, distinctly little shorter than hind tibia; forewing with stigma pale and colorless but with a distinct dark brown border (Gupta et al. 2011).

***Cotesia vestalis* (Haliday, 1834) (Hymenoptera: Braconidae) (Fig. 2A–D)**

Diagnosis Body black with the following areas yellowish: legs bright reddish yellow, hind femur with dark tip, second tergite distal to basal field often extensively yellow-marked, metasoma usually laterally bright yellowish (Fig. 2A), tegula yellow, frequently third tergite with a pale band segment. Ocelli in slightly lower triangle. Punctuation of mesoscutum coarse and dense, shining interspaces on each side of the middle line, scutellum densely rugose-punctate all over (Fig. 2C), no smooth interspaces anteriorly. Hind coxa dull, densely rugose all over, inner spur of hind tibia not longer than outer one and not reaching beyond middle of hind basitarsus. Metasoma T3 setose on its almost entire surface (Fig. 2B).

Material examined 3♀ February; 3♀, 2♂ March; 5♀, 4♂ April; 10♀, 3♂ May; 4♀, 2♂ June.2022 emerged from larvae and 2♀ March; 2♂, 2♀ May.2022 cabbage; 2♂, 2♀ May.2022 cauliflower, yellow pan trap, ICAR-IARI, New Delhi (HC).

Host records around 30 lepidopteran species in Noctuidae (*Helicoverpa armigera* and *Spodoptera exigua*), Plutellidae (*P. xylostella*), Arctiidae, Pieridae, Nymphalidae, Lasiocampidae, Lymantriidae, Notodontidae, Pterophoridae, Pyralidae and Tortricidae (Nixon 1974; Rousse and Gupta 2013).

Distribution Palearctic, Oriental, Australasian, Ethiopian Region, Benin and South Africa and Reunion (Rousse and Gupta 2013).

Remarks Cotesia vestalis closely resembles *C. ruficrus*. Both species are distinguishable by the microsculpture of the scutellum (which is coarser in *C. vestalis*) and the pilosity of T3 entirely setose in *C. vestalis*, while in *C. ruficrus* the pilosity is restricted to the apical margin.

***Diadegma insulare* (Cresson 1865) (Hymenoptera: Ichneumonidae) (Fig. 3A–F)**

Diagnosis

Female Body length 4.75–5.90 mm. Hind tibia light yellow with sub-basal and apical dark brown bands (Fig. 3E), metasoma generally black with brown to orange–brown on T2 to T4 or from T2 onwards laterally (and sometimes postero-dorsally). Antennae with 20–23 flagellomeres, occipital carina complete. Vein 3rs-m of the forewing present, vein M receiving vein 2m-cu at the middle or slightly after the middle of the areolet. Area superomedia of propodeum distinctly narrowing posteriorly and angulations indicate its posterior end in the median longitudinal carinae, costula strong and usually complete, anterior of area superomedia pointed (Fig. 3B), no dorsolateral depression above spiracle on T1, apical margin of 7th metasomal tergite a little emarginate sometime emargination indistinct, no apical emargination of 5th and 6th metasomal tergites.

Male Similar to female, except for absence of apical emargination of T7, antennae with 23–25 flagellomeres and male thinner than female (Fig. 3F).

Material examined 1♀ February; 2♀ March; 2♀, 1♂ April; 2♀, 2♂ May; 2♀ June.2022 emerged from larvae and 1♀ March; 1♀ May.2022 cabbage; 1♂ May.2022 cauliflower, yellow pan trap, ICAR-IARI, New Delhi (HC).

Host records Plutella xylostella, *P. armoraciae* Busck, *P. omissa* Walsingham (Lepidoptera: Plutellidae), *Phthorimaea operculella* (Zeller) (Lepidoptera: Gelechiidae) and *Hellula undalis* (Fabricius) (Lepidoptera: Crambidae) (Rousse and Villemant 2012).

