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INFLUENCE OF PARASITOID, *ERETMOCERUS EREMICUS* (HYMENOPTERA: APHELINIDAE) ON COTTON WHITEFLY, *BEMISIA TABACI* (HEMIPTERA: ALEYRODIDAE) UNDER *VIVO* AND *VITRO* CONDITIONS AT UPPER SINDH

Hakim Ali Sahito[1-2], Fozia Soomro[1*], Tasneem Kousar[1], Zafar Hussain Shah[1], Wali Muhammad Mangrio[1] and Faheem Ahmed Jatoi[1]

[1]*Department of Zoology, Faculty of Natural Sciences, Shah Abdul Latif University, Khairpur, Sindh - Pakistan.*
[2]*Date Palm Research Institute (DPRI), Shah Abdul Latif University, Khairpur, Sindh - Pakistan.*
*Corresponding author: Email, foziasoomro51@yahoo.com. Ph., #. (92) 305-3629110

ABSTRACT

The population of whitefly on cotton leaves was investigated under field and laboratory conditions (kept unsprayed) at Shah Abdul Latif University, Khairpur during, 2017. The data were collected from randomly selected twenty plants per week for the whitefly pest population and its parasitoid emergence that appeared from seedling to crop harvesting. The whitefly population was counted from various portions of the plant (upper, mid and lower) under field conditions. The highest population of whitefly was found on the leaves of the middle part of the plant 4.45 ± 0.53 in September, and a minimum population of whitefly was found on the leaves of the bottom portion of a plant; 0.53 ± 0.54 in July. The overall mean population of whiteflies per week was compared among four months of data collection. Among these months the maximum per week whitefly population was observed in September 4.38 ± 0.05, and the minimum per week whitefly population was found in July 0.72 ± 0.14. In laboratory conditions the maximum population percent of the parasite, *Eretmocerus eremicus* was calculated in August 21.43 ± 0.89% and minimum parasite % was recorded in July 19.37 ± 0.89%. It is concluded that the whitefly population and the parasitoid, *Eretmocerus eremicus* population, fluctuated throughout the observation period. It is suggested that if promoted *Eretmocerus eremicus* may control the whitefly of the cotton crop at the upper region of Sindh province.

Keywords: Biological control, cotton, field, and lab condition, and pest occurrence.

INTRODUCTION

The cotton whitefly, *Bemisia tabaci* (Gennadius) found in several regions of the world, over 100 years ago (Anonymous, 1989). This insect is a serious pest of the cotton crop, decorative plants and 164 varieties of the cotton plant (Attique *et al*., 2003). The whitefly has been declared as a major pest in 16 countries out of 27 cotton-growing countries in areas where cotton grows in mid and late season (Anonymous, 1989). The American cotton varieties became unsuccessful in the Punjab region of the subcontinent during 1919 and 1926 and somewhat in 1921, 1923 and 1927 due to the presence of whitefly (Hussain and Trehan, 1933). The whitefly showed various activities relating to the host, egg-laying, environmental variation and the spread of the virus (De Barro *et al*., 2005; Jones, 2003). The massive attack of whitefly lowers the production of the cotton crop, which causes the disease chlorosis and irregular maturing of the bolls. The feeding of *B. tabaci* causes physical sicknesses in plants and its consequences in shedding or falls of immature portions of the fruit, this situation resulting in reduced plant growth (Jones, 2003). This insect pest attacks the underside surface of the leaves from where it sucks the juices of the plant and causes great damage through dusty fungus (Khan and Ahmad, 2005).

