



## Seasonal incidence of insect pests and their natural enemies in mustard ecosystems: A comprehensive review

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### Abstract

Mustard (*Brassica* spp.) is a major oilseed crop in India and is prone to attack by a wide range of insect pests throughout its growth stages, leading to substantial yield losses. Among these, the mustard aphid *Lipaphis erysimi* (Kalt.), mustard sawfly *Athalia lugensproxima*, flea beetle *Phyllotreta cruciferae*, and painted bug (*Bagrada cruciferarum* and *B. hilaris*) are of major economic importance. This review synthesizes decades of research on the seasonal incidence, population dynamics, and influencing meteorological parameters of these pests, along with the occurrence of their natural enemies. Studies consistently reveal that *L. erysimi* appears from November to April, with peak activity during January-February under temperature ranges of 17-24°C and relative humidity between 60-85%. Rainfall exerts variable effects, with light showers favouring population build-up and heavy rains causing dislodgement. Mustard sawfly incidence generally begins in October-December, with optimal development at temperatures between 19-30°C, while flea beetle populations peak in February. Painted bugs show seedling-stage damage and activity peaks either in winter or during crop maturity depending on the species. Natural enemies, particularly *Diaeretiella rapae*, *Coccinella septempunctata*, *Cheilomenes sexmaculata*, syrphid flies, and lacewings, play a vital role in pest suppression, with parasitism levels often exceeding 80-90% during late crop stages. Temperature, humidity, sunshine hours, wind velocity, and crop phenology significantly influences the timing and intensity of both pest and predator populations. Understanding these seasonal patterns are critical for developing timely, ecologically sound pest management strategies in mustard cultivation.

**Keywords:** *Athalia lugens proxima*, *Bagrada cruciferarum*, *Bagrada hilaris*, *Brassica* pests, *Coccinella septempunctata*, *Diaeretiella rapae*, *Lipaphis erysimi*, *Phyllotreta cruciferae*, population dynamics

### Introduction

Mustard (*Brassica* spp.) is one of the most important oilseed crops grown in India, occupying a significant place in the agricultural economy due to its edible oil, industrial by-products, and role in crop diversification. It is cultivated extensively in the rabi season across diverse agro-climatic zones, contributing substantially to the national oilseed production. However, mustard productivity is often constrained by a variety of biotic stresses, among which insect pests are of prime concern. The crop is highly vulnerable from seedling to maturity, and pest outbreaks not only reduce yield but also adversely affect oil content and quality. Several insect pests infest mustard, with the mustard aphid, *Lipaphis erysimi* (Kalt.), being the most destructive and widespread, capable of causing yield losses up to 70-90% under severe infestation. Other economically

important pest includes mustard sawfly (*Athalia lugensproxima*), flea beetle (*Phyllotreta cruciferae*), and painted bugs (*Bagrada cruciferarum* and *B. hilaris*). The incidence and severity of these pests are closely linked to weather conditions such as temperature, relative humidity, rainfall, sunshine hours, and wind velocity, as well as crop phenology and sowing time. Understanding these seasonal patterns is essential for predicting pest outbreaks and implementing timely, effective management strategies. In addition to pests, mustard fields harbour a range of natural enemies including parasitoids, predators, and entomophagous insects, which play a significant role in suppressing pest populations. The seasonal abundance and activity of these natural enemies are also influenced by climatic factors and pest population dynamics. This review consolidates findings from previous studies on the seasonal incidence of major

Table 1: Seasonal incidence and population dynamics of mustard aphid (*Lipaphis erysimi*) in India

