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# Biology and morphometrics of *Thrips parvispinus* (Karny) (Thysanoptera: Thripidae) on chilli, *Capsicum annuum* L.

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**ABSTRACT:** The Southeast Asian thrips, *Thrips parvispinus* (Thysanoptera: Thripidae), has recently invaded India, posing a significant threat to the country's chilli industry. Laboratory studies were conducted at the Department of Agricultural Entomology, College of Agriculture, Raichur, to understand the growth and development of this invasive pest on chilli. The study was conducted at controlled conditions of 25 ± 1 °C and a relative humidity of 65 ± 5%. The results revealed that the mean egg incubation period was 5.74 ± 0.34 days, with egg dimensions measuring 0.23 ± 0.01 mm in length and 0.13 ± 0.01 mm in breadth. The first and second larval instars lasted 2.16 ± 0.24 days and 3.76 ± 0.42 days, respectively, with a total larval duration of 5.92 ± 0.66 days. The pre-pupal stage lasted 1.83 ± 0.23 days, while the pupal stage lasted 4.17 ± 0.50 days. Adult males had an average lifespan of 5.55 ± 0.46 days, whereas adult females lived for 10.18 ± 0.47 days. The pre-oviposition, oviposition, and post-oviposition periods were 2.51 ± 0.24 days, 3.58 ± 0.25 days, and 4.09 ± 0.37 days, respectively. The mean fecundity was 15.53 ± 3.46 eggs per female. This study provides the first documented report on the biological parameters of *T. parvispinus* in the invaded regions.

**Keywords:** Biology, *Capsicum annuum,* Chilli thrips, Invasive pest, Fecundity, Morphometrics.

## INTRODUCTION

Thrips (Thysanoptera: Thripidae) are among the most significant pests affecting a wide variety of crops. Within the insect order Thysanoptera, *Thrips* is one of the largest genera, containing several agricultural important species. In India alone, 44 species have been documented with a new geographical distribution records (Rachana and Varatharajan, 2017). Among the members of Thripidae, the *Thrips parvispinus* also known as South East Asian thrips, tobacco thrips, western thrips, and Taiwanese thrips was recently reported from India, where it devastated over 0.4 million hectares of chilli crop (Timmanna *et al*. 2022). This species is predicted to continue spreading and establishing itself in India, due to the large-scale cultivation of its major hosts, *viz*., papaya and chilli, coupled with the favourable meteorological conditions. These factors contribute to significant population increases and yield losses of 10 to 30 percent compared to other countries. The districts of Warangal, Khammam, and Guntur in Andhra Pradesh have experienced the highest levels of infestation, with thrips numbers ranging from 10 to 20 per flower (Janyala, 2021; Directorate of Plant Protection Quarantine and Storage of India, 2021).

In India, the first recorded occurrence of *T. parvispinus* on papaya (*Carica papaya*) was documented in Karnataka in 2015 (Tyagi *et al*., 2015). Originally native to Southeast Asian countries, *T. parvispinus* has been reported in Australia, Thailand, North America, Europe, Malaysia, and Africa, establishing itself as a global and polyphagous pest (Waterhouse, 1993; Zhang *et al*., 2011; Lim, 1989). Following its invasion, *T. parvispinus* has been found on a variety of host plants, including paprika, watermelon, mums, dahlia, cotton, mango, bitter gourd, marigold, and tamarind (Nagaraju *et al*., 2021; Rachana *et al*., 2022; Roselin *et al*., 2021). Reports of severe infestations on chilli plants (*Capsicum annuum*) have emerged from Gujarat (Lodaya *et al*., 2022), Telangana, Andhra Pradesh (Timmanna *et al*., 2022; Veeranna *et al*., 2022), and Karnataka (Basavaraj *et al*., 2022). Despite its widespread documentation, a detailed understanding of the biology of *T. parvispinus* in the newly invaded regions remains lacking. Therefore, it is hypothesized that studying the biological parameters of *T. parvispinus* will provide essential information for effective management.

## MATERIALS AND METHODS

The biology of *T. parvispinus* was studied in the insectary of the Department of Agricultural Entomology, College of Agriculture, Raichur, University of Agricultural Sciences, Raichur (16°15' N latitude and 77°20 E' longitudes at 398.37 m above mean sea level)

during 2022-23. The controlled room temperature of 25±1 °C and relative humidity (65±5 %) were maintained during the study period.