Parasitoids were usually endearing in the controlling of the *B. tabaci* population (Gerling, 1992). About 115 parasitoids of *Bemisia tabaci* have been reported but out of these, 3 species mostly utilize for natural control of whitefly (Stansly and Natwick, 2010). Among them, *Eretmocerus eremicus* (Hymenoptera: Aphelinidae) has been introduced as a natural control of *B. tabaci* some years ago (Greenberg *et al.*, 2000). The *E. eremicus* succeded to control whitefly due to its thrilling quality (Greenberg *et al.*, 2002), this can recognize patches of *Bemisia tabaci* fastly (Hoddle *et al.*, 1997). *E. eremicus* was naturally found on a few crops (Cortes and Perez, 2013). This parasitoid has a tiny size of 1 mm, native to some desert areas of America (Rose and Zolnerowich, 1997). This parasitizes on different *Bemisia* species including *B. tabaci*, *T. vaporariorum* and *T. abutiloneus* (Gould *et al*., 2008), it is stated that it partiality infesting second and third instar nymphs but retaining capability of parasitizing on any nymphal instar of whitefly (Headrick *et al*., 1996). *E. eremicus* is accessible in America and Europe for commercial control of *B. tabaci* (Bellamy *et al*., 2004). This parasitoid is a monoecious parasite native in the Southwest, USA. It is noticeable for *B. tabaci* control and at present being produced in large numbers (Rose and Zolnerowich, 1997). Eggs of all parasitoids are laid in or under the host. The females of *Eretmocerus eremicus* oviposit their eggs underside of the host and then its larva enters into the developing host, where they develop within

nymphs of *B. tabaci* and come out from the 4th instar (Liu *et al.,* 2015). The parasitoid feeds on hemolymph (Van Driesche *et al.,* 1999).

This paper investigates the influence of parasitoid *Eretmocerus eremicus* on cotton whitefly, *Bemisia tabacii* in vivo and in vitro conditions of upper Sindh.

MATERIALS AND METHODS

Experiments under field conditions

The research was conducted on sucking pest, whitefly on cotton crop cultivated in May at Taluka Kotdiji during the Kharif season, 2017 on the five-acre field, which was kept insecticides free and the population of natural enemies was collected per week from the initial appearance of whitefly till harvesting the cotton crop. The data was counted on twenty plants of the cotton crop randomly basis. The data was taken on the mature and immature population of whitefly (nymphs and adult stages) per leaf basis from each observation and in each sampling time. For this purpose, the 3 leaves were selected from single plant of cotton, 1st leaf from top region of plant, 2nd from mid-region of plant and 3rd leaf from bottom region of the plant at 8:00 AM early in the morning, before disturbing the soft-bodied whiteflies and its biological agents because at early morning time whiteflies were in resting and at the mid-day, they become active to search food and mating. The population of the whitefly pest was counted with the help of 5x magnifier lens in vitro conditions.

Experiment under laboratory conditions

For experiments in the laboratory, the infested samples of plants were collected in plastic bags and were brought to Entomology Laboratory, Department of Zoology, Shah Abdul Latif University Khairpur to observe the appearance of parasites. For this purpose, the single leaf of cotton plants was kept in the Petri plate up to 5 cm in diameter. Therefore, the 5 treatments were kept which were replicated 5 times during the research period. The eggs of the parasitoids were observed under the host through identifying the mummified as changed their color as in brownish in appearance. The female of *Eretmocerus eremicus* oviposited their eggs under suitable host, then its infested larva entered into the developing nymph of the host, where parasite has completed its development and then parasite came out from the 4th instar of whitefly by damaging it (Liu *et al.,* 2015) and in this way endoparasites were observed. After the collection of parasites, these were recognized from different sources of taxonomists. The total experimental work has been picturized, both *in vitro* as well as *in vivo* conditions.

STATISTICAL ANALYSIS

The data were analyzed statistically through statistical software (Statistics- 8.1) USA. The percentage of parasitism was calculated as follows:

$$\text{Parasitism (\%)} = \frac{\text{No. of parasites}}{\text{No. of whiteflies}} \text{ x100}$$

RESULTS

Population dynamics of whitefly, *Bemisia tabaci* (Gennadius) *in vitro* conditions

In vitro conditions, the population of whitefly were calculated separately on three portions of the plant on weekly basis from July to October and then collected data were compared per leaf, per portion, per week and month. So during July by comparing the upper region of the cotton plant, the highest per leaf population of whitefly were observed during the second week (1.25 ± 0.97) while; the lowest population of whitefly were found during the fourth week (0.65 ± 0.67). While; comparing the mid portions of the plant for per leaf whitefly population the highest population was found during fourth week (1.10 ± 1.25) and lowest population was found during first week (0.20 ± 0.41) and when bottom region of the cotton plant was compared, the per leaf greatest population was calculated during fourth week (0.85 ± 0.93) while; the per leaf lowest population was found during the first week (0.25 ± 0.55) in the same month. So when the portions of the cotton plant were averagely compared in July collectively the overall per leaf maximum mean population was calculated on the upper portion (1.00 ± 1.24) of the plant while; the minimum on the lower portion (0.53 ± 0.54). By comparing the month of August for having the whitefly population per leaf of the cotton plant, the highest population was calculated on the upper portion during the first week (3.50 ± 1.28) while; the lowest population was found during the second week (1.80 ± 1.06). When compared to the mid-region of the plant, the greatest population was collected during the second week (2.75 ± 0.97) and the least population during the third week (1.15 ± 1.46). The bottom side of the cotton plant leaves, the highest population per leaf was found during the 1stweek (3.65 ± 1.27) whereas the least population was found during the

