International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; SP4: 29-36

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(Special Issue -4)
International Conference on Food Security and Sustainable Agriculture
(Thailand on 21-24 December, 2018)

Biology and morphological description of *Ocimum* tingid, *Cochlochila bullita* (Stal) (Heteroptera: Tingidae), an important pest of Camphor tulsi, *Ocimum kilimandscharicum* Gurke in Karnataka, India

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Abstract
The present investigation on biology and morphological description of *Ocimum* tingid, *Cochlochila bullita* (Stal) on camphor tulsi were carried out during 2016 - 2017 at Dept. of Agri. Entomology, UAS, GKVK, Bengaluru. The incubation period of the eggs of *C. bullita* varied from 8.95 to 10.12 days, with an average of 9.37±0.57 days, nymphs took 12.86 to 17.81 days to complete five instars with an average of 14.85±1.61 days and total developmental period from 21.81-31.37 days with a mean 24.18±0.74 days. The first, second, third, fourth and fifth in stars were completed in 1.87 - 4.00, 1.79 - 5.16, 2.13 - 3.00, 1.98 - 4.00 and 2.95 - 4.66 days, respectively. The adult female and male insect can live upto 35.22 - 48.00 days and 40.00 - 47.20 days with food and 1.50-1.80 days and 1.30-1.58 days without food, respectively. The egg, first, second, third, fourth and fifth instars length was with a mean of 0.48 - 0.52, 0.49 - 0.62, 0.72 - 0.82, 0.99 - 1.05, 1.22 - 1.58, 1.88 - 2.11 and 1.88 - 2.11 mm, respectively. The body length of adult female and male insect was 2.27 - 2.67, 2.10 - 2.80 mm, respectively; whereas width of adult female and male insect was1.00 - 1.18, 0.89 - 1.15 mm, respectively.

Keywords: *Cochlochila bullita*, Camphor tulsi

1. Introduction
Ocimum kilimandscharicum is popularly known as Camphor tulsi, which is native of Kenya (East Africa). It was introduced and cultivated in India and some parts of Turkey belonging to the family Lamiaceae. *Ocimum* sp. leaves have antibacterial, antifungal and insecticidal properties. Seeds are recommended for urinary system complaints (Gulati and Suri, 1982) [4]. Tulsi hybrid is now being cultivated in about 2000 hectares of land in India (Balyan and Pushpangadan, 1988) [2] as ayurvedic and medicinal plant. Its leaves, stem, shoots, seeds and roots have tremendous economic importance in epidemiology and industry. Its leaves have anthelminthic and anti-tussive effects. Seeds yield various essential oils, monoterpenes, sesquiterpenes and phenols which provide pleasant odour and flavours to the crop. Tulsi extract has fungicidal, insecticidal, antibacterial, antifeedent and larvicidal activities (Sathe *et al*., 2014) [9]. Results from scientific studies have led *Ocimum* sp. based products to be high demand by the public. Consequently, this has created interest among farmers and investors to grow the herb as a plantation crop.
Tulsi crop is attacked by several sucking insect pests like lace bug *Cochlochila bullita* (Stal), whitefly *Aleurodicus disperses* Russell, *Dialeurodes* sp. and aphid *Macrosiphum* sp. but *C. bullita* caused severe damage. Besides these pests, basil plant is also attacked by other insect The Ocimum tingid, *Cochlochila bullita* (Stal) (Heteroptera tingidae) is a lace bug, has been

