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# Arthropod fauna of *Thymelaea hirsuta* in the Egyptian western desert, with a special reference to *Olpium kochi*

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## Abstract

**Background:** Natural and semi-natural ecosystems in the Egyptian Western Desert are in serious danger of being degraded or lost through overgrazing, and overcutting of dominant vegetation, shrubs and trees and tourism activities. The study shows the effect of Man's use during 1990 and recently in 2018 led to desertification.

**Results:** *Thymelaea hirsuta* (L.) (Thymelaeaceae) was an important component (shrubs) in the natural ecosystems of the Egyptian Western Desert that harbors rich arthropod fauna all the year around. The spiders, pseudoscorpions (Arachnida: Araneae), and insects associated with this shrub were monthly sampled in 1990 at two different protected sites. One is on a very nice coastal ridge, semi-arid site, and the other is in the inland depression, arid site. The sites had distinctive characteristic of populations of non-insect predatory arthropods responding to habitat characteristics. The insects, spiders and pseudoscorpions occurred throughout the year in both sites. However, on the less arid site, the pronounced insect population occurred in winter months while the non-insect was relatively higher in summer months. On the more arid site, the highest insect population was in winter and the non-insect population was higher in autumn. The false-scorpion *Olpium kochi* Simon (Arachnida, Pseudoscorpionida, Olpiidae), a native rare predator to the Saharan fauna, was very common and its activity reflects its effective predatory role in both sites. In 2017–2018, several visits to the above sites showed that they were completely degraded and most of figs, olive, palm trees and dominant vegetations were removed. The survived shrub populations were very far from each other, sparse very low number and are very poor in arthropod fauna. Thus, several visits were essential to be paid just to collect enough numbers of *O. kochi*. The life-cycle of *O. kochi* is through egg-stage and three nymphal instars. There was no active feeding period by the end of each of these stages. Adults can live for 2–4 months. The developmental period takes 10 to 14 months/generation. Cannibalism tendency was among nymphs, but was very rare among fed or starved adults.

**Conclusions:** The study sites were seriously degraded with irreversible changes. The nice cost ridge was completely degraded and lost by removing the leading dominant vegetations and fruit trees and replacing building houses. Houses replaced most of the site in the inland depression for more desertification.

**Keywords:** Egyptian Western Desert, *Thymelaea hirsuta*, Spiders, Pseudoscorpions, *Olpium kochi*, Natural ecosystems, Desertification

## Background

The Egyptian Western Desert is a part of the great desert which extends across Africa from the Red Sea in the east to the Atlantic coast in the west. At present, the desert provides an example of natural and semi-natural ecosystems that are in serious danger of being degraded or lost through Man's short-term economic gains, e.g.,

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overgrazing, and overcutting of shrubs and trees and tourism activities. The main threats to desert biodiversity are habitat loss and land degradation due to overgrazing (Ayyad and Ghabbour 1977). These circumstances lead easily to desertification. The desert is arid with a rare plant covers except in the oases (Siwa, Bahariya, Farafra, Dakhla, Kharga and Faiyum) (Abd El-Ghani and Fawzi 2006) where water is found. The interest concerning the arthropod fauna of the Egyptian desert started early in 1908 (Flower 1933; Alfieri 1976; Kenawy and Abdel-Hamid 2015). *Thymelaea hirsuta* L. (Fig. 1) is one of the common shrubs in the Egyptian Western Desert that harbors rich fauna all the year around. Despite the importance and abundance of non-insect predatory arthropods, they have been insufficiently studied in the Egyptian western desert. Moursi and Hegazi (1983) recorded that some wild plants in the Egyptian Western Desert harbor well-known pests in the Nile delta; they also act as the breeding places of pests which migrate to agricultural areas. Hegazi et al. (1979) reported that the predatory arthropods play an important role in regulating the destructive arthropod fauna in the natural ecosystems of the Egyptian desert. Of these, the spiders and pseudoscorpions constitute pronounced agents. This investigation gives a close view of the latter two groups on two different ecosystems in the Egyptian Western Desert, with special references to the biology of the common desert pseudoscorpion, *Olpium kochi* Simon, (Arachnida, Pseudoscorpionida, Olpiidae). The present

work aimed to explore variation in non-insect predatory arthropod communities with season and habitat. This study is a part of an ongoing research studying the non-insect arthropod fauna of the Egyptian western desert and desertification.

## Methods

### Study area

The first part of the study was carried out in 1990 at two different areas representing two types of habitats found between Alexandria and Al Alamein town, northern Matrouh Governorate, Egypt. One is on the coastal ridge at El Gharbaniat town (52 km west of Alexandria) at (30° 57' 31" N, 28° 46' 19" E) which is characterized by a nice view of dunes of almost snow-white calcareous sands. The other is in the inland depression (30° 49' 05" N, 29° 09' 44" E at El Omayed (80 km west of Alexandria; 12 km from the sea shore). The sites were partially degraded through Man's short-term economic gains, so selected just 2 less damaged sites in each habitat.

