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# Studies on Thrips Species and Their Associated Predators in Shendi Area, River Nile State, Sudan

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## Abstract

This study was conducted during November 2011 to February 2013 in Shendi, a promising agricultural area in the River Nile State, Sudan. It aimed to recognize the important thrips species, their host plants, and associated predators via field surveys. Preliminary laboratory investigations were also carried out, regarding life cycle (durations of pre-imaginal stages) of two key species of thrips as well as of two dominant predators, in addition to feeding capacity test for such predators when provided with adults of onion thrips (*Thrips tabaci*). The results revealed two thrips species, viz., onion thrips and cotton leaf thrips (*Caliothrips sudanensis*), with the former species reflected a wider host range (in terms of plant family and species) than the latter one. In addition, four predatory insects were detected, among which the green lacewing (*Chrysoperla carnea*) and the 11-spotted ladybird (*Coccinella undecimpunctata*) were predominant. The average total durations of immature stages of *T. tabaci* and *C. sudanensis*, during January-February 2013 in winter (av. 25°C and 35.8%R.H.), were 10.66±0.08 and 13.33±0.30 days, respectively. The shorter developmental period of *T. tabaci* and its threat to several host crops suggested its major pest status. On the other hand, the average durations of immature stages of *C. carnea* and *C. undecimpunctata*, during October-November 2013 of pre-winter time (av. 34°C and 42%R.H.), were 24.98±1.02 and 21.67±0.49 days, respectively. The results of feeding rates reflected that the larvae of *C. carnea* devoured insignificantly larger number of *T. tabaci* (76.45±1.66 adults) than those of *C. undecimpunctata* (74.00±3.88), during their lifetimes. However, such relative inferiority of the latter predator, regarding larval duration and feeding rate, seemed to be compensated by predation in adult stage. Therefore, both predators look important in regulating thrips populations, and this awaits further studies.

**Keywords:** Thripidae, *Thrips tabaci*, *Caliothrips*, *Chrysoperla*, life cycle, feeding.

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## Introduction

Shendi Locality is one of the important irrigated agricultural areas in the River Nile State. The arable lands in Shendi area is about 9,000 feddans (one feddan=0.42ha). Several crops are grown there, e.g. okra [*Abelmoschus esculentus* (L.) Moench], snake cucumber [*Cucumis melo* var.

*flexuosus* (L.) Naudin], onion [*Allium cepa* L.], rocket [*Eruca sativa* L.], Jew's mallow [*Corchorus olitorius* L.], tomato [*Solanum lycopersicum* L.], broad bean [*Vicia faba* L.], common bean [*Phaseolus vulgaris* L.], cowpea [*Vigna sinensis* L.], lablab bean [*Lablab purpureus* (L.) Sweet], alfalfa [*Medicago sativa* L.], and a variety of fruits. Fallow areas also present, where different wild plants generally grow.

Pests and diseases represent the major threat for production of vegetable and field crops in the area. However, among common polyphagous insects are thrips (Thripidae), whitefly (Aleyrodidae), different aphids (Aphididae), leaf miners (Agromyzidae), cutworms and fruit borers (Noctuidae), fruit flies (Tephritidae), and many other pest species. Of these pests, thrips are economically important to various crops, particularly the onion. For example, the average of onion yield losses due to onion thrips (*Thrips tabaci* Lind.) attack may exceed 39% in some parts of the country (Kisha, 1977). Accordingly, this species is the only major economic insect pest attacking onion, which leads to yield losses through complete defoliation of leaves and consequently reduction of flowers and fruit sets. Besides onion, *T. tabaci* also attacks many other vegetables and field crops. Other thrips pests in the country may include some *Caliothrips* spp., which attack different host plants (Bagnall and Cameron, 1932, and Schmutterer, 1969).

