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The blister beetle *Meloe proscarabaeus* (Coleoptera: Meloidae) a dangerous pest threatens field crops in New Valley Governorate, Egypt

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Abstract:

The blister beetle, *Meloe proscarabaeus* L. (Coleoptera: Meloidae) was recorded for the first time as a serious insect pest attacking wheat (*Triticum aestivum*), faba bean , peas, alfalfa, onion and wild weeds in El-Farafra Oasis, Western Desert, Egypt. Beetles feed on foliage and flowers of injured plants causing defoliation and crop loss. The population dynamics and bionomic observations in the wheat fields of *M. proscarabaeus* were studied during two successive seasons (2016/2017 and 2017/2018) in Wheat fields. The pest develops one generation per year. The beetle continued to appear during the first week of December to the first week of April, with the peak of adults at the first week of February. Beetles secrete a cantharidin fluid, a potent blistering agent which burns plant leaves and flowers and at the same time, it is strong poison to all livestock and domestic animals feeding on contaminated plants. The present work shed light on food plants, symptoms of infested crops, adult activity, environmental effects, and sexual behavior of the blister beetle *M. proscarabaeus* under the circumstances of El- Farafra Oasis.

Introduction

Blister beetles or oil beetles are members of the family Meloidae (Coleoptera). This family includes over 300 species in the United States (Selander and Bouseman, 1960; Stebnicka, 1987; Bologna, 1988 and Odegaard and Ligaard, 2000). The genus Epicuta is the largest and contains many species that concern forage producers in semi - arid regions of the western United States. In Egypt, Alfieri (1976) recorded 9 species belonging to family Meloidae collected from different desert localities vicinity to Cairo. Most adults eat only floral parts, but some, particularly those of *Epicuta* spp., eat leaves. El-Sheikh (2007) observed that beetles belonging to *Meloe proscarabaeus* L. (Coleoptera: Meloidae)

eat leaves and flowers of faba bean plants. A few adults are noctural; most are diurnal or show no distinct diel cycle (Selander and Fasulo, 2000 and Bologna and pinto, 2002). However, except for first instar larvae (triunglins) frequenting flowers or clinging to adult bees. So far as known, all larvae are predators. Larvae of most genera enter the nests of wild bees, where they consume both immature bees and the provisions of one or more cells ((Lückmann and Kuhlman, 1997; Klausintzer and Rauch, 2000 and Stebnicka, 1987).

In Central Europe, several types of the Meloidae family have become rare in some regions. The fertility of Meloidae has reached 90% the number of eggs per female is 9500 eggs inside a trench dug by the female (Lückmann, 2001 and Bologna and Pinto, 2001). Blister beetles produce cantharidin, which is toxic to people and animals (Ward, 1985). For centuries, cantharidin was prescribed as a cure for variety of animals. Spanshfly or cantharis, an oreparation of dried beetles, was thought to cure gout, carbuncles, rheumatism and many other medical disorders, in addition to its use as an aphrodisiac (Kinney *et al*., 1998).

The present article sheds light on the occurrence of the blister beetle *M. proscarabaeus*, population dynamics and bionomic observations in the Wheat fields and other legume crops as being recorded for the first time in El-Farafra Oasis.

Materials and methods

1.Study area:

El-Farafra Oasis lies in the western desert, south part of Egypt, located at latitude and longitude (26°49′23.3″N 27°46′33.3″E), belonging to New Valley Governorate; it is 600 km far from Giza. El-Farafra Oasis is rich with submersible water which facilitates reclamation of many thousand hectares. Many different field crops have grown successfully with high yields, especially winter Wheat and legume crops. El-Farafra Oasis is characterized by a very hot desert climate, temperatures during the summer season reach 60 degrees Celsius and decrease significantly in some months during the winter to one degree Celsius. Rain is rare and the average relative humidity is 30-45%. One of the most common cultivated crops there is Wheat (*Triticum aestivum*), its cultivated area amounts approximately 6500 feddans, however, and this crop is threatened by the attack of the blister beetle, *M. proscarabaeus* L., the most serious pest **(El-Sheikh, 2007).**

2.Beetles sampling:

Field observations on the blister beetle, *M. proscarabaeus* L. (Coleoptera : Meloidae) including beetle emergence , distribution, sexual behavior, feeding habits, and dial activity were carried out throughout the years 2016 /2017 and 2017 / 2018 in El-Farafra Oasis, western desert of Egypt. Observations commenced from mid-November till late April; activity period of beetles in the field at about 10 am. The field observations included the study of emergence period, population ecology of the beetles at different times and sexual behavior. This was carried out in two ways: (a) Oviposition sites of the newly emerged female beetles were recognized in the field and marked; these were separated into eight groups, three sites each, according to date of egg laying. Each site contained one egg mass (4000 – 4500 eggs). Wire – wooden cages, 35 x 50 x 50 cm each, were fixed on each site. Daily observations of cages were continued until beetle's emergence. The number emerged beetle of each group was recorded as well as time of

emergence and related environmental prevailing temperature. (b) In El-Farafra as a whole adult *M. proscarabaeus* have been recognized in the months December, January, February, March and April. Freshly emerged beetles were marked with a color code (Whitehead, 1991). This proved that emergence took place in synchronous waves during November and December. Similarly, number of emerged beetles was correlated with prevailing temperature of the environment. Population dynamics of newly emerged beetles and adult abundance in relation to prevailing temperature and relative humidity were conducted in Wheat fields during two successive seasons 2016 / 17 and 2017 / 18. Density of beetles was assessed as direct count in 100 m of Wheat plants. Counting of beetles was carried out in the different directions (north, south, east, and west) of the field at weekly intervals (El-Sheikh, 2019).

The micro-climatic conditions of the air as temperature and relative humidity were also measured. The life – span and the fecundity of adult were determined by confinement freshly emerged beetles in pairs (female & male) on Wheat plants inside wire - wooden cages (35 x 50 x 50 cm) fixed in the field. Daily observations on sexual behavior, feeding habits periodicity and egg laying were started from the first week of December (first beetle emergence) to mid-February (last date of beetle emergence). Data were derived from 24 field cages.

3.Meteorological data:

Daily maximum & minimum air temperatures (˚C), air relative humidity (%) were supplied by the Meteorological Station at New Valley Governorate.

4.Statistical analysis:

To analyze the association between agro-climatic factors prevailing in El-Farafra Oasis and population dynamic of the blister beetle adults through activity time. Weekly number of collected beetles was plotted against the considered agro-climatic factors to establish the relationships between these factors and adult density using correlation and partial regression analysis (α) (Fisher *et al*., 1943).

Results and discussion

1. Food and feeding habits:

Adult beetles *M. proscarabaeus* were feeding on wheat leaves, stem, and spikes, where the beetles are observed moving from places where they were located during their summer (aestivation) dorms towards wheat fields and adults attack in swarms where they disperse and start feeding for up to 80 days. El-Sheikh (2007) explained the blister beetle insect pest infesting crops of beans, alfalfa, onions and wild herbs, which is a pest on flowers, sugar beets and cabbage in Europe (Ozbeck and Szaloki, 1998; Stebnicka, 1987 and Selander and Fasulo, 2000). Date of planting wheat in Farafra Oasis From mid-November, beetles begin to appear when wheat is in the seedling stage about 10-15 days after planting these young plants are the most preferable food for Blister beetles (Figure, 1).

The newly emerged blister beetle are distinguished by strong mandibles and long legs that help them climb the plant, attack wheat seedlings, and feed on leaves and stem, causing completely destroy the whole plants. At risk, the *M. proscarabaeus* secrete a yellow liquid from coxal and antennal joints (Figure, 1). These blister beetles are used to defend themselves, and this liquid causes the leaves to burn and turn brown, eventually the plant dies. Plants that are

under severe attack by blister beetle fail to produce flowers and spikes and consequently the crop is completely lost. Turco (2003) recorded a female *M. proscarabaeus* grazing on *Ranuchus* sp. in Cornwall. Feeding of beetles occurs during the day- light and continues until sunset, and we notice the most general number of beetles on the field side closest to the irrigation canals. Ward (1985) reported that blister beetles feed on plant materials, particularly flowers of such plants as alfalfa, careless weed , peanuts, soybeans and many other species. As shown by Pinto and Selander (1970), the beetles were not recorded on the wheat crop. It appears that the wheat crop is not registered as food for beetles and thus becomes food plant as a diet of *M. proscarabaeus* the first record in Egypt.

2. Seasonal activity of beetles :

In EL-Farafra Oasis, all adult blister beetle, *M. proscarabaeus* were recognized in December, January, February, March and April in 2016 and 2017. We noticed the emergence and dispersion of newly emerging beetles in the fields of wheat. The weekly assessment of the density of adult beetles in different parts of the wheat field indicates that November 3th is the first adult activity and April 2th as the last (Table, 1). Adults emerged from larvae that were in the soil and then evolution into a pupa stage and then an adult insect in first week of November with a few ranged between 12 and 15 beetles / 100 bean plants It was average air temperatures 25.3 - 26 °C and relative humidity 51.5 - 60 % , in 2016 and 2017 respectively (Tables, 1 and 2). The population density of the blister beetle gradually increased with a distinct peak in the first week of February; the average adult density was 115 and 130 beetles / 100 plants in 2016 and 2017 (Tables, 1 and 2).