The two habitats are essentially unsuitable for agriculture although the local inhabitants are able to make a living under such conditions. The littoral dunes are extensively covered by rain-fed fig and palm trees, whereas the inland depression is used for herding sheep and goats. The stocking rate is estimated at one sheep per hectare, but the availability of grazing land changes from year to year depending on rainfall (Ayyad and Ghabbour 1977). The inland depression site is suitable for breeding



**Fig. 1** *Thymelaea hirsuta* (L.) (Thymelaeaceae), A: a young plant on the inland depression, at El Omayed site; B: a mature plant at blooming stage on the coastal ridge at El Gharbaniat site

common desert snail, *Eremina desertorum* (Forskål) an important species of the Western desert natural ecosystem (Hegazi 1981).

The leading dominant vegetations on the littoral dunes are *Elymus farctus* (Viv.), *Ammophila arenaria* (L.), *Curcianella maritima* L., *Pancratium maritimum* L., *Echinops spinosissimus Turra* subsp. *neumayeri* (Vis.), *Euphorbia paralias* L., *Ononis vaginalis*, Vahl., *Lygos raetam* (Forssk) and *Thymelaea hirsute* (Fig. 1). Whereas, the inland depression is mostly covered by *Anabasis articulata*, (Forssk), *Asphodelus microcarpus* Salzem et Viv., *T. hirsuta* and *Gymnocarpos decandram* Viv. (Ayyad and El-Ghoneimay 1975; Ayyad 1976). *T. hirsuta*, is a xerophytic shrub which can grow to 2 m in height and has a root system reaching depths of up to 3.5 m. Some noteworthy characteristics of this species are the tiny size of its fleshy leaves and flowers. Like many other members of Thymelaeaceae, it is a toxic plant with medicinal properties that also yields a strong fiber used in the making of rope and paper (Ayyad and Ghabbour 1977; Ayyad 1976). *T. hirsuta* is also valued in the traditional veterinary practices of the Bedouin, in which it is used as a topical medication to prevent miscarriage in camels (Ayyad and El-Ghoneimay 1975).

The mean annual rainfall of 1990 at the nearest meteorological station to the sand-dunes at Gharbaniat was 157 mm, and that at Omayed was 132 mm. The rainy seasons are effective from October–November to February–March. The mean monthly minimum temperature varies from 8 °C in January to 20 °C in August, and the mean monthly maximum temperature varies from 19 °C in January to 31 °C in August. The mean relative humidity at 6:00 Greenwich Mean Time varies between 66% in May and 86% in December.