Vegetable growers and other farmers rely heavily on application of broad spectrum insecticides for controlling different pests, though, some of these insecticides are highly or extremely toxic (Kannan, 1997). At present, the chemical control appears to be the main approach of combating agricultural pests in Sudan (Elbadawi, 2014), despite its various hazards and drawbacks to the environment. However, an integrated pest management had proved successful in combating cotton pests during last decades of the 20$^{th}$ century, utilizing certain cultural practices, natural enemies and other management tactics, and with least application of chemicals (Abdelrahman and Munir, 1989), but no similar attempts had been done for vegetable crops.

Natural enemies such as predators are important bio-agents that may contribute in maintaining thrips populations at low levels in different parts of the world (Tummala and Haynes, 1980, and Lewis, 1997). However, the actual interaction of predatory species with most pests, particularly thrips, in the country, is still pending thorough investigations especially with respect to bio-ecological aspects. Studies on these fields could be of great value for indicating the potential predators and their investment among other elements in thrips management. On this understanding, the current research was aimed to recognize the important thrips species, their host plants, and associated predators prevailing in Shendi area, and to investigate some biological aspects (life cycle) of thrips species as well as of two major predators, in addition to test feeding capacity of such predators when reared on adults of onion thrips.

## Materials and Methods

This research has been fulfilled through field surveys, and laboratory studies dealt with thrips species and their major predators on different host plants in Shendi area.

### 1. A study area

Shendi is located on the eastern bank of the River Nile (latitude 16° 40`N: longitude 33° 33`E), about 150 km northeast of Khartoum, the capital of Sudan. This area is confined within the semi-arid zone of the country that characterized by a hot summer (March – June) and a cold dry winter (November – February). The average annual temperature is about 29°C, but the maximum temperature may exceed 45°C in summer season. This followed by the autumn season (July – October), where the average annual rainfalls is around 100 mm. In general, River Nile State is an agricultural area that depends on irrigation systems, where vegetable, field crops and different fruit trees are grown.

### 2. Field surveys

Field surveys were conducted every 10 days at three locations (viz., Al-shqalwa, Moyes and Al-misektab) in Shendi area during the period from November 2011 to February 2013, where wild and cultivated plants were investigated for infestations by thrips. The collected thrips samples were identified at the Insect Collection of the Agricultural Research Corporation (ARC), Wad Medani/ Sudan. Hence, host plants infested with each thrips species, and predators associated with them, were recognized.

## 3. Laboratory studies

Three biological aspects of thrips and their major predators were studied under laboratory conditions, at Shendi University. These included the life cycle of pre-adult stages of two thrips species, viz. *Thrips tabaci* and *Caliothrips sudanensis* (Bagnall & Cameron), and two of their major predators, viz. *Chrysoperla carnea* (Stephens) and *Coccinella undecimpunctata* L., besides testing the feeding rates of these predators when reared on adults of *T. tabaci*. The completely randomized design (CRD) was applied. The data were statistically analyzed and compared based on the LSD test.

### 3.1. Life cycle of major thrips species

The life cycle of the two thrips species was conducted during January – February 2013. The average temperature during the study period was 25°C (20 – 32°C), and the relative humidity was 35.8% (20 – 50%). To prepare culture of thrips for the study, fresh leaves of onion and alfalfa plants were collected where *T. tabaci* and *C. sudanensis* were respectively reared, as explained herewith:

***Thrips tabaci*:** In order to develop the initial culture of thrips for breeding, ten adults of *T. tabaci* were collected with the help of an aspirator from an untreated onion field at Al-shqalwa area, on January 2013, and released into a glass tube (200×40 mm) containing fresh leaves of onion. The tube vent was covered using a muslin cloth, transferred to the laboratory and reared for the next generation. The leaves in the glass cage were replaced with new ones every 24 h. Removed leaves were placed in Petri-dishes, kept under laboratory conditions, and then observed on daily basis. When nymphs (larvae) emerged from the leaves, then the time taken from egg laying (i.e., time of leaf removal) until the day of egg hatching was taken as an incubation period. To determine the life durations of different larval instars, the newly hatched larvae of *T. tabaci* were kept individually in Petri-dishes, fed on onion leaves, and observed daily for molting. The total larval period was calculated. At first, the prepupal stage was detected. When the pupae formed, they were collected and kept individually in new Petri-dishes and closely observed for adult emergence.