Period	Researcher(s)	Seasonal incidence & population trends	Favourable / unfavourable conditions
1950s-1970s			
	Narayanan (1958)	persists till April; winged adults common in Feb-Mar; decline in summer. Population fluctuations linked to temperature & host maturity; rainfall caused short-term decline. Maximum abundance at 17-18°C and RH 61-83%. Independent of temperature & humidity; rainfall suppressed populations.	First appearance in November; Decline with high temperature. High temp & maturity <sup>†</sup> ; rainfall temporary decline. Optimal: 17-18°C, RH 61-83%. Rainfall <sup>†</sup> population.
	Atwal <i>et al.</i> (1971)		
	Srivastava & Srivastava (1972) Roy (1975)		
1980s	Bakhetia & Sidhu (1983)	Fecundity & reproduction adversely affected by rainfall, >30°C, and sub-zero temp; best at 20-30°C.	Optimal: 20-30°C; adverse: >30°C, <0°C, rainfall.
	Singh & Singh (1986)	Max 25.3°C, Min 5.1°C; RH 88% (morning), 28% (evening) conducive; >30°C, predation, crop maturity reduced aphids.	Moderate temp & RH favourable.
	Ram & Gupta (1987)	Max 21.4-22.8°C, Min 5.9-7.6°C, RH 31-41% (evening) favourable; mild showers & cloudy weather <sup>†</sup> aphids, heavy rainfall <sup>†</sup> .	Mild rain/cloudiness <sup>†</sup> ; heavy rain <sup>†</sup> .
	Sinha <i>et al.</i> (1989)	Appearance: 3rd week Nov; peak: 2nd week Feb (23.5°C max, 8.5°C min, RH 74.5/55.7%); light rains increased infestation.	Light rain & moderate temp support buildup.
1990s	Ahuja (1990)	Appearance late Dec; peak late Jan-early Feb; negative correlation with temperature & sunshine; positive with humidity.	Low temp & high RH favourable.
	Sinha <i>et al.</i> (1990)	Optimum: Max 21.7-23.5°C, Min 7.2-9.4°C, RH 55.7-69.4%; ceased when RH <50.9%.	RH above 50% critical.
	Bishnoi <i>et al.</i> (1992)	Optimum development at 10-13.5°C and RH 72-85%; cloudiness enhanced abundance.	Cool, humid, cloudy conditions.
	Rana <i>et al.</i> (1993)	Appearance late Dec/early Jan; 14.1°C avg temp & 85% RH most favourable.	Low temp + high RH.
	Singh & Rai (1994)	Maximum RH three days prior strongly associated with population buildup.	Lag effect of RH.
	Shrivastava <i>et al.</i> (1995)	Rapid multiplication in Feb (15.8-24.7°C, RH 61-65%); Jan-mid Feb rains <sup>†</sup> , late Feb rains <sup>†</sup> population.	Rainfall timing important.
	Samdur <i>et al.</i> (1997)	Negative correlation with temp, evaporation, sunshine, wind; positive with RH. Optimum: Max 23°C, Min 10°C, RH 85-88% (max), 30-35% (min), sunshine 4-7h/day, evaporation 2-3 mm/day, wind 3-4.5 km/h.	Balanced moderate weather.
	Singh & Malik (1998)	Onset early Jan; peak mid-Feb; higher RH & wind velocity reduced aphids. Direct relation between max temp and aphid population in B. juncea cv. Varuna.	Moderate RH & low wind favourable. Higher temp <sup>†</sup> aphids.
	Srivastava <i>et al.</i> (1999)	Delayed sowing <sup>†</sup> aphid abundance & infestation index; peak early Jan-late Feb.	Delayed sowing <sup>†</sup> severity.
	Sonkar & Desai (1999)	Infestation: 5 <sup>th</sup> -14 <sup>th</sup> SW; peak in 7 <sup>th</sup> SW (-70-day crop) with 602 aphids/plant.	Peak in early Feb.
	Panda <i>et al.</i> (2000)	Numbers <sup>†</sup> until 3 <sup>rd</sup> week, then decline; ETL-based spraying improved yield (9.2 q/ha), profit (₹ 10,020/ha), oil (40.6%).	ETL-based management effective.
	Sharma & Yadav (2000)		
2000s-2010s	Chaudhari <i>et al.</i> (2001)	<i>B. carinata</i> resistant; <i>B. campestris</i> & <i>B. napus</i> more susceptible under higher fertilization.	Fertility <sup>†</sup> susceptibility.
	Kulkarni & Patel (2001)	High incidence Jan-Feb; peak in 1 <sup>st</sup> week Feb.	Early Feb peak.
	Talpur & Kuhro (2004)	First on leaves (late Jan), then on inflorescences (mid-Feb); continued till harvest.	Long infestation window.
	Sahito <i>et al.</i> (2016)	<i>L. erysimi</i> persisted from seedling to crop maturity.	Whole crop duration at risk.

insect pests of mustard and their natural enemies across different regions of India. It aims to provide a comprehensive understanding of pest-weather-crop interactions to support the development of ecologically sound, location-specific integrated pest management (IPM) strategies for sustainable mustard production.

### **1. Seasonal incidence and population dynamics of pests and natural enemies**

In rapeseed-mustard ecosystems, the seasonal incidence of insect pests shows a predictable progression influenced by prevailing weather conditions. Mustard aphid (*Lipaphis erysimi*) typically appears from the last fortnight of December, with populations rapidly building up through January and peaking in February under cool temperatures and bright sunshine. The population declines sharply as temperatures rise in March. Flea beetle (*Phyllotreta cruciferae*) activity also begins in late December, with infestation levels reaching their maximum in February, particularly during dry spells with low rainfall. Painted bugs (*Bagrada cruciferarum* and *B. hilaris*) are more prevalent at the seedling stage, with *B. hilaris* often showing activity peaks during October-November and again in March-April, while *B. cruciferarum* causes the most damage during early crop establishment in January-February. Natural enemies such as parasitoids (*Diaeretiella rapae*), coccinellids, syrphid fly larvae, lacewings, and predatory bugs follow seasonal trends, with their numbers generally increasing after pest populations have peaked. This natural build-up during February-March plays a key role in suppressing pests towards the end of the season. Recognizing these patterns enables farmers to synchronize monitoring and management measures, ensuring timely interventions for effective pest control and reduced crop losses.

#### **Mustard aphid (*Lipaphis erysimi*)**

The mustard aphid, *Lipaphis erysimi* (Kaltenbach), is a key pest of rapeseed-mustard and other cruciferous crops in India, with its occurrence and severity closely linked to prevailing agro-climatic conditions. The pest's appearance, population peaks, and decline have been extensively documented across different agro-ecological regions, revealing considerable variability in seasonal dynamics.

#### **Early observations (1950s-1970s)**

Narayanan (1958) reported that *L. erysimi* typically appears in November and continues to cause severe damage to cruciferous crops until April. As summer approaches, rising temperatures induce a decline in population, accompanied by the development of winged adults, which are often observed flying during February-

March. Atwal *et al.* (1971) noted that population fluctuations were primarily driven by high temperatures and host plant maturity. Rainfall events caused immediate population declines, although numbers generally recovered within a week during spring. Srivastava and Srivastava (1972) found that the pest reached maximum abundance at temperatures of 17-18°C and relative humidity levels of 61-83%. Conversely, Roy (1975) suggested that population dynamics were largely independent of temperature and humidity but were consistently suppressed by rainfall.