second week (1.90 ± 1.21). The highest overall mean population in August was found on the bottom region (2.73 ± 1.13) and the minimum on the middle side (2.01 ± 1.26), respectively.

In September, the highest population was found on upper portion of the plant during the third week (8.40 ± 8.15) and the minimum population during the fourth week (2.60 ± 2.54), whereas; on the mid-region of plant of cotton, the maximum population during the third week (7.15 ± 6.50) and minimum population during the first week (1.20 ± 1.58). Thus, on the bottom portion of the plant the greatest population was found during the third week (6.25 ± 4.23) and minimum during the 1st week (3.05 ± 1.43) in the same month. In September, the greatest overall population was found in the middle portion (4.45 ± 0.53) while; the least on the lower region of the plant (4.29 ± 0.81).

In October, the highest population of whitefly was recorded on upper region of the plant during the third week (7.40 ± 5.63) while; the lowest population during the second week (1.65 ± 1.43) whereas; on the mid-region of the plant of cotton, the greatest population of whitefly were observed during the third week (5.15 ± 3.78) and the least population during the first week (2.20 ± 01.22). While on the bottom side the greatest population of whitefly was found during the second week (3.15 ± 2.64) and the lowest population during the fourth week (1.70 ± 0.72). The highest mean of the overall whitefly population was recorded on the upper region of the plant (3.91 ± 0.66) per leaf and lowest on the lower portion of the plant of cotton (2.29 ± 1.10) as shown in (Table 1). The ANOVA showed the non-significant difference by comparing the overall mean of whitefly population per week across the season (DF= 3, 1; F= 0.49; P= 0.487) and across the different portions of the cotton plant (DF= 3, 1; F= 1.85; P= 0. 1528).

Table 1. Population dynamics of whitefly on cotton crop *in vitro* conditions.

Week	July			August		
	Upper	Mid	Lower	Upper	Mid	Lower
First	1.00±1.45	0.20±0.41	0.25±0.55	3.50±1.28	2.55±1.23	3.65±1.27
Second	1.25±0.97	0.40±0.94	0.45±0.76	1.80±1.06	2.75±0.97	1.90±1.21
Third	1.10±1.21	0.85±0.88	0.55±0.83	2.30±2.45	1.15±1.46	2.50±1.36
Fourth	0.65±0.67	1.10±1.25	0.85±0.93	1.85±1.46	1.60±1.47	2.85±1.63
Mean±S.E	1.00±1.24	0.64±0.43	0.53±0.54	2.36±1.38	2.01±1.26	2.73±1.13
	September			**October**		
	Upper	Mid	Lower	Upper	Mid	Lower
First	4.00±2.00	1.20±1.58	3.05±1.43	2.00±0.53	2.20±01.22	2.05±0.49
Second	2.65±2.56	5.10±4.29	3.15±2.54	1.65±1.43	3.10±1.47	3.15±2.64
Third	8.40±8.15	7.15±6.50	6.25±4.23	7.40±5.63	5.15±3.78	2.25±1.21
Fourth	2.60±2.54	4.35±3.63	4.70±3.69	4.60±2.11	3.35±1.98	1.70±0.72
Mean±S.E	4.41±1.24	4.45±0.53	4.29±0.81	3.91±0.66	3.45±0.81	2.29±1.10