**Maintenance of pure culture of thrips**

The cultivation of chilli plants involved the use of earthen pots, which were protected from pests by being covered with nylon net cages (0.15 × 0.15 mm) (Fig 1). A single pair of male and female adults of *Thrips parvispinus* were obtained from the thrips infected chilli field and introduced to these enclosed plants (Fig 1). The adults for biological studies were collected from stock culture and reared in a cylindrical tubes made out of overhead projector (OHP) sheets. The cylindrical OHP sheets of 21 cm length and 6 cm diameter were open at both ends; one end was pressed gently into the soil, and the other end was covered with a plastic plate with mesh top (Fig 2). Fresh chilli seedling was put inside the cylindrical tube. A pair of adult thrips were released for oviposition in such OHP cylindrical tubes.

**Fig.1. Maintenance of *T. parvispinus* pure culture for biology study**

**Pre-ovipositional, ovipositional and post ovipositional period**

The cylindrical OHP sheet tubes were opened daily and the leaves were taken after following the procedure of chlorophyll bleaching and staining method and observed for oviposition under stereo zoom binocular microscope (Nikon SMZ745) and continued till the first egg laid and duration was recorded as pre-oviposition period. The procedure, which was adopted for the pre-ovipositional period, was continued further, provided with fresh seedlings, and observed the oviposition until the last egg deposition (Fig 2). The duration between the first and the last egg laid was recorded as an ovipositional period.

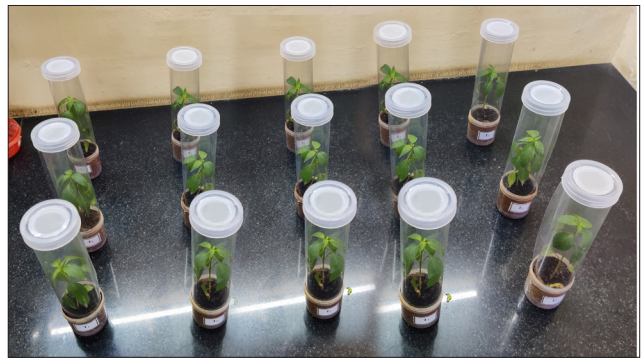

**Fig. 2. Experimental set up for study of preoviposition, oviposition, post oviposition and fecundity studies of *T. parvispinus***

***Fecundity count using chlorophyll bleaching and staining method***

The mated females (n= 15) were collected from pure culture and allowed to lay eggs on chilli leaf. The oviposited leaves were collected daily, and each female was given fresh leaves until they died. The leaves were immersed into a beaker containing 100 ml of Dimethyl sulfoxide (DMSO). This beaker with leaflets and DMSO were kept in the water bath at 60- 70□C for 30 minutes. After removing chlorophyll, the leaves were kept on a petri plate (Fig 3). Later, the bleached leaflets were stained with acetocarmine 1% solution for 1 to 2 hours (Fig 3). The stained eggs were observed, counted and measured under the stereo zoom trinocular microscope (Nikon SMZ745) and its measuring software. The total number of eggs deposited by each female was documented.

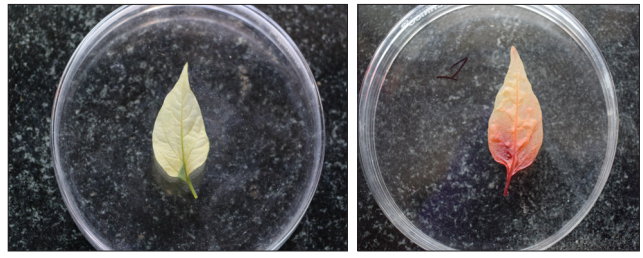

**Fig.3. Chlorophyll bleaching and staining of chilli leaves**

**The incubation period**

To determine the incubation period, the oviposited leaves, which were used in earlier fecundity studies, were transferred from the rearing tubes to a sterile, moist cotton wad in a petri plate at a temperature of 25±1 °C and a relative humidity of 65±5 % per cent in the laboratory. The hatching of newly laid eggs on chilli leaves placed inside the rearing tubes was monitored,

and fifteen observations were made, including the time between egg laying and the emergence of the first instar larva.