#### **Effects of temperature and humidity (1980s)**

Bakheta and Sidhu (1983) demonstrated that fecundity, lifespan, and reproduction of *L. erysimi* were adversely affected by rainfall, temperatures above 30°C, and sub-zero winter temperatures, with optimal development occurring between 20-30°C. Singh and Singh (1986) observed that average maximum and minimum temperatures of 25.31°C and 5.15°C, respectively, coupled with morning and evening relative humidity levels of 88% and 28%, were most conducive for aphid development, regardless of host variety. However, temperatures above 30°C, predation by *Coccinella septempunctata*, and crop maturity reduced aphid numbers. Similarly, Ram and Gupta (1987) found that maximum temperatures of 21.4-22.8°C, minimum temperatures of 5.9-7.6°C, and evening relative humidity between 31.2% and 40.9% favoured population buildup. Mild showers (~2.0 mm) and cloudy weather enhanced aphid abundance, whereas heavy rainfall (~10.0 mm) caused significant mortality. Sinha *et al.* (1989) recorded initial aphid appearance in the third week of November, with peak populations in the second week of February at maximum and minimum temperatures of 23.5°C and 8.45°C, respectively, and relative humidity of 74.5% (morning) and 55.7% (evening). Correlation analyses indicated non-significant negative relationships between aphid numbers and major weather parameters, although light rains during the population buildup phase supported higher infestations.

#### **Weather-linked population trends (1990s)**

Ahuja (1990) reported pest appearance in late December, with peak numbers between 26 January and 1 February, noting negative correlations with mean maximum and minimum temperature and sunshine, and positive correlations with humidity. Sinha *et al.* (1990) found that January-February temperatures of 21.7-23.5°C (maximum) and 7.2-9.4°C (minimum), along with relative humidity of 55.7-69.4%, were optimal for aphid buildup, while activity ceased when humidity dropped below 50.9%. Bishnoi *et al.* (1992) observed optimum population development at

Table 2: Seasonal incidence and population dynamics of mustard sawfly (*Athalia lugensproxima* Klug) in India

Parameters	Researcher(s)	Key findings	Favourable / unfavourable conditions
Temperature & humidity requirements	Chaudhary & Bhamburkar (1970)	Alternating low & high temp accelerated development; most favourable: 10-29°C at 60% RH (Nagpur: 9-30°C, 30-90% RH).	Optimal: 10-29°C, 60% RH.
	Thakur (1976) Verma (1992)	Optimum multiplication at 19.7-24.8°C and 62-75% RH. Highest larval population at 26.9-32.1°C with 78-87% RH (morning) and 38-40% (evening). Optimal larval development at 19-30°C; 35°C lethal.	Moderate temperature & RH. Warm days + high morning RH.
Seasonal appearance & peak activity	Singh <i>et al.</i> (1993)	25°C most suitable: shorter larval period, higher pupation & adult emergence.	19-30°C suitable; >35°C lethal.
	Singh & Sachan (1997)	Max temp 20.0-27.2°C, Min 13.1-15.9°C, RH ~64% favoured multiplication.	25°C optimum.
	Anonymous (1998)	First appearance in October; peak damage Oct-Nov.	Cool, humid weather best.
	Bakhetia & Brar (1982)	Peak: 3.4 larvae/plant (49 <sup>th</sup> SW); max/min temp 23.8°C/7.6°C.	Early season pest.
Weather influence on population regulation	Manzar <i>et al.</i> (2000)	Pest occurrence favoured by max 25.6°C-7.7°C and min 24.0°C-14.0°C; humidity effect unclear.	Cooler conditions favourable.
	Gupta <i>et al.</i> (2002)	Infestation begins in December; populations fluctuate till harvest.	Lower temp conducive.
Damage patterns & crop losses	Bhatt & Bhapodra (2004)	Temp & rainfall had negative effects on populations.	Cool season activity.
	Manzar <i>et al.</i> (1998)	Moderate temp & RH favoured multiplication.	Rainfall suppressive.
	Singh <i>et al.</i> (1993); Anonymous (1998)	Maximum damage at early growth stages, 50-60 DAS; up to 73.2% loss recorded.	Moderate weather favours build-up.
	Ansari & Naqshbandi (2004)		Early infestations most destructive.

10-13.5°C and 72-85% relative humidity, with cloudiness further enhancing aphid abundance. Rana *et al.* (1993) recorded appearance in late December or early January, with average temperature of 14.12°C and 85% relative humidity being most favourable. Singh and Rai (1994) emphasized the role of maximum relative humidity three days prior to observation as a key driver of population increases.

Shrivastava *et al.* (1995) linked rapid multiplication during February to maximum temperature of 15.8-24.7°C and relative humidity of 61-65%, with rainfall in January-mid-February enhancing populations, while late-February rains reduced them. Samdur *et al.* (1997) found significant negative correlations with maximum temperature, evaporation, sunshine, and wind velocity, and positive correlations with maximum relative humidity. Optimal conditions included average maximum temperature of ~23°C, minimum temperature of ~10°C, 85-88% maximum relative humidity, 30-35% minimum relative humidity, sunshine for 4-7 h/day, evaporation of 2-3 mm/day, and wind velocity of 3.0-4.5 km/h/day. Singh and Malik (1998) reported pest onset in early January with a mid-February peak, noting negative effects of increasing relative humidity and wind velocity. Srivastava *et al.* (1999) recorded a direct relationship between average maximum temperature and aphid population in *B. juncea* cv. Varuna. Sonkar and Desai (1999) showed that delayed sowing increased aphid abundance and infestation index, peaking between early January and late February.