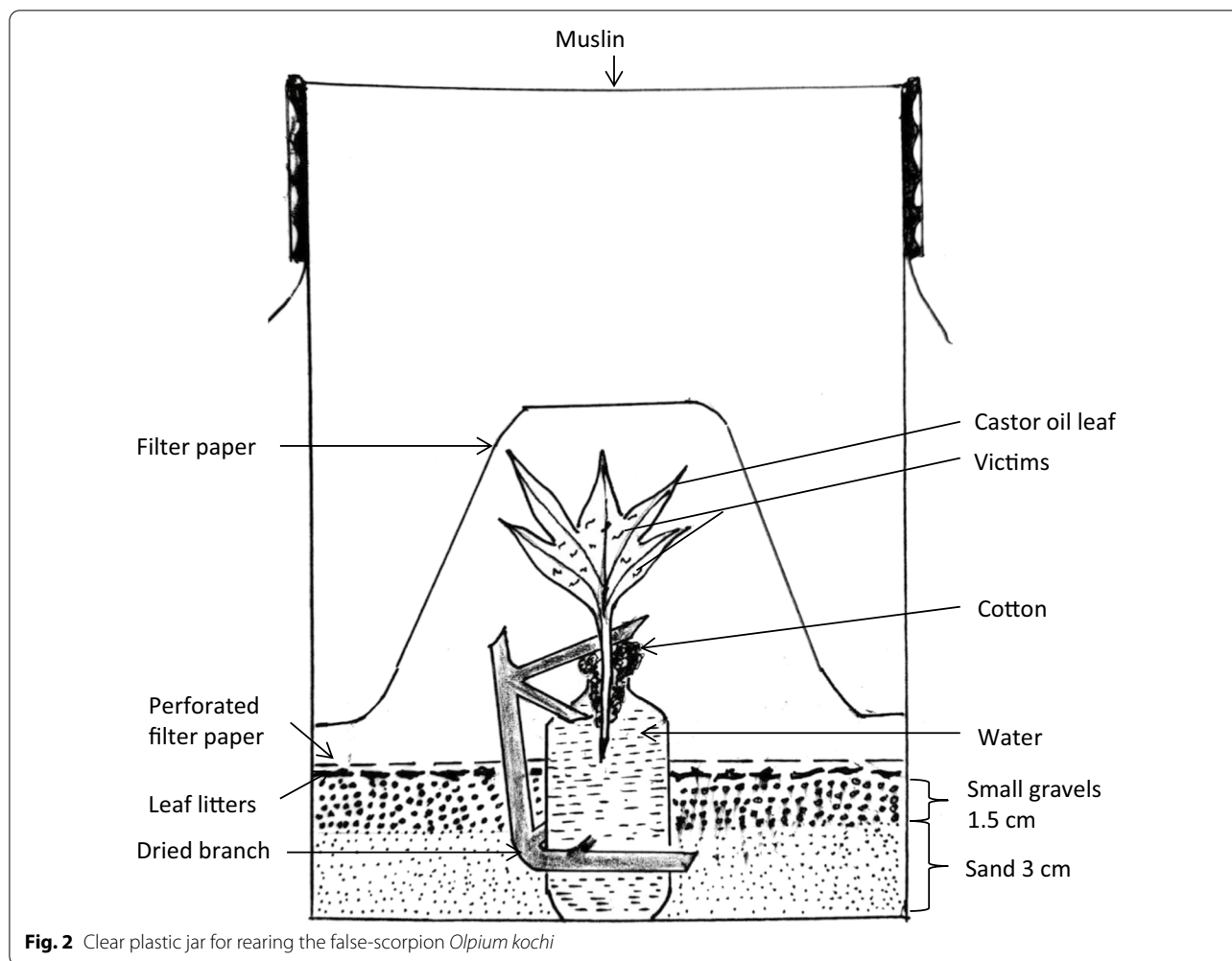
#### Non-insect arthropods activity

The *T. hirsuta* fauna of the two sites were inspected once a month during 1990 and collected by 38.1 cm Aerial heavy-duty sweep-net and branch-picking methods, at 6.30–8.30 am. In each site visit, three shrubs were selected for each method, six shrubs were selected from each site for each representative sample. The sweep-net samples were collected by 15 double net strokes for each plant. In the other method, four randomized branches (ca. 30 cm long) representing different sides were picked from each plant and carefully inserted into muslin bags. The samples were transferred to the laboratory at Alexandria University and placed in the refrigerator to anesthetize the arthropods. Later on, the samples were poured on a white tray for separating the arthropods from plant particles. The arthropods were sorted out into insects, spiders and pseudoscorpions. The samples were collected monthly from January until December 1990.

#### Rearing and biology of the false-scorpion, *Olpium kochi*

From September through May 2017–2018, several visits were made to the above study areas and found that both sites were completely degraded and lost through Man's use by building houses. Under this human disturbance, the second part was started on *O. kochi* by searching for some good and healthy *T. hirsuta* shrubs for collection of *O. kochi*. To study this false-scorpion, some simple modifications on the rearing jar described by Weygoldt (1969) were necessary to be made. The modified rearing jar (15 cm in height and 11.5 cm in diameter) had some advantages, of these, it provides nearly similar micro-environment for the false-scorpion, the filter papers used increase the space through the animal would move, and the wet cotton wool on the leaf-petiole sustains the freshness of the small plant leaf for at least 48 h during which the tested victims of this animal feed (Fig. 2). The jar was prepared by ca. 3 cm of sand, placed at the bottom of the jar. On the sand surface, small gravels (1.3–2.0 mm in diameter) were provided and some pieces of dry leaves were placed on the sand as well. A filter paper of the same diameter of the jar was placed on top. A small castor-oil leaf was held by inserting its small protruding petiole through the center of other filter paper. The small petiole was wrapped with a wet piece of cotton wool and inserted in small vial filled with water to provide moisture. The leaf was infested with certain preys and placed inside the rearing jar. The close study was carried out with smaller glass vials with similar components. To study the biology of the false-scorpion under laboratory conditions and at constant temperature of rearing chambers (27 °C & 60% R.H.), the newly hatched animals of the laboratory culture were reared in pairs (male and female) and 15–20 of the first instar of the cotton leaf worm *Spodoptera littoralis* (Boisd.), (Lepidoptera: Noctuidae) were provided as victims. Numbers of the devoured victims were checked each day or every 48 h and fresh ones were given and the duration of the different stages of the pseudoscorpion were observed and recorded. Four groups of newly hatched individuals of the false-scorpion were reared on the eggs, 1 arvae of the cotton leaf worm, spider mites *Tetranychus telarias* L., and *Drosophila* flies *Drosophela melanogaster* Meigen, to observe the biology of the animal on each prey. To study the effect of starvation, and the period of prey availability on the adult longevity, six groups of newly formed adults of the false-scorpion were selected (each composed of 10 females and 10 males). The 1st group was provided daily with victims, the 2nd every 48 h, the 3rd every 72 h, the 4th every 96 h and the 5th every 169 h. For these groups, enough victims of the 1st instar *S. littoralis* were offered at the proper time of the feeding schedule, and after 6 h, the remaining victims were removed and counted. The sixth group was left





without victims, and all groups were checked daily for mortality counts.

