Chapter-5
Observation

5.1 Thysanopterans on Chilli Crop in District Aligarh of Western Uttar Pradesh
5.2 Occurrence and Damage of Thrips on Chilli Crop
5.3 Pest Investigation by the Monitoring Observation on Chilli Crop
5.4 Weather Influences on Insects
5.5 Taxonomy of *Scirtothrips dorsalis*
5.6 Biology of *Scirtothrips dorsalis*
5.7 Life Cycle of *S. dorsalis*
5.8 Taxonomy and Biology of Natural Enemies of Thrips
5.1 Thysanopterans on Chilli Crop in District Aligarh of Western Uttar Pradesh

In the field of agriculture, an insect may be understood as a pest if the damage caused by it reduces the yield of the host crop quantitatively and qualitatively by an amount that is unacceptable to the farmers. Pest activities cause injury on the plants and consequently damage to the crop as a whole results in significant loss. In the field of agriculture chilli has occupied an important position due to its large scale use in vegetables, spices and daily meals. Many insects attack this crop. The insects included under the order, Thysanoptera are popularly known as “Thrips” or “Bladder-footed insects.” They are one of the smallest pterygotes. They range from 0.5mm to 1.0mm. They possess remarkable structural peculiarities like fringe wings, asymmetrical feeding apparatus and a protrusible bladder. They received little attention in the past among entomologists possibly because of its minute size and unattractive colouration. They have assumed considerable importance as pests of many crops of agriculture and horticulture. Some species of Thrips are vectors of viral diseases. But, majority of the species are phytophagous. Thrips are found in different types of vegetation and are considered to be very susceptible to environmental changes and can thrive only under particular climatic and microclimatic situation. The Biological diversity of Thysanopterans possess remarkable structural diversity. The structural diversity stimulated possibly due to fluctuations in habitat and internal environment. Most of the Thrips species are unicolorous and bright, some are bicolorous and tricolorous. Cuticle shows striking patterns of sculptures, irregular corrugations and transverse striae or granulations.

In a regular monitoring survey of chilli crop in the selected outfields during favourable environmental conditions, we observed that the thrips breeding population infested chilli plant and almost failed to produce any fruits or produced very minimum number of deformed fruits. It was also observed
that thrips were feeding on meristems, terminals and other tender plant parts of the host plant. Thrips feeding was examined on those parts which were present above the soil surface. This pest preferred young plant tissues and was not observed to feed on mature host tissues. During infestation, the colour of damaged tissues changed from silvery to brown or black. The infestation usually started from seedling stage although severe infestation appeared first in the vegetative stages of the chilli plants and then in the flowering and fruiting stages. Thrips population were mostly confined in the ventral surface of the chilli leaf more than what they were in the upper leaf surface. Thrips nymphs and adults sucked the cell sap mostly from the ventral surface of the leaf. This resulted in the infested leaf, which lost its vitality and vigour leaves became curled or twisted. We also observed at that time along with leaf both nymphs and adults sucked the cell sap from the twigs and stem and finally infested and affected twigs which were distorted due to loss of vitality. The indirect damage on host plant also occurred in the form of photosynthetic reduction. During regular monitoring it was also observed that under favourable conditions, thrips reproduced at a faster rate and caused damage upto 35-40% of total chilli production.

Among many pests, thrips is one of the most important constraints in chilli production. Feeding injury by thrips can reduce the leaf size affecting photosynthetic activity of plant and eventually can result in significant yield loss. The thrips may constitute a substantial part of insect fauna associated with chilli fields. In our observation it was found that chilli plants are very sensitive to direct cosmetic damage caused by thrips on the fruits and it is more injurious to the yield loss. On the basis of our observation we found that the short time periods of high densities of thrips resulted in immediate loss in fruit quality which would affect the economic return.
Figure 5.1: (a) Pest preferred young plant tissues; (b) Thrips feeding on meristems, terminals and tender parts of the chilli plant; (c) The colour of damaged tissue changes from silvery to brown or black; (d) Plant loses their vitality; (e) Thrips: Vector of viral disease; (f) Chilli plant produced minimum number of deformed fruits; (g) Thrips: Mostly confined in the Ventral Surface
5.2 Occurrence and Damage of Thrips on Chilli Crop

Direct Damage

It is by their mouth parts that thrips feed upon the plant tissues. They pierce into it and suck out the cell contents of the their host plant. In this manner, tissue scarification on the leaves of the plants are visible. The result is that the natural resources for the growth of the plants become deficient leaving it in diseased form. This pest prefers young plant tissue. It was seen during our observation that on mature tissues they fed less than they had already done on the young ones. The infestation of thrips reduced the value of the crop directly. The leaves of the plants were used as oviposition site and food for their survival and growth was also used from there. In this manner, damage to the plant was done to such an extent that deformation in the leaves, flowers and fruits were clearly visible. Silver patches and flecking on expanded leaves were also seen. Chilli thrips can feed on the wide range of plant species. But its real growth and heavy infestation can be found among those plants which provide safer place for their reproduction besides provisioning food and shelter. Plants infested with thrips showed the damaged symptoms; leaf surface was spotted with silvery patches. Leaf lamina thickened in linear manner and in some cases the senescence and abscission of leaves occurred alongwith brown frass markings on the infested leaves. Damage included feeding scars and leaf-distortion. They caused damage such as streaking and scarring of petals, distortion of chilli flowers and flower buds. Feeding on chilli plant caused hazy streaks of spots on the chilli fruit. It was found that thrips fed on the fruist calyx and turned its colour and created ghost spotting. In this manner, heavy infestation reduced the ability of the host plant to photosynthesize. Thus, the infested plant became dwarfed with its leaves beginning to detach from the stem. It caused defoliation in a few plants. We observed that the abundance of thrips population was not on growth during rainy season. In the dry weather, it had better growth. Heavy infestations on chilli plants caused by thrips resulted in the changes in plant appearance. In some plants where thrips inserted their eggs, we found discoloured spots and it was due to the damage to the plant cells in the event of thrips feeding on them. Deformation of leaves and shoots and discolouring and dwarfing of fruits were the next symptoms resulting out of thrips feeding. It was seen that thrips deposited their greenish black fecal on the leaves while feeding on them. It was also observed that one thrips adult and its pathogen could infect a plant after feeding on it for about 30 minutes. In this manner it is understood that it is highly polyphagous pest which causes serious infestation in the form of totally defoliated plant.
Figure 5.2: (a) Silver patches on expanded leaves; (b) Brown frass marking on the infected leaf; (c) Frass marking on infected fruit; (d) Flower deformation; (e) Ghost spotting by thrips feeding on chilli fruit; (f) Linear thickening of the leaf lamina; (g) Deformed chilli plant growth; (h) Tissue scarification on chilli plant.

