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**Triveni B**

Post-Graduation,  
Department of Agriculture  
Entomology, University of  
Agricultural Sciences, GKVK,  
Bengaluru, Karnataka, India

**Jagadish KS**

Professor, Department of  
Agriculture Entomology,  
University of Agricultural  
Sciences, GKVK, Bengaluru,  
Karnataka, India

**Devika Rani**

Ph. D. Research Scholar,  
Department of Agriculture  
Entomology, University of  
Agricultural Sciences, GKVK,  
Bengaluru, Karnataka, India

## Life table of *Ocimum tingid*, *Cochlochila bullita* (Stal.) on camphor tulsi, *Ocimum kilimandscharicum*, Gurke from South Indian condition

**Triveni B, Jagadish KS and Devika Rani**

**Abstract**

The present investigation on life-table 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  $9.37 \pm 0.57$  days, nymphs took 12.86 to 17.81 days to complete five instars with an average of  $14.85 \pm 1.61$  days and total developmental period from 21.81-31.37 days with a mean  $24.18 \pm 0.74$  days. The life fecundity table were studied for *C. bullita* on camphor tulsi under laboratory conditions at 28.30 to 36.00 °C. The net reproductive rate ( $R_0$ ) was 1182.82 females with generation period (T) was 26.88 days. The innate capacity (rm) and finite rate of increase ( $\lambda$ ) for increase in number was calculated to be 0.2632 and 1.32 female/day, respectively with weekly multiplication rate of 6.91 times.

**Keywords:** *Ocimum kilimandscharicum*, camphor tulsi, *Cochlochila bullita* *Ocimum tingid*, Life-table

**Introduction**

Himalayan sage scholar of traditional medicine has said “*Nanaushadhi Bhootam Jagat Kinchit*” i.e. ‘there is no plant in the world, which does not have medicinal properties.’ Medicinal plants are those plants which are rich in secondary-metabolites (alkaloids, glycosides, coumarins, flavonoides, steroids etc.) which are potential source of drugs. India is one of the few countries where almost all the known medicinal plants can be cultivated in some region or the other. The Lamiaceae is one of the diverse and widespread plant families in terms of ethnomedicine and its medicinal value is based on the volatile oils concentration.

*Ocimum kilimandscharicum* Gurke (Family: Lamiaceae) is popularly known as Camphor tulsi which is an perennial, undershrub with pubescent branchlets of height 30-90 cm. It is native of Kenya (East Africa). The occurrence has been reported by Gulati and Suri [5] in U.P., West Bengal, Maharastra, Mysore, Madras, Kerala, Jammu and Darjeeling.

Tulsi, *Ocimum* spp. is seriously attacked by about ten spp. of insect pests of which *Ocimum tingid - Cochlochila. bullita*, whiteflies - *Aleurodicus dispersus* Russell, *Dialeurodes* sp. and aphid - *Macrosiphum* sp. *Ocimum tingid - C. bullita* occurs in the old world tropics and it was mostly found in India and china, also been studied in Thailand as reported by Tigvatnanont [11]. Among all the pests, *C. bullita* is a key pest which limiting the production and productivity of tulsi and it causes around 27.80 percent yield loss in Bihar, Anonymous [1]. Bhattacharyya and Chakravorty [2] reported the incidence of *C. bullita* on tulsi plants in Kalyani, West Bengal. *C. bullita* occurs on several host plants belonging to the family - lamiaceae which include, camphor basil - *Ocimum kilimandscharicum* Gurke, sweet basil - *Ocimum basilicum* Linn., tulsi - *Ocimum tenuiflorum* Linn., mint - *Mentha* spp., lavender - *Lavendula* spp., safflower - *Carthamus tinctorius* L., rosemary - *Rosmarinus officinalis* L., and cat's whiskers plant - *Orthosiphon aristatus* as reported by Peng *et al.* [7]. *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. The lace bug damages the host plant by piercing and sucking young leaves and shoots, resulting in the curling and drying of the leaves and shoots. The infestation pattern and survival of *C. bullita* on *O. stamineus* indicates that lace bug has the potential to be a serious pest of the medicinal plant as reported by Sajap and Peng [8]. The plant, *O. basilicum* is severely attacked by *C. bullita* at Saharapur and causes the drying and wilting of leaves resulting in ultimate death of the plants as reported by Dhiman and Datta [4]. *C. bullita* (Stal.) is an important pest of cultivated herbs in Southern Asia and has been intercepted several times at ports of entry in the