#### Statistical methods

Data were subjected to one way analysis of variance for determination of differences between means. Where significant differences occurred, Duncan's multiple range test or Student's t-test were applied for mean separation. The percentages data were transformed to arcsine square root before analysis.

#### Results

##### Occurrence of the non-insects predatory arthropods

The perennial plant cover *T. hirsuta* was a dominant shrub in El Gharbaniat and El Omayed sites of the Egyptian western desert in 1990. The plant acts as a suitable desert plant for harboring several destructive and visiting arthropods associated with most annual plants of the area when the latter are absent. Also, most of the flying arthropods use this shrub as a shelter from the severe

heat during the mid-day (Hegazi et al. 1979). Therefore, a study on the activity of the non-insect predatory arthropods associated with this shrub may give a close view about the activity of these animals in the area of study. The predatory arthropods refer only to the spiders and pseudoscorpions collected from both sites, i.e., predatory insects were excluded from collected samples.

The preliminary samples of the associated arthropods with the desert plant indicated that, the sweep-net method proved to be a quick capturing method for the flying adult arthropods but inaccurate for estimating the population of some unflying arthropods, as the later drop down quickly by approaching the shrub. Since the branch-picking methods have the disadvantage of the lacking off and the escape of the flying arthropods the 2 methods were applied monthly together for the representative samples of 1990. As shown in Table 1, a doubled number of the arthropods were found in the full year count of Gharbaniat site more than those of Omayed. In both sites, the insect fauna comprised the highest

**Table 1** Monthly variations in population density of insect, pseudoscorpion and spider fauna in *Thymelaea hirsuta* samples at two different natural sites in the Egyptian Western Desert, in 1990

Date	Semi-arid site (Gharbaniat)				Arid site (Omayed)			
	Total n	% of total			Total n	% of total		
		Insects	Non-insects			Insects	Non-insects	
			Pseudo-scorpions	Spiders			Pseudo-scorpions	Spiders
January	273.0	86.4	7.3	6.1	302.0	99.0	0.1	0.7
February	266.0	86.4	4.8	8.4	302.0	98.0	0.0	2.0
March	188.0	82.5	8.2	9.3	312.0	98.2	0.5	0.7
April	197.0	88.8	3.5	7.6	237.0	93.7	0.0	4.6
May	155.0	73.4	14.6	12.0	165.0	94.2	1.1	4.2
June	217.0	65.3	14.7	19.8	35.0	74.3	0.0	25.7
July	406.0	93.1	2.5	3.9	33.0	90.9	0.0	9.1
August	108.0	78.3	11.1	10.2	35.0	80.0	3.3	16.7
September	47.0	68.8	9.6	21.3	104.0	84.5	4.6	10.6
October	258.0	89.0	4.4	6.6	63.0	75.3	5.1	19.6
November	283.0	91.5	4.6	3.9	191.0	95.3	0.0	4.7
December	440.0	94.6	2.3	2.8	206.0	98.5	0.0	1.5

fraction in all samples. While the non-insect fraction was ca. 3 folds in the samples of the less arid site (Gharbaniat) than the arid area (Omayed). However, the spider fauna, in both sites, comprised the higher fraction of the non-insect fauna than the pseudoscorpions. The latter comprised ca. 0.4 and 5.5% of the full year count of the arthropod fauna of the arid and less arid sites, respectively (Table 1). As shown in Table 2, the insects, spiders and pseudoscorpions occurred throughout the year in both sites. However, on the less arid site the pronounced insect population occurred in winter months (Nov.–Jan.) while the non-insect were relatively higher in summer months (Jun.–Sep.). On the more arid site, the highest insect population was in winter and the non-insect

population was higher in autumn (Sep.–Oct.). Of the total full year counts of 2838 and 1995 collected arthropods, the spiders and pseudoscorpions together constituted 13.5 and 5.6% in semi- and arid sites, respectively.