***Caliothrips sudanensis*:** Adults of *C. sudanensis* were collected from a field of alfalfa crop at Al-shqalwa area. They reared under the laboratory conditions, as demonstrated for *T. tabaci*. Accordingly, the durations of different pre-adult stages were determined.

### 3.2. Life cycle of major predatory species

This work was carried out during pre-winter season (October - November 2013). Daily temperatures (maximum and minimum) and relative humidity were recorded for the laboratory during the study period. The durations of immature stages of *Chrysoperla carnea* and *Coccinella undecimpunctata*, reared on adult *T. tabaci*, were determined, which will help tentatively in comparing the potentiality of the two predators in controlling *T. tabaci*. Adults of both predators were collected from untreated farms at Al-shqalwa area and treated as follows:

***Chrysoperla carnea*:** Adults of *C. carnea* collected from the field were sorted out in the laboratory so that coupling pairs were selected for oviposition. Each couple was kept in a separate Petri-dish, provided with *T. tabaci* to secure feeding. A black paper sheet was fixed to the inside of each dish's cover to facilitate oviposition. Freshly laid eggs were collected from the black sheets using a razor and a forceps. These eggs were placed individually in Petri-dishes. Nine replications were prepared and kept under the laboratory conditions. Upon hatching, the first instar larvae were provided with leaves infested with *T. tabaci* adults to secure feeding until they fully developed and molted. The durations of the subsequent larval stages were also determined in the same Petri-dishes.

***Coccinella undecimpunctata*:** Adults of *C. undecimpunctata* collected from the field were also sorted out in the laboratory so that coupling pairs were selected for oviposition. Each couple was kept in a separate Petri-dish, provided with *T. tabaci* on infested leaves. The eggs deposited by the females were immediately collected in the same day and placed individually (i.e. a batch) in Petri-dishes with nine replications. Upon hatching, the first instar larvae were provided with leaves infested with *T. tabaci*. The Petri-dishes were observed daily and newly emerged larvae were removed with a help of a camel's hair brush and transferred to new Petri-dishes. Daily observations continued to check molting and development of subsequent stages. The pupae formed were put in new Petri-dishes and followed until adult emergence, to determine the durations of the different immature stages.

### 3.3. Feeding rates of important predators

*Chrysoperla carnea* and *Coccinella undecimpunctata* were collected (30 adults from each) via a sweeping net technique from an onion farm at Al-shqalwa area during January 2013. In the laboratory, the samples were sexed and reared on onion thrips, in glass cages. The larvae obtained from the mass culture were used in this study. The average temperature and relative humidity were recorded during the study period. The feeding rate of the two predators was studied as follows:

***Chrysoperla carnea*:** A laboratory test was performed in plastic Petri-dishes, 7 cm in diameter, during January – February 2013. A hole of 2 cm diameter was made on the top of the lid, and covered from exterior side with a fine piece of muslin cloth in order to provide sufficient air circulation and to prevent insects' escaping. Each newly emerged larva of *C. carnea* was provided with 40 adults of *T. tabaci* on an onion leaf placed inside the Petri-dish to check its daily feeding capacity. The 40 adult thrips were renewed on daily basis. Nine replications were made. The numbers of consumed *T. tabaci* adults were counted after 24 h (next day), and continued for the whole lifetime of each larval stage. This test was done separately for each larval instar. Data were analyzed according to a CRD design and means separation by the LSD test.

***Coccinella undecimpunctata*:** Egg-batches deposited by the reared sexed adults of *C. undecimpunctata* were removed and kept in Petri-dishes, and observed for larval emergence. Upon hatching, each first instar larva was provided with 40 *T. tabaci* adults in a separate Petri-dish. The numbers of consumed thrips were counted daily, and new 40 adults were provided each day until molting. The same process was repeated for each larval instar; hence, the feeding rate of each stage was determined. The results were statistically analyzed based on a CRD, and means compared via the LSD test.