recorded to attack culinary herbs, sweet basil – *Ocimum basilicum* L., *Ocimum tenuiflorum* L., camphor tulsi - *Ocimum kilimandscharicum* Gurke, clocimum tulsi - *Ocimum gratissimum* L., Krishna and Rama tulsi - *Ocimum sanctum* L. and also attack other medicinal herbs (Samuel 1939; Sharga 1953; Tigvattnanont 1989) [10, 11, 13]. This pest was reported for the first time on *O. basilicum* in the eastern part of India and 100 per cent plant infestation by *C. bullita* was reported in Jharkhand (Kumar 2014) [5]. In India, it is a particularly destructive pest of aromatic and medicinal plants of the genus *Ocimum* sp. It occurs in the old world tropics and found in India, Thailand, China, Southern Asia and United States. It was recently discovered in Malaysia during 2010 on *Orthosiphon stamineus* Bentham (Cat's whiskers plant). *C. bullita* attracted attention in India during 1950 when serious damage was caused by it to the leaves of *O. kilimandscharium* which was grown experimentally for the production of camphor in Kanpur. It was previously recorded as a pest of *Mentha* leaves all over India (Sharga, 1953) [11]. *C. bullita* is a key pest limiting the production and productivity of tulsi and it is estimated that *C. bullita* causes approximately 27.8 per cent yield loss in Bihar (Anon., 2012-2013). *C. bullita* was observed feeding gregariously on *Orthosiphon stamineus*, resulting in curling and drying of leaf tips, serious damage causes complete wilting of the plant. Despite enormous damage to *Ocimum* sp. by *C. bullita*, the damage pattern, biology, morphometrics and seasonal incidence of this pest have not been thoroughly studied. Thus, the present investigation was conducted to obtain detailed information about the nature of damage, host range, biology and morphometrics of *C. bullita* was also carried out. This is the first report of this pest feeding on, and its detailed study on *O. kilimandscharicum* from southern part of Karnataka.

2. Materials and Method

The present investigation on biology and morphometrics of *Ocimum* tingid *Cochlochila bullita* (Stal) on camphor tulsi were carried out during 2016-2017 at Dept. of Agri. Entomology, UAS, GKVK, Bengaluru. The biology and morphometrics of the tingid bug was studied under laboratory conditions at 31±2 ºC, 36±4 % RH. The details of the materials used and the methodologies adopted for achieving different objectives of this investigation are described here under.

2.1. Preperation of host plants

The beds of 1.5m x 0.5m size were raised. Seeds (10g/ bed) mixed with fine sand (1:4) were sown in lines of 6 cm apart or broadcast over the beds. Then it was covered with a thin layer of sand and watered. Seeds were germinated three days after sowing. Three to four week seedlings were used for experimental purpose. These seedlings were transferred to polythene bags containing Sand: Clay: FYM (1: 1:1 ratio).

2.2. Rearing method

C. bullita nymphs were collected from the field in punched polythene bags of size 20 x 13cm and maintained in rearing cage (35cm x 30cm x 25cm) on seedlings. The emerged adults were collected and maintained in petridish (Brandon disposable petridish; 9.0 x 1.5cm) and one day old adults were sexed and used for study.

2.3. Biology and Morphometrics of *Ocimum* tingid, *Cochlochila bullita* (Stal)

To study the biology of different stages of *C. bullita*, nymphs were collected from the field in punched polythene bags of size 20 x 13cm and maintained in rearing cage (35cm x 30cm x 25cm) on seedlings. Thirty pairs of emerged male and female adults were sexed and each pair was placed in to petridishes containing the round piece of moistened filter paper (Advantec grade no. 1 qualitative filter paper; diameter 5.5 cm) and two leaves were placed as feeding material. Feeding material and filter paper were changed for alternate days. Mating period was followed for five days. After five days, females were separated from all petridishes and released in mass on four week seedlings for egg laying. A cohort of 100 eggs with three replications was selected to study biology of *Ocimum* tingid bug. For measurements and morphological description were obtained from 15 nymphs from each instar and adults of both sexes. Eggs were randomly chosen and colour pattern was described. Collected eggs, nymphs and adults of both sexes were then kept in 70% ethanol for further examination.

3. Results and Discussion

The results and discussion including the nature of damage, host range, biology and morphometrics of *C. bullita* are presented here under.

3.1 Nature of damage

The nymph after emergence from the egg started moving and feeding the leaves. They first penetrated their head on surface of leaves and suck the sap with the help of rostrum. Due to feeding of nymphs - yellowing, dechlorophylled blotches were observed which later turned into brownish patches. A series of dark brown fecal pellets was observed on leaves, technically called as stippling symptom (Fig: 1). These brown spots changed to purple pinkish colour and they later these spots causes discolouration of the leaves.

More damage was caused by fourth, fifth instar nymphs and adult insects. Both nymphs and adults were found on both upper and lower surface of leaves but more population was observed on lower surface. They feed in groups. Heavily infested shoots would wither and drop off prematurely. Crinkling of older leaves, charring of tender leaves and inflorescence and ultimate withering were the more common symptoms (Fig: 2). Adherence of nymphal exuviae to the contaminated area ensures the damage of *C. bullita*. Adults curl the leaves from the margin and remain inside the curled leaves. Severe infestation of the pest results in wilting of the plants. The similar nature and symptom of damage was reported by Sharga (1953) [11], Kumar (2014) [5], Peng *et al*. (2014) [8], Dhiman and Jain (2010), Sajap and Peng (2010) [12].