### Recent observations (2000s-2010s)

Panda *et al.* (2000) reported infestation from the 52<sup>nd</sup> to the 14<sup>th</sup> standard week, peak in the 7<sup>th</sup> week (~70-day-old crop) with 602.10 aphids/plant. Sharma and Yadav (2000) found that aphid numbers increased with exposure duration up to the third week, after which they declined. Timely spraying at economic threshold levels (ETL) resulted in significant yield (9.2 q/ha) and profit (₹ 10,020/ha) gains, alongside improved oil content (40.6%). Chaudhari *et al.* (2001) identified *B. carinata* as resistant across fertility levels, whereas *B. campestris* and *B. napus* showed varying susceptibility with increased fertilization. Kulkarni and Patel (2001) recorded high aphid incidence from early January to late February, peaking in the first week of February. Talpur and Kuhro (2004) observed appearance on leaves in late January and on inflorescences by mid-February, with infestation continuing until harvest. Sahito *et al.* (2016) confirmed that *L. erysimi* could persist from seedling emergence until crop maturity.

### Mustard sawfly (*Athalia lugensproxima* Klug)

The mustard sawfly, *Athalia lugensproxima* Klug, is a serious defoliator of rapeseed-mustard crops in India, with its seasonal activity, population buildup, and intensity of damage closely linked to prevailing temperature and humidity regimes.

### Temperature and humidity requirements

Chaudhary and Bhamburkar (1970) demonstrated that newly hatched larvae exposed to alternating low and high temperatures exhibited accelerated development compared to those maintained at constant high temperatures. They reported that the most favourable range for both larval and adult development was 10-29°C at 60% relative humidity-conditions prevailing in Nagpur from August to February, where temperatures ranged from 9-30°C and humidity from 30-90%. Thakur (1976) found that optimum multiplication occurred between 19.7-24.8°C and 62.2-75.0% relative humidity. Verma (1992) further observed that highest larval populations on toria occurred when maximum temperatures were between 26.9-32.1°C and relative humidity ranged from 78-87% in the morning to 38-40% in the evening. Singh *et al.* (1993) recorded optimal larval development at 19-30°C, with 35°C proving lethal. Singh and Sachan (1997) confirmed that 25°C was the most suitable temperature for the species, producing shorter larval periods, higher pupation, and greater adult emergence. Anonymous (1998) reported that minimum temperatures of 13.1-15.9°C and maximum temperatures of 20.0-27.2°C, along with 64% relative humidity, favoured multiplication.

### Seasonal appearance and peak activity

Bakhetia and Brar (1982) noted that *A. lugensproxima* first appeared in October, with maximum damage occurring during October-November. Manzar *et al.* (2000) reported a peak population of 3.4 larvae/plant during 49<sup>th</sup> standard week, coinciding with maximum and minimum temperatures of 23.8°C and 7.6°C, respectively. Gupta *et al.* (2002) similarly found that temperature of 25.6-7.74°C and 24.0-14.0°C (maximum and minimum, respectively) favoured pest occurrence, with lower temperatures generally conducive to development. However, humidity effects were not clearly established. Bhatt and Bhapodra (2004) recorded the onset of infestation in December, with populations fluctuating through the crop season.

### Weather influence on population regulation

The role of weather factors in regulating *A. lugensproxima* populations has been variable. Manzar *et al.* (1998)

reported negative effects of temperature and rainfall on sawfly populations, while other studies highlighted favourable effects of moderate temperature and humidity on multiplication (Singh *et al.*, 1993; Anonymous, 1998).

### Damage patterns and crop losses

Ansari and Naqshbandi (2004) observed that crop damage was significantly higher at early growth stages, with maximum injury occurring 50-60 days after sowing. They recorded up to 73.20% damage under favourable conditions. This finding underscores the pest's potential to cause severe yield losses when early infestations coincide with susceptible crop stages.

### Flea Beetle (*Phyllotretacruciferae*)

The mustard flea beetle, *P. cruciferae*, is a sporadically serious pest of rapeseed-mustard, particularly during the cooler months of the growing season. Gogoi (1998) reported that the beetle population began increasing from the last fortnight of December, peaking in February. Among meteorological factors, bright sunshine hours and rainfall exhibited a stronger association with fluctuations in population than temperature or relative humidity. Nath and Saikia (2002) provided detailed biological observations, noting that mating occurred during morning hours and lasted 2-18 hours. The incubation period ranged from 6-9 days, while pre-oviposition, oviposition, and post-oviposition periods lasted 14-22, 5-6, and 25-32 days, respectively. Longevity was greater in mated individuals (44-60 days in females and 36-45 days in males) compared to unmated beetles (36-50 days in females and 32-42 days in males). Seasonal abundance trends paralleled earlier reports, with populations rising from late December and peaking in February.

### Painted Bug (*Bagrada cruciferarum* and *Bagrada hilaris*)

The painted bug complex-*B. cruciferarum* and *B. Hilaris*-is known to attack mustard and other cruciferous crops at various growth stages. Srivastava *et al.* (1972) recorded *B. hilaris* infestations in Uttar Pradesh from January to March, with peak activity in February-March. Singh *et al.* (1993) found that *B. hilaris* remained active year-round, exhibiting two major peaks: October-November, coinciding with the seedling stage, and March-April, coinciding with crop maturity, in both paper and Indian mustard. Bhatia and Verma (1994), in a study on cabbage pests, identified *B. hilaris* as a major species in the pest complex. Rohilla *et al.* (2003) specifically noted that *B. cruciferarum* infestations typically occur at the seedling stage, which can lead to substantial early-season damage and poor crop establishment.