## Results and Discussion

### 1. Survey results

### 1.1. Detected thrips species and their host plants

The results of field surveys revealed the prevalence of two thrips species at Shendi area during the study period (Nov. 2011 – Dec. 2013). These were the onion thrips (*Thrips tabaci* Lind.) and the grey cotton leaf thrips (*Caliothrips sudanensis* (Bag. & Cam.). As shown in table 1, there were five host plants found infested by *T. tabaci*, and three hosts by *C. sudanensis*. It is clear that hosts of *T. tabaci* belong to different plant families, whereas all hosts of *C. sudanensis* are members of Fabaceae.

The survey conducted during this study represents the first comprehensive collection of thrips from different habitats (various crops and regions) in Shendi area. However, earlier records show the occurrence of the same thrips species in other parts of the country (Pollard, 1955; Schmutterer, 1969, and Kisha, 1977). This study also might give attention to thysanopteran order as one of richest fauna in Sudan, where about 68 species of thrips are present (Priesner, 1936; Schmutterer, 1969, and Younis, 1970) including some serious pests, a group which receives little research interest. According to Younis (1970), a sum of 18 thrips species in nine genera are known merely from Shambat area, Khartoum State. However, Schmutterer (1969) stated that the cotton thrips (*T. tabaci*) is present in many parts of the tropics and sub-tropics. In Sudan, it is almost present in all parts of the country, including mainly Gezira, Khartoum, Kordofan, Kassala, White Nile, Blue Nile, and Darfur States (Schmutterer, 1969; Kisha, 1977, and Idriss, 2011). *Thrips tabaci* in particular is a cosmopolitan pest of major economic importance for onion production (Bagnall and Cameron, 1932; Schmutterer, 1969; Theunissen and Legutowska, 1991; Hussain *et al*., 1997; Hazara *et al*., 1999; Ahmed, 2000, and Ali, 2009).

The current results proved that *T. tabaci* is a polyphagous pest (Ananthakrishnan, 1971). It seemed more serious than *C. sudanensis*, which appeared on limited hosts. The latter species is considered as a minor pest of cotton and legumes in the Sudan (Pearson and Darling, 1958; Ripper and George, 1965; Schmutterer, 1969, and Younis, 1970).

Table 1. Thrips species and their main host plants detected in Shendi area, November 2011-February 2013.

| **Thrips species** | **Host plants** | | |
|---|---|---|---|
| | **Common name** | **Scientific name** | **Family** |
| *Thrips tabaci* Lindeman | onion | *Allium cepa* L. | Amaryllidaceae |
| | rocket | *Eruca sativa* L. | Brassicaceae |
| | okra | *Abelmoschus esculentus* (L.) Moench | Malvaceae |
| | tomato | *Solanum lycopersicum* L. | Solanaceae |
| | eggplant | *Solanum melongena* L. | Solanaceae |
| *Caliothrips sudanensis* (Bagnall & Cameron) | lablab bean | *Lablab purpureus* (L.) Sweet | Fabaceae |
| | alfalfa | *Medicago sativa* L. | Fabaceae |
| | common bean | *Phaseolus vulgaris* L. | Fabaceae |

### 1.2. Detected predatory species

Table 2 shows four predatory insects associated with thrips species, during the study period. All these predators were found associating with *T. tabaci* on its surveyed hosts, whereas, only two predatory species (*Chrysoperla carnea* and *Coccinella undecimpunctata*) were detected in connection with *C. sudanensis* on some leguminous crops. It was observed that the occurrence of the aforementioned predators on the studied host plants were closely synchronizing with their preys (thrips), which entail seasonality studies. These species are recognized among predators of thrips elsewhere (Ananthakrishnan, 1979; Habib *et al*., 1980; Rueda and Shelton, 1995, and Fok *et al*., 2014).