Fig 1: Stippling symptom

Fig 2: Leaf drying and marginal leaf rolling due to *C. bullita* infestation on camphor tulsi

3.2 Biology and morphometrics of *C. bullita* Egg

After undergoing mating period for five days the gravid females started laying eggs in 0.09±0.01 (0.08-0.12) days. Egg was small, blackish brown, oblong and slightly tapered towards their opercular end and are cup shaped at the bottom. The operculum is having a circular rim. Operculum fits into mouth of the egg body. Eggs were light coloured when freshly laid becoming dark blackish, later onwards. The egg measured 0.50±0.01 (0.48-0.52) mm in length and 0.18±0.02 (0.16-0.22) mm in width (Table: 1), as similar studies were reported by Pang *et al* (2016). Eggs were mainly laid in groups or sometimes singly (Fig: 3) or in groups (Fig: 4), inserted inside the tender plant tissue vertically all along the leaf margins, midrib (Fig: 5), veins (Fig: 6), in between veins, leaf petioles and also inside the young stem leaving only the cap shaped opercula exposed. Similar study was reported by Sharga (1953) [11] and Peng *et al*. (2013) and Kumar (2014) [5].

Table 1: Morphometric observation on different life stages of *C. bullita* reared on *O. kilimandscharicum*

Stage	Duration (in days)		Body length (mm)		Width (mm)		Head capsule width (mm)	
	Range	Mean ± S.D.	Range	Mean ± S.D.	Range	Mean ± S.D.	Range	Mean ± S.D.
Egg	8.96 - 10.13	9.37 ± 0.57	0.48 - 0.52	0.50 ± 0.01	0.16 - 0.22	0.18 ± 0.02	-	-
Nymph								
I	1.87 - 4.00	2.85 ± 0.62	0.49 - 0.62	0.56 ± 0.04	0.25 - 0.26	0.26 ± 0.00	0.16	0.16 ± 0.00
II	1.79 - 5.16	2.66 ± 0.74	0.72 - 0.82	0.80 ± 0.04	0.42 - 0.43	0.43 ± 0.00	0.26	0.26 ± 0.00
III	2.13 - 3.00	2.58 ± 0.47	0.99 - 1.05	1.04 ± 0.04	0.46 - 0.49	0.48 ± 0.02	0.29 - 0.36	0.34 ± 0.02
IV	1.98 - 4.00	2.78 ± 0.63	1.22 - 1.58	1.41 ± 0.14	0.66 - 0.85	0.73 ± 0.07	0.39 - 0.42	0.40 ± 0.01
V	2.95 - 4.66	3.88 ± 0.55	1.88 - 2.11	1.95 ± 0.09	0.95 - 1.28	1.09 ± 0.14	0.42 - 0.62	0.49 ± 0.07
Adult								
Female	35.22 - 48.00	46.36 ± 3.92	2.27 - 2.67	2.45 ± 0.13	1.00 - 1.18	1.39 ± 0.08	0.42 - 0.56	0.43 ± 0.08
Male	40.00 - 47.20	45.85 ± 2.82	2.10 - 2.80	2.05 ± 0.19	0.89 - 1.15	1.19 ± 0.04	0.39 - 0.50	0.42 ± 0.04

Table 2: Duration of different life stages of *C. bullita* on *O. kilimandscharicum* under laboratory conditions

Statistical parameters	Incubation period (in days)	Duration of nymphal instars (in days)					Total nymphal duration (in days)	Total developmental period (in days)
		I	II	III	IV	V		
Range	8.95-10.12	1.87-3.83	1.79-5.16	2.13-3.00	1.98-4.00	2.95-4.66	12.86-17.81	21.81-31.37
Mean ± S.D.	9.37±0.57	2.85±0.62	2.85±0.62	2.58± 0.47	2.78±0.63	3.88±0.55	14.85± 1.61	24.18 ± 0.74

Oviposition occurred during day time between 10 AM to 4 PM. Cent per cent egg hatching was observed. The eclosion and incubation period ranged between from 13.00 – 14.50 minutes and 8.96 - 10.13 days, with a mean incubation of 9.37±0.57 days, respectively (Table: 2). In contrast, egg period reported by Tigavattnanont (1989) and Kumar (2014) [5] was 6.50 on on the *O. basilicum* and 6.06 *O. santum* days, respectively.