**Larval instars**

To study the larval instars, a fine-toothed, moistened camel hairbrush was used to transport newly hatched larvae onto a leaf arena on a wet cotton pad in petri dishes. Every two or three days, fresh leaves were brought into the arena; *i.e.* three leaves were used in this experiment, and vaseline was used all over the leaf corners. This way, the larval instars did not escape from the leaf arena (Fig 4). Examining the shed skin with a binocular microscope (Nikon SMZ745) and recording the number of larval instars and the days needed to complete each larval instar.

**Fig.4. Experimental set up for larval rearing of *T. parvispinus***

**Prepupa and Pupa**

The dull second instars larvae of *T. parvispinus* were shifted with a camel hairbrush to another Petri plate containing one mm thick of fine black soil for easy pupation (Fig 5). The visual observations *viz*., length of the wing pad up to the end or half to the abdomen and antennae position, were considered to differentiate the pre-pupa and pupa.

**Fig.5. Experimental set up for pre-pupa and pupal stages of *T. parvispinus***

**Adult longevity**

The duration of adult longevity in thrips is observed from the time they emerge until they die in an OHP sheet cylindrical tube.

**Morpho-metric measurements and statistical analysis**

All morphological stages, including the egg, larva, pre-pupa, pupa, and adult, were observed, and the length (mm) and breadth (mm) measurements were taken using a trinocular stereo zoom microscope (Nikon SMZ25) and the imaging programme NIS-Elements D version 5.02.03 (64 bit). The mean durations of different biological parameters were worked out using Excel 2013. Similarly, the mean and standard deviation of morphometric values of various stages were worked out.

**RESULTS AND DISCUSSION**

**Egg**

A female thrips lays eggs irregularly on the leaf. The eggs are bean-shaped and shiny white, with a pair of tiny brownish-red eyes visible through the chorion at the anterior end just before hatching (Fig. 6). The incubation period ranges from 5.00 to 6.00 days, averaging 5.74 ± 0.34 days (Fig. 7 and Table 1). On average, the eggs measure 0.23 ± 0.01 mm in length and 0.13 ± 0.01 mm in breadth (Table 2).

**Larval instars**

Upon hatching, the larva emerged headfirst, wriggling in all directions and leaving the eggshell inside the leaf tissue. Chilli thrips have two larval instars, first and second, with distinct characteristics. The newly hatched first instar larva was translucent white, gradually turning light yellow with seven-segmented antennae and red eyes (Fig. 6). This stage lasted between 2.00 and 3.00 days, averaging 2.16 ± 0.24 days (Fig. 7 and Table 1). The first instar larva had an average length of 0.35 ± 0.02 mm and a width of 0.11 ± 0.01 mm (Table 2). The second instar larva was dark yellowish with red eyes, distinct antennal segments with pale brownish setae, and a stout, elongated body (Fig. 6). This stage lasted an average of 3.76 ± 0.42 days, ranging from 3.00 to 5.00 days (Fig. 7 and Table 1). The second instar larva had an average length of 1.06 ± 0.02 mm and a width of 0.22 ± 0.01 mm (Table 2).

**Pre-pupa and Pupa**

The pre-pupa was dark yellow with red eyes and two pairs of small, transparent white wing pads that extended

almost one-third of the way down the abdominal segment, with antennae pointing forward (Fig. 6). The pre-pupa was markedly different from the second instar, being dull and immobile. In contrast, the second instar was very active and fast-moving. The pre-pupal phase lasted between 1 and 2 days, with an average duration of 1.83 ± 0.23 days (Fig. 7 and Table 1). The average length and width of the pre-pupa were 0.93 ± 0.01 mm and 0.19 ± 0.01 mm, respectively (Table 2). The pupa was dark yellow with dark red eyes, with antennae positioned backward over the head towards the pro-thorax and longer wings extending to the sixth abdominal segment (Fig. 6). The pupal stage lasted 3 to 5 days, averaging 4.17 ± 0.50 days (Fig. 7 and Table 1). The average length and width of the pupa were 0.86 ± 0.01 mm and 0.20 ± 0.01 mm, respectively (Table 2).

**Adults**

**Female**: The females of *T. parvispinus* are brownish-black with yellow legs and fringed wings that are brown at the base and black at the ends. The thorax is brown, and the abdomen is black. They have seven-segmented antennae. Females are larger than males and can be identified by their dark brown colour and the well-developed saw-like ovipositor (Fig. 6). The female lifespan ranges from 8 to 11 days, with an average duration of 10.18 ± 0.47 days (Fig. 7 and Table 1). The total life cycle of females was in the range of 25.00 – 29.00 days with an average of 27.84 ± 0.89 days. The average length and width of females are 1.29 ± 0.09 mm and 0.32 ± 0.01 mm, respectively (Table 2).