Table 2. The major predators detected associated with thrips species in Shendi area, November 2011 - February 2013.

| **Predatory species** | | | |
|---|---|---|---|
| **Common name** | **Scientific name** | **Order** | **Family** |
| Green lace wing | *Chrysoperla carnea* (Stephens) | Neuroptera | Chrysopidae |
| Eleven-spotted ladybird | *Coccinella undecimpunctata* L. | Coleoptera | Coccinellidae |
| Variegated ladybird | *Hippodamia variegata* Goeze | Coleoptera | Coccinellidae |
| Syrphid flies | *Xanthogramma aegyptium* Wied. | Diptera | Syrphidae |

## 2. Laboratory results

### 2.1. Duration of immature stages of thrips species

Preliminary life cycle studies were executed for the two thrips species (*T. tabaci* and *C. sudanensis*), at Shendi University, where only immature stages were followed. The average and range of temperature and relative humidity recorded for the laboratory during the study period were 25°C (20 - 32°C) and 35.8% (20 - 50%), respectively.

Results presented in table 3 explain the range and mean (±S.E.) lifetime for each stage, and the overall pre-adult duration (from egg to adult emergence) for the two pest species. Analysis of variances revealed no significant differences between stages of *T. tabaci*, but those of *C. sudanensis* showed significant variations. The incubation period was significantly shorter than the first instar nymph, the second instar nymph and the pupa; but without significant difference from the prepupa. This pest exhibited relatively longer pre-adult duration (13.33±0.30 days) than that of *T. tabaci* (10.66±0.08 days). Such short developmental periods of both pest species, particularly in *T. tabaci*, may entail many generations per year or season. The obtained results somehow support previous works in that the life cycle of *T. tabaci* is short and has many generations per year (Mound, 1968). This is almost the case in different parts of the country (Schmutterer, 1969, and Ali, 2009) as well as in abroad (Bagnall and Cameron, 1932; Lewis, 1973, and Fok *et al*., 2014). However, the pre-adult stages followed (egg, two larval instars, pre-pupa and pupa) were consistent with those of Lewis (1997).

The present results also partially agree with Abdelgawad and El-shazly (1969) who stated that the life cycle of *T. tabaci* consists of an egg, first and second larval instars, pre-pupa and pupa, which found to take 2-3, 2-3, 2, 2 and 2 days, respectively. Watts (1934) stated that the average duration of the life cycle of *T. tabaci* from egg to adult emergence under constant temperature (30$^o$C) was 13.21 days, but the different stages reflected variable results relative to their own conditions. Lall and Singh (1968) stated that on fluctuating temperature with a mean of 30.8$^o$C, the duration of the life cycle from egg to adult is 9-13 days. Again, Mound and Masumoto (2005) reported that the pre-adult duration of this pest ranges from 11 to 23 days at a mean temperature of 22.4°C, whereas Arrieche *et al*. (2006) revealed that the duration under constant temperature (23.4$^o$C) was 3.2, 2.7, 2.9, 1.9 and 3.5 for egg, larva I, larva II, pre-pupa and pupa, respectively. The results confirmed what has been reported in Sudan by Ripper and George (1965), who indicated that the completion of egg stage of cotton thrips is variable, between 2 and 6 to even 10 days at a favorable temperature, and average of 3 days during the warmer periods of

Table 3. Durations (days) of immature stages of *Thrips tabaci* and *Caliothrips sudanensis* reared, respectively, on onion and alfalfa leaves, under laboratory conditions at Shendi University, January – February 2013.