### Seasonal incidence of natural enemies of mustard aphid (*Lipaphis serysimi*)

A diverse complex of parasitoids and predators plays a critical role in regulating mustard aphid populations, with *Diaeretiella rapae* (Curtis) (Hymenoptera: Braconidae) emerging as the most important aphid parasitoid in the Indian subcontinent. Atwal *et al.* (1969) conducted detailed studies on the bionomics and parasitization rate of *D. rapae* on *Rhopalosiphum erysimi* (L.) under laboratory and field conditions at Ludhiana, Punjab. The parasitoid completed its life cycle in 6.6-9.5 days, with egg and larval development inside the host lasting 3-5 days, followed by a pupal stage of 3.5-4.5 days after host immobilization. Field observations revealed significant parasitism of *R. erysimi*, *Myzus persicae* (Sulz.), and *Aphis craccivora* (Koch.), with parasitism rates ranging from 15.4% to 97.4%, peaking in early April. In Madhya Pradesh, *D. rapae* was first reported by Singh and Rawat (1981) in 1978, parasitizing *L. erysimi*. The parasitoid became active from mid-January, with initial parasitism rates of ~2%, increasing to over 96% by late February or early March in consecutive years. A sharp decline in aphid populations in late February coincided with the disappearance of both host and parasitoid by mid-March. Similar seasonal trends were reported for *Aphidius* sp., with parasitism beginning in late January and reaching 80-90% by late February, after which both host and parasitoid populations declined (Singh & Rawat, 1983). Predatory coccinellids also contribute substantially to aphid suppression. Shenmar and Brar (1995) demonstrated that *Coccinella septempunctata* (Linn.) and *Cheilomenes sexmaculatus* (Fabricius) consumed an average of 380.4 and 304.3 aphids per larva, respectively. Field releases of second instar larvae at 1000/ha effectively reduced aphid populations, with *C. septempunctata* outperforming *C. sexmaculatus*. Parasitization activity generally commences within 7-10 days after aphid appearance, with initial rates of 6.86-15.34% increasing to over 94% within four weeks (Katole *et al.*, 1998).

Geographical variation in peak parasitization was noted, with maxima recorded in mid-January at Yavatmal (96.63%), late January at Nagpur (88.17%), and end-January at Tarsa (60.63%). In north Gujrat, *D. rapae* and syrphid fly maggots appeared simultaneously around the 11<sup>th</sup> week after sowing, remaining active until crop harvest (Vekaria & Patel, 1999). Kulkarni and Patel (2001) observed that *D. rapae* first appeared on *L. erysimi* in early February (11.27% parasitization), increasing to 43.68% by late February. Populations of *C. septempunctata* and syrphid flies peaked in mid-February (2.90 beetles/plant and 1.70 larvae/plant, respectively) before declining towards the

Table 3: Seasonal incidence and biology of mustard flea beetle (*Phyllotreta cruciferae* Goeze)

Parameters	Researcher(s)	Key findings	Favourable / unfavourable conditions
Seasonal incidence	Gogoi (1998)	Population rose from late December, peaked in February.	Cool season pest, peak in Feb.
Weather influence	Gogoi (1998)	Sunshine hours & rainfall influenced fluctuations more than temperature or RH.	Sunshine & rainfall major drivers.
Biology	Nath & Saikia (2002)	Mating: morning hours, 2-18 h; incubation 6-9 days; pre-oviposition 14-22 d, oviposition 5-6 d, post-oviposition 25-32 d. Longevity: females 44-60 d (mated), 36-50 d (unmated); males 36-45 d (mated), 32-42 d (unmated).	Longer life span in mated individuals.
Population trend	Nath & Saikia (2002)	Population build-up similar to earlier reports-rise in late December, peak in February.	Peak activity in Feb.

Table 4: Seasonal incidence of painted bug complex (*Bagrada cruciferarum* & *B. hilaris*)

Parameters	Researcher(s)	Key findings	Favourable / unfavourable conditions
Seasonal incidence	Srivastava <i>et al.</i> (1972)	<i>B. hilaris</i> infestations Jan-Mar, peak Feb-Mar (U.P.).	Winter-spring activity.
	Singh <i>et al.</i> (1993)	<i>B. hilaris</i> active year-round; two peaks: Oct-Nov (seedling stage) & Mar-Apr (crop maturity).	Seedling & maturity stages vulnerable.
	Bhatia & Verma (1994)	Identified <i>B. hilaris</i> as major pest species in cabbage complex.	Cabbage & crucifers at risk.
	Rohilla <i>et al.</i> (2003)	<i>B. cruciferarum</i> infestations common at seedling stage, causing poor crop establishment.	Early season most damaging.