**Correspondence****Triveni B**

Post-Graduation,  
Department of Agriculture  
Entomology, University of  
Agricultural Sciences, GKVK,  
Bengaluru, Karnataka, India

United States including large numbers of individuals, which would pose a greater potential threat of *C. bullita* becoming established, over the last 20 years as earlier reported by Smith [11]. *C. bullita* performance on *O. kilimandscharicum* in terms of its demographic characteristics on camphor tulsi has yet to be unknown. Demographic parameters of an insect can be elucidated using a life table analysis Southwood and Handerson [13].

### Materials and Method

The present investigation on life-table of *Ocimum* tingid *Cochlochila bullita* (Stal.) on camphor tulsi were carried out during 2016-2017 at Dept. of Agri. Entomology, UAS, GKVK, Bengaluru. The life cycle of the tingid bug was studied under laboratory conditions at  $31 \pm 2$  °C with  $36 \pm 4\%$  RH. The details of the materials used and the methodologies followed were described here under.

**Preparation 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).

### 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.

### Life table study

To study the life expectancy 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 (Fig 1& 2) 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 of two replication was selected for study and further number of eggs hatched and survival of successive instars at different stages were recorded.

To study the age specific fecundity of *C. bullita* on *O. kilimandscharicum*, fifteen pairs of emerged adults were selected from previous population and each pair was placed in to petridish 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. After five days, females were separated from all petridishes and released on four week seedlings for egg laying. Each gravid female was provided with single host plant for oviposition and after every 24 hrs, the host plants were replaced by another plant and females were placed on the new host plant carefully for oviposition. The number of eggs laid per day were counted and waited for the neonates to be emerged.

Once the neonates were emerged, they were counted and then left on the plant till they moulted. Second instars were then transferred with the help of camel hair brush No.1 individually into a petridish containing a moistened filter paper and a fresh filter paper. Pre-ovipositional, Ovipositional, Post-ovipositional period and fecundity were recorded as per the methodology suggested by Peng *et al.* (2015). The possibility of reproduction without mating was also investigated. These females (unmated) were kept separately on the host plants and examined once in every 24 hrs for oviposition.

### Statistical analysis

All life table and fertility table parameters were measured and calculated as described by Birch [3]. Population parameters were calculated as:

X: Age of the insect in days

lx: Number surviving at the beginning of each interval, out of 200

dx: Number dying during the age interval, out of 200

ex: Expectation of life or mean life remaining for individuals of age x.

$ex = Tx / Lx$

To obtain the life expectation ( $e_x$ ) two other parameters  $T_x$  and  $L_x$  were also computed as detailed below.

$L_x$ : The number of individuals alive between ages, x and x+1 and calculated by the equation.

$L_x = lx + (lx+1) / 2$

$T_x$ : The total number of individuals of x age units and beyond the age x, and obtained by the equation.

$T_x = lx + (lx+1) + (lx+2) + (lx+3) + \dots + (lw)$ .

Where, lw = The last age interval

Life Table and Age - Specific fecundity table

The life table was constructed as per the suggestions made by Birch [3] and Southwood [12]. It consisted of the following columns:

X: Pivotal age of female (in days)

lx: Number of females alive at the beginning of the age interval x.

mx: Average number of female eggs laid per female in each age interval.

lxmx: Total number of birth in each age interval.