The weekly comparison of the population of whitefly as observed during the experimental months (July, August, September, and October) is shown in Fig. 1. By comparing the 1st week of all the four months, the maximum whitefly population on leaves was recorded in 1st week of August (3.23 ± 0.34) followed by 1st weeks of September, October and July (2.75 ± 0.82), (2.08 ± 0.06) and (0.48 ± 0.26), respectively. Likewise; comparison between 2nd weeks of these months, the maximum population of whitefly were recorded in 2nd week of September (3.63 ± 0.75) followed by October (2.63 ± 0.49), August (2.15 ± 0.30) and July (0.70 ± 0.28). In comparison, the 3rd week of these months, the maximum population was observed in September (7.27 ± 0.62) followed by October (4.93 ± 1.49), August (1.98 ± 0.42) and July (0.83±0.16). In last by comparing 4th week of each month, the maximum whiteflies were reported in 4th week of September (3.88 ± 0.65) followed by October (3.22 ± 0.84), August (2.10 ± 0.38) and July (0.87 ± 0.13). That is to say that the greatest population of whiteflies was recorded in September (4.38 ± 0.05) followed by October (3.22 ± 0.48), August (2.37 ± 0.21) and July (0.72 ± 0.14).

Population dynamics of whitefly and *Eretmocerus eremicus in vivo* conditions

In laboratory conditions the population of whiteflies and hatching of its parasite, *E. eremicus* was calculated every week from July to October in the Kharif season, 2017. In July, the maximum population of whitefly was observed during the fourth week (3.00 ± 2.12), in same week mean population of parasites was found (0.75 ± 1.73) and parasite percent become (25.00 ± 0.30%) whereas; the lowest population of whitefly was counted during the first week (1.25 ± 1.17), mean population of parasite in the same week (0.25 ± 1.00) while the highest parasite percent was observed (14.28 ± 0.14%) during the second week. In August, the highest population of whiteflies (4.50

± 3.67) and *Eretmocerus eremicus* (1.25 ± 2.24) with its % (27.78 ± 0.26) were recorded during the fourth week while the lowest population of whiteflies (1.75 ± 2.65) and *Eretmocerus eremicus* (0.25 ± 1.00) with its % (14.29 ± 0.18) were recorded during the second week of the same month.

In September the highest population of whiteflies (5.75 ± 1.91), parasitoid (1.30 ± 1.17) and percent of parasitoid (22.61 ± 0.30) were recorded during the third week while; the lowest population of whiteflies (3.75 ± 2.02) and parasite (0.75 ± 1.73) emerged during the second week and the lowest percent of parasitoid (15.79 ± 0.36) were found during the fourth week. In October, the highest population of whiteflies (6.00 ± 1.73), parasitoid (1.50 ± 1.22) and percent of parasitoid (25.00 ± 0.51) were recorded during the fourth week while; the lowest population of whiteflies (4.50 ± 3.67), parasite (0.75 ± 1.73) and percent of parasite (16.67 ± 0.36) was found during the second week (Table 2). The ANOVA showed the per week non-significant differences by comparing the overall mean population of whiteflies and their parasitoid *in vivo* conditions during the entire experimental period at (DF= 3, 1; F=0.23; P= 0. 876) whereas on per month non-significant differences were also statistically analyzed (DF= 3; F= 0.06; P= 0. 0.979) at (P<0.05).

