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IDENTIFICATION, CONSERVATION AND AUGMENTATION OF SAW-TOOTHED GRAIN BEETLE PARASITOID, *CEPHALONOMIA TARSALIS* (ASHMEAD, 1893) IN DATE FRUITS

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ABSTRACT

The renown of date fruits is growing day by day therefore, the high quality with no or less chemical treatment is a topic of interest for consumers worldwide. For this purpose, this kind of research was scheduled for the proper biological control agent's identification and its confirmation of the dry date's major pest. The sample collection was made from the different godowns of the vicinity of Khairpur and the bulk stock was made to initiate the study from the Aseel date variety. For each treatment there were counted (n=200) date fruits by releasing different doses of male and female parasitoids hence; there were 5 treatments including control and replicated 5 times. The results showed that the release of T_1=03 couples of parasitoids mean control efficiency resulted after 10 days after release (DAR) 34.40, DAR 20; 40.20, and DAR 30; 42.60 when compared with the overall mean of control. In this next T_2=04 couples of natural enemies showed the efficiency up to 24.50; 38.45; 43.70 followed by T_3=05 indicated up to 21.25; 26.30; 33.30; and T_4=06 found with 35.45; 38.55; 43.70, respectively. The effectiveness of natural enemies against pests was found to be the most effective of all treatments. Couples four and six yielded the best results for effectively controlling the STGB larvae stage. Furthermore, it is suggested that the conservation and augmentation processes be encouraged in order to reduce the pest population on date fruits.

Keywords: aseel variety, biological control, dates, export quality, godowns

INTRODUCTION

The *Phoenix dactylifera* L. is the oldest human-cultivated tree, with historical evidence indicating that its fruits have been used and cultivated for thousands of years (Popenoe, 1813). It is a monocotyledon woody, evergreen, dioecious, perennial plant that belongs to the Palmae; Arecaceae family and grows smoothly in hot and arid environments around the world (Anukiruthika *et al*., 2021; Omotesho *et al*., 2015). It has different gender types as evaluated through molecular methods and spectroscopic methods (Khan *et al.,* 2021). There were also a few native and exotic kinds of parasitoid species, which are known as natural enemy control agents, that can reduce the pest because the larvae of the insect pests are voracious feeder stages (Mangrio *et al*., 2020). Only its motivation is to mass rearing and release in the vicinity of the pest. The most prominent are *Brachymeria* spp., *Cephalonomia* spp., and *H. hervetor* are the larval and pupal parasitoids (Stejskal *et al.,* 2006).

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The infestation rate was up from 19% to 67% thus, the *C. tarsus* was found parasitizing over the saw-toothed grain pest. It is the ectoparasitoid (Amante *et al.,* 2017) and serves as the major suppressing pest agent. It is recently known as the wasp species that provided significant results to reduce the pest population was observed higher (Eliopoulos *et al.,* 2016). Biological control over the saw-toothed grain beetle is well recognized throughout the world (Mazza *et al.,* 2014). Only parasitoid species may reduce the population density of pests. Hence, it was reported by (Singh *et al.,* 2021) that there were 45 kinds of species belonging to the Bethylidae (*Cephalonomia tritici*), whereas; (Eliopoulos *et al.,* 2019) also evaluated its efficiency over the saw-toothed grain beetle of stored pest to keep the pest under suppression. This insect pest hits both types of dry and semi-dry date fruits (Kousar *et al.,* 2021; Sahito *et al*., 2017). Keeping this in mind, the current studies were conducted to develop pest management strategies for *Oryzaephilus surinamensis* (L.) in order to increase the economic value of date fruits.

MATERIALS AND METHODS

Confirmation of biological control agent of saw-toothed grain beetle

The infested fruits were collected from the prominent variety (cv=Aseel) which is the most cultivated throughout the district of Khairpur.This district is known as the Queen district while the cultivation of this date palm variety in different orchards of dates farm which the dry and semi-dry dates are being made for export quality and transported throughout the world.

Pest and parasitoid interaction

The local cultivars of date orchards of this region, Sukkur are suffering enormous loss due to the moonsoon. If the production increase at any cost, it is being destroyed by the pest in stored godowns. Hence the biological control agent takes an essential role to suppress the pest. For experimentation the native parasitoid was observed and confirmed under Date Palm Research Institute (DPRI) Shah Abdul Latif University, Khairpur starting with consequent years, 2019-20. Further, the studies were parallel and continued for the proper conservation and augmentation of the parasitoid over the pest. The facility of rearing the biological control agent was available under the laboratory condition where the temperature of 25 ± 2^{o}C was maintained at (L:12 and D:12) hours with the relative humidity of 55 ± 5%. Having the bulk population of natural enemies under laboratory conditions was transferred for pest population control.