With the decrease in air temperatures and the increase in relative humidity, the number of blister beetle increased gradually, with the average monthly catch rate of about 39-36 % during the months of January and February in 2016 /17. Adult activity decreased significantly, as the average catch rate in March and April was 8-1% of blister beetle in 2017/18 (Tables, 1 and 2). The study showed that the period from December to February was the highest number of beetles. The weather conditions that prevailed during the two seasons of the study did not differ significantly, accordingly, the variation of *M. proscarabaeus* population for adults mean in 2016/17 (44.8 beetles) and 2017/18 (53.05 beetles). However, climate factors played a large role in the number of beetles in significantly reducing or increasing the population of beetles, and the relationship of temperature was a direct and the relative humidity is an inverse relationship during the two seasons (Tables, 1 and 2). Results from the weekly follow-up of the insect population reveal the persistence of behavior in adults blister beetle *M. proscarabaeus* under EL-Farafra and has only one generation per year. Whitehead (1991) reported that an adult from *M. rugosus* was identified in October and November and that the apparition occurred in simultaneous waves during September and October. However, the frequency of the appearance of adults *M. rugosus* occurs in the same period as *M. proscarabaeus* three waves of one stage have been observed for the present species.

Table (1): Mean numbers of the blister beetle *Meloe proscarabaeus* adult emerged in EL-Farafra Oasis 2016, 2017 in relation to air temperatures and relative humidity.

Inspection date	Mean no. of beetles /100 plants	Climatic factors		% Number of monthly beetles
		Mean air temp. ^{o}C	Relative humidity %	
Dec. 3/2016	12	25.3	51.5	14% b
10/2016	17	23.1	66.5	
17/2016	20	24.0	53.5	
24/2016	26	22.5	46	
31/2016	34	21.2	58.6	
Jan. 7/2017	56	19.6	61.3	39% a
14/2017	73	20.1	67.5	
21/2017	89	19.7	71.5	
28/2017	101	18.2	57.5	
Feb. 4/2017	115	17.0	58	36% ab
11/2017	75	16.8	66	
18/2017	61	18.6	55.3	
25/2017	40	20.3	45.2	
March 5/2017	31	22.9	39.4	10% c
12/2017	28	24.4	37	
19/2017	17	26.5	39	
26/2017	8	30.7	32	
April 2/2017	5	35.4	30	1% d
Total	**808**			**100%**
Mean	**44.8**			**25%**

Table (2): Mean numbers of the blister beetle *Meloe proscarabaeus* adult emerged in EL-Farafra Oasis 2017, 2018 in relation to air temperatures and relative humidity.

Inspection date	Mean no. of beetles /100 plants	Climatic factors		% Number of monthly beetles
		Mean air tmp. ^{o}C	Relative humidity %	
Dec. 5/2017	15	26	60	10% b
12/2017	19	24.3	58	
19/2017	25	25.1	56.2	
27/2017	31	23.2	52	
Jan. 3/2018	40	20.6	59	
10/2018	55	18.8	63.2	42% a
17/2018	69	20.7	64.3	
24/2018	95	18.6	70.4	
31/2018	113	17.5	65	
Feb. 7/2018	130	16	60	39% ab
14/2018	95	15.8	58	
21/2018	75	16.4	52	
28/2018	53	18.9	44	
March 7/2018	30	20	42.1	8% c
14/2018	18	23.5	36.5	
21/2018	10	25.7	38.2	
28/2018	7	28.9	32.4	
April 5/2018	5	34.7	31	1% d
Total	**955**			**100%**
Mean	**53.05**			**25%**

3. Mating:

Several pairs of adult's blister beetle were observed in intercourse during the periodic inspection of affected wheat fields, copulation occurred during daylight. Blister beetle, *M. proscarabaeus* showed evidence of mating that reached sexual maturity (50 days post emergence). Certainly those males are attracted to females by sex pheromone emitted by the female. The male begins searching for the female in the early morning and when they meet, courtship may start. Primarily, males touch the female partner's antennae that have faced their side and when the female shows a response, the male touches her abdomen by its antennae. Repeated touches may occur until the female stops quietly, the courtship period lasts 30 minutes. The male jumped on the female side quickly and held the female by the front legs in the thorax area and the back legs in the female's abdominal area (Figure, 1).