242 | Chapter 5 | Observation
Chilli thrips fed on succulent leaves and young fruits. Feeding on young leaves caused irregular bronzing or scarring on both upper and lower sides of the leaf. It was observed that discolouration was typically concentrated along the midrib and lateral leaf veins. It also appeared in scattered patches between veins as population increased. Rapid breeding of thrips caused premature leaf drop. As fruits grew, this early feeding became apparent as scabby or leathery brown scars expanded across the skin. Thrips scarring is sometimes called ‘Alligator skin’. During survey, the mechanical injury or abrasion as the blows of strong winds, also caused fruit scarring that could be confused with thrips injury. Chilli thrips prefer to feed and lay eggs in the succulent leaves. They move to young fruit when leaves harden. We observed that major damage occurred when fruit was 0.2-0.6 inch (5-5mm) long. Although fruit was susceptible to thrips feeding when they attained the growth about 2 inches (5 cm) in length. The feeding only caused scars on leaves as well as on fruits, when they were less than about ¾ inch (19mm) long. Prolonged feeding by thrips is recognized as ‘Mudra Disease’. We also observed that thrips feed in high densities and insufficiently dry climates. The process results in the desiccation and death of their host plant. Yield loss solely dedicated to *S. dorsalis* damage can range between 61-74%.

![Figure 5.3](image-url): (a) Desiccation and Death of the chilli leaf; (b) Prolonged feeding: Recognized as ‘Murda Disease’; (c) Scattered patches between veins; (d) Discolouration: Concentrated along the midrib and lateral leaf veins
Chilli Leaf Curl Disease caused by *Scirtothrips dorsalis*

Thrips is a general plant feeder. Plant provides for thrips the food, a protective habitat and the site of oviposition. Chilli thrips has a potential to cause damage to the leaves and reduce the photosynthetic capacity of the host plant. Heavy feeding reduces the physiobiological reaction of the host plant. Thereafter, infestation caused by Chilli thrips on chilli plant changes in the appearance of plant and it is termed “Chilli leaf curl”. It is due to the major damage factor of this pest on the chilli plant that this pest is generally known as “Chilli thrips”.

![Image of Chilli Leaf Curl](image1)

**Figure 5.4 : Chilli Leaf Curl caused by Chilli Thrips**

![Image of Reduced Photosynthetic Capacity and Physiobiological Reaction](image2)

**Figure 5.5 : Reduced Photosynthetic Capacity and Physiobiological Reaction of the Chilli Plant**

**Indirect Damage**

As noted earlier, thrips cause direct damage to the plants as twisting of leaves, decolouring of fruits and dwarfing of the plant as whole. Besides this, it causes indirect damage to affect other plants in the surrounding region. It spreads vectors indirectly in the form of several viruses. Following plant viruses have been identified: (1) Chilli Leaf Curl (CLC), (2) Peanut Necrosis Virus (PBNV), (3) Peanut Yellow Spot Virus (PYSV), (4) Tobacco Streak Virus (TSV), (5) Watermelon Silver Mottle Virus (WSMOV).
5.3 Pest Investigation by the Monitoring Observation on Chilli Crop

During our survey, we observed newly flushed leaves of chilli plant by the sampling and tapping method to get a clue about the availability of thrips to make a problem and examined them till the young fruits appeared. A biological monitoring was conducted in growing season of chilli crop, when the production of the chilli crop was high. Monitoring observation on thrips was done before young fruits started coming and continued our monitoring till fruits were full grown. During observation survey succulent leaves were marked and inspected with the help of magnifying glass lens. On inspection leaves were found in light green colour to reddish brown. In our examination we avoided those leaves that were fully hardened and dark green in colour. We also avoided those leaves that touched fruit and were very close to flower. In this manner, we monitored young fruits and pinched stem and then examined the entire fruit surface. We knew that thrips developed significantly in cool temperature and dry weather. During monitoring, population typically began increasing in early summer and spring, when chilli thrips fed on young leaves. Abundance of thrips reached its peak in spring and early summer days. It was the time when fruits were young. Thrips get better opportunity for growth from foliage to young fruits. Thrips population was suppressed by Rainy and Winter conditions and when most fruits were large and ready to be harvested and no long susceptible to new damage.