Distribution Argentina, Canada, Cuba, Egypt, Honduras, Israel, Jamaica, Mexico, Morocco, Nearctic;

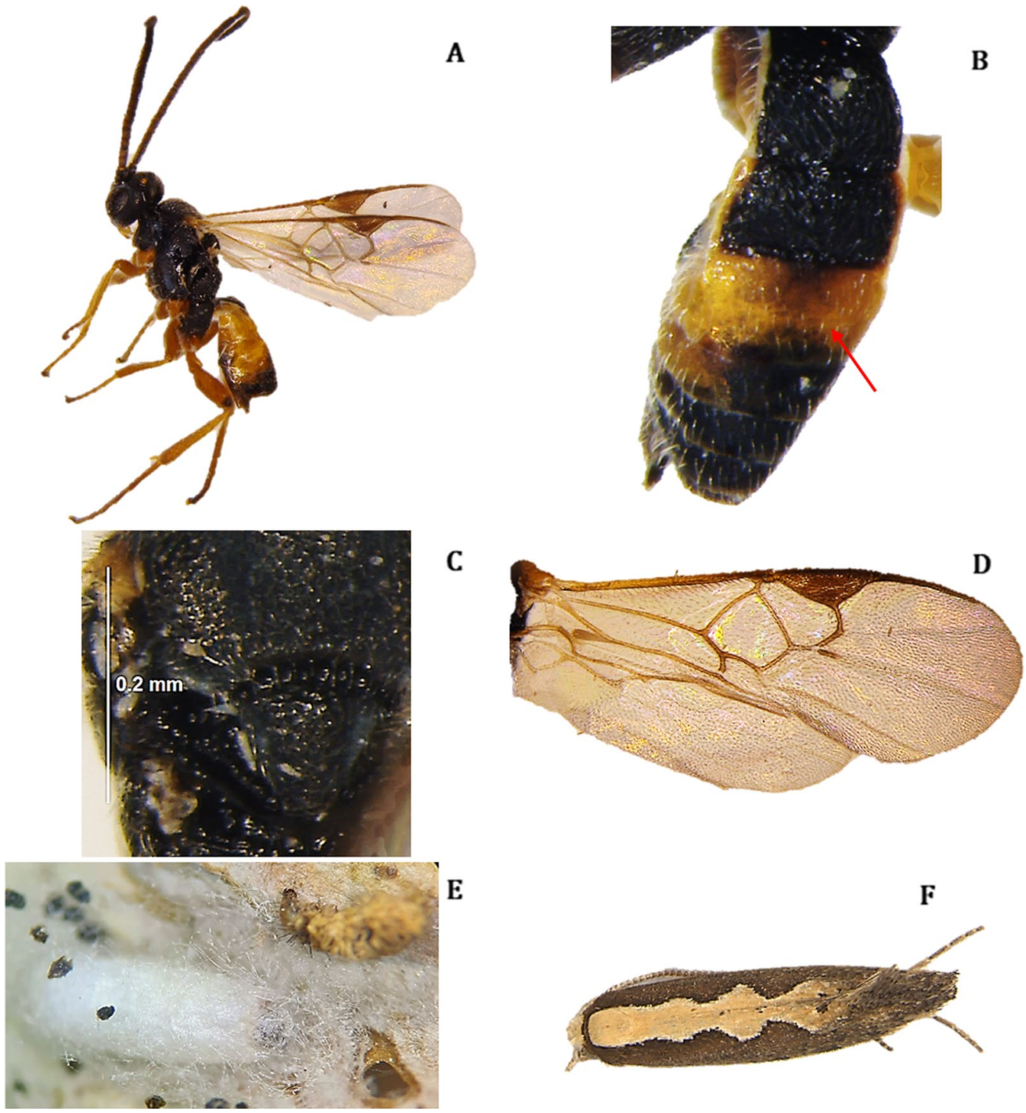

Fig. 2 *Cotesia vestalis* (Haliday, 1834) (female); **A**. lateral habitus, **B**. dorsolateral view of metasoma, **C**. mesoscutum (part) and scutellum, **D**. forewing and hind wing, **E**. pupa of parasite and **F**. *Plutella xylostella*

Neotropical; Oceanic; Oriental; Western Palaearctic, Peru, Philippines, Réunion, Thailand, USA and Venezuela (Yu et al. 2016).

Remarks D. insulare is similar to *D. rapi*, area superomedia of propodeum distinctly narrowing posteriorly and its posterior end indicated by angulations in the median longitudinal carinae and area superomedia wider compared to *D. rapi*, and Vein 3rs-m of the forewing present in *D. insulare*, while it is absent in *D. rapi*. Additionally, *D. insulare* and *D. semiclausum* are very similar, differentiated by the emargination of apical tergites in females. Females have a little emarginate, sometime emargination indistinct (Azidah et al. 2000).