Fig 3: Egg (Single)

Fig 4: Egg (Group)

Fig 5: Eggs of *C. bullita* along the leaf vein

Fig 6: Eggs of *C. bullita* along the midrib

3.3. Nymph

Eggs were observed to hatch mostly between 9 AM to 3 PM, while a few eggs hatched during the later part of the day also. The emergence of first instar from egg was confirmed by the presence of completely opened operculum, but in some cases the opercular end was attached to the dorsal surface of the newly emerged nymph. The freshly emerged nymph possess prominent red coloured compound eyes and pale yellow coloured body later the body gradually hardened and pigmentation was formed. After emerging from eggs, the nymph started moving in search of food. Nymphs start feeding on the leaves after perceiving the gustatory stimuli emitting from the camphor tulsi leaves. Nymphs first penetrate their stylet on leaf surface and starts sucking the sap continuously. The initial feeding resulted in removal of chlorophyll, followed by yellowish spots on leaves and later the leaves turned to brownish colour. The nymphs suck the sap from leaves and were also observed to feed on inflorescence and succulent stem in the field. When the nymph was about to moult, feeding cessation occurred, then it cast off the exuvium from the entire body.

Five nymphal instars were observed in the laboratory. All the five instars of tingid exhibited remarkable outgrowths on the body surface. Nymphs and adults had piercing and sucking type of mouth parts. All the five instars were differentiated based on the tubular processes which were present on the dorsal and body margin distributed from head to last abdominal segments as well as appendages and the forewing pads, absent in the legs and antennae of these instars. These tubular outgrowths were glandular spines, called so because of their secretary nature. These spines bear waxy exudation at the tip.

(a) These secretion appears to be shining globules and technically they are called as 'sweating in tingids', they are present in different sizes, depending on stage of instars that bears it and sometimes aggregation of dust and sand particles were attached on these spines. These tubercles were long, slender, without setae along the sides, but had small row of tiny denticles. This exudation could not be seen in newly emerged nymphs and it was completely absent in the adults of both male and female. The exudation progressively increased in size and gradually became viscous as the nymph advanced in age. In exuviae, this exudation attained a semisolid state. All the five instars were having characteristic features as detailed below: Newly emerged nymphs were yellowish in colour, later gradually turned to brown – blackish during first and second in stars, whereas they turned completely blackish in third, fourth and fifth in stars. Three longitudinal carinal lines passed from head and reached upto the abdomen. Trochanter appeared to be two segmented.
(b) Four segmented antennae and elongated rostrum and stylet was not protected by any structure and labrum was continuous with the rostrum and it was not modified in all instars as in case of adults, red coloured compound eyes and ocelli was absent, presence of cephalic, pronotal and abdominal tubular spines with tiny denticles which were absent in adult stages.
(c) The first pair of pronotal spines and the tubular spines were located on first, fourth, sixth, eighth and ninth segments of the abdomen having similar in its length..

The total larval period occupied 14.85 ± 1.61 days (12.86 - 21.25 days) (Table: 2) during January to March. The length of instars from first to fifth ranged from 0.56 – 1.97 (Table: 1) mm. Description of each nymphal instars is given below.

First instar

The newly emerged first instar was pale yellowish in colour with red coloured compound eyes (Fig: 7). Later body colouration changed to brown colour and gradually to blackish in colour (Fig: 8). When the body colour changed to brown, the joints between head and abdomen, lateral side and segments ventrally at the base of the legs were yellowish in colour. Body was oval in shape. Antennae was four segmented, first segment was short and stout with 0.06 mm length of third and fourth segment. Head and abdominal segments carried stout hair-like processes which were smooth on the sides. The tubular spines were very thin and needle like which were distributed throughout the body. Three longitudinal carinal lines which were yellowish in colour, of which two lines arise from behind the compound eyes and these two were joined together by another one line medially which reached the segments of abdomen. Labium reaching up to hind coxae, darkish terminally. Thorax with some dark granular spots on the dorsal side. Coxae broad and darker in colour, trochanter short, femur and tibia fairly long. Tarsus was long with a pair of prominent claws at the terminal end. Pronotum and wing buds were not developed as earlier explained by Livingstone (1961) [6].