It was necessary for us to monitor thrips population so that the related problem in the chilli crop might be understood in the right perspective for adopting appropriate control actions. Early detection of the problem is necessary because the elimination of thrips can be and should be done at the early stage. There is no use controlling the thrips if the damage to the plants had already been done. Moreover, it is easier to control small thrips in early stages in comparison to larger ones. In our experiments and observations it was difficult to count thrips on the plants. It was time consuming as well as cost effective. So we assessed the presence of thrips on sampled basis. In the selected samples, we monitored thrips alternatively with sticky traps and the tapping method. Having tapped the leaves and flowers of a selected sample on the sheet of white paper, we dislodged thrips and made them visible. Such a tapping of plants was used to find out where thrips presence was there or not. In this manner, we could get a rough idea and estimate of the number of thrips per plant.
Figure 5.6: Monitoring: (a) For Chilli Plants; (b) Monitoring of Newly flushed leaves, (c) Defoliation of Flower; (d) Reduced of photosynthetic activity; (e) Necrosis tissues of chilli plant; (f) Distortion of chilli plant; (g) Discolouration of chilli plant; (h) Dislodged Thrips population
For more precision, sticky cards were used. We observed the presence of thrips on sticky traps when they were placed near the host plant. Yellow sticky card was used to monitor the presence of thrips and it was an important feature during our survey.

During our monitoring survey some species of thrips other than *S. dorsalis* were also found on chilli crop of different selected localities namely:

- *Thrips tabaci*
- *Frankiniella occidentalis*
- *Frankoniella schultzei*

Infestation caused by these thrips species on chilli resulted in the form of curling of leaves, necrosis tissues, silver to brown scars on fruits, complete defoliation of buds and flowers, distortion and discolouration of plant and finally yield loss. We observed thrips feeding was high and in dry climates and it resulted in the form of desication and death of the host plant.

*Thrips tabaci* (Commonly called Onion Thrips)

**Key Characters**

1. They have seven segmented antennae.
2. They do not possess elongated anterior setae on the pronotum.
3. Its Pleurotergites contain rows of fine microtrichia.
4. They have pigmented ocelli which are grey in colour in comparison to red pigmented ocelli in other thrips species.
5. During development period, the body colours vary with temperature and are seen from yellow to brown in colour.

*Frankliniella occidentalis* (Commonly called Western Flower Thrips)

**Key Characters**

1. Western Flower Thrips is yellow to brown in colour and it has eight antenal segments.
2. Third and fourth segments of antennae have forked sensorium. The fourth, postocular setae is more pronounced.
3. With its long and irregular setae the tergite VIII comb is present in it.

*Frankliniella schultzei* (Commonly called Tomato Thrips – Blossom Thrips)

Key Characters

1. It is found in two colours – yellow with a little brownish colour and dark brown.
2. Eight segmented antennae is also found in it.
3. Setae originate along the marginal line connecting the front edges. Its front edges are connected with marginal lines where from setae originates. It has two hind ocelli.
4. Its anteroangular setae is longer than its prenatal anteromarginal.
5. Absence of tergite VIII can also be marked in it.

5.4 Weather Influences on Insects

Thrips are minute insects in average of 1mm in length. They show diverse life features and habits. Majority of these species feeds upon plant materials like leaves, flowers and stem tissues. During observation it was seen that weather conditions significantly affect the proliferation rate. Warm dry conditions are most suitable for the growth of thrips pests. They can hardly survive where temperature goes down 4°C. Sometimes adaptation on high temperature was observed within thrips population. Drought stress conditions could increase the population development of thrips. Direct effect
of temperature can be seen not only on the growth of pests but also on its natural enemies – Predators and Parasitoids. If extreme winter reduces thrips population, it also reduced the number of natural enemies. Rainfall and wind also affected the density of the pest population. Prolonged rainy season did not affect the thrips population as much. The population remained most active towards growth during long dry seasons. Pest attacks fluctuated widely throughout the year because of changing weather patterns on the one hand and on the other hand due to the activity of predators and parasitoids. Some natural enemies; predatory mites, minute pirate bugs etc. were much effective predators for chilli thrips. The presence of *S. dorsalis* is known to foreage on several plant species, but it grows more rapidly on chilli plants because its leaves, stems and flowers provide better support to their reproduction in addition to food and shelter.

5.5 **Taxonomy of *Scirtothrips dorsalis***

The genus *Scirtothrips* is related to more than 100 species in the tropics and sub-tropic regions. *Scirtothrips dorsalis* is commonly known as the Assam thrips, Castor thrips, Chilli thrips, Berry thrips and Yellow tea thrips. It is a highly polyphagous adventive pest. The morphological traits of taxonomic importance for identification of *S. dorsalis* are well defined in the literature. With slide mount images, we illustrated a taxonomic identification key of *S. dorsalis*. We noted that only 2 of the 21 species of *Scirtothrips* have microtrichial folds extending fully across the sternites. The taxonomic traits of *S. dorsalis* with thrips slide mount images are very helpful. The accurate and rapid identification of this invasive and potentially devastating pest is essential to implement for an effective management.
**Scientific Classification**

Kingdom : Animalia  
Phylum : Arthropoda  
Class : Insecta  
Order : Thysanoptera  
Family : Thripidae  
Sub-family : Thripinae  
Genus : *Scirtothrips*  
Species : *dorsalis*

**Binomial Name** : *Scirtothrips dorsalis*

**Synonyms** :  
*Heliothrips minutissimus*  
*Anaphothrips andreae*  
*Neophysopus fragariae*  
*Scirtothrips padmae*  

*S. dorsalis* belongs to subfamily Thripinae under family Thripidae. Members of this family have a saw-like ovipositor curving downwards. They have narrow wings with two veins, and antennae of 6-10 antennomeres with stiletto-like forked sense cones on antennal segments (III) and (IV) Thripidae family belongs to suborder terebrantia under order Thysanoptera.
The following characters of *S. dorsalis* were given by Vivek Kumar, University of Florida for positive identification and morphological analysis.

1. Body of adult *S. dorsalis* is pale yellow in colour bearing dark brown antecostal ridge (AR) on tergites and sternites.

![Image](image1.png)

Source : Vivek Kumar, University of Florida

**Figure 5.11**: *S. dorsalis* adult presenting dark brown antecostal ridge (AR) on tergites (Dorsal View)

2. Head wider than long, bearing closely spaced lineation and a pair of eight segmented antennae with third and fourth segment each presents a forked sensorium.