Females are taller and larger in size than males; females pull their abdominal segments (telescope movement) to cope male's abdominal end. *Male* abdominal tip flexed below the abdominal tip of the female, the highly chitinized male genitalia protruding and a great part of it was inside the female body, widely opening the female genitalia aperture for the entrance of the apical fleshy part of aedeagus. After this, the male rolled up to the opposite direction (tail to tail position) and mating was carried out see Figure (1). The maximum period of the act of copulation lasted for about one hour. When the male and female are disturbed during copulation, they soon separate from one another. Selander and Pinto (1967) describes sexual behavior in the Meloidae family, as it is very similar in sexual behavior. The male and female meet in the early morning and start feeding, Then the male begins to flirt with the female, and its duration varies from one type to the next,

after the female's approval, copulation takes place. *Turco et al*. (2003) explain that the sexual behavior of the beetle includes strange stages, when the male meets the female, the female controls the male through a sexual pheromone.

4. Oviposition habits:

It was noticed that the female blister beetles after mating begin to search for the preferred location for ovulating and she spent two hours searching for the right place. These blister beetle, *M. proscarabaeus* prefer sandy soil and choose elevated sites from the field near the irrigation canals. Females begin to prepare the egg chamber hole, which is 5 cm in diameter and 6 cm deep in the border strip of the field, and used mandibles, fore and hind legs in excavating the oviposition chamber. After finishing the ovary chamber preparation, it will settle inside and the head and the rest of the body appear inside the chamber, oviposition lasted four hours. The female lays eggs at once, and the eggs are distinguished by a yellow color and arranged in a wonderful way. The female started laying eggs in the last week of January, and after finishing laying the eggs, you then go to the wheat fields for feeding until death see Figure (1).

The results agree with Selander and Fasulo (2000) that a blister beetle, *M. proscarabaeus,* dig an eggs chamber and lay eggs inside. There are some species that lay eggs on the leaves of the plant. Although the female *M. proscarabaeus* laid eggs once in January, the *M. rugosus* females deposit their eggs once in November and twice in December (Whitehead, 1991). The *Meloe* female forms an egg chamber 2 to 3 cm deep in the ground and lays several batches of yellow eggs (Bohac and Winkler, 1964).

5. Significance of the blister beetles:

Field and laboratory research has shown that adult beetles, *M. proscarabaeus* exudates a yellow liquid in abundance from the joints of their legs and Antenna. This fluid is often excreted by reflexive bleeding when an adult beetles are at risk see Fig. (1). This phenomenon is most common in most type's species of Meloid beetles (Ward 1985; Edwards *et al*., 1989 and Whitehead 1991). Like other species of blister beetle, *M. proscarabaeus* contain a large amount of oily, yellow hemolymph that you exude on annoyance. This fluid has been identified as a cantharidin (a bicyclic terpenoid C10 H12 O4). It is found in hemolymph and gonads of beetles. Lytta respiratory (Meloidae) contains more cantharidin than any other member of the family; cantharidin is found mainly in elytra but it has also been shown to exist in the genitalia and the hemolymph (Bohac and Winkler, 1964). Males have the highest levels of cantharidin and they transfer it to females during copulation. Adult blister beetles feed on alfalfa leaves and flowers in the United States, but the real problem lies in the secretion of beetles to the cantharidin substance that toxicity livestock, especially horses, when they are accidentally consumed in feed (Schmitz, 1989).

Many of the common species of blister beetles contain cantharidin (Spanish-fly), a substance that will cause blisters when applied to the skin (Beasley *et al.,* 1983). Ward (1985) reported that cantharidin is a stable chemical and long-term health threat to nearly all livestock, particularly horses that are fed contaminated alfalfa hay. Research reports indicate cantharidin toxicosis can be induced in dairy and beef cattle, goats and sheep; other reports include rapist, hedgehogs, mice and dogs (Graziano *et*

al., 1987). Cases of human death also have been reported. However, horses appear to be more susceptible to toxic effects of this potent chemical than other livestock. Although the toxic effects of cantharidin to all livestock and human, blister beetles use this fluid and related analogs as defensive compounds against larger herbivores and predators see Figure (1).

According to the previously mentioned results, the presence of the blister beetle *M. proscarabaeus* as a new insect pest in El- Farafra Oasis may bring us to ring the dangerous bell about the great loss and damage that threat our legume crops and all livestock in such new reclaimed and cultivated areas in Egypt.

Figure (1): a. Blister beetle feeding on wheat plant. b. Courtship period between male and female. c. Mating and copulation behavior (tail to tail position) of the blister beetle. d. Egg laying holes excavated by adult females. e. Egg mass of the blister beetle *Meloe proscarabaeus*. f. Cantharidin fluid excreted by adult beetles on beetle leg.

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