***Diadromus collaris* (Gravenhorst, 1829) (Hymenoptera: Ichneumonidae) (Fig. 4A–F)**

Diagnosis Body reddish orange with the following area black: head, propodeum (Fig. 4D), apex and base of metasoma (Fig. 4C). Face, frons, vertex and temple shallowly and densely to moderately punctate, antenna with 23–30 flagellomeres. Mesosoma entirely polished and middling setose, pronotum moderately punctate with a large median smooth area, mesopleuron densely punctate, speculum smooth, metapleuron coarsely punctate rugose, mesonotum moderately punctate, scuto-scutellar groove smooth, scutellum carinate to mid-length, propodeum shallowly punctate rugose, area petiolaris concave,

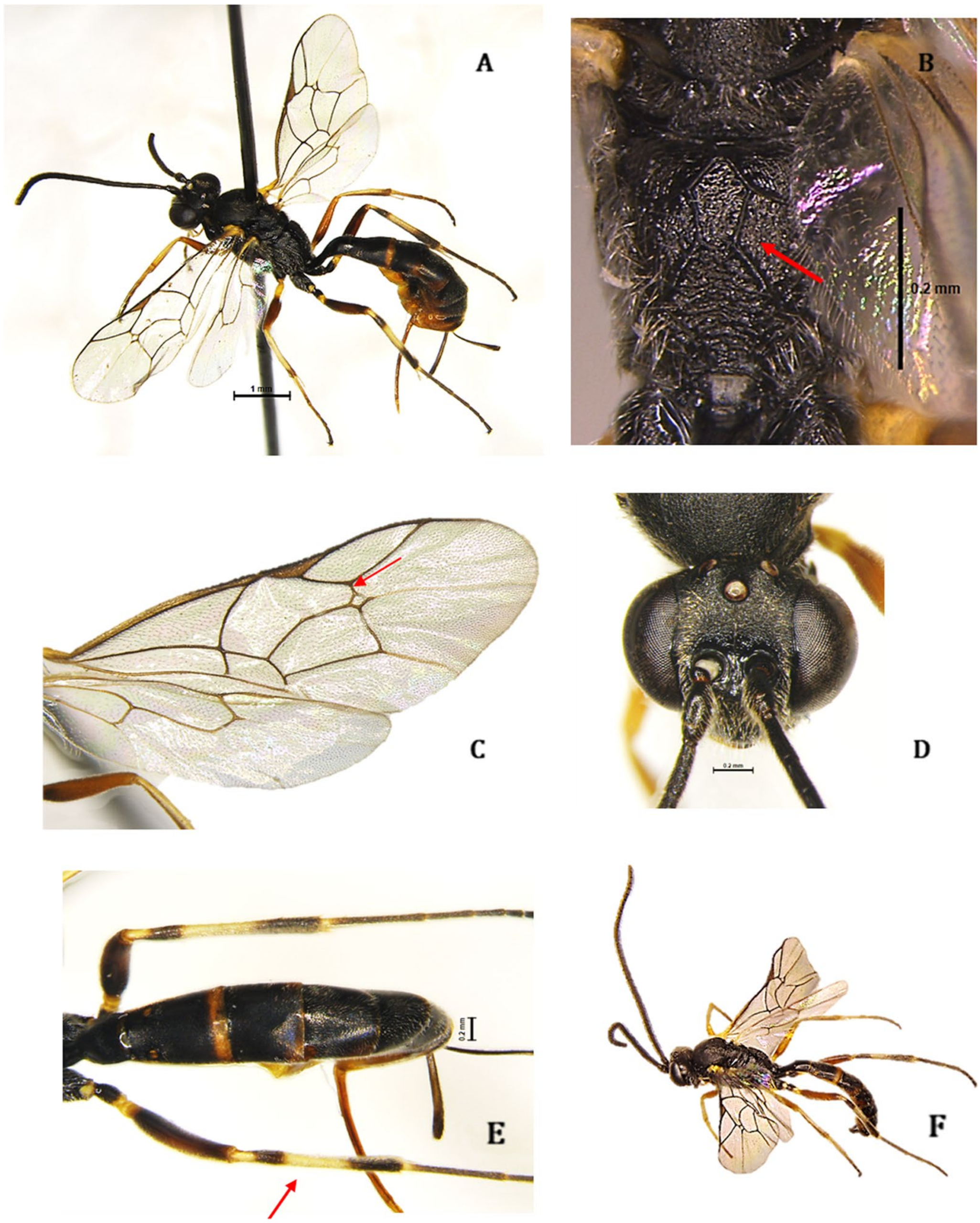

Fig. 3 *Diadegma insulare* (Cresson, 1865) (female: **A**–**E**); **A**. dorso-lateral habitus, **B**. propodeum, **C**. forewing and hind wing (arrow shows petiolate areolet), **D**. frontal view of head, **E**. dorsal view of metasoma and hind leg (arrow shows color pattern of hind tibia) and **F**. dorso-lateral habitus of male

carination complete with area superomedia hexagonal, slightly wider than long, hind wing with distal abscissa of Cu1 discernible though faint, metasoma alutaceous but apical half of T1 and base of T2 longitudinally striate.

Material examined 1♀ February; 2♀ March; 3♀, 2♂ April; 7♀ May; 4♀ June.2022 emerged from larvae and 1♀ March; 1♀ May.2022 cabbage; 2♀ May.2022 cauliflower, yellow pan trap, ICAR-IARI, New Delhi (HC).

Host records Commonly used as a biological control agent of *P. xylostella* (Lepidoptera: Plutellidae) on cultivated cruciferous crops (*Brassica* spp.). Also, it reared from *Crolepiopis assectella* (Lepidoptera: Plutellidae) (Rousse et al. 2013).

Distribution South Africa, Mexico, Europe, Middle East, Indo-Australian region, Asia, China and Japan (Rousse et al. 2013).