![Image](image2.png)

Source : Vivek Kumar, University of Florida

**Figure 5.12**: Eight segmented antenna III and IV segments : presenting a forked sensorium
3. Of the three pairs of ocellar setae, the third pair, also known as interocellar setae (IOS), arises between the 2 hind ocelli (HO) and is nearly the same size as the two pairs of post ocellar setae (POS) on the head.

Figure 5.13:  *S. dorsalis* head with ocellar triangle, interocellar setae (IOS), hind ocelli (HO) and postocular setae (POS) – (Dorsal view)

4. Pronotum presents closely spaced transverse lineation.

Figure 5.14:  Pronotum of *S. dorsalis* presenting horizontal closely spaced sculpture lines
5. Pronotal setae (anteroangular, antero marginal and discal setae) are short and approximately equal in length posteromarginal seta-II is broader and 1.5 times longer than posteromarginal setae-I and III. Posterior half of the metanotum presents longitudinal striations; medially located metanotal setae arise behind anterior margin, companiform sensilla are absent.

Source: Vivek Kumar, University of Florida

Figure 5.15: Metanotum (Posterior half) presents longitudinal striations; medially located metanotal setae arise behind anterior margin, companiform sensilla are absent

6. Forewings are distally light in colour with posteromarginal straight cilia, on distal half, first and second veins bear 3 and 2 widely spaced setae, respectively.

Source: Vivek Kumar, University of Florida

Figure 5.16: Shaded forewing of S. dorsalis is light in colour distally with first and second vein: presenting 3 and 2 widely spaced setae
7. Abdominal tergites III to VI, each present a pair of small medially located setae.

Source: Vivek Kumar, University of Florida

Figure 5.17: Abdominal tergites III to VI of *S. dorsalis* present small setae medially situated close to each other

8. The posteromarginal comb on segment VIII is complete, tergite IX of female presents medially located discal microtrichia.

Source: Vivek Kumar, University of Florida

Figure 5.18: The posteromarginal comb (row of microtrichia) on segment VIII is complete
9. Discal setae absent on sternites, sternites covered with rows of microtrichia excluding on the antero-medial region i.e. a complete band of microtrichia transverse the posterior half of each sternite.

Source: Vivek Kumar, University of Florida

Figure 5.19: Discal setae absent on sternites, posterior half of sternite presents a continuous band of microtrichia, but microtrichia are absent in the antero-medial region

**Taxonomic Key for *Scirtothrips dorsalis***

Identification of *Scirtothrips* spp. is based on male or female adults, both of which are winged. They are pale in colour and minute, and cleared specimens on microscopic slides are needed for identification. For identification of thrips a magnification factor between 100 and 600 is necessary.

Following key characters that allow the identification down to the genus *Scirtothrips* are shown in Table.
### Key for the Identification of adults of the genus *Scirtothrips*

<table>
<thead>
<tr>
<th>Abdominal segment X usually conical, not tubular, serrated ovipositor present; wing surface with microtrichia</th>
<th>Terabrantia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ovipositor downturned at the apex; abdominal sternite VIII not developed; sense cones on antennal segments III &amp; IV emergent, each more than twice as long as wide</td>
<td>Thripidae</td>
</tr>
<tr>
<td>Head and legs not strongly reticulately, sculptured, abdominal tergites may be laterally sculptured; antennal segments III and IV usually with microtrichia; terminal antennal segments rarely elongate; meso and/ or metathoracic furcae with or without spinula; forewing first vein not fused to costa</td>
<td>Thripinae</td>
</tr>
<tr>
<td>Abdominal tergites covered with numerous microtrichia body often clear yellow, 8 antennal segments, 3 ocellar setae, posteromarginal pronotal setae 2, usually elongate, pronotum transversely striate, regular without dark internal apodeme.</td>
<td><em>Scirtothrips</em></td>
</tr>
</tbody>
</table>

**Figure 5.20**:  (a) Ovipositor of *S. dorsalis*; (b) Antenna of *S. dorsalis*; (c) Right half tergite V of *S. dorsalis*; (d) Head and pronotum of *S. dorsalis*; (e) Metanotum of *S. dorsalis*
5.6 Biology of *Scirtothrips dorsalis*

Like most members within the sub-order Terebrantia and the family, Thripidae *Scirtothrips dorsalis* develops in several stages – two nymphal and two pupal stages. The average size of thrips is about 1.2 mm. In structural appearances, thrips are not as attractive as many other insects are. Generally *Scirtothrips dorsalis* are plant feeders. They suck plant cells with their mouthparts. They develop at six stages. The egg is their first stage and then they pass through two larval stages. Thereafter we find inactive and non-feeding prepupal stage. Then they pass on to pupal stage and finally become adults either male or female. Under favourable conditions the adult stage is attained within 7 to 10 days. Sometimes, a few individuals take two weeks time in their full growth depending on conditions. It depends on an individual’s access to nourishing contents and favourable or unfavourable conditions of temperature. However, it can be concluded that chilli thrips is the fastest spreading thrips. Adult thrips are slender and can be noticed with naked eyes, if viewed carefully. But these thrips flying in the experimental net house are hard to be noticed. Through microscopic studies, it can be seen that adult thrips develop a few distinctive features on their external bodies. Two pairs of feathers may be seen in their long but narrow wings. Their wings are marked with fringes of fine hairs. These hairs are visible only when they flutter their wings in the act of flying. When they are at rest, their wings lie parallel to their back. In immature thrips these wings are not visible. In the external features the colours of the thrips vary from creamish to yellow and even to brownish. In their biological needs they require plant cells which they suck by piercing plant tissues. In this process the plant is damaged. Leaves are studded with greenish black fecal of thrips while they feed on them. Initially, these spots on the leaves caused by thrips feeding were considered as “Murda disease”. It was only at the later stage that this change of the colours on the twisted and deformed leaves was known to be the cause of the thrips infestation. When these chilli thrips feed on the plants for a longer duration, flowers and fruits of chilli begin to change colour from bronze to black and thus the plant material becomes unmarketable. When thrips feed in high densities, or in sufficiently dry climates, this process results in the eventual desication and death of the
plant. Sometimes low densities of thrips can contribute to the decline in fruit production and plant health.