| Species/ Stage | *Thrips tabaci* | | *Caliothrips sudanensis* | |
|---|---|---|---|---|
| | **Range** | **(Mean±S.E.)** | **Range** | **(Mean±S.E.)** |
| Egg | 1 – 3 | 02.00±0.24$^a$ | 2 – 3 | 02.33±0.17$^b$ |
| 1$^{st}$ instar nymph | 1 – 3 | 02.00±0.29$^a$ | 2 – 4 | 03.00±0.29$^a$ |
| 2$^{nd}$ instar nymph | 2 – 3 | 02.33±0.17$^a$ | 3 – 4 | 03.33±0.17$^a$ |
| Pre-pupa | 1 – 3 | 02.00±0.24$^a$ | 1 – 2 | 01.67±0.17$^b$ |
| Pupa | 2 – 3 | 02.33±0.17$^a$ | 2 – 4 | 03.00±0.29$^a$ |
| C.V% | | 31.40 | | 25.20 |
| LSD (0.05) | | 00.67 | | 00.67 |
| Total pre-adult duration | 9 – 13 | 10.66±0.08 | 10 – 16 | 13.33±0.30 |

* Means followed by the same letter (s), in each column for each pest, are not significantly different according to the LSD test.

summer to 2 weeks or more in cooler periods. There are two larval stages, and they pass through a pre-pupal stage of a one day and a pupal stage of three days. The developmental time from egg laying to emergence of adults was 9 days, but commonly 11 days. According to Harris *et al*. (1936), temperature is the main factor affecting the number of generations produced each year.

The grey cotton leaf thrips (*C. sudanensis*) appeared to be of less importance in Shendi area. This could be attributed to various bio-ecological factors, including the relatively long life cycle duration (i.e., slower developmental period) of this pest besides its limited host plants compared with *T. tabaci*. No recent information is detected regarding life cycle of *C. sudansensis* in the country. However, the average duration obtained for pre-adult stages of this pest largely agrees with that of Schmutterer (1969).

## 2.2. Duration of immature stages of major predators

Table 4 shows the durations of immature stages of *Chrysoperla carnea* and *Coccinella undecimpunctata* reared on *Thrips tabaci* under laboratory conditions, during October – November 2013. The two predators passed through three and four larval instars, respectively, with variable durations before pupation. The third instar almost attained significantly the longest duration regarding the larval stages in each species. However, *C. carnea* revealed slightly longer larval duration (13.45±1.05 days) than that of C. *undecimpunctata* (13.23±0.27), though it has less instars number, which adds to potentiality of *C. carnea*. On the other hand, the pupal stage was relatively shorter in *C. undecimpunctata* than in *C. carnea*, which is a credit for the former predator. This is critical in determining the length of total pre-adult durations, as the non-feeding pupal stage manifested significantly the longest duration in both predators (08.22±0.43 and 05.11±0.26 days for *C. carnea* and *C. undecimpunctata*, respectively). Considering the overall pre-adult stages, again the average total developmental period from egg to adult emergence was relatively longer in *C. carnea* (24.98±1.02 days) than in *C. undecimpunctata* (21.67±0.49 days). Nevertheless, *C. undecimpunctata* is distinguished by being a predator at the adult stage, whereas adult of *C. carnea* is not. Hence, both predators seemed to have comparable ability in regulating thrips populations, which expose them as important natural control agents eligible for further valuations in this field.

Table 4. Durations (days) of immature stages of *Chrysoperla carnea* and *Coccinella undecimpunctata*, reared on *Thrips tabaci* under laboratory conditions at Shendi University, October – November 2013.

| **Predator species/ Stage** | ***Chrysoperla carnea*** | | ***Coccinella undecimpunctata*** | |
|---|---|---|---|---|
| | **Range** | **(Mean±S.E.)** | **Range** | **(Mean±S.E.)** |
| Egg | 3 – 4 | 03.22±0.15[c] | 2 – 3 | 02.33±0.17[c] |
| 1st instar larva | 3 – 4 | 03.56±0.18[c] | 3 – 4 | 03.33±0.17[b] |
| 2nd instar larva | 2 – 4 | 03.22±0.22[c] | 2 – 3 | 02.56±0.18[c] |
| 3rd instar larva | 6 – 7 | 06.67±0.17[b] | 3 – 4 | 03.78±0.15[b] |
| 4th instar larva | - | - | 3 – 4 | 03.56±0.18[b] |
| Pre-pupa | - | - | 1 – 1 | 01.00±0.00[d] |
| Pupa | 7 – 10 | 08.22±0.43[a] | 4 – 6 | 05.11±0.26[a] |
| C.V.% | | 15.20 | | 00.30 |
| LSD (0.05) | | 00.76 | | 00.52 |
| Total larval duration | - | 13.45±1.05 | - | 13.23±0.27 |
| Total pre-adult duration | 24 – 26 | 24.98±1.02 | 19 – 24 | 21.67±0.49 |