Table 5: Seasonal incidence of natural enemies of mustard aphid (*Lipaphis erysimi*) in India

Natural Enemy	Location/Study	Seasonal incidence & parasitism/predation	Reference
<i>Diaeretiella rapae</i> (Curtis) (Hymenoptera: Braconidae)	Ludhiana, Punjab	Life cycle completed in 6.6-9.5 days; parasitism of <i>R. erysimi</i> , <i>M. persicae</i> , and <i>A. craccivora</i> ranged 15.4-97.4%, peaking in early April.	Atwal <i>et al.</i> (1969)
<i>D. rapae</i>	Madhya Pradesh	Active from mid-January; parasitism ~2% initially, reaching >96% by late Feb/early Mar; host and parasitoid disappeared by mid-March.	Singh & Rawat (1981)
<i>Aphidius</i> sp.	Madhya Pradesh	Parasitism began in late January, peaked at 80-90% by late February, followed by decline.	Singh & Rawat (1983)
<i>Coccinella septempunctata</i> (Linn.) & <i>Cheilomenes sexmaculatus</i> (Fab.)	Punjab	Consumed 380.4 and 304.3 aphids/larva, respectively; release at 1000 larvae /ha suppressed aphids, <i>C. septempunctata</i> superior.	Shenmar & Brar (1995)

season's end. Dogra *et al.* (2003) reported parasitization onset in mid-January, with maximum rates (5-10%) occurring in early March under mean maximum and minimum temperatures of 22.5°C and 10.3°C, respectively, and 36% relative humidity. Singh *et al.* (2003), in multi-year surveys in eastern Uttar Pradesh, found *C. septempunctata* to be the most abundant predator (41.97%), followed by *Coccinella transversalis* (25.03%), *D. rapae* (11.78%), *Chrysoperla carnea* (7.64%), *Menochilus sexmaculatus* (6.00%), *Ischiodon scutellaris* (3.93%), and *Brumoides suturalis* (3.65%). Natural enemies were present by late December and generally increased until crop maturity, with the exception of *C. carnea* and *I. scutellaris*. Temperature appears to be a key driver of predator-prey dynamics. Talpur and Kuhro (2004) noted that 16.5-20.6°C favored both aphid multiplication and the activity of predators such as *C. carnea*, *C. undecimpunctata*, and *C. septempunctata*, with their appearance coinciding with established aphid populations.

### Seasonal incidence and natural regulation of mustard pests in Assam

The seasonal incidence of insect pests and their natural enemies in mustard ecosystems of Assam has been extensively studied in relation to weather factors. Mustard aphid (*Lipaphis erysimi*) is reported as the most destructive pest, with peak activity during cool and dry months, whereas populations decline under high temperature and humidity (Pradhan *et al.*, 2020c). Surveys have revealed a diverse assemblage of natural enemies, including coccinellids, syrphid flies, chrysopids, and the parasitoid *Diaeretiella rapae*, which play a significant role in natural aphid regulation (Pradhan *et al.*, 2020b). Seasonal fluctuations of both pests and natural enemies were closely associated with meteorological parameters, as also reported in other crops of Assam, where insect population dynamics were shaped by temperature and relative humidity (Borkakati *et al.*, 2007; Ahmed *et al.*, 2016; Begam *et al.*, 2016; Borkakati *et al.*, 2021). Furthermore, habitat manipulation and ecological engineering have been advocated as sustainable approaches to enhance natural enemy activity and reduce pest outbreaks in crucifer and solanaceous ecosystems (Borkakati *et al.*, 2019a; Borkakati *et al.*, 2019b). These findings suggest that integrating weather-based forecasting with natural enemy conservation could offer long-term solutions for mustard pest management in Assam.

### Conclusion

Understanding the seasonal incidence patterns of major insect pests and their natural enemies in mustard ecosystems is crucial for developing timely and effective pest management strategies. The compiled evidence from

various agro-climatic zones of India reveals that *Lipaphis erysimi* remains the most destructive pest across regions, with peak infestations generally occurring from late January to mid-February, coinciding with the crop's flowering stage. Likewise, key natural enemies such as *Coccinella septempunctata*, *Diaeretiella rapae*, and syrphid flies exhibit synchronized population peaks with the pest, indicating their significant role in natural regulation. These insights can guide the precise timing of interventions, allowing integration of biological control agents into pest management schedules and reducing reliance on chemical insecticides. Region-specific monitoring and forecasting models, coupled with habitat manipulation strategies, hold promise for enhancing the sustainability of mustard production in India.

### References

- Ahmed SS, Saikia DK and Borkakati RN. 2016. Seasonal incidence of major pests of cabbage and their natural enemies in Jorhat district of Assam. *Pestology* **40**: 54-60.
- Ahuja DB. 1990. Population dynamics of mustard aphid, *Lipaphis erysimi* (Kalt.) on Indian mustard, *Brassica juncea* (subsp. *juncea*). *J Plant Prot* **18**: 233-235.
- Anonymous. 1998. Annual Progress Report. All India Coordinated Research Project on Rapeseed-Mustard. National Research Centre on Rapeseed-Mustard, Bharatpur, Rajasthan, India.
- Ansari MS and Naqshbandi S. 2004. Incidence of mustard sawfly, *Athalia proxima* (Klug.) on rapeseed-mustard varieties. *J Entomol Res* **28**: 355-359.
- Atwal AS, Chaudhary JP and Ramrajan M. 1969. Some preliminary studies in India on the bionomics and rate of parasitization of *Diaeretiella rapae* Curtis on aphids. *J Res Punjab Agric Univ* **6**: 177-182.
- Atwal AS, Chaudhary JP and Ramrajan M. 1971. Mortality factors in natural population of cabbage aphid *Lipaphis erysimi* Kalt. (Aphididae: Homoptera) in relation to parasite, predators and weather. *Ind J Agric Sci* **41**: 507-510.
- Bakhetia DRC and Brar KS. 1982. Pest control in rapeseed and mustard. *Ind Farm* **11**: 60-63.
- Bakhetia DRC and Sidhu SS. 1983. Effect of rainfall and temperature on the mustard aphid, *Lipaphis erysimi* Kalt. *Ind J Entomol* **45**: 202-205.
- Begam N, Saikia DK and Borkakati RN. 2016. Seasonal incidence of major insect-pests and their natural enemies of Bhut Jolokia. *Ann Plant Prot Sci* **24**: 259-264.
- Bhatia R and Verma A. 1994. Seasonal incidence of major insect pests associated with winter crop of cabbage in Himachal Pradesh. *Ann Agric Res* **15**: 222-225.