Population Growth Attributes

Net reproductive rate ( $R_0$ ) is the total number of female offspring's produced per female during single generation

$R_0 = \sum lxmx$

Mean length of generation (or) appropriate generation time, independent of 'rm' or mean duration of generation

$Tc = \sum lxmx \cdot x / R_0$

Innate capacity for increase (rc) =  $\log_e R_0 / T$

Where, e = natural log (i.e. 2.71828)

The above rc was an appropriate value of intrinsic rate of natural increase (rm) and is slightly lower than rm value for insects with overlapping generations as suggested by Southwood [13].

'rm' values (Intrinsic rate of increase)

This appropriate value (rc) and other provisional values (rm) were substituted in the following equation to obtain accurate value of intrinsic rate of increase (rm)

$\sum e^{-rm \cdot x} lxmx = 1$

Where, e = natural log (2.71828)

Two trial values of 'rm' differing two points in second place were substituted in the above equation. In each case  $e^{-rm}$  values were multiplied with lxmx values. These two trial

values were found by trial and error, which lie immediately above and below '1'. The trial 'r' values on Y-axis and the summation value from the equation  $\sum e^{-rm.x}$  Ixmx on X-axis were plotted on graph. The point of trial 'rm' values against summation was connected by a straight line at which it was intercepted with the vertical line drawn from established value, '1' from X-axis, considered as 'rm' value. This value is substituted in the above equation to check whether the summation is '1' or not. If it is not less than one then tried for another  $r_m$  value, then the same procedure was repeated, until '1' was obtained. Finally, this value was considered as accurate 'rm' value. From the 'rm' value, the corrected generation time (T), finite rate of increase ( $\lambda$ ) and weekly multiplication rate (WMR) were derived by using the following formulae.

Corrected generation time (T):  $\log_e R_0 / rm$

Finite rate of increase ( $\lambda$ ):  $\text{anti } \log_e rm$

Weekly multiplication rate (WMR):  $(e^{rm})^7$

Hypothetical  $F_2$  females:  $(R_0)^2$

Doubling time:  $\ln 2 / rm$

**Result and Discussion**

The eggs of *C. bullita* which were held at  $31 \pm 2$  °C, hatched in  $9.37 \pm 0.57$  d (Table : 1). When fed on *O. kilimandscharicum* the lace bug had a cumulative developmental time from egg laid till adult emergence ranging from 21.81 to 31.37 d. The nymph completes four successive moults with five instars. The total nymphal period was 12.86-17.81 d. Whereas, incubation and total developmental period was  $8.80 \pm 0.2$  d and 21.40 – 24.40 d on *O. basilicum* as earlier reported by Peng *et al.* [7].

**Table 1:** Duration of different life stage periods of *C. bullita* on *O. kilimandscharicum* under laboratory condition

| Statistical parameters               | Range       | Mean±S.D.    |
|--------------------------------------|-------------|--------------|
| Incubation period (in days)          | 8.95-10.12  | 9.37±0.57    |
| Total nymphal duration (in days)     | 12.86-17.81 | 14.85± 1.61  |
| Total developmental period (in days) | 21.81-31.37 | 24.18 ± 0.74 |

**Oviposition**

The female started egg laying from five days after mating and continued upto a maximum of  $15.70 \pm 0.67$  (14-16) days after mating. The female was found to lay eggs during day time in