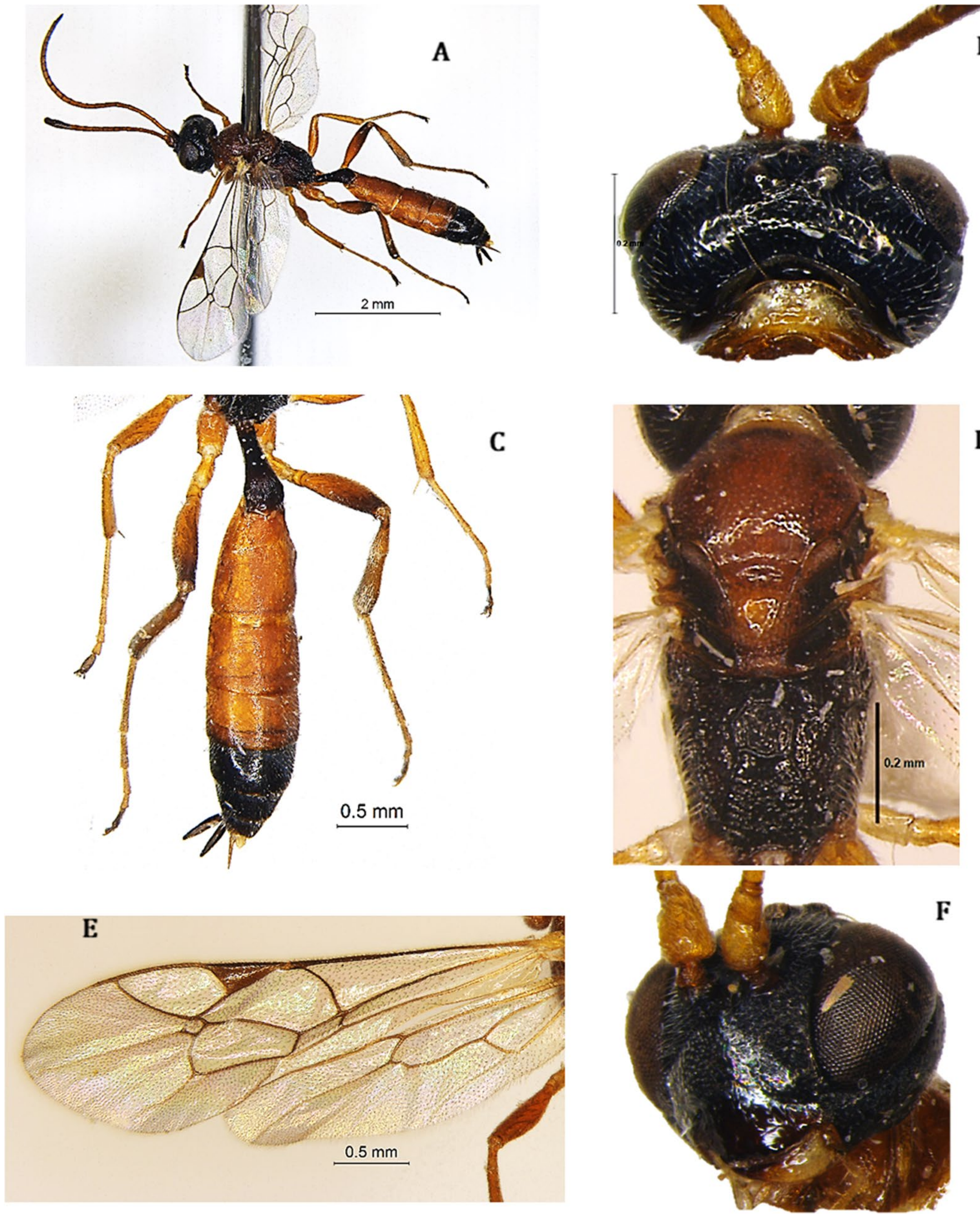

Fig. 4 *Diadromus collaris* (Gravenhorst, 1829) (female); **A**. dorso-lateral habitus, **B**. head dorsal view, **C**. dorsal view of metasoma, **D**. dorsal view of mesosoma, **E**. forewing and hind wing and **F**. frontal view of head

Biological studies

To assess the parasitism rate, the larvae and pupae of *P. xylostella* were collected weekly from cabbage, cauliflower and broccoli grown in organic and conventional fields from December 2021 to June 2022. The collected *P. xylostella* was subsequently reared in the laboratory. Emerged parasitoid species were recorded, and the parasitism percentage during each month was estimated. Our findings revealed that the trend in parasitism was likely to vary due to factors such as environmental conditions, farming methods and species of parasitoids. Occurrence of parasitoids was observed from March to June in organic and conventional vegetable fields. The parasitism percentage by all parasitoid species gradually increased, with lowest rates in February and the highest was in May, followed by a decrease in June (Table 1 and Fig. 5).

Table 1 Rate of parasitism (%) on *Plutella xylostella* (L.) in organic and conventional fields from December 2021 to June 2022

Months	Organic field				Conventional field			
	C. vestalis	*D. collaris*	*D. insulare*	*A. mohandasi*	*C. vestalis*	*D. collaris*	*D. insulare*	*A. mohandasi*
December	0	0	0	0	0	0	0	0
January	0	0	0	0	0	0	0	0
February	8	4	4	0	5	0	0	0
March	15	7.5	5	2.5	12.12	6.06	3.03	0
April	17.5	10	10	5	12.5	9.37	6.25	3.12
May	22.5	15	12.5	7.5	16.67	13.33	10	3.57
June	16.66	10	6.67	3.33	13.33	6.66	3.33	2.71