Mass rearing of pests and their natural enemies

For the rearing of natural enemies under laboratory conditions, there was a handmade wooden sheet chamber with different shelves. The wooden chamber was consisting over 2 feet to 6 feet in latitude and longitude up to the weight of 20 kg having the four basil feet which were dipped under the water kept in a plastic bowl. Hence, the grease oil was used on the surface of the water to not reach any secondry predators to disturb the culture of natural enemies. The different 3 shelves were installed into the chamber where the damaged with pest dry and semi-dry dates were kept as food for the saw-toothed grain beetle to enlarge their life cycle as its natural enemies can survive over this and can enlarge its population. As a huge population of males and females of the parasitoid was observed through its 6 plastic jars weighing 200-300 grams. The 10% honey solution in water with glucose 75% dipped in a cotton swab and placed in these mini plastic jars for nutritional requirements. As the population density of parasitoids became huge it came through its flying outside in the different jars installed outside the chamber which were interconnected with 3 different shelves of the chamber. While flying and mating purpose those used to come in the jars which were directed connected with the outside kept light 100 watts bulbs, that reflected and encouraged the parasitoid to come outside into the jars from the chamber. At that time the jars were able to be separated and the parasitoids were transferred to another plastic jar weighing up to 2 kg to bring outside the laboratory and could thirty five parasitiods at the godowns located at the Khajoor mandi, Khairpur. Hence, the population of natural enemies was released to suppress the pest. The count was made and released as a scheduled experiment on a fortnightly interval basis.

Conservation and augmentation of biological control agent on saw-toothed grain beetle

To check its proper efficacy of natural enemies, such a scientific method was adopted as having counted 200 dry date fruits placed weighting 10 kg caring plastic jars whereas; the larvae as counted in some 200, in the stage of 4th instar were also placed over the dry date fruits in different plastic jars as the pre-treatment observations. Thus, the counted number of couples such as, 03, 04, 05, and 06 number of parasitoids were released over the larval stages to check their efficiency and parasitizing level. It was also given to each treatment. For this purpose, 4 treatments were replicated 5 times under laboratory conditions whereas; the 5th treatment was kept without the release of the natural enemy in jars compare with other kept 4 treatments of parasitism efficiency. Consequently, their efficiency level was observed on the 10th, 20th, and 30th day as day post-treatment (as an exposure time in days) as days after release (DAR) for this purpose, 3 treatments were replicated 5 times for days confirmation and population enlargement basis. In the control kept experiment the pest population was observed with enlarging the life cycle with its natural mortality, which was compared with other kept treatments mentioned above. Like as, the un-treated insects at the larval stage were placed at the same room 25^{o}c temperature. The initial trails were kept during, 2019 for their proper confirmation, the further

trails were replicated for the next year, 2020 hence data was formulated for the conclusion in percent formulation as described under:

$$\text{Percentage (\%)} = \frac{\text{No. of parasitized larvae}}{\text{No. of un-parasitized larvae}} \times 100$$

Statistical analysis

The data was incorporated in Excel spread sheets for both consequent years, 2019-20. The statistical analysis of variances was done among the insect management through its proper biological control on their effectiveness basses. The least significant differences were done at the P-value of 5 percent for their comparison with the help of Graph Pad Prism version 5 software.

RESULTS AND DISCUSSION

Biological control of *O. surinamensis* through larval parasitoid *Cephalonomia tarsalis*

The saw-toothed grain beetle larval parasitoid, *Cephalonomia tarsalis* (Ashmead, 1893) was identified attacking *Oryzaephilus surinamensis* (Linnaeus) (Coleoptera: Silvanidae) which infesting stored date fruits by the Entomological experts of biological control agents. Our results revealed that a total counted 200 infested dry date fruits were kept having 200 larval stage of pest population and the count was made at pre-treatment level with an overall mean population such as; 62.55 found at survived whereas; post-treatment (as an exposure time in days such as; 10th, 20th and 30th day) hence; at 10th day, 34.40; 20th day, 40.20; and 30th day, 42.60 with overall mean control efficiency or parasitized. Consequently, in control on the 10th day, 78.10; 20th day, 82.55 and after the 30th day, 79.90, respectively. The work is similar to that reported previously by (Eliopoulos, 2019) who described that the *O. surinamensis* and its larval stage parasitoid, *C. tarsalis* were reared under laboratory conditions. Another research study also agreed with (Tavakolian *et al.,* 2013; Mailafiya *et al.,* 2021) they also found another kind of species. The statistical analysis data was done at pre-treatment which was observed among significant difference (df= 1; f= 2.40; *p*= 0.00) hence, the biological control agent increased with its population when compared within the days level, which was found at 10th day (df= 1; f= 7596; *p*= 0.01) significant difference followed by 20th day (df= 1; f= 4489; *p*= 0.03) and 30th day (df= 1; f= 3840; *p*= 0.02). In five replication the same letter values were found with a non-significant difference at *p*<0.05 level as sorted out through the Tukey test after one-way ANOVA, shown in Figure 1.