**Table 2:** Fecundity of *C. bullita* on *O. kilimandscharicum*

| Female number | Day wise egg laying (No.) during ovipositional period |     |      |    |      |      |      |      |      |      |     |     |     |     |     |     |    | Male progeny | Female progeny | Total |
|---------------|---|-----|------|----|------|------|------|------|------|------|-----|-----|-----|-----|-----|-----|----|--------------|----------------|-------|
|               | 1   | 2   | 3    | 4  | 5    | 6    | 7    | 8    | 9    | 10   | 11  | 12  | 13  | 14  | 15  | 16  | 17 |              |                |       |
| 1             | 2   | 6   | 7    | 9  | 20   | 36   | 19   | 17   | 15   | 12   | 9   | 6   | 6   | 5   | 2   | 2   | 0  | 41           | 132            | 173   |
| 2             | 4   | 6   | 8    | 12 | 23   | 32   | 26   | 19   | 15   | 14   | 8   | 8   | 5   | 4   | 2   | 1   | 0  | 55           | 132            | 187   |
| 3             | 5   | 7   | 8    | 10 | 21   | 29   | 25   | 21   | 14   | 10   | 8   | 7   | 4   | 3   | 3   | 2   | 0  | 55           | 122            | 177   |
| 4             | 3   | 10  | 14   | 17 | 26   | 38   | 24   | 18   | 10   | 12   | 7   | 5   | 3   | 3   | 0   | 0   | 0  | 58           | 133            | 191   |
| 5             | 6   | 1   | 12   | 18 | 19   | 28   | 17   | 16   | 14   | 10   | 9   | 8   | 4   | 2   | 2   | 2   | 0  | 27           | 141            | 168   |
| 6             | 3   | 5   | 20   | 26 | 28   | 39   | 30   | 27   | 18   | 17   | 15  | 12  | 9   | 5   | 3   | 2   | 0  | 77           | 182            | 259   |
| 7             | 4   | 8   | 16   | 20 | 26   | 33   | 25   | 23   | 19   | 10   | 8   | 7   | 5   | 4   | 1   | 2   | 0  | 53           | 148            | 211   |
| 8             | 7   | 8   | 17   | 27 | 29   | 40   | 17   | 10   | 9    | 8    | 5   | 6   | 4   | 3   | 0   | 2   | 0  | 56           | 136            | 192   |
| 9             | 3   | 5   | 12   | 18 | 16   | 12   | 19   | 17   | 14   | 14   | 11  | 7   | 3   | 2   | 2   | 1   | 0  | 47           | 109            | 156   |
| 10            | 7   | 13  | 18   | 23 | 28   | 35   | 20   | 17   | 8    | 8    | 7   | 5   | 4   | 5   | 3   | 0   | 0  | 60           | 141            | 201   |
| Average       | 4.4   | 6.9 | 13.2 | 18 | 23.6 | 32.2 | 22.2 | 18.5 | 13.6 | 11.5 | 8.7 | 7.1 | 4.7 | 3.6 | 1.8 | 1.4 | 0  |              |                | 191.4 |

**Life table of *C. bullita***

The survival of different life stages of *C. bullita* on camphor tulsi was found to be 9, 14 and 46 days in egg, nymphal and adult stages, respectively. The host plants also influenced the mortality of the immatures. Higher mortality occurred in the early nymphal stages. There was 9.50 percent mortality in egg

the plant tissue vertically in tender leaves, leaf petiole, tender shoot and stem, either singly or in clusters (Fig: 1) as earlier reported by Sharga [10] and Kumar [6]. The eggs could be easily identified under microscope because of eggs were black in colour with operculum exposed outside (Fig: 2). Each female laid 156 to 259 eggs (Table: 2). Egg laying was observed on sixth day after mating and continued upto 16 days and peak egg laying was observed on sixth day with average number of eggs being 32.20, eventually egg laying was decreased up to 17<sup>th</sup> day as represented by vitality curve. More or less similar findings were reported by Sathe and Sathe [9] on *O. sanctum*.



**Fig 1:** Adult male (Ventral view) with 'U' shaped abdominal tip



**Fig 2:** Adult female (Ventral view) with 'V' shaped ovipositor

stage, 18.75, 6.00, 5.07, 6.10, and 2.43 percent mortality observed in first, second, third, fourth and fifth instars, respectively. These differences contributed to the overall mortality from the egg to adult stages of 47.85 percent on *O. kilimandscharicum* (Table: 3).