- Bhatt PD and Bapodra JG. 2004. Population dynamics of mustard sawfly, *Athalia lugensproxima* (Klug) on mustard in relation to weather parameters. *Ind J Entomol* **66**: 284-285.
- Bishnoi OP, Singh H and Singh R. 1992. Incidence and multiplication of mustard aphid, *Lipaphis erysimi* in relation to meteorological variables. *Ind J Agric Sci* **62**: 710-712.
- Borkakati RN, Saikia DK and Sarma D. 2019. Manipulation of crop habitat to encourage natural enemies against key pests of cabbage ecosystem. *J Entomol Zool Stud* **7**(3): 151-154.
- Borkakati RN, Saikia DK and Venkatesh MR. 2019. Habitat manipulation for managing insect pests of brinjal. *Ind J Entomol* **81**: 717-720.
- Borkakati RN, Saikia DK and Venkatesh MR. 2021. Influence of meteorological parameters on population build-up of brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee. *J Agromet* **23**: 249-251.
- Chaudhari AK, Lai R and Sharma V. 2001. Incidence of mustard aphid, *Lipaphis erysimi* (Kalt.) and *Myzus persicae* (Sulzer) in *Brassica* spp. at varying fertility levels in Himachal Pradesh. *Insect Environ* **7**: 28-29.
- Choudhary MG and Bhamburkar BL. 1970. Effect of alternating temperature on development and longevity of *Athalia proxima* Klug. *Labdev J Sci Technol* **8**: 227-232.
- Dogra I, Devi N and Raj D. 2003. Parasitization of mustard aphid, *Lipaphis erysimi* Kalt. by *Diaeretiella rapae* M'Intosh in Himachal Pradesh. *J Entomol Res* **27**: 145-149.
- Gogoi LP. 1998. Biology and management of mustard flea beetle, *Phyllotreta cruciferae* on mustard. M.Sc. Thesis, Assam Agricultural University, Jorhat, India.
- Gupta RK, Agrawal N and Pandey SD. 2002. Influence of abiotic factors on the population dynamics of mustard sawfly, *Athalia proxima* Klug and mustard aphid, *Lipaphis erysimi* Kalt. *Ind J Environ Sci* **6**: 141-148.
- Katole SR, Nimbalkar SA, Yadgirwar PV, Kadu NR and Kolhe AV. 1998. Parasitization of *Diaeretiella rapae* (M'Intosh) on mustard aphid, *Lipaphis erysimi* (Kalt.). *PKV Res J* **22**: 214-216.
- Kulkarni AI and Patel IS. 2001. Seasonal abundance of mustard aphid (*Lipaphis erysimi*) and associated bio-agent in Indian mustard crop. *Ind J Agric Sci* **71**: 681-682.
- Manzar A, Lal MN and Singh SS. 1998. Correlation between incidence of insect pests on *Brassica* spp. and ecological parameters. *Shashpa* **5**: 171-174.
- Manzar A, Lal MN and Singh SS. 2000. Effect of temperature on incidence of mustard sawfly, *Athalia proxima* Klug; leaf miner, *Chromatomyia horticola* and painted bug, *Bagrada hilaris* on rapeseed-mustard. *Ann Plant Prot Sci* **5**: 44-47.
- Narayanan ES. 1958. Insect pests of rapeseed and mustard and method of their control. *Rape and Mustard (Monograph)*. ICAR, New Delhi, pp. 87-97.
- Nath RK and Saikia DK. 2002. Biology, incidence and population build-up of mustard flea beetle, *Phyllotreta cruciferae* (Goeze) on mustard. *Insect Environ* **8**: 78-79.
- Panda D, Thakur BS and Patil B. 2000. Population dynamics of *Lipaphis erysimi* (Kalt.) on *Brassica juncea* L. at Raipur, M.P. *Plant Prot Bull* **52**: 28-30.
- Pradhan PP, Borkakati RN and Saikia DK. 2020. Bio-efficacy of certain entomopathogenic fungi against major insect pests of *Brassica campestris* var. *toria*. *J Entomol Zool Stud* **8**: 840-843.
- Pradhan PP, Borkakati RN and Saikia DK. 2020. Insect pests of mustard and their natural enemies in Assam. *Int J Curr Microbiol Appl Sci* **9**: 2785-2790. doi: 10.20546/ijcmas.2020.907.328.
- Pradhan PP, Borkakati RN and Saikia DK. 2020. Seasonal incidence of insect pests and natural enemies of mustard in relation to meteorological parameters. *J Entomol Zool Stud* **8**: 1538-1542.
- Borkakati RN, Basit A and Hazarika LK. 2007. Effect of temperature and relative humidity on seasonal abundance of water hyacinth weevil, *Neochetina eichhorniae* Warner and *N. Bruchi* Hustache. *J Ent Res* **31**: 233-236.
- Ram S and Gupta MP. 1987. Effects of weather and sowing time on incidence of mustard aphid, *Lipaphis erysimi* (Kalt.). *Bhartiya Krishi Anusandhan Patrika* **2**: 29-34.
- Rana JS, Khokhar S, Singh H and Sucheta. 1993. Influence of abiotic environment on population dynamics of mustard aphid, *Lipaphis erysimi* Kalt. *Crop Res* **6**: 116-119.
- Rohilla HR, Singh H, Singh H and Chillar BS. 2003. Postharvest losses caused by painted bug, *Bagrada hilaris* (Burm.) in rapeseed-mustard. *J Oilseeds Res* **20**: 257-268.
- Roy P. 1975. Population dynamics of mustard aphid, *Lipaphis erysimi* Kalt. in West Bengal. *Ind J Entomol* **37**: 318-321.
- Sahito HA, Solangi R, Kousar T, Shah ZF and Mangrio WF. 2016. Population fluctuation of aphids, *Lipaphis erysimi* (Kalt.) and response of biological control