The first instar nymph measured 0.56±0.04 mm (0.49-0.62mm) in length, 0.26±0.00 (0.25-0.26) mm in breadth and 0.16 mm in width of head capsule (Table 1) are in line with findings of Peng *et al*. (2013). The first instar nymphal period lasted between 1.87 - 4 days, with mean duration of 2.85 ± 0.62 days (Table: 2).

Fig 7: Emergence of first instar from egg

Fig 8: First instar

Second instar

The newly emerged nymphs are yellowish in colour (Fig: 9) which turn from dark brown to blackish colour eventually (Fig: 10). General body colouration was darker than the first instar. Body was more rounded in shape as compared to the first instar. Paranotum and wing buds were not developed. Body has got tubular spines which were distributed along dorsum and margins of the body and were thicker than found in first instar. Joints of were antennae longer and similar to the first stage. Other body appendages were similar to that of the first instar. These findings were in line with Livingstone (1961) [6].

The length, breadth and head capsule width of of second instar were 0.80 mm, 0.43 mm and 0.26 mm (Table 1) respectively. Similar result was obtained by Peng *et al*. (2013) who reported that 0.77 and 0.40 mm of length and width of second instar. The average duration of the second instar was 1.79-5.16 (2.66 ± 0.74) days (Table 2).

Third instar

The newly emerged nymph was yellowish in colour with red coloured compound eyes (Fig: 11), which turned to dark blackish in colour (Fig: 12). Antennae were four segmented and black yellow in colour. Several hairs were situated anteriorly. Head, thorax and abdomen carried stout tubular processes. Legs were yellowish black with well-defined claws. Development of paranotum started during this instar and wing buds were absent. Cephalic spines were developed. Laterally paranotum possesses two spines of unequal length. Three longitudinal carinal lines were prsesnt which were yellowish in colour, of which two lines are aroses from behind the compound eyes and these two were joined together by another one line medially which reached the segments of abdomen. Similar studies reportrd by Livingstone (1974) and Peng *et al*. (2013).

The length and breadth of third instar were 1.04 ± 0.04 (range =0.99-1.05) mm and 0.48± 0.02 (range =0.46-0.49) mm respectively. The head capsule measured 0.34 ± 0.02 (range =0.29-0.36) mm in width (Table 1). Similar result was obtained by Peng *et al*. (2013) who reported that 1.03 and 0.53 mm of length and width of second instar. The average duration of the third instar was 2.58± 0.47 (Range 2.13-3.00) days (Table 2).

Fig 9: Newly emerged second instar

Fig 10: Second instar (Dorsal view)

Fig 11: Moulting of second instar

Fig 12: Third instar (Dorsal view)

Fourth instar

The newly emerged nymph was yellowish in colour with red coloured compound eyes (Fig: 12), which turned dark blackish in colour (Fig: 13). Antennae were four segmented and blackish yellow in colour. Paranotum was separated and well developed, wider on the thorax as compared to the third instar. Wing buds started developing. Cephalic spines were five in number, among which anterior three were longer and posterior two spines were shorter in length. Three longitudinal carinal lines which were yellowish in colour, of which two lines arose from behind the compound eyes and these two were joined together by another one line medially which reached upto posterior end of the wing buds. On the paranotum two pair of tubular spines were present which are separated by carinal line, in which anterior pair is longer than the posterior pair. Laterally paronotum had three spines on each side which were of unequal length and gradually increased in length from first pair to last pair.

Fig 13: Moulting of third instar

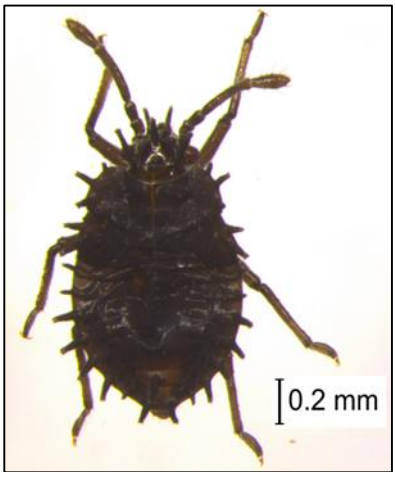

Fig 14: Fourth instar (Dorsal view)

The length and breadth of the fourth instars were 1.41±0.14 (1.22-1.58) mm and 0.73±0.07 (0.66-0.85) mm (Table 1), respectively. The head capsule measured 0.40 ± 0.01 (0.39-0.42) mm in width (Table 43). The average duration of the fourth instar was 2.78±0.63 (1.98-4.00) days (Table 2).