* Means followed by the same letter (s), in each column for each predator, are not significantly different according to the LSD test.

The obtained results indicated that the two predators might have ability to produce many generations per season, and this necessitates additional research as well. However, it is well known that the effect of climatic conditions under which rearing is taking place, kind of prey species fed upon, and amount of prey consumed are very critical in development and fertility/ reproduction of such predators (Malais and Ravensberg, 2003; Batool *et al*., 2014; VKM, 2014, and Takalloozadeh, 2015). Temperature is one of the main climatic factors affecting the developmental and reproductive traits of *C. carnea* (Nadeem *et al*., 2012).

The current results were relatively different from some other works conducted at different regions, largely due to differences in climatic conditions (viz., temperature and relative humidity) and prey species used in rearing. Malais and Ravensberg (2003) stated that the development of *C. carnea* from egg to adult takes an average of 69 (at 16°C), 35 (at 21°C), and 25 days (at 28°C), whereas an incomplete development is attained at constant temperatures below 10°C. The results were comparable with those of El-Dakroury *et al*. (1977) and Chakraborty and Korat (2010) regarding the variation indicated between the successive stages of *C. carnea*, but slightly different when the duration of each instar is considered, based on differences in prey species and climatic factors as mentioned above. For instances, the latter authors reported that the pupal stage takes between 5 and 8 days with an average of 5.80±0.11 days, under mean temperature of 32.57±0.08 and relative humidity of 55.43±1.56%. In Sudan, immature stages of *C. carnea* had proved to perform differently when cultured on different prey species (Eisa, 1999). From another viewpoint, such observed variations in life cycle of this species also seem logical since *C. carnea* has now considered a complex of many cryptic and sibling species that are morphologically indistinguishable. There are 21 valid worldwide described species among such complex up to date in addition to other cryptic ones not yet described (Lourenco *et al*., 2006, and Henry *et al*., 2013). As the *C. undecimpunctata* is concerned, equally, the results were comparatively different from those of Bashir (1968), Malik (2006) and Asifa *et al*. (2013), almost due to the same previously stated eco-environmental reasons. However, no similar findings are available from the study area.

### 2.3. Feeding rates of important predators

The results of feeding potentiality of larval stages of the two predators (*C. carnea* and *C. undecimpunctata*), provided with adult *Thrips tabaci* as prey, were presented in table 5. The larvae of both predators were very active and consumed successfully appreciable number of prey individuals per life stages. The mean predation rate of each predator's larvae increased gradually from one stage to another to reach its peak in the last larval instar. The mean number of *T. tabaci* consumed per the entire larval period ranged from 15.55±0.98 to 33.35±0.20 and 9.67±1.39 to 30.11±3.73 adults for *C. carnea* and *C. undecimpunctata*, respectively. Comparing the total larval duration of *C. carnea* (13.45±1.05 days) with that of *C. undecimpunctata* (13.23±0.27), and their total consumption rates (76.45±1.66 and 74.00±3.88, respectively), may indicate that *C. carnea* is more forceful than the other predator in its preying activity on *T. tabaci*, though no significant differences were detected between the two predators. This is true at least for larval stages, but the fact that *C. undecimpunctata* is a predator in the adult stage should not be ignored.