### 5.7 Life Cycle of *S. dorsalis*

<table>
<thead>
<tr>
<th>Stage</th>
<th>Approx. Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg</td>
<td>2-4 days at 68 – 98°F</td>
</tr>
<tr>
<td>1\textsuperscript{st} Instar</td>
<td>1-2 days</td>
</tr>
<tr>
<td>2\textsuperscript{nd} Instar</td>
<td>2-4 days</td>
</tr>
<tr>
<td>Prepupal stage</td>
<td>1-2 days</td>
</tr>
<tr>
<td>Pupal stage</td>
<td>1-3 days</td>
</tr>
<tr>
<td>Adults</td>
<td>12-15 days</td>
</tr>
</tbody>
</table>

![Figure 5.21: Life Cycle of Scirtothrips dorsalis under controlled conditions](image-url)
Under the green house conditions, it was seen that most of the thrips were females and hence their population grows fast. In thrips, the process of reproduction without fertilization is a frequent occurrence. In our survey, the body of thrips was observed as heavily sclerotized. Thrips were gregarious in nature. The growth and longevity of the life of thrips is directly affected by humidity and temperature. The thrips development could continue uninterrupted throughout the year depending on the variety of temperature. When the weather conditions are warm and dry thrips swarm like anythings. Thrips had a rapid life cycle and showed a thigmotactic behaviour. Due to its thigmotactic behaviour and several biological characteristics, control over it was extremely difficult in our examination. Thrips produce eggs and insert them into leaves and petal tissues. The eggs hatched into larval. In this manner, thrips insects passed through two larval stages. These stages were fed under protected areas where they showed a high reproductive rate. Sometimes the adult thrips spread with wind currents. The females started laying the eggs (3-5 days) after their emergence. Eggs were deposited on soft and succulent parts of the host plant.

**Longevity**

Longevity of the adult female varies from 21-24 days at a constant temperature of 27±1°C in the laboratory.

**Oviposition**

The eggs are deposited on the surface of the plant parts and start laying eggs in 3-5 days after their emergence. Each female lays 15-40 eggs per day and the total number of laid eggs ranges from 70-200. Eggs are heavily filled with yolk. These eggs are produced sexually as well as parthenogenetically.

**Egg**

The minute bean-shaped eggs (0.075mm long and 0.070 mm wide) are inserted in the tender plant tissues, including leaf, flower, stem and fruit by a tiny, saw like ovipositor. In capsicum, egg hatched on leaves and have a speckled appearance. After an incubation period of 6-8 days, the egg ruptures at the anterior end. In this manner, the lid gets shifted to one side and the first instar larva wriggles out. Antennae comes out and then it is first followed by the head and thereafter, the rest of the body. In thrips life cycle the
development intermediates hemimetabolism and holometabolism. Temperature and weather conditions directly affect the reproductive potential of *Scirtothrips dorsalis*, their preoviposition, fecundity and longevity.

All species are haploid (male) – diploid (female). Thrips shows a facultative parthenogenesis. Male offsprings grow from unfertilized females and female offsprings come from fertilized females and this phenomenon is known as arrhenotokous.

**First Instar Larva**

A fleshy emerged larva is creamish colour with red-pigmentation on the lateral sides of the body. Nymphs feed on plant leaves and suck plant cells and when their feeding finishes, they either fall on the ground or they come in sedate posture on the leaves of the plant and grow into the next stage of their development.

**Second Instar Larva**

General body structure of second Instar larva is quite similar to first instar larva, except they are bigger in size. It is creamish yellow in colour, with red pigments. These pigments are scattered all over the body. Both immature forms of thrips are wingless. We observed that extreme winter restrained the population growth of the thrips and when the warmer days of the year came, they began to grow in numbers. Actually their abundance and thickness depended on the availability of their food and sheltner. Thrips population was readily destroyed by heavily rains. They were most numerous in arid and semi arid climates.

Figure 5.22: Ist and 2nd Instar (Nymph) of *S. dorsalis*
Prepupa

It is the short duration life stage of thrips life cycle. They do not exhibit any marked and characteristic feature. In this stage, the wing buds are not distinct. The duration of life span of prepupal stage is at 1-1.5 days.

It is due to the availability of chilli crop throughout the year that the thrips also continue to develop throughout the year with rapid, less rapid or slow growth rate. During warmer periods in late afternoon the thrips sometimes shows swarming activity. They are caught by wind currents. In this manner, they are dispersed over a wide area.

Pupa

It is generally creamish in colour with red pigmentation over the body. Pupa is robust. They are non-feeding and quite inactive. Pupae of chill thrips could be seen growing on the axial of leaves and leaf litter and under the calyxes of flowers and fruits.

Small size (< 2mm) of *S. dorsalis* life stages and its rapid movement under controlled conditions made it less detectable in fresh vegetation. The thigmotactic behaviour of thrips may increase the chance of transportation through internal trade of fresh plant material. Thrips are opportunistic and they are exploiting intermittently in occurring environment.