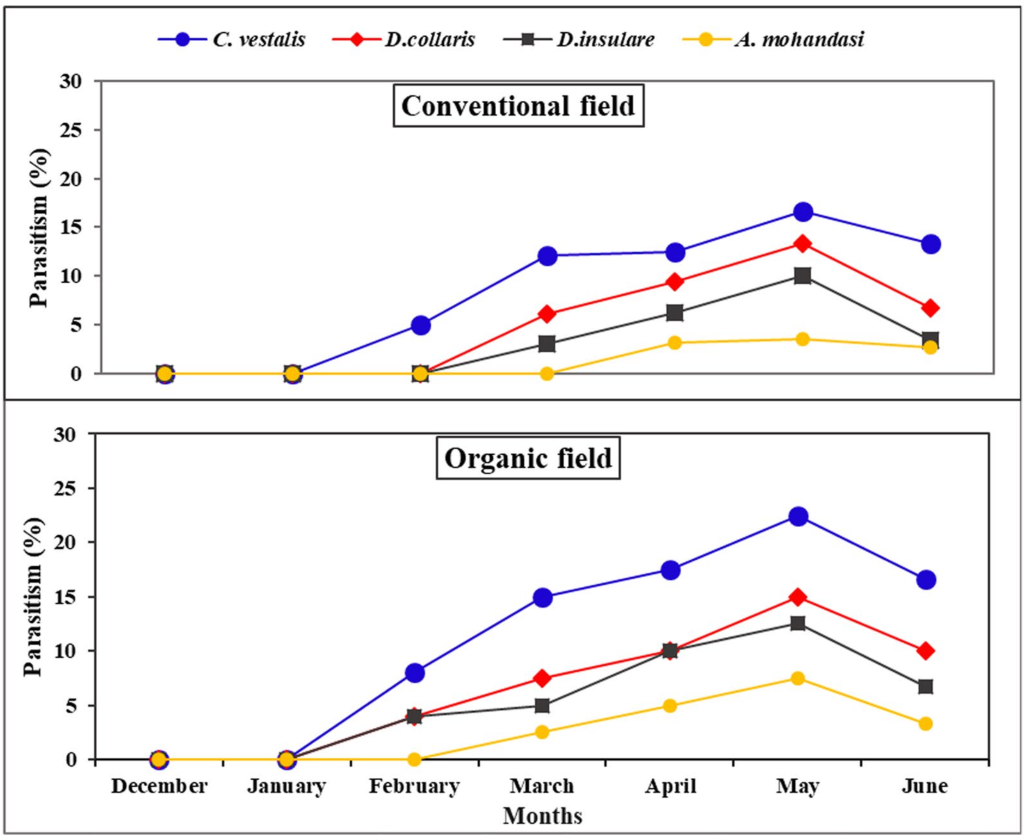

Fig. 5 Rate of parasitism (%) on *Plutella xylostella* (L.) in organic and conventional fields from December 2021 to June 2022

Cotesia vestalis, the larval endoparasitoid of *P. xylostella*, exhibited highest parasitism rates in organic and conventional fields during May, reaching 22.50% and 16.67%, respectively. In February, the parasitism rate was 8% and 5% in organic and conventional fields, respectively. However, the parasitism rate increased in June, recording 16.66% and 13.33% in organic and conventional fields, respectively. *Diadromus collaris* was one of the major pupal endoparasitoids of *P. xylostella*, exhibiting parasitism rates of 15% and 13.33% in organic and conventional fields, respectively, in May, followed by 10% and 9.37% in April and 10% and 6.66% in June. *Diadegma insulare*, the larval parasitoid of *P. xylostella*, caused parasitism (%) of 12.5 and 10% in organic and conventional fields, respectively, in May, followed by 10% and 6.25%, in April, and followed by 6.67% and 3.33%, respectively, in June. Lastly, *A. mohandasi*, the larval parasitoid of *P. xylostella*, was first recorded on this pest in the present study and caused parasitism (%) of 7.5% and 3.57% in organic and conventional fields, respectively, in May, followed by 5% and 3.12% in April, and 3.33% and 2.71% in June (Table 1 and Fig. 5).

Discussion

Four species belonging to four genera in two families (Braconidae and Ichneumonidae) attacking the larvae and pupae of *P. xylostella* were identified. Among them, three species *A. mohandasi*, *C. vestalis* and *D. collaris* were reported for the first time in Delhi, and one species *D. insulare* was recorded for the first time in India. These species were obtained by rearing the larvae and pupae of *P. xylostella*, which were collected from infested host crops (cabbage, cauliflower and broccoli). The highest infestation of this insect was observed in cauliflower, while broccoli had the lower infestation rate.

Parasitism percentage of *C. vestalis* on *P. xylostella* varied throughout the months in both organic and conventional fields, with the highest rates in May and the lowest in February. These results align with a previous study conducted by Chaubey and Murthy (2018), who found that *C. vestalis* exhibited a 10% parasitism in July. Additionally, Kahuthia-Gathu et al. (2017) reported a 50% parasitism rate of *C. vestalis* on *P. xylostella*. Similarly, Syed et al. (2018) reported that parasitism of *C. vestalis* on *P. xylostella* was highest in the non-sprayed farm compared to farms treated with insecticides. This suggests that *C. vestalis* has a considerable potential as a biological control agent for *P. xylostella* (Sithole et al. 2019).