The protected study area is a unique area with two different habitats as mentioned before. Collecting samples, showed that *T. hirsuta* harbored rich fauna all the year around with numerous identified and many arthropods species have not been yet identified. Specimens were members of 7 arachnid families collected during 12 trips to semi-arid site (January–December 1990). These were members of Salticidae, Scytodidae (*Scutodis* sp.), Gnaphosidae (*Zelotes* sp.), Dysderidae (*Dysdera crocata* C. L. Koch) Loxoscelidae (*Loxosceles* sp.), Philodromidae

**Table 2** Seasonal occurrence of insect, pseudoscorpion, and spider fauna in *Thymelaea hirsuta* samples in two different natural habitats, in 1990

Site	Full year (Total n.)	Occurrence (%)			
		Winter	Spring	Summer	Autumn
Semi-arid site					
Pseudoscorpions	171.0	23.1	24.4	34.6	17.9
Spiders	211.0	25.0	24.1	30.8	20.1
Insects	2456.0	36.3	18.0	24.5	21.1
Arid site					
Pseudoscorpions	28.0	1.2	12.5	13.2	73.0
Spiders	83.0	13.2	28.9	20.5	37.4
Insects	1884.0	42.4	36.6	4.1	16.8

(*Philodromus* sp.), and Olpiidae (*Olpium kochi*). Members of insect families collected were Noctuidae (*Metachrostis velox* (Hübner), *Agrotis pierreti* (Bugnion), *Heliothis* sp., Geometridae (*Gymnosceles pumilata* Hübner.), Pyralidae (*Hastula heyrana* Mill., *Denticera divisella* Dup. *Staudingeria vinospersella* Turati, *Mecyna polygonalis* Hübner), Tortricidae (*Lobesia botrana* D & S), Sphingidae (*Celerio lineata livornica* Esp.), Tephritidae (*Acanthophilus helianthi* Rossi) and Formicidae (*Messor* sp.). In the arid site, the arachnid members were Gnaphosidae (*Zelotes* sp.), Salticidae, Filistatidae (*Filistata* sp.), Olpiidae (*Olpium kochi*). Also, members of insect families were collected. Of these were Miridae (*Capsodes cingulatus* Tamanini), Formicidae (*Messor* sp.), Gelechiidae (*Oecocercis* sp.) and Pyralidae (*Staudingeria vinospersella* Turati.).

#### Notes on the bionomics of the false-scorpion *O. kochi*

The close analysis of the non-insect predatory arthropod samples carried out in 1990 revealed that the false-scorpion *O. kochi* was common and this may reflect its effective role in the natural ecosystems of the Egyptian western desert. In September 2017, the above study areas were completely degraded and lost through Man's use by removing the leading dominant vegetations and fruit trees for building houses. Therefore, it was of interest to search some remaining *T. hirsuta* shrubs to collect *O. kochi* to study their bionomics under the laboratory conditions. It was so difficult to find out some *T. hirsuta* shrubs; thus, some visits were essentially made to intact sites near by just to collect few numbers of *O. kochi*.

The *O. kochi* is a small common arachnid with an average body length of  $3.2 \pm 1.3$  mm and range of 2.4–3.8 mm. The life-cycle is through egg-stage, and 3 nymphal instars (protonymph, deutonymph and tritonymph,

respectively) and finally the adult stage (Table 3). The protonymph is light in color and the most active instar that able to search and find food immediately after short rest. Its searching behavior is different (restless nymph) from the other proceeding nymphs. The adults are dark brown and may eat once a day or every other day. The *Olpium* mated females deposited their eggs during 1–2 days. The eggs are translucent, glued to each other and are attached to the ventral surface of the female. At the end of the ovipositional period, the female constructs a very thin silky chamber with fine sand granules sticking on the external surface of the chamber, making it difficult for unexperienced eye to detect such chambers. Inside the latter, the female stays without feeding for a period ranging from 11 to 24 days (average of  $14.3 \pm 2.1$  days, under laboratory conditions). Then the female leaves its chamber when its eggs are about to hatch and stays also additional days (1–4 days) without feeding, during which the eggs hatch and the resulted offspring remain attaching to the mother's ventral surface, sucking her internal fluid until it dies, then the protonymphs disperse. Unmated females can also deposit unfertilized eggs and undergo the behavior as described above for the mated ones. However, after few days, the eggs soon dry and fall-off from the ventral surface of the mother. The number of eggs deposited per female ranged from 15 to 25 with a mean  $\pm$  SE of  $19.3 \pm 1.2$  eggs and the incubation period lasted  $16.8 \pm 1.7$  days with sex-ratio of 1:1 for the resulted adults. The dispersed offspring (protonymphal stage) of the false-scorpion remain inactive without feeding for ca. 1 to 2.4 days as their bodies start to harden, then they begin to actively searching for their victims. This stage is referred to protonymphal stage. After the latter stage, the deutonymphal and tritonymphal stages are developed.