Fifth instar

The newly emerged nymph was yellowish in colour with red coloured compound eyes (Fig: 14), which turned dark black in colour (Fig: 15). Body shape was similar to that of the fourth instar, but more elongated. Antennae were four segmented and blackish yellow in colour. Paranotum was completely separated and clearly noticeable. On the paranotum two pair of tubular spines which were separated by carinal lines became equal in length as compared to that in fourth instar. Three carinal lines which were yellowish in colour, of which two lines arise from behind the compound eyes and these two were joined together by another one line medially which reached upto third abdominal segments and these segments were constricted. The paranotum laterally possessed the four unequal spines which were gradually increased in length from anterior towards the posterior.

The length and breadth of fifth instar were 1.95 ± 0.09 (1.88-2.11) mm and 1.09 ± 0.14 (0.95-1.28) mm (Table 1), respectively. The head capsule measured 0.49 ± 0.07 (0.42-0.62) mm in width (Table 43). The average duration of the fifth instars was 3.88±0.55 (2.95-4.66) days (Table 2).

The wing bud develops in both fourth and fifth in stars as earlier reported by Livingstone (1974) and Peng *et al*. (2013). The length, breadth and head capsule width of fourth and fifth instar was similar with the Peng *et al*. (2013)

Fig 15: Newly emerged fifth instar

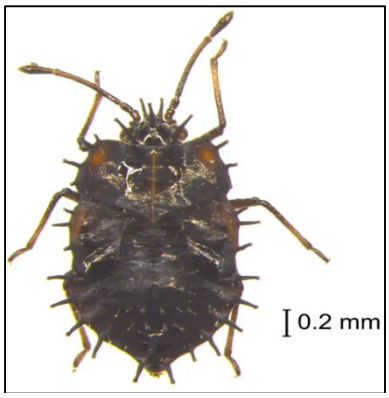

Fig 16: Fifth instar (Dorsal view)

3.5. Adult female

Newly emerged female was yellowish in colour with red coloured compound eyes, after pigmentation colour changed to blackish brown in colour (Fig: 16). A well-developed body with antennae which was four segmented and blackish brown in colour. Rostrum was four segmented, light blackish red in colour. Labrum was modified in reproductives and it protected the rostrum. At resting condition, the length of rostrum reached upto the first abdominal segment. Tubular processes were completely absent. Body and forewing had lacework, brown in colour whereas in hind wing's no lace work could be observed and it is shining with reduced wing venation. Three longitudinal carinal lines could be seen all along the paranotum. Wings were held flat over the body. Paranotum completely covered the head from the dorsal side. Mid coxae was very closer to hind coxae as compared to fore coxae. Eighth and ninth abdominal segments were greatly modified in females which had the genitalia capsule in the 'V' form (Fig: 17).

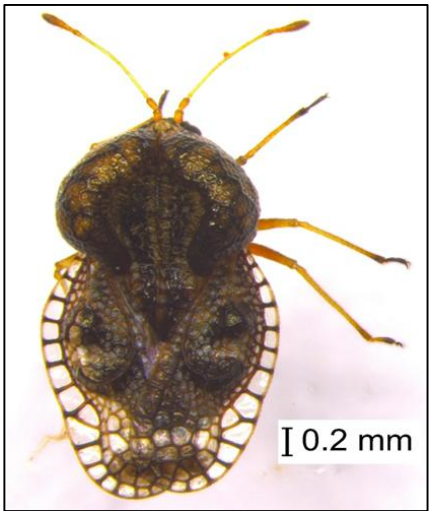

Fig 17: Adult female (Dorsal view)

Fig 18: Adult female (Ventral view)

The length and breadth of female were 2.45 ± 0.13 (2.27-2.67) mm and 1.39 ± 0.08 (1.00-1.18) mm, respectively. The head capsule measured 0.43 ± 0.08 (0.42-0.56) mm in width (Table 1). The average duration of the adult female with food and without food was 46.36 ± 3.92 (35.22-48.00) days and 1.62 ± 0.07 (1.5-1.80) days respectively (Table: 3).