**Table 3:** Life table depicting the life expectancy of *C. bullita* on *O. kilimandscharicum*

| X | Age Category (x) | # surviving        | # deaths | Prop (lx) | nx   | dx  | Qx    | Lx    | Tx     | ex    |
|---|------------------|--------------------|----------|-----------|------|-----|-------|-------|--------|-------|
| 1 | Eggs             | 200                | 19       | 1         | 1000 | 95  | 0.095 | 952.5 | 4400   | 4.619 |
| 2 | First instar     | 181                | 34       | 0.905     | 905  | 170 | 0.188 | 820   | 3447.5 | 4.204 |
| 3 | Second instar    | 147                | 9        | 0.735     | 735  | 45  | 0.061 | 712.5 | 2627.5 | 3.688 |
| 4 | Third instar     | 138                | 7        | 0.69      | 690  | 35  | 0.051 | 672.5 | 1915   | 2.848 |
| 5 | Fourth instar    | 131                | 8        | 0.655     | 655  | 40  | 0.061 | 635   | 1242.5 | 1.957 |
| 6 | Fifth instar     | 123                | 3        | 0.615     | 615  | 15  | 0.024 | 607.5 | 607.5  | 1.000 |
| 7 | Adult            | 120                |          | 0.6       | 600  | 0   | 0.000 |       | 0      |       |
|   | Total            |                    |          |           | 5200 |     |       | 4400  |        |       |
|   | Sex Ratio        | 1:2.6              |          |           |      |     |       |       |        |       |
|   | Vitality         | 191.4 eggs/ female |          |           |      |     |       |       |        |       |

Survival rate (lx) followed almost type III survivorship curve, with a higher mortality occurred during the early nymphal stages, specifically during the first instar and decreased gradually as they matured. The life table data presented in (Table: 4) represented that the first female mortality was observed on 46<sup>th</sup> day (lx=0.90) after the emergence of adult female which increased on subsequent days. The net

reproductive rate indicating the (R<sub>0</sub>) 1182.82. The pre-oviposition period of *C. bullita* was on the 30<sup>th</sup> day of pivotal age. The females deposited first batch of eggs on 30<sup>th</sup> day and continued oviposition upto 45<sup>th</sup> day. The female contributed highest births (mx=198.15) in their life cycle on 35<sup>th</sup> day of pivotal age.

**Table 4:** Life table (for female) and age specific fecundity of *C. bullita* on *O. kilimandscharicum*

| Pivotal age in days (x) | Survival of female at different age interval (lx) | Age schedule for female birth (mx) | (lxmx)           | (x. lxmx)           |
|-------------------------|---|------------------------------------|------------------|---------------------|
| 0-24                    | Immature stages                                   |                                    |                  |                     |
| 25                      | 1   | -                                  | 1                | 25                  |
| 26                      | 1   | -                                  | 1                | 26                  |
| 27                      | 1   | -                                  | 1                | 27                  |
| 28                      | 1   | -                                  | 1                | 28                  |
| 29                      | 1   | -                                  | 1                | 29                  |
| 30                      | 1   | 27.07                              | 27.07            | 812.1               |
| 31                      | 1   | 42.46                              | 42.46            | 1316.26             |
| 32                      | 1   | 81.23                              | 81.23            | 2599.36             |
| 33                      | 1   | 110.77                             | 110.77           | 3655.41             |
| 34                      | 1   | 145.23                             | 145.23           | 4937.82             |
| 35                      | 1   | 198.15                             | 198.15           | 6935.25             |
| 36                      | 1   | 136.61                             | 136.61           | 4917.96             |
| 37                      | 1   | 113.85                             | 113.85           | 4212.45             |
| 38                      | 1   | 83.69                              | 83.69            | 3180.22             |
| 39                      | 1   | 70.77                              | 70.77            | 2760.03             |
| 40                      | 1   | 53.54                              | 53.54            | 2141.6              |
| 41                      | 1   | 43.69                              | 43.69            | 1791.29             |
| 42                      | 1   | 28.92                              | 28.92            | 1214.64             |
| 43                      | 1   | 22.15                              | 22.15            | 952.45              |
| 44                      | 1   | 11.08                              | 11.08            | 487.52              |
| 45                      | 1   | 8.61                               | 8.61             | 387.45              |
| 46                      | 1   | 0                                  | 0                | 0                   |
| 47                      | 1   | 0                                  | 0                | 0                   |
| 48                      | 1   | 0                                  | 0                | 0                   |
| 49                      | 1   | 0                                  | 0                | 0                   |
| 50                      | 1   | 0                                  | 0                | 0                   |
| 51                      | 0.9   | 0                                  | 0                | 0                   |
| 52                      | 0.9   | 0                                  | 0                | 0                   |
| 53                      | 0.9   | 0                                  | 0                | 0                   |
| 54                      | 0.9   | 0                                  | 0                | 0                   |
| 55                      | 0.9   | 0                                  | 0                | 0                   |
| 56                      | 0.9   | 0                                  | 0                | 0                   |
| 57                      | 0.9   | 0                                  | 0                | 0                   |
| 58                      | 0.9   | 0                                  | 0                | 0                   |
| 59                      | 0.9   | 0                                  | 0                | 0                   |
| 60                      | 0.9   | 0                                  | 0                | 0                   |
| 61                      | 0.9   | 0                                  | 0                | 0                   |
| 62                      | 0.9   | 0                                  | 0                | 0                   |
| 63                      | 0.9   | 0                                  | 0                | 0                   |
| 64                      | 0.9   | 0                                  | 0                | 0                   |
| 65                      | 0.9   | 0                                  | 0                | 0                   |
| 66                      | 0.4   | 0                                  | 0                | 0                   |
| 67                      | 0.2   | 0                                  | 0                | 0                   |
| 68                      | 0   | 0                                  | 0                | 0                   |
|                         |   |                                    | Σ lxmx = 1182.82 | Σ x.lxmx = 42436.81 |