- under mustard field conditions. *J Entomol Zool Stud* **4**: 326-331.
- Samdur MY, Gulati SC, Raman R and Manivel P. 1997. Effect of environmental factors on mustard aphid (*Lipaphis erysimi* Kalt.) infestation in *Brassica juncea* germplasm. *J Oilseeds Res* **14**: 278-283.
- Sharma ML and Yadav NS. 2000. Effect of exposure periods on aphid (*Lipaphis erysimi* Kalt.) incidence, seed yield and oil content in *Brassica juncea* var. Pusa Bold. *Natl Seminar Agric Sci - Challenges and Opportunities*, p. 163.
- Shenmar M and Brar KS. 1995. Biological control of mustard aphid, *Lipaphis erysimi* (Kalt.) in Punjab. *J Biol Control* **9**: 9-12.
- Shrivastava A, Singh H and Thakur HI. 1995. Impact of abiotic factors on population dynamics of mustard aphid, *Lipaphis erysimi*. *J Oilseeds Res* **12**: 197-202.
- Singh SV and Malik YP. 1998. Population dynamics and threshold of *Lipaphis erysimi* (Kalt.) on mustard. *Ind J Entomol* **60**: 43-49.
- Singh H and Singh B. 1986. Population dynamics of mustard aphid *Lipaphis erysimi* Kalt. on Brassica genotypes. *Proc Natn Conf Key Pests of Agril Crops*, CSAUAT, Kanpur, 21-23 Dec 1985: 117-123.
- Singh H, Rohilla HR, Ram P and Ahlawat DS. 1993. Outbreak of painted bug, *Bagrada cruciferarum* (Kirk) on oilseeds *Brassicaceae* in India. *Int J Trop Agric* **11**: 153-154.
- Singh NN and Rai VN. 1994. Effect of abiotic factors on development of aphid, *Lipaphis erysimi* Kalt. *Ind J Entomol* **56**: 99-103.
- Singh NN, Pandey R and Rai R. 2003. Relative abundance of effective natural enemies of mustard aphid, *Lipaphis erysimi* (Kalt). *J Appl Zool Res* **14**: 209-211.
- Singh OP and Rawat RR. 1981. Note on safety of some insecticides for *Diaeretiella rapae* M'Intosh, a parasitoid of mustard aphid. *Ind J Agric Sci* **51**: 204-205.
- Singh OP and Rawat RR. 1983. Seasonal incidence and toxicological studies on *L. erysimi* and its parasitoid *Aphidius* sp. in Madhya Pradesh. *Pranikee* **4**: 259-267.
- Singh YP, Upadhyay KD and Awasthi BK. 1993. Efficacy of some plant products against *Athalia proxima* Klug, a pest of mustard crop. *Natl Conf Ecofriendly Approaches in Pest & Disease Management*, CSAUAT, Kanpur, 20-22 Dec: 14.
- Sinha RP, Yazdani SS and Verma GD. 1989. Population dynamics of mustard aphid, *Lipaphis erysimi* (Kalt.) in relation to ecological parameters. *Ind J Entomol* **51**: 334-339.
- Sinha RP, Yazani SS and Verma GD. 1990. Population dynamics of mustard aphid, *Lipaphis erysimi* (Kalt.) in relation to ecological parameters. *Ind J Entomol* **52**: 387-392.
- Sonkar UB and Desai BD. 1999. Effect of sowing dates on incidence of mustard aphid, *Lipaphis erysimi* (Kalt.) on mustard. *Shashpa* **6**: 41-44.
- Srivastava A, Kashyap NP and Srivastava A. 1999. Population buildup of mustard aphid, *Lipaphis erysimi* Kalt. on *Brassica* in relation to weather. *J Insect Sci* **12**: 141-142.
- Srivastava AS and Srivastava JL. 1972. Ecological studies on aphid, painted bug and sawfly attack on mustard and rape in India. *FAO Plant Prot Bull* **20**: 135-140.
- Srivastava AS, Nigam PM and Awasthi BK. 1972. Survey of pests on mustard crop. *Labdev J Sci Technol* **10**: 165-166.
- Talpur MA and Khuhro RD. 2004. Relative occurrence and abundance of mustard aphid, *Lipaphis erysimi* (Kalt.) and their predators on canola varieties. *J Asia Pac Entomol* **7**: 215-219.
- Thakur DK. 1976. Pest complex of mustard crop and efficacy of insecticides against key pests. Ph.D. Thesis Abstract. HAU **2**: 119.
- Vekaria MN and Patel GM. 1999. Succession of important pests of mustard in North Gujarat. *Ind J Entomol* **61**: 356-361.
- Verma RK. 1992. Population dynamics of *Athalia proxima* Klug with reference to efficacy of some plant products. Ph.D. Thesis, GB Pant Univ. Agric. & Tech., Pantnagar, India, p.116.