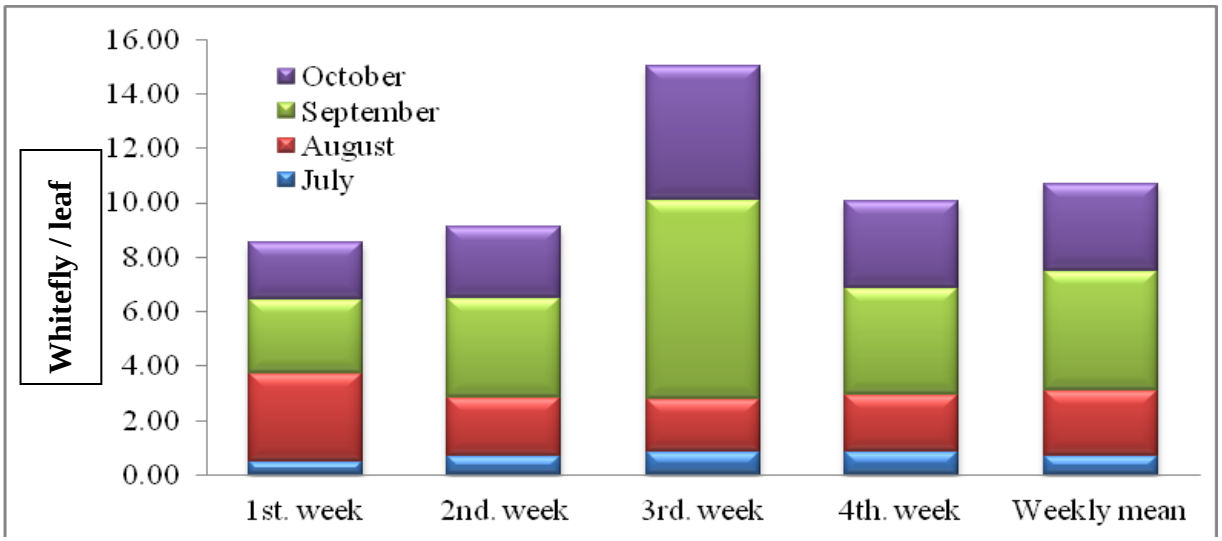

Fig. 1. Weekly population fluctuation of whitefly *in vitro* conditions.

Table 2. The population of *E. eremicus* on cotton whitefly *in vivo* conditions.

Weeks	July			August		
	Pest±S.E	Parasite±S.E	Parasitism%±S.E	Pest±S.E	Parasite±S.E	Parasitism%±S.E
First	1.25±1.17	0.25±1.00	20.00±0.14	2.25±0.57	0.50±0.71	22.22±0.24
Second	1.75±2.65	0.25±1.00	14.28±0.14	1.75±2.65	0.25±1.00	14.29±0.18
Third	2.75±1.73	0.50±1.22	18.18±0.22	3.50±3.24	0.75±1.73	21.43±0.22
Fourth	3.00±2.12	0.75±1.73	25.00±0.30	4.50±3.67	1.25±2.24	27.78±0.26
	September			**October**		
First	4.75±2.28	1.00±1.22	21.05±0.31	5.75±4.80	1.00±1.22	17.39±0.31
Second	3.75±2.02	0.75±1.73	20.00±0.31	4.50±3.67	0.75±1.73	16.67±0.36
Third	5.75±1.91	1.30±1.17	22.61±0.30	5.75±2.50	1.25±2.24	21.74±0.58
Fourth	4.75±4.36	0.75±1.73	15.79±0.36	6.00±1.73	1.50±1.22	25.00±0.51

The overall results about the mean of the whitefly population and percent population of the parasitoid were observed in the different months as shown in (Fig. 2). From which in July percent population of the parasite of whitefly was (19.37 ± 0.89) and the mean of whitefly population was recorded (2.19 ± 0.65). In August the overall population of the parasite was observed (21.43 ± 0.89) and the mean of whitefly population was recorded (3.13 ± 0.71). In September overall percent population of the parasite was observed (19.86 ± 1.15) and the mean of whitefly population was recorded (4.75 ± 1.00). In October the overall percent population of the parasite was observed (20.20

± 0.83) and the mean of whitefly population was recorded (5.50 ± 0.98). While the average of whitefly population throughout the season has remained overall (3.89 ± 0.75) and percent population of the parasite was found overall (20.22 ± 0.44) throughout the season.