Table 3: Adult longevity of *C. bullita* on *O. kilimandscharicum*

Adult	With food (in days)		Without food (in days)	
	Range	Mean ± S.D	Range	Mean ± S.D
Female	35.22 – 48.00	46.36 ± 3.92	1.50-1.80	1.62 ± 0.07
Male	40.00 - 47.20	45.85 ± 2.82	1.30-1.58	1.54 ± 0.09

Adult male

All features were similar to that of female (Fig: 18) but the posterior end of male abdomen had a genitalia capsule in 'U' form (Fig: 19). The length and breadth of male were 2.05±0.19 (2.10-2.80) mm and 1.19 ± 0.04 (0.89-1.15) mm, respectively (Table 43). The head capsule measured 0.42 ± 0.04 (0.39-0.50) mm in width (Table 1). The average duration of the adult male with food and without food 45.85±2.82 (40.00-47.20) days and 1.54 ± 0.09 (1.30-1.58) days, respectively (Table: 3)

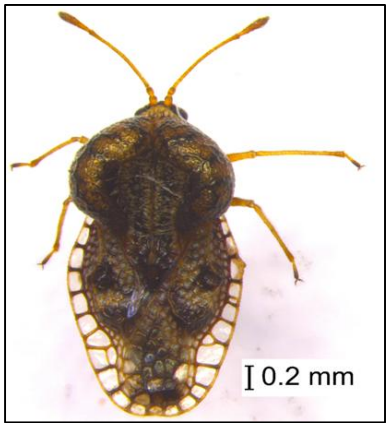

Fig 19: Adult male (Dorsal view)

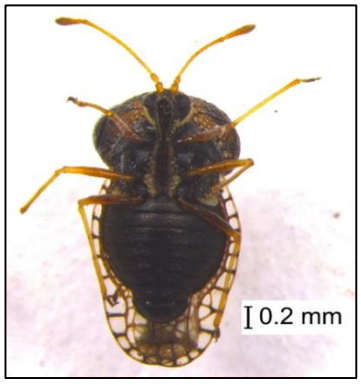

Fig 20: Adult male (Ventral view)

3.6. Copulation and Oviposition

Copulation (Fig: 20 & 21) took place after one day of emergence mostly during 4 PM to 9 PM and even during day time also. The male and female copulated in side by side position. The male held the female during copulation with the help of claspers. The average mating period of ten pairs for the first time took place in 0.78 ± 0.49 (0.23-1.33) hours. Both the male and female could mate more than one time during a period of five days.

The female started egg laying from five days after mating and continued upto a maximum of 15.70 ± 0.67 (14-16) days after mating. The female was found to lay eggs during day time inside the plant tissue vertically in tender leaves, leaf petiole, tender shoot and stem, either singly or in clusters. The eggs could be easily identified under microscope because eggs were black in colour with operculum exposed outside. Each female laid 156 to 259 eggs.

Fig 20: Mating position of male and female (Doral view)

Fig 21: Mating position of male and female (Ventral view)

3.3 Host range of *C. bullita*

During the study, it was recorded that the *C. bullita* infests all the five types of tulsi and also infests the adjacent plot of sage. The adult was capable of short flights. The distance which it could fly at any one time in the calm air of the laboratory varied from a few inches. They drifted along with the wind to long distances from sources of infestation to uninfected plots. The plants which were attacked by tinged bug during the course of this investigation are listed below:

a. Camphor tulsi: *Ocimum kilimandscharicum* Gurke
b. Clocimum tulsi: *Ocimum gratissimum* Linn.
c. Krishna tulsi: *Ocimum sanctum* Linn.
d. Rama tulsi: *Ocimum sancum* Linn.
e. Sweet basil: *Ocimum basilicum* Linn.
f. Sage: *Salvia officinalis* Linn.

4. Conclusion

In conclusion, the nature of damage differentiate the damage caused by early and later instars with that of the adults. The biology and morphometrics is useful to know the developmental periods and also to distinguish the different stages. Copulation and oviposition are the key factors in identification, recognition and monitoring of this pest on tulsi and oviposition pattern also leads to further in detailed studies of natural enemies like parasitiods on this pest eggs.

5. Acknowledgement

I wish to thank Dr. Vasundhara. M for providing the chance to work in Sugandhavana Garden at College of Agriculture, UAS, GKVK, Bengaluru. I also thank H. M. Yeshwanth and Miss. Nirmala for identifying the insect pests of Patchouli, Tulsi and Mint.

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