**Table 3** Mean duration (in days) of the different stages of *Olpium kochi* and the number of victims (1st instar of *Spodoptera littoralis*) that were consumed by nymphal and adult stages of the animal

	Protonymph		Deutonymph		Tritonymph		Subtotal		Adult stage	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Laboratory conditions (22–25 °C & 50–65% R.H.), 2018										
Active period (days)	24.2	23.6	24.6	23.0	39.0	35.2	87.8 $\pm$ 0.4	81.8 $\pm$ 0.3	132.6	140.4
Inactive period (days)	14.2	14.2	9.4	11.0	13.2	12.8	36.8 $\pm$ 0.6	38.0 $\pm$ 0.3	0.0	0.0
Total period (days)	38.4	37.8	34.0	34.0	52.2	48.0	124. $\pm$ 0.4A	119.8 $\pm$ 0.3B	123.6	140.4
Consumed victims (No.)	31.0	30.8	34.4	32.4	30.6	28.4	96.6 $\pm$ 0.5	91.6 $\pm$ 0.4	102.2	126.4
Constant conditions (27 $\pm$ 1 °C & 60% R.H.)										
Active period (days)	11.2	12.6	13.8	13.0	16.0	16.0	41.0 $\pm$ 0.2	41.6 $\pm$ 0.2	107.4	166.2
Inactive period (days)	14.0	14.2	12.20	11.0	10.4	11.2	37.6 $\pm$ 0.4	36.4 $\pm$ 0.3	0.0	0.0
Total period (days)	26.0	26.8	26.0	24.0	26.4	27.2	78.6 $\pm$ 0.1A	78.0 $\pm$ 0.3A	107.4	166.2
Consumed victims (No.)	26.0	22.0	28.4	28.4	31.6	29.6	86.0 $\pm$ 0.2	80.0 $\pm$ 0.3	101.0	170.4

\*Means based on 15 individually reared animals per rearing conditions

Means within a row with the same letter are not significantly different (t test,  $P > 0.05$ )

There was no active feeding periods by the end of each of those stages. Data of rearing the newly hatched nymphs of the false-scorpion on the 1st instar of the cotton leaf-worms as victims are tabulated in Table 3. It was found that the life-span of the adult stage was doubled or more than that of the total durations of its immature stages. The female in general lived slightly longer than the males. The duration of the immature stages was significantly less ( $t=28$ ,  $df=10$ ,  $P<0.05$ ) for nymphs reared under temperature of  $27\pm 1$  °C (Table 3) than those reared under normal laboratory conditions ( $22-25$  °C). At constant temperature, the duration of the immature males and females in each stage is about the same while the females reached the adult stage earlier than the males under normal laboratory rearing conditions (Table 3). The nymph after ecdysis is white in color, but later it darkens to its brown color. Cannibalism was observed among all three nymphs, and at least one of them was eaten by siblings within 1 to 2 days. The cannibalistic tendencies among fed or starved adults were very rare.

It is worth mentioning here that all reared individuals of the false-scorpion at constant temperature reached adult stage and most of them never mated for an unknown reason. But two of 22 mated and deposited eggs and started the second generation. The results further indicated that the false-scorpion may have one to two generations per 1 and 3 years depending upon the prevailing conditions. Also, it can be concluded that the false-scorpion consumed relatively a high number of prey throughout its life-cycle and this is a further indication that this animal plays an important role in regulating the population of other small arthropods in the undisturbed natural ecosystem of the Western Desert.

### Factors affecting the biology of the false-scorpion

The first factor that can be concluded from the above results is temperature in which the life-span became shorter under higher constant temperature than lower laboratory conditions (Table 3). At constant temperature ( $27\pm 1$  °C), the mean duration (days) of total immature stages was  $78.6\pm 0.3$  for male and  $78.0\pm 0.1$  for female, with non-significant differences. At laboratory conditions ( $22-25$  °C), significant differences ( $t=3.5$ ,  $df=10$ ,  $P<0.05$ ) were recorded between male ( $124.6\pm 0.8$  days) and female ( $119.7\pm 1.0$  day). However, significant differences ( $t=36.3$ ,  $df=10$ ,  $P<0.05$ ) were noted between the mean duration of total immature stages of female at higher constant temperature than lower laboratory conditions. The second factor is the type of prey. The results of the experiment are tabulated in Tables 3 and 4 from which the following facts could be drawn: (a) the duration of the life-cycle of the animal differed according to the prey offered to it. The longest life-cycle was observed in those individuals reared on mites where the duration of the immature stages lasted 152.2 and 157.6 days for male and female, respectively (data not shown), On the other hand, the shortest duration of the immature stage lasted 122.2 and 135.4 days for male and female reared on first instar of the cotton leaf worm, respectively (data not shown). (b) All individuals fed on *Drosophila* flies died in deutonymphal stage which indicates that this fly was not a suitable prey for the immature stage of this predator, since it was observed in the field that the adults of *O. kochi* can readily capture and feed on small species of flies. (c) Food item, high significant difference between adult longevity was found where adults reared on newly hatched larvae of the cotton leaf worm lived longer,