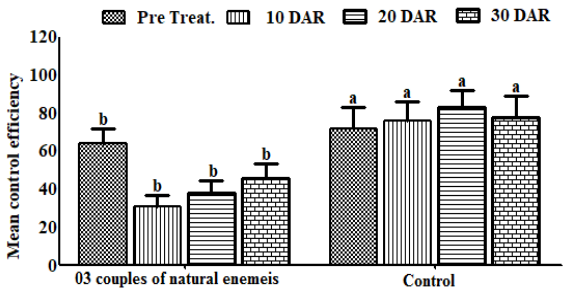

Figure 1. At different time intervals the overall mean infestation control efficacy of pest after releasing 03 couples of *C. tarsalis* on dry date fruits

The 04 couples were released parasitoids results shows that a total pest population was observed at pre-treatment with an overall mean population of 62.65 whereas; post-treatment on the 10th day, 24.50; 20th day, 38.45; and 30th day, 43.70 with overall mean control efficiency. Whereas, in control on the 10th day, 65.45; 20th day, 72.20 and after the 30th day, 69.45, respectively. For better production, the issues creel the making of date fruits in Pakistan as described by Fatim a *et al*. (2016), Ata *et al*. (2014; 2012) and its major role-playing in the livelihoods of farmers. The statistical analysis data was done at pre-treatment which was observed with a significant difference (df= 1; f= 184; *p*= 0.01), the population of *C. tarsalis* was found at an increasing level which was found significantly different on the 10th day (df= 1; f= 8640; *p*= 0.02) on 20th day (df= 1; f= 4900; p= 0.02) and 30th day (df= 1; f= 3840; *p*= 0.02) which was found non-significantly different (Figure 2). The results of our research are more comparable with (Agrafioti *et al*., 2021), they reported that there are the two most common species were *Rhyzopertha dominica* (F.) and *Oryzaephilus surinamensis* (L.) in stored products. Hence, both were controlled by the CO_2 and its efficacy was higher (El-Lakwah *et al.,* 2010; Hashem *et al.,* 2014). Whereas, phosphine was found the resistant in saw-toothed grain beetle (Hubhachen *et al.,* 2018) hence; the safest mode of action to suppress the pest is to control the biological from insect to insect, thus the research studies were carried out to encourage the IPM strategy. Our results findings are in harmony with those (El-Shafie, 2012) who listed *P. dactylifera* L. arthropod pests and their natural enemies worldwide.

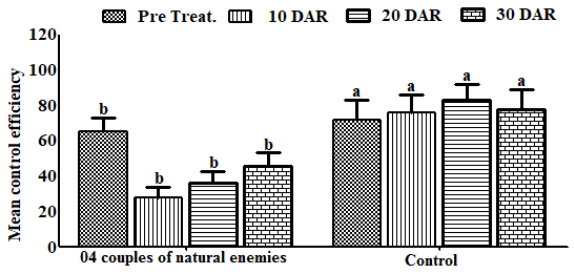

Figure 2. At different time intervals the overall mean infestation control efficacy of pest after releasing 04 couples of *C. tarsalis* on dry date fruits

The results of 05 couples of parasitoids were released to show the control efficiency that revealed, at pre-treatment with an overall mean population of 68.90 whereas; post-treatment at 10th day, 21.25; 20th day, 26.30; and 30th day, 33.40 with overall mean control efficiency thus, in control treatment on 20th day provided bit enlarging efficiency. The statistical analysis data was done at pre-treatment which was observed with a significant difference at (df= 1; f= 5.00; *p*= 0.03) hence; the *C. tarsalis* population was increasing and was found significantly different on the 10th day (df= 1; f= 10543; *p*= 0.01) on 20th day (df= 1; f= 6480; *p*= 0.02) followed by 30th day (df= 1; f= 8284; p= 0.02) further, data graphically described in (Figure 3). The date fruits are mostly dried through the hot water to make its better quality as can be exported as the finding are being encouraged by Yahia *et al.* (2014) who described that dry-dates may be incubated up to 3-4°C for making its better and transparent quality as well for its better flavor.