![Prepupal and Pupal Stage of *S. dorsalis*](image)

**Figure 5.23 : Prepupal and Pupal Stage of *S. dorsalis***

Adult

Under favourable conditions, the young attain full growth i.e. adult stage in 7 to 10 days. Adult species are as large as 1-2mm long and can be noticed by open eyes without the use of microscope. But they evade normal
human range of visibility when they come in the act of flying. In thrips life cycle, the most distinctive external features can be seen on the full grown thrips. They develop haired feather in their long and narrow wings. The adults, while flying in the air and then resting on leaves for food and shelter may continue their lives about 30 to 40 days. Reproduction occurs with or without mating. There are one to many generations of thrips in a year. Hibernation most commonly occurs in this stage. They can hibernate in fresh vegetation and in their curled leaves. The process of migration is hardly seen, if sufficient food is available for the adult thrips. They are weak fliers and pass their time in getting food from the leaves and other plant tissues.

**Adult Female**

The adult female of thrips is deeply pigmented. They are pale yellow in colour. They are found under protected areas of the plant such as flowers and terminals. Antennae are light segmented with different shades of pale yellow (Segment I and II) to the (Segment III – VIII). Prothoracic setae are dark. Head is pale in colour longer than broad. Wings are well developed and devoid of microtrichia, Mouth cone is triangular in shape and acutely pointed at the end.

**Adult Male**

This species (male) is reproduced by arrhenotokous parthenogenesis (producing males from unfertilized eggs).

![S. dorsalis: Young attain full growth](image)
5.8 Taxonomy and Biology of Natural Enemies of Thrips

Predators

We selected two species of predator to the measured control on thrips species. To evaluate the applied measures, we performed their taxonomy and biological study under laboratory conditions with the help of taxonomic experts.

(1) **Amblyseius cucumeris or Neoseiulus cucumeris**

*Amblyseius* is a large genus of predatory mites belonging to the family Phytoseiidae under superfamily Phytosioidea of class, Arachnida. Many members of this genus feed on the population of other mites and also on thrips.

**Scientific Classification**

- **Kingdom**: Animalia
- **Phylum**: Arthropoda
- **Class**: Arachnida
- **Subclass**: Acari
- **Order**: Mesostigmata
- **Superfamily**: Phytosioidea
- **Family**: Phytoseiidae
- **Genus**: Amblyseius
- **Species**: cucumeris

**Habit and Habitat**

Mites are not parasitic but they are free-living and have predatory habit. They can be recognized by the single pair of spiracles positioned laterally on the body.

Cucumeris is a predator better known for thrips control. The colour is hazy and tan. They are found on the underside of chilli leaves along the veins or inside mature flowers of chilli plant. Mites are most effective at preventing thrips build up, when we apply them during the early days of growing season of chilli. Adult had 4 pairs of legs. The size of adult is \(~0.3 – 0.5\) mm and we observed that females of predatory mites were bigger in size than males.
They had elongated, pear shaped body. The colour of mite was completely dependent on what they ate. They can vary from dark red, to purple and white to light yellow. But, when they preyed on thrips, the colour tended a kind of light orange. They lacked the true head. The mite body is conspicuous and did not show segmentation. So, the body of *A. cucumeris* is a whole unit.

Predatory mites have distinctive features. It has relatively few hairs on its back, 20 pairs of hairs at the most. The palps of this mite was noted using feeding and handling the food. Adult had got typical long legs, which enabled them to move quickly. Each leg was consisted of the coxa, trochanter, femur, genu, tibia, tarsus and apotile.

**Biology of Amblyseius cucumeris**

In a chilli crop, the predatory mites lived in the microclimate and were found in the layer of air tight which was next to the leaf surface. Female of *A. cucumeris* laid 4-5 eggs per day, with an average of 40 eggs during her life cycle. Eggs of mite are oval and transparent. Eggs were deposited on hairs on the underside of leaves. They were hatched after 3 days. The eggs hatched and developed into many developmental stages such as:

\[
\text{Egg} \rightarrow \text{Larva} \rightarrow \text{Protonymph} \rightarrow \text{Deutonymph} \rightarrow \text{Adult}. 
\]

<table>
<thead>
<tr>
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<th>Duration</th>
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<tr>
<td>Egg – adult</td>
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<tr>
<td>Sex – ratio (% Female)</td>
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<tr>
<td>Eggs/ Female</td>
<td>40 eggs</td>
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</table>

**Life cycle at 20°C (68°F)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Longevity</td>
<td>3 Weeks</td>
</tr>
<tr>
<td>Consumption / day</td>
<td>6 thrips larvae/day</td>
</tr>
</tbody>
</table>

**Mode of Action**

It was observed that the nymphs and adults of *Amblyseius cucumeris* fed on young thrips larvae (mainly 1st instar).

Newly hatched larvae did not feed until they moulted within 2 days. The larvae, nymphs and adults are droplet shaped. The optimum temperature for *A. cucumeris* lies between 25 - 28 degree celsius. *A. cucumeris* is not able to survive at high temperatures, if sufficient food was available. In *A. cucumeris* the development from egg to the adult phase took only five to
six days. The predatory mite did not go into diapause (dormancy) in response to shorter days of lower temperatures. This means that the A. cucumeris was also active on shorter days and showed much better efficacy on thrips population. An adult of A. cucumeris lived for about 3 weeks. The young larvae that emerged had only six legs. They do not feed. A nymph looked like a smaller adult, so there was found no metamorphosis. Adults pierced their prey and then fed over it.

![Figure 5.26](image)

**Figure 5.26**: *Amblyseius cucumeris*: (a) Feeding on 1st Instar larvae; (b) Feeding on Thrips pupa; (c) Active on thrips population; (d) Searching for their prey

**Life Cycle**

The life cycle of A. cucumeris begins with small white eggs. There are two nymphal stages which last 7 days and the adult stage which lasts up to 30 days and they feed upon immature stages of thrips. An adult can eat an average of 1 thrips per day.
**Macrotracheliella nigra**: Commonly known as Minute Pirate Bug

**Taxonomy**

Anthocorids have long been recognized as beneficial predators. They are considered to be of economic importance to man. They are phytophagous in nature. The adult male length is 2.24 mm and the width 0.77 mm. The length of head is 0.45 mm. The adult female length is 2.52-2.66 mm, and 0.91-0.98 mm in width. They are more robust. They are dark reddish brown in colour. *Macrotracheliella nigra* belongs to the Family Anthocoridae under superfamily Cimicoidae.