The parasitism of *D. collaris* on *P. xylostella* (L.) was observed in organic and conventional fields between February and June, with the highest occurrence in May and the lowest in February. Our findings agree with Liu et al. (2000), who recorded a 40% parasitism rate of *D. collaris* on *P. xylostella* in Brassica crops. In their study, the unsprayed plots exhibited higher parasitism rates than the sprayed ones. Additionally, Sithole et al. (2019) corroborated our findings regarding the parasitism of *D. collaris* on *P. xylostella*.

Diadegma species plays a significant role as natural regulators of *P. xylostella* populations worldwide. The parasitism of *D. insulare* on *P. xylostella* was recorded from February to June in the organic field and March to June in conventional field, with the highest incidence observed in May. Our results partially support the findings of Monnerat et al. (2002), who reported that *D. insulare* can parasitize 70–90% of *P. xylostella* larvae, leading to a 35–80% reduction in food consumption compared to non-parasitized larvae. Hutchison et al. (2004) also observed high levels of parasitism by *D. insulare*, exceeding 80% for 4th instar and 50% for 3rd instar, while 1st instar exhibited low parasitism rates.

Finally, *A. mohandasi* is a solitary endoparasitoid of *P. xylostella* larvae, first recorded on this pest in the present study. It was recorded during the period between March to June in the organic field and from April to June in the conventional field, with the highest occurrence in May. Our findings are supported by Bhat and Bhagat (2008), who reported the presence of *Apanteles* sp. on *P. xylostella* in India. Similarly, in South Africa, Dennill and Pretorius (1995) recorded *Apanteles halfordi* Ullyett on *P. xylostella*. Additionally, Guilloux et al. (2003) identified *Apanteles piceotrichosus* (Blanchard) as the dominant parasitoid in *P. xylostella*; however, its parasitism was insufficient to regulate *P. xylostella* populations. Furthermore, Ayalew and Ogol (2006) recorded a 17.7% parasitism of *Apanteles* sp. on *P. xylostella* in Ethiopia.

Conclusions

The diamondback moth, *P. xylostella*, is the most destructive pest that causes significant losses of cruciferous crops in Delhi, where cauliflower is more heavily infested than cabbage and broccoli. The present study identified four species, viz. *A. mohandasi, C. vestalis, D. insulare* and *D. collaris*, emerged from *P. xylostella*. The dominant parasitoid was *C. vestalis*, exhibiting a higher parasitism rate in both fields, followed by *D. collaris*, *D. insulare* and *A. mohandasi*. The parasitoid *A. mohandasi* was recorded for the first time as a parasitoid of *P. xylostella* in India. The parasitism percentage in the organic field was higher than in the conventional field, which could be attributed to the insecticide application in the conventional field, which negatively affected the parasitism rates. Based on our findings, applying insecticides in conventional fields negatively impacted the parasitoids and their host. Therefore, augmentation of these parasitoids and reducing reliance on insecticides in the IPM program of *P. xylostella* was strongly encouraged.

Abbreviations

T1	First metasoma tergite
T2	Second metasoma tergite
T3	Third metasoma tergite
T7	Seventh metasoma tergite
Cu	Cubital vein
M	Medius vein
m-cu	Medio-cubital cross-vein
3rs-m	Areolet distinctively large when delimited by 3rs-m vein
Cu1	Cubitus 1 vein
NPC	National Pusa Collection
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agricultural Research
HC	Hager collection

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s41938-023-00735-7.

Additional file 1: Fig. S1. Weather parameters during the study period from December 2021 and June 2022. Data was recorded by the Agrometeorological Observatory, Division of Agricultural Physics, IARI, New Delhi. TMAX, Maximum Temperature; TMIN, Minimum Temperature; RH, Relative Humidity.

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Author contributions
H.M.M.S. collected the specimens and took part in writing—draft preparation. D.D. contributed to supervision and wrote—reviewed and edited—the manuscript. B.S.T. wrote—reviewed and edited—the manuscript. All the authors have read and approved the final manuscript.

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Availability of data and materials
Not applicable.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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