**Table 4** Effect of prey type and its availability on the longevity of newly formed adults and the amount of predated victims by *Olpium kochi* in 2017

Type of prey	Availability of victims	Longevity (days)				Consumed victims (n.)			
		Male		Female		Male		Female	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean
Nothing	0.0	60–70	$64.4\pm 1.03D$	78–95	$85.2\pm 1.2D$	No data	No data	No data	No data
<i>S. littoralis</i> 1st instar	Daily	128–139	$132.6\pm 1.0A$	136–197	$146.4\pm 0.7A$	98–106	$102.2\pm 0.4A$	122–129	$126.4\pm 0.7A$
	Each 48 h	118–130	$122.0\pm 0.9B$	131–143	$134.8\pm 0.4B$	40–49	$43.2\pm 0.9B$	78–83	$80.6\pm 0.9B$
	Each 96 h	109–119	$114.2\pm 0.9C$	114–122	$118.6\pm 0.8C$	12–25	$14.2\pm 1.8C$	69–74	$65.6\pm 1.3C$
<i>S. littoralis</i> 2nd instar	Daily	58–80	$70.4\pm 0.6$	39–120	$93.2\pm 0.5$	39–53	$46.6\pm 0.3$	15–68	$48.6\pm 0.4$
<i>S. littoralis</i> Eggs	Daily	29–50	$34.6\pm 0.2$	10–24	$20.2\pm 0.2$	No data	No data	No data	No data
<i>T. telarias</i>	Daily	23–40	30.6	2–7	$5.8\pm 0.5$	No data	No data	No data	No data

\*Adults resulted from young's fed on the same adult victims

\*Means based on 15–20 individually reared animals per experiment

Means within a column with the same letter are not significantly different (ANOVA,  $P>0.05$ )

followed by those reared on egg-masses and the least was of those reared on mites.

The second and third factors affecting the longevity of *O. kochi* adults were the starvation and period of prey availability (daily, each 48 h and each 96 h), in respect, (Table 4). The study on the effect of starvation and time of prey availability on the longevity of *O. kochi* was conducted on the newly formed adults obtained from laboratory rearing and again on newly formed adults obtained from tritonymphal individuals collected from the field as field cohort. The one-way ANOVA used showed significant differences (for male:  $F=822.9$ ;  $df=3, 36$ ;  $L.S.D=3.02$ ;  $P<0.05$ ; for female:  $F=649.1$ ;  $df=3, 36$ ;  $L.S.D=2.99$ ;  $P<0.05$ ). The following facts can be noted:

(1) The adult false-scorpion survived starvation for a relatively large period. There was apparently no difference between the survival rate of the males of field collection and laboratory rearing while the female from the field seemed to be more tolerant to starvation than the female of laboratory rearing. (2) Both males and females of the field collection provided with young larvae of cotton leaf worm daily survived longer than the laboratory rearing. This may suggest that field strain selected more suitable food for longer live comparing with the laboratory reared ones.

Results of the effect of the period in which prey is available (Table 4) on the longevity of the adults of *O. kochi* and the following facts were obtained:

1. The females under all feeding conditions survived for a longer periods than the males, e.g., group provided daily with victims lived means of  $132.6 \pm 1.0$  and  $146.4 \pm 0.7$  days for males and females, respectively,  $t=18.4$ ,  $df=10$ ,  $P<0.05$  (Table 4).
2. Adult life-span was longer among those individuals in which preys were available daily than those in the rest of other treatments.
3. Significant reduction in life-span was observed in adults when were offered preys after 168 h each (Table 4).
4. Number of consumed preys differed from group to group significantly (Table 4, for male:  $F=829.9$ ;  $df=2, 27$ ;  $L.S.D=2.4$ ;  $P<0.05$ , for female:  $F=961.6$ ;  $df=2, 27$ ;  $L.S.D=2.97$ ;  $P<0.05$ ).

Although it was expected that the *O. kochi* consumes large numbers of prey after long interval of starvation, almost same amount of preys was eaten every each time. This indicated that the predator almost consumed a constant ratio every time they get their preys.

Data on the effect of the prey age on the longevity of false-scorpion adults concluded that, the life-span is longer in adults fed on the 1st instar than in those fed on

the 2nd or the 3rd instars of the cotton leafworm. This could still indicate that the false-scorpion may prefer the newly hatched larvae as suitable prey than the older ones. Also, the data revealed that the false-scorpion consumed more preys in the 1st instar than in the subsequent instars, i.e., the amount of consumed prey by the false-scorpion varied with age and type of the prey itself, e.g., cotton leaf worm larvae.