These bugs belong to the order Hemiptera. The Hemipterans – are most often known as “true bugs”. The Heteropterans can be diagnosed with the help of their mouthparts. The typical hemipterans have mandibular stylets concentric and surrounding maxillary stylets. The labium is inserted anteriorly
on the head to form a “beak” or “rostrum”, called proboscis. This proboscis is able to pierce plant tissues. Rostrum extends to anterior coxae. The antennae of *Macrotracheliella nigra* are typically segmented. The second antennal segment of this bug is about 0.28 mm long and black in colour. But terminal segments are reddish brown in colour. The pronotum of this bug is 0.73mm wide at base, black in colour as well as shiny. The body is oval to triangular. They have shield body. So, they are called Hemelytran. This species is characterized by the long neck and the shape of their pronotum. The genital clasper is similar to that found in other species; *Orius*. The osteolar canal is distinctive in feature.

![Image of Macrotracheliella nigra](image)

*Figure 5.29: Macrotracheliella nigra preyed on their host: thrips*

**Scientific Classification**

<table>
<thead>
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<tr>
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They are recognized as beneficial predators. They have predatory nature and depend on insects and other arthropods, thrips for food. During
our observation they mostly preyed on thrips eggs. When the supplied food exhausted in one habitat, they sought other areas for food and shelter. The habitats of prey provided excellent hiding place for this predator.

**Biology and Life Cycle of *Macrotracheliella nigra***

*Macrotracheliella nigra* was found in the population of chilli thrips in natural conditions. They are a potential predator which feed on the different species of thrips. They might vary from 1.07 – 4.9 mm in length. The general appearance of anthocorids is similar to the mirids except that anthocorids have ocelli. They are flattened and glabrous or pubescent. The wings of this predator are Macropterous or Brachypterous. After spawning, the duration of the developmental stages takes place depending on the varied temperature. Only within a few minutes hatching takes place. The nymphs of *Macrotracheliella nigra* are almost similar to the adults. *Macrotracheliella nigra* did not show metamorphosis during growth after hatching. They were only driven by shedding or the process ecdysis. The main characteristic of this predator is *Fledging* in which they accompany the development of their structure. Even the wings and sexual organs develop at this stage. During their life cycle, the nymphs develop in five stages. On examination, it was found that their sexual organs were visible externally. In the fifth instar of this predator, the ovipositor of the female could be seen apparently. The other sources of this predator other than arthropod insects were noticed during our observation such as forbs, shrubs and trees etc. Nymphal food was as much useful to them as the adults. They preferred only individuals for their food and chose them on the basis of their size. During the nymphal stage of a single individual several hundred thrips were consumed. It seemed that at least one meal was needed between two molts, and the most hearty meal preceded for the phenomenon of ecdysis. The egg of this predator was ovoid and appeared pale sculptured chorion. Fertilization tubes or micropyles were not present in them. However, numerous pseudo micropyles were present in them. Oviposition of this predator varied on the basis of different developmental levels of the ovipositor of the females. Predatory habits of most Anthocorids are well recognized during our research examination.
Parasitoids

Introduction: Thrips known to be parasitized by many hymenopterans which belongs to the Family; Eulophidae. Parasitoids are mostly host specific and appeared more effective to prevent the population of thrips at low densities. It was because parasitoids have inability to switch on to another host. Some factors such as, Reproductive Strategies and fecundity limits could influence the efficiency of the parasitoids. In order to assess their role as biocontrol agents for the biological management over Scirtothrips dorsalis, we evaluated the information on aspects such as, the biology, reproductive behaviour of selected parasitoids and their bioefficacy. An attempt was made in detail with reference to two parasitoids; Thripobius semiluteus and Ceranisus menes.

Hymenoptera is found as a significant order in all the entomophagous insects. Over two-third insects and pests are biologically controlled by hymenopterous parasites. Hymenopterous parasitoids of thrips are related to the superfamily Chalcidoidea. There are several extremely interesting biological adaptations among the Hymenopterans, in which one is the ovipositor (specialized organ or egg laying). It is composed of long interlocking chitinous stylets. Egg passes in Hymenopterans through this stylet. The ovipositor acts as a drill to pierce the host or the material.
surrounding the host. In many cases parasitoids serves as a hypotermic (inject paralyzing venom into the host). In some species it is used to secret and form a feeding tube. This feeding tube helps adult parasitoids suck the host body fluid in order to obtain protein for continued egg production. Most of Hymenopterans are solitary endoparasitoids of larvae (Eulophidae). Ovipositor of Hymenopterans lacks muscles and it is supplied with nerves which extends its length to the tip. Ovipositor bears highly sensitive sense organs that can be discerned by chemical stimuli whether a host is suitable or not. The well-known method of reproduction of female production is from fertilized eggs. But the production of male shows arrhenotoky (production from unfertilized eggs). Hymenopterans shows the characteristic of biparental. But this characteristic is supplemented in some species in which uniparental reproduction and parthenogenesis occurred. The phenomenon of parthenogenesis is called Thelytoky. In this process, females give rise to females and males are either lost or if they survive they became capable of killing the pest.

Parasites may have one generation and it is called univoltine. If in certain cases, these parasites have two or more generation it is called Multivoltine to one of the host. The Life cycle of hymenopteran parasites are generally short, of course, they live only between ten days and thirty days. In warm and hot weather, it is only for about ten days and in cold weather, it can go upto 30 days. In general, parasitoids have great potential rate of increase.