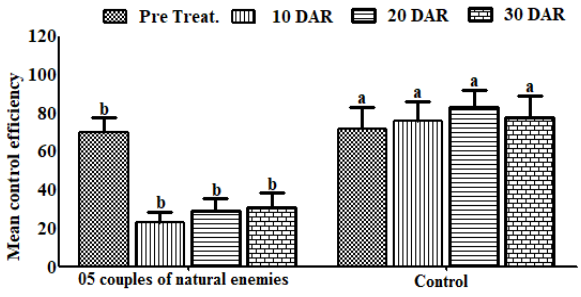

Figure 3. At different time intervals the overall mean infestation control efficacy of pest after releasing 05 couples of *C. tarsalis* on dry date fruits

The results of 06 couples were released parasitoids resuts showed the control efficiency at pre-treatment with an overall mean population of 65.45 hence; the post-treatment was found on the 10th day, 35.45; on the 20th day, 38.55; and 30th day, 43.70 with overall mean control efficiency thus, in control treatment on 20th day provided enlarging efficiency. When pre-treatment data was statistically analysed found significant difference (df= 1; f= 60.0; *p*= 0.02), at 10th day (df= 1; f= 6304; *p*= 0.02) followed by the 20th day (df= 1; f= 3721; *p*= 0.03) and in 30th day (df= 1; f= 3375; *p*= 0.01), respectively as described in (Figure 4). Keeping in mind, the importance of dates, the trials were initiated for the encouraging to the date palm orchards growers at local stage. Moreover, their fruitful results agreed with those of PARC (2009) who reported the good additional recipe for tasty salads and other use. Furthermore, advantages are also described by Al-Deeb, (2012), Awad *et al*. (2022). Consequently, the benefit-cost ratio was also evaluated by Sarraf *et al*. (2021). The findings of our research work correlated to other findings of the researchers, in which there are descriptions of the huge infestation loss due to the saw-toothed grain beetle so there should be bit information about the control strategy against this pest on dry or even on semi-dry date fruits throughout the queen district Khairpur of the province, Sindh-Pakistan.

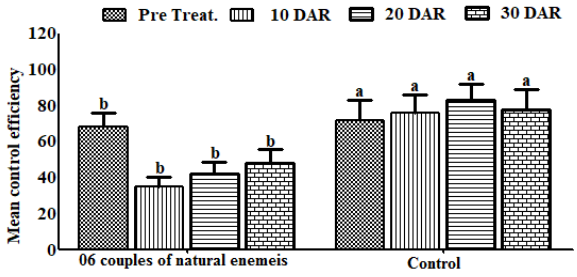

Figure 4. At different time intervals the overall mean control efficacy of pest after releasing 06 couples of *C. tarsalis* on dry date fruits

CONCLUSION AND RECOMMENDATIONS

In the present research study, it was concluded that the long period of date fruits storage, was found to be increased the date fruit damage, which is arising due to this pest populace, that is known as the key pest of stored grains as saw-toothed grain beetle. This region is especially known as the hot and dry climate region of upper Sindh hence, the date palm is cultivated in huge condition that ultimately supports the growth of the dates whereas; the monsoon season destroys the mature and immature dates handing over the date palm trees. The stored dates in different factories and godowns are considered safe but unsafe for the stored pest. It is recommended that the dates are fumigated with methyl bromide and phosphine tablets

which are sometimes hazardous to human health while using the date fruits. So, it was much needed to conduct the research study on the indigenous parasite or parasitoid appearance, its mass culturing with its proper conservation and augmentation process with its growth rate per pest efficiency. The development of efficient bulk population *C. tarsalis* with the mass rearing techniques to have the augmentation release at the time of the season of pest appearance in godowns and date fruit factories; hence, it would suppress the frequent pest population.

IMPACT STATEMENT

As well, the saw-toothed grain beetle larval parasitoid, *Cephalonomia tarsalis* (Ashmead) appeared as the major biological control agent of dry date frits located in district Khairpur. Its efficiency can be efficiently used against this pest for its suppression in the godowns or different exporting quality keeping factories, so it should be encouraged.

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We thank R. Muhamood (CABI), Rawalpindi, known as biological control specialist for the proper identification of bio-control agents, and the director of DPRI, SALU-Khairpur for providing space to conduct the research under the Entomology, Laboratory, where this work was initiated and findings came out to share among the livelihood and local growers of date palm orchards.

CONFLICT OF INTEREST

Regarding this publication, the authors have declared there is no conflict of interest.

AUTHOR'S CONTRIBUTION

T. Kousar: Designed scientific research work, gathered data curation, formally analyzed, investigate, planned methodology, and wrote the original draft.

Z. N. Memon: Gone through the manuscript and provided critical suggestions.

W. A. Panhwar: Helped with proof reading the manuscript, provided technical support and facilitated at the Entomology Laboratory.

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