**Male:** The males were smaller than the females, with their whole body being yellow (Fig. 6). Male longevity ranged from 4.00 to 6.00 days, with an average duration of 5.55 ± 0.46 days (Fig. 7 and Table 1). The total life cycle of males was in the range of 22.00- 24.00 days with an average of 23.21 ± 0.56 days. The average length and width were 0.88 ± 0.03 mm and 0.17 ± 0.01 mm, respectively (Table 2).

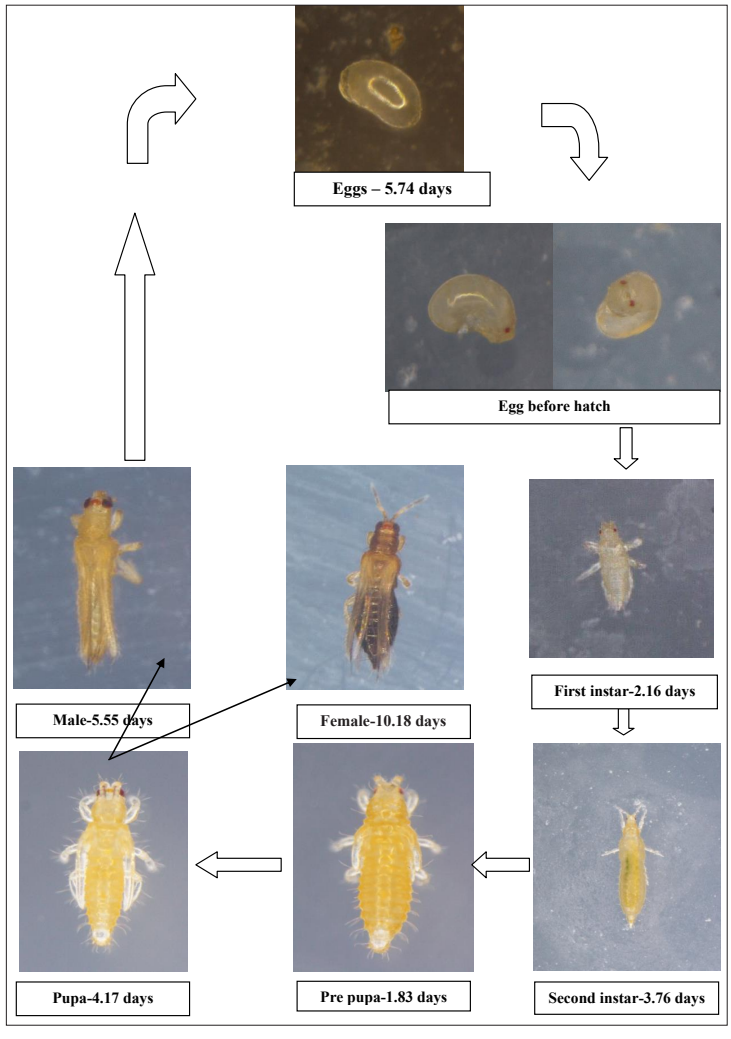


**Fig.6. Life cycle of *T. parvispinus* on chilli**

**Table 1. Biology of *T. parvispinus* on chilli under laboratory conditions**

| Stage of development | Range (days) | Mean ± SD |
|---|---|---|
| Incubation period | 5 - 6 | 5.74 ± 0.34 |
| I instar | 2 - 3 | 2.16 ± 0.24 |
| II instar | 3- 5 | 3.76 ± 0.42 |
| Pre –pupa | 1-2 | 1.83 ± 0.23 |
| Pupa | 3-5 | 4.17 ± 0.50 |
| Pre-ovipositional period | 2-3 | 2.51 ± 0.24 |
| Ovipositional period | 3-4 | 3.58 ± 0.25 |
| Post ovipositional period | 3-5 | 4.09 ± 0.37 |
| Adult longevity | | |
| Female | 8-11 | 10.18 ± 0.47 |
| Male | 4 - 6 | 5.55 ± 0.46 |
| Adult life cycle | | |
| Total female life cycle | 25 - 29 | 27.84 ± 0.89 |
| Total male life cycle | 22 - 24 | 23.21 ± 0.56 |
| Total Average life cycle | 24 - 27 | 25.53 ± 0.70 |
| Number per female | | |
| Fecundity | 12 - 22 | 15.53 ± 3.46 |