## Discussion

Data of 1990 revealed that the arid and less arid natural sites had distinctive characteristic of populations of non-insect predatory arthropods responding to habitat characteristics. It seems that the temperature ( $^{\circ}\text{C}$ ) and the relative humidity (R.H.) play an important role on the non-insect activity. The decrease of  $^{\circ}\text{C}$  and R.H (November–December) or the decrease of  $^{\circ}\text{C}$  with the increase of R.H (January–March) and or the high increase of  $^{\circ}\text{C}$  and R.H (July) were suitable for the spiders and the false-scorpions. Nevertheless, the latter conditions caused the flourishing of insect population. On the other hand, the moderate increase of  $^{\circ}\text{C}$  and R.H caused the pronounced abundance of the non-insect arthropods (May–June and September–October). The obtained results suggest that the climatic conditions of each site regulate the activity of its arthropod fauna, in spite of the 2 sites were not very far from each other.

Also, it could be seen that the decrease of insect numbers was followed by the increase of the non-insect ones. So, it is highly possible that the spiders and the pseudoscorpions of the natural ecosystems play an important role in regulating the insect population in undisturbed sites. The unpublished data of the same authors about the entomophagous agents in the natural ecosystems in the Egyptian Western Desert indicated that the predatory agents in these systems had more significant role than the parasitic agents in regulating the destructive arthropod population on *T. hirsuta*. Some potential entomophagous agents, which scarcely disturbed in agro-ecosystems, can be collected from the insects of the wild plants including *T. hirsuta*. They could be reintroduced for biological pest control.

Pseudoscorpions are not widely known in nature to the ordinary observer, due to their small size and habits that keep them far from view by others. They are not seemingly affect human comfort and happiness so there is interest to investigate them (Gilbert, 1951). Accordingly, much remain to be learned about their activities and life histories.

The desert false scorpion, *O. kochi* is a cosmopolitan species frequently seen in the Western desert. Simon (1881) described *Olpium kochi* and cited under the species name, thus giving the appearance that it was offered



as another replacement name for *Chelifer Hermannii* Audouin (1826). The desert pseudoscorpion *O. kochi* is predominantly solitary animal that can live in the ground substratum, among the *Thymelaea* vegetation, or in both. However, pseudoscorpions are commonly found in habitats such as leaf litter, moss, bird nests, or under bark (Weygoldt, 1969; Harvey, 1986).

Weygoldt (1969) pointed out that the postembryonic development of pseudoscorpions can be prolonged for more than one year, without presenting reliable information about adult lifetime. Also, the lifetime of the adults of pseudoscorpions is poorly known (Levi, 1953); literature data suggest that their lifetime is too variable just as their habitat preferences. Pseudoscorpions have an extended life cycle of 1 to 3 years, depending on the location and temperature (Levi, 1953).

The present study showed that the desert pseudoscorpion *O. kochi* molts three times before adulthood. Adults do not molt and can live for 2–4 months. The developmental period was temperature and food item dependent and lasted 10–14 months/generation in the laboratory. Cannibalism among fed or starved adults was very rare but common among the protonymphs, and at least one of them was eaten by its fellows. Cannibalism had been reported previously by Vachon (1933) in animals that had been starved for some time. Visits of 2018 revealed that the Man's mistaking use of Gharbaniat and Omayad sites caused very serious environmental damage and loss of great parts of biodiversity of natural habitats and related components, e.g., magnificent view of the coastal ridges at Gharbaniat site which add characterized by dunes of almost snow-white calcareous sands.

## Conclusions

Natural and semi-natural ecosystems in the Egyptian Western Desert are being seriously degraded by Man's short-term economic gains, where ill-advised land-use methods have led to obstruction of native flora and arthropod fauna. Minor changes in the physical environment entail dramatic changes in plant and animal life. The present study represents Man's mistaking use that leads to desertification (animals & plants.. Etc). The close analysis of the non-insect predatory arthropod samples revealed that the false-scorpion *O. kochi*, a native rare predator to the saharan fauna was common in 1990 and sporadic in 2018 in the study areas this may reflect its effective role in the natural ecosystems of the Egyptian western desert. In the late 2017, it was noticed that above study areas were completely degraded and lost through Man's use by removing the leading dominant vegetations and fruit trees replaced by building houses, and for other purposes of more desertification.

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## Author contributions

EH conceived the idea, wrote the first draft of the manuscript and general supervision of the research group and was a major contributor in writing the manuscript. WK collected the data and participated in its design and coordination and aided to draft the manuscript. EA analyzed the data and helped to draft the manuscript. All authors read and approved the final manuscript.

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## Availability of data and materials

The data sets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

## Declarations

### Ethics approval and consent to participate

Not applicable.

### Consent for publication

The manuscript has not been published in completely or in part elsewhere.

### Competing interests

No conflict of interest. We all unanimously agreed to publish in the journal.

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