The mean time required to complete the generation (T) was 26.88 days (Table 5). The innate capacity ( $r_m$ ) and finite rate of increase ( $\lambda$ ) for increase in number was calculated to be 0.2632 and 1.32 females per female per day, respectively. At this rate, the population of *C. bullita* was capable to multiply

6.91 times/week under the given set of conditions. The hypothetical  $F_2$  values were found to be in the tune of 1399033. The population doubled its number in 25.80 days. More or less similar observations were recorded earlier by Peng *et al.*, 2015 and Sathe and Sathe, 2014.

**Table 5:** Mean length of generation, innate capacity for increase in number and finite rate of increase in number of *C. bullita* on *O. kilimandscharicum*

| Population growth statistics                    | Formula                             | Calculated value            |
|---|-------------------------------------|-----------------------------|
| Net reproductive rate                           | $R_o = \sum l_x m_x$                | 1182.82                     |
| Mean length of generation                       | $T_c = \sum l_x m_x \cdot x / R_o$  | 26.88 days                  |
| Innate capacity for increase in number          | $r_c = \log_e R_o / T$              | 0.2632 Females/ Female/ day |
| Arbitrary ' $r_m$ ' ( $r_c$ )                   | -                                   | 0.27 and 0.28               |
| Corrected ' $r_m$ '                             | -                                   | 0.2758                      |
| Corrected generation time (T)                   | $T = \log_e R_o / r_m$              | 25.65 days                  |
| Finite rate of increase in number ( $\lambda$ ) | $\lambda = \text{anti } \log_e r_m$ | 1.32 Females/ Female/ day   |
| Weekly multiplication of population             | $(\lambda)^7$                       | 6.91                        |
| Hypothetical $F_2$ females                      | $(R_o)^2$                           | 1399033.00                  |
| Doubling time                                   | $DT = \ln 2 / r$                    | 25.80                       |

### Conclusion

There are many factors influencing on growth, longevity, reproduction and mortality of an insect in natural condition. The cohort life table was constructed under a controlled environment that eliminated many natural variables like natural enemies and weather factors which might have affect the parameters. Thus, the life table data obtained in this study provides an insight into the demographics of *C. bullita* populations and enables us to discern patterns and make predictions about the changes of its populations in future. Although, *C. bullita* has been reported as a host for *O. kilimandscharicum*. This is the first study on the life table of tingid bug on *O. kilimandscharicum*.

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