**Note: n=15, SD-Standard deviation**

**Reproductive parameters**

The pre-ovipositional period ranged from 2.00 to 3.00 days, averaging 2.51 ± 0.24 days (Fig. 7 and Table 1). The ovipositional period ranged from 3.00- 4.00 days with an average of 3.58 ± 0.25 days (Fig. 7 and Table 1). The post-ovipositional phase lasted 3–5 days, averaging 4.09 ± 0.37 days (Fig. 7 and Table 1). The fecundity ranged from 12.00 to 22.00 eggs, averaging 15.53 ± 3.46 eggs per female (Table 1).

**Table 2. Morphometric studies of different life stages of thrips, *T. parvispinus***

| Life stage | Length (mm) | | Breadth (mm) | |
|---|---|---|---|---|
| | Range | Mean ± SD | Range | Mean ± SD |
| Egg | 0.21- 0.23 | 0.23 ± 0.01 | 0.12 - 0.15 | 0.13 ± 0.01 |
| I Instar | 0.29 – 0.37 | 0.35 ± 0.02 | 0.10 – 0.13 | 0.11 ± 0.01 |
| II Instar | 1.02 – 1.08 | 1.06 ± 0.02 | 0.21 – 0.24 | 0.22 ± 0.01 |
| Pre-pupa | 0.91 - 0.96 | 0.93 ± 0.01 | 0.18 - 0.19 | 0.19 ± 0.01 |
| Pupa | 0.82 - 0.87 | 0.86 ± 0.01 | 0.18 – 0.21 | 0.20 ± 0.01 |
| Adult (male) Adult | 0.82 - 0.93 | 0.88 ± 0.03 | 0.14 – 0.18 | 0.17 ± 0.01 |
| (female) | 0.95 - 1.34 | 1.29 ± 0.09 | 0.31 – 0.33 | 0.32 ± 0.01 |