A common parasitoids has two distinctions such as Ectoparasitoids and Endoparasitoids. Ectoparasitoids feeds externally upon the host, but in case of Endoparasitoids, the development is internal within the host. Certain species of parasitoids may start their life as endoparasitoids and later emerge from their host externally for continuous feeding on it. Some others may start as ectoparasites and then bear into the host.

During our monitoring observation, ectoparasitoids most frequently occurred in hosts that live in some protected areas – a larva in a leaf mine, a pupa in soil and an armored insect under a wax shield. It was because they were likely to be dislodged and lost their host. Many of them parasitoids stang and paralyzed the host prior to oviposition. On the other hand,
endoparasitoids were usually well protected within the host. So, we selected for our research work those endoparasitoids which acted more dominantly over the population of thrips species. In this manner, we observed a special adaptation in those endoparasitoids. They respired in a liquid or semi-liquid medium. Some endoparasitoids larvae could directly obtain oxygen from the host’s body fluids (either it was through the entire integument or through a posterior vesicle). Many endoparasitoids ‘Mummified’ their hosts upon completion of their own larval development. This was especially noticeable in parasitized thrips, in which the integument becomes distended and hard. It is a biological characteristic that most insects parasitize upon other insects; they are protelean parasites. They parasitize only in their larval (immature) stages, and prefer free lives as soon as they become adults. They feed upon their victims body material first and then begin eating pupates.

(1)  *Thripobius semiluteus*

**Synonyms**

- *Thripobius hirticornis*
- *Thripobius semiluteus*

**Scientific Classification**

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<tr>
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</tr>
</tbody>
</table>

![Figure 5.31: Thripobius semiluteus: A Parasitic Wasp](image)
Taxonomy

*Thripobius semiluteus*, a larval endoparasitoid belongs to the order Hymenoptera of the family Eulophidae. It is solitary in habit and shows a uniparental characteristic. In preference it parasites the first and early second larvae of *S. dorsalis*. Females of this species are 0.6mm in size. Head and thorax are purple black in colour and in the lateral view it seems sharply convex in shape. Their wings are almost transparent and are called hyaline. They have slightly curved subcubital vein. Their antennae are pale yellow in colour. The gaster of *T. semiluteus* has 1-2 small dark spots which is sublateral in position. The male of *T. semiluteus* was not known during our research examination.

Biology

*T. semiluteus* is uniparental (only females are produced). During searching for their hosts, the female of this species walks slowly at sideways over the leaf surface. In the beginning they feed upon larvae of first and early stages. However, the parasitoids were found less comfortable in feeding upon the second stage larvae and the result was that about half of the pupae could not develop due to want of food. The prepupal and pupal stages of thrips could not provide sufficient food for parasitoids. The parasitoid killed mature larva for its food and having eaten upon it and it transformed into black pupa.
This pupa is present on the surface where the parasitized thrips larva has been feeding. The Developmental time of *T. semiluteus* averages 22-25 days at 23°C during our research examination.

(2) *Ceranisus menes*

**Synonyms**
- *Ceranisus*
- *Thripoctenus*
- *Epomphale*
- *Cryptomphale*

The C.m. is solitary in habit. It acts as internal parasitoids of the larval stages. But, sometimes the prepupa and pupa may be attacked.

**Scientific Classification**
- Kingdom: Animalia
- Subkingdom: Eumetazoa
- Phylum: Arthropoda
- Subphylum: Hexapoda
- Class: Insecta
- Order: Hymenoptera
- Suborder: Apocrita
- Superfamily: Chalcidoidea
- Family: Eulophidae
- Subfamily: Entedoninae
- Genus: *Ceranisus*
- Species: *menes*

**Taxonomy**

*Ceranisus menes* belongs to the subfamily Entedoninae under the family Eulophidae. Hymenoptera is a large order of insects that is represented by several hundred thousand different species. Head and mesosoma of adult female was observed as dark brown in colour. Females are 0.66mm till 1.06mm in size. Ovipositor sheath infuscata if viewed apically of *C. menes* is characterized as head and thorax. All legs are yellow in colour. The hyaline wings are a distinguished feature of this species. The antennae of male and
female have marked differences and it is on this basis that they are distinguished. Further, the male has truncate brownish abdomen. In many records, colour features of this species are not mentioned. But on the basis of observation, it was found that the colour of the abdomen of the females was yellowish, whereas in males we found brownish abdomen. The only known males of *C. menes* are also associated with females having a brown metastoma during our taxonomical examination.

![Image of Ceranisus menes](image)

Source: Antoon Loomans, 1995, Revised on 14th June, 2016 Netherlands

Figure 5.34: *Ceranisus menes*: 1. Adult female; 2. Antenna of Female and Male; 2. Front Wing (showing Sinuate subcubital vein – arrow)

**Biology and Life Cycle of *C. menes***

*C. menes* is a very effective parasitoid of thrips larvae. Female inserted its ovipositor into the abdomen of their host; *S. dorsalis* and deposited a single egg inside the abdomen of the paralyzed larva of thrips. Both the males and females reproduce by arrhenotokous and thelytokous parthenogenesis. During our observation, larvae of this species slowly recovered within a few seconds. The larvae of *C. menes* consumed the entire body of the larval host inside its empty shell. They search for their host by handling behaviour and it is similar for various host parasitoid combinations. The incubation period of *C. menes* is about 1-3 days. Larvae moulted in pupa within 3-4 days and the pupa converted to adult in 5-6 days. Hence, the complete life cycle of *C. menes* was about 18-22 days under optimum temperature.
Figure 5.35: *Ceranisus menes*: Oviposition postures: (a) Lifting; (b) Tailing or Dragging (Original)

Figure 5.35: *Ceranisus menes*: (a) Prepupa at the movement of pupation; (b) Emerged pupa of *Ceranisus menes*. A = pupa, B = host skin, C = orange/red central spot. The way by which the pupa emerged from the host skin, is indicated by the arrow (original).