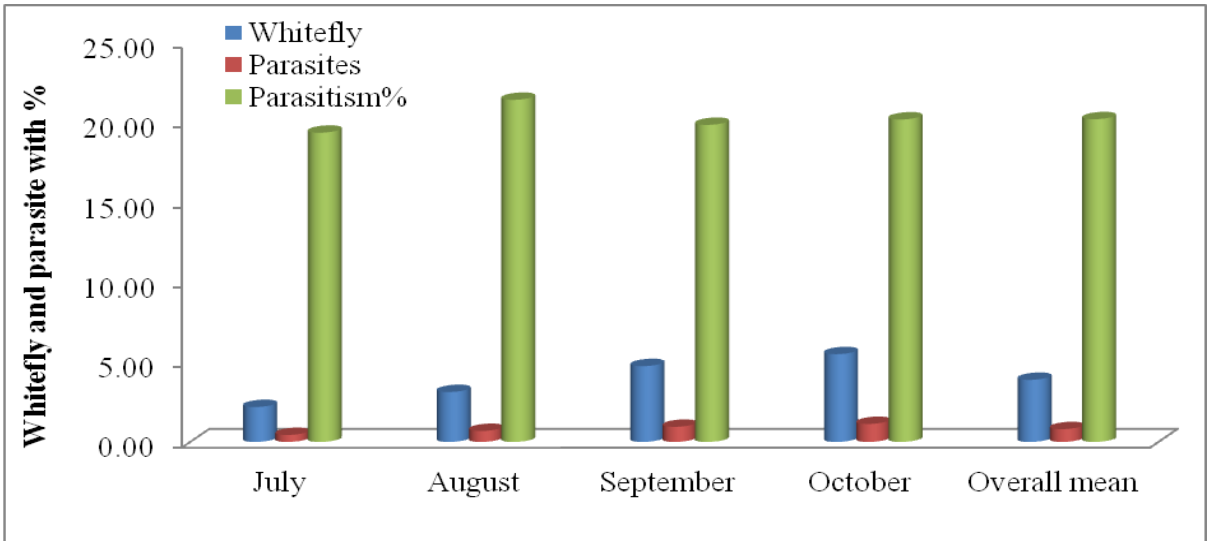

Fig.2. Population of cotton whitefly and *E. eremicus* with parasitism % *in vivo* conditions.

DISCUSSION

The experimental studies were carried out on the population of sucking pest; whitefly on the crop of cotton under field conditions and experimental work about natural controlling agent was done in laboratory conditions at Zoology Department, SALU – Khairpur during, 2017. It was noticed that the whitefly population increased on the cotton crop due to the increase in temperature. This pest is cause of viral disease (CLCuV) on cotton crop that's why known as casual organism, as indicated by Kumar and Agarwal (1990); Sahito *et al*. (2018); Rafiq *et al*. (2008) who described that due to increase in temperature after the cold season, growth of whitefly increased on the crop, vegetables and alternative host plants like; *P. aureus, L. culinaris, P. mungo, G. max, H. annus, S. melongena, C. melo* etc. So, this sucking pest; whitefly works as a major part of the damage to the production of the cotton crop. In our findings, the whitefly population appeared in July and increased in August and September, this is supported by the Shah and Sahito (2020) who described that the increase in damage % of the crop by whitefly was observed from June up to August and October after that gradually decreased under field conditions of cotton plants. Furthermore, our research experiment was kept free of pesticide spray due to the harmful effect of insecticides on living beings, so control of sucking pest, whitefly was left on natural enemies. According to Khan and Atta (2007) who used botanicals sprays like; extracts of neem and Dhatura for lowering down the whitefly population because these sprays were safer for biological control agents, and also these have decreased the population of pest, as well as these, were eco-friendly to the atmosphere.

In our findings the parasite, *E. erimicus* was observed as the key agent for natural control of whitefly, *Bemisia tabaci* (Genn.) that have parasitized the whitefly nymph's and effectively decreased its population. As indicated by Gerling *et al*. (2001) who described those parasitoids as are the main controlling agents of whitefly, that parasitizing to this pest's nymphs that produce its new population and afterward feed on the whiteflies to raise their stability. *Encarsia formosa* and *Eretmocerus eremicus* became the main parasite species among the parasites of whitefly, including 34 *Encarsia* spp., 12 *Eretmocerus* spp. Our results showed that whiteflies were biologically controlled by a parasite, *Eretmocerus eremicus*; the only inspiring quality of this parasite is that it efficiently controls *B. tabaci.* The nymphs of the whitefly were parasitized by the larvae of *E. eremicus* which are hatched from the laid eggs of their females. Our findings were likewise in agreement with Parrelta *et al*. (1992); Naranjo *et al*. (2004); Cortes and Perez (2013) who stated that parasitoid; *Eretmocerus eremicus* was the biologically controlling agent of whitefly may exist on the comparative time. The natural parasitoids of whitefly have been observed in our studies, the crop has been held free of insecticides use, so only the *E. eremicus* parasite was found on whiteflies and also infested it, ranging from 19 to 21%. Our findings were in agreement with Carruthers *et al.* (1993) who worked with whitefly parasites, *E. formosa and* E. *eremicus*. In his work, different parasitoid species among the genera - *Encarsia* and

Eretmocerus were found attacking the whitefly. As many researchers in an insecticide-free field reported the parasitism level 70-90% on the host. As indicated by Mohyuddin *et al*. (1989) who discussed eleven species of parasitoids in Pakistan.

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