**Note: n=15**

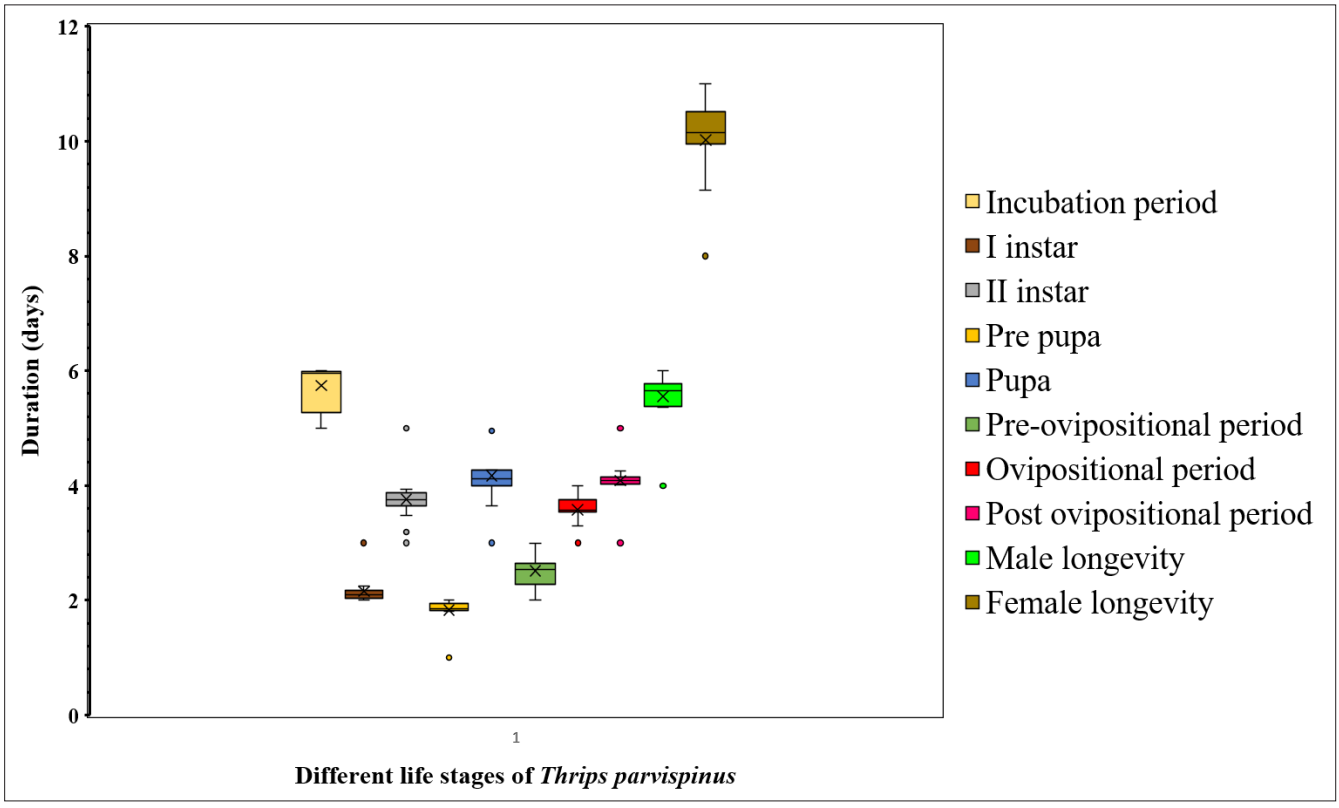


**Fig.7. Box plot of the life cycle stages of *T. parvispinus***

The current findings align with Hutasoit *et al*. (2017), who reported average durations for egg, first instar larva, second instar larva, prepupa, and pupa as 4.79, 1.36, 3.54, 1.08, and 1.96 days, respectively. They also noted mean values for the pre-oviposition period, life cycle, adult lifespan, and fecundity as 1.11 days, 13.68 days, 8.55 days (female), 6.00 days (male), and 15.33 eggs, respectively. These figures are similar to our findings, which reported averages of 5.74, 2.16, 3.76, 1.83, and 4.17 days for the same developmental stages, with mean values of 2.51 days for the pre-oviposition period, 25.53 days for the life cycle, 10.18 days (female) and 5.55 days (male) for adult lifespan, and 15.53 eggs for fecundity. These variations can be attributed to environmental changes, as suggested by Hutasoit *et al*. (2019), who highlighted that temperature and host plants influence pest development duration.

Our results partially agree with Murai *et al*. (2010), who found mean generation times of 37.6, 24.8, and 18.8 days and mean fecundity of 50, 69, and 56 eggs at 20, 25, and 30°C, respectively. The mean generation time at 25°C (23.35 days) aligns with our findings, but fecundity differs due to varying climatic conditions, such as the photoperiod used in their study. Ahmed *et al*. (2023) reported an egg period of 4-5 days, first and second larval stages of 2-3 days each, prepupa and pupa stages of 2-3 days each, adult female lifespan of nine days, male lifespan of six days, and a total lifecycle of 13-14 days with a fecundity of up to 15 eggs per female. These findings partially conflict with ours, likely due to differences in host plants used in the studies.

Given the limited information on the biology of *T. parvispinus*, our study draws on data from studies on *Thrips orientalis* and *Thrips tabaci* for reference. The comparable life cycle duration of *T. parvispinus* and *T. orientalis*, despite significant differences in fecundity, underscores the need for further research to understand the role of host plants and local climatic conditions in pest development. Devi and Roy (2019) observed similar developmental stages: incubation period (2-6 days), first instar (2-3 days), second instar larva (4-6 days), prepupa (2-3 days), pupal duration (3-5 days), pre-ovipositional phase (1-3 days), post-ovipositional period (2-3 days), average life cycle (22-28 days), and fecundity (18-42 eggs per female). However, differences in the post-ovipositional period and fecundity may be due to the nutritional status of the host and laboratory conditions.

Johari *et al*. (2014) examined the body size variations of *T. parvispinus* in the lowland and highland areas

of Jambi Province, Indonesia. They found that in the lowland area, long-sized thrips measured 1.42 ± 0.065 mm, medium-sized thrips were 1.32 ± 1.15 mm, and short-sized thrips were 0.122 ± 0.051 mm. The thorax width measurements were 0.30 ± 0.017 mm for long-sized thrips, 0.28 ± 0.021 mm for medium-sized thrips, and 0.29 ± 0.027 mm for short-sized thrips. Our findings somewhat correspond to the medium-length adult thrips from the lowland areas (100-500 m above sea level), which is similar to the mean sea level range in Raichur.

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