The two studied predators are prevalent in different parts of the country (Theobald, 1904; Bashir, 1968; Schmutterer, 1969; Satti and Bilal, 2012, and Satti, 2015). They act as natural enemies of *T. tabaci* and other pests in various countries (Adashkevich *et al*., 1972; Ananthakrishnan, 1979; Habib *et al*., 1980, and Rueda and Shelton, 1995). These species also recognized among the main predators inhabiting onion crop in Egypt (Awadalla *et al*., 2011). This does not necessarily mean that *T. tabaci* is the best prey for such predators as there may be other more preferred species for them. The green lacewing larvae can prey on more than 90 species of insects and mites (Beglyarov and Ushchekov, 1974). According to Awadalla *et al*. (1975), some insects are more suitable than *T. tabaci* for *C. carnea* feeding; hence, they may be more preferred as prey. Adashkevich *et al*. (1972) found that *C. carnea* larvae prefer to attack aphid first and then thrips. However, the results agree in some part with Huang *et al*. (2010), who reported that the third instar of *C. carnea* is the most voracious larval stage in feeding.

Table 5. *Thrips tabaci* adults consumed by *Chrysoperla carnea* and *Coccinella undecimpunctata* larvae under laboratory conditions at Shendi, Jan.– Feb. 2013.

| **Predator species/ Stage** | ***T. tabaci*** **consumed (Mean±S.E.)** | **Comparison of predators (Mean±S.E.)** |
|---|---|---|
| ***Chrysoperla carnea:*** | | |
| 1st instar larva | 15.55±0.98$^{c}$ | |
| 2nd instar larva | 27.55±0.67$^{b}$ | |
| 3rd instar larva | 33.35±0.20$^{a}$ | |
| C.V% | 04.70 | |
| LSD (0.05) | 02.40 | |
| Total larval stages | 76.45±1.66 | 76.45±1.66$^{ns}$ |
| ***Coccinella undecimpunctata*:** | | |
| 1st instar larvae | 09.67±1.39$^{c}$ | |
| 2nd instar larvae | 15.00±2.08$^{bc}$ | |
| 3rd instar larvae | 19.22±2.44$^{b}$ | |
| 4th instar larvae | 30.11±3.73$^{a}$ | |
| C.V% | 23.90 | |
| LSD (0.05) | 8.33 | |
| Total larval stages | 74.00±3.88 | 74.00±3.88$^{ns}$ |

*Means followed by the same letter(s), in each column for each predator's instars, are not significantly different due to the LSD test.

Although the studied predators devoured appreciable numbers of thrips adults, in particular *C. carnea* (76.45±1.66), but their performances seem relatively modest compared to previous records. For instances in a study using *Aphis gossypii* as prey, *C. carnea* consumed an average of 401.58±15.20 aphids during its larval period of 18.10±1.19 days (Afzal and Khan, 1978). Such discrepancy could be due to several reasons, among which the prey preference, prey stage tested, larval duration and environmental factors look important. It is clear that the total larval period of both predators took less than 14 days in this study (October-November), but expected to be longer during winter season accompanied with a higher consumption rate. Such consumption ability may increase if different instars of thrip are provided for feeding, instead of adults only as done in the present test. All these aspects await careful evaluation in forthcoming research. In light of the current findings, it is essential to complete the bio-ecological studies of the two predators to ascertain their suitability in integrated management of onion thrips, meanwhile the search for other more effective bio-agent should continue.

## Conclusions and Recommendations

There are two thrips species (Thripidae) prevailing in Shendi area; with *Thrips tabaci* being the most devastating pest on various vegetable and field crops, particularly the onion. *Chrysoperla carnea* and *Coccinella undecimpunctata* are the most abundant predators currently associated with both thrips species, and may exert good actions in regulating such pests if they conserved and properly managed in the field. The larvae of the former species seemed to be potent in their feeding ability on thrips, but each species have some advantages over the other, which necessitates additional research on both predators. The seasonality of the two thrips species and their major predators, accompanied with the effect of various cultural practices on their interactions, need thorough investigation for proper management of thrips. Environmentally sound chemical insecticides soft to natural enemies and/or natural bio-pesticides can be considered in pest management with caution.

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