RESEARCH ARTICLE OPEN ACCESS

NEW VALLEY JOURNAL OF AGRICULTURAL SCIENCE

Published by Faculty of Agriculture, New Valley University, Egypt

Print ISSN 2805-2420 Online ISSN 2805-2439

10.21608/nvjas.2024.340157.1296

First Report on the Biology and Behavior of Blister Beetle (*Meloe proscarabaeus*) in the Western Desert Agro-Ecosystem of Egypt

Wael. E. A. El-Sheikh

Department of Plant Protection, Faculty of Agriculture, Beni-Suef University, Egypt

* Corresponding author

W. E. A, El-Sheikh

Received: 28/11/2024

Revised: 04/12/2024

Accepted: 22/12/2024

Published: 22/12/2024

Abstract

Blister beetles are phytophagous insects observed attacking various crops, including faba beans, peas, clover, wheat, and onions. These beetles feed on plant foliage and flowers, causing significant defoliation and crop losses. Additionally, they secrete cantharidin, a potent toxin harmful to livestock and domestic animals that consume contaminated plants. The field biology of *M. proscarabaeus* was studied during two successive seasons in faba bean fields. The obtained results showed that the pest develops to one generation per year. Beetles emerge from the 1st of December to the 4th of March with peak adults in late January. Females oviposit between early January and mid-April, laying an average of 2,475.8 eggs in the soil. The eggs' incubation period averaged 23.3 days, with a hatchability rate of 92.05%. The larvae undergo hypermetamorphic development, passing through three distinct phases. The active 1st & 2nd instar larvae, known as triungulins, feed on grasshopper, leafhopper, and honeybee eggs, with each instar lasting an average of 4.0 and 4.5 days, respectively. The inactive fifth and sixth instar larvae survive in soil chambers for 13.6 and 17.0 days on average. The Seventh instar larvae undergo aestivation in the soil for approximately 95.3 days under adverse environmental conditions. The duration of the pupal stage ranges on average from 43.3 days. The study illustrated mating and oviposition behaviors and emphasized the need for effective pest control measures based on field biology and monitoring techniques.

Keywords: Blister beetle, Field biology, Hypermetamorphic, Agro-Ecosystem, Desert

Introduction

Blister beetles (Coleoptera: Meloidae) are phytophagous insects that significantly damage leguminous crops, particularly alfalfa, in regions such as Europe (Demir & Kabalak, 2023; Zack et al., 2023; Wagner et al., 2024), Asia (Sharma & Singh, 2018; Joshi & Gaur, 2019; Singh et al., 2021), Africa (El-Sheikh & El-Kenway, 2020), and the USA (Horsfall, 1941; Selander, 1981; Ward, 1985). Previously, no records existed of *M. proscarabaeus* as a phytophagous pest in Egypt until El-Sheikh and El-Tokhy (2020) documented its presence on faba beans (*Vicia faba* L.) in the Western Desert region. The development of most blister beetle species is characterized by hypermetamorphosis, involving distinct larval stages with unique feeding behaviors.

Research on the biology and behavior of Meloidae has been conducted in regions such as Illinois (Numata & Shintani, 2023; Ma et al., 2024), Poland (Horsfall, 1941), New Mexico (Ward, 1985), and the United Kingdom (Whitehead, 1991). The annual life cycle typically includes a diapause phase, during which 7th instar larvae aestivate in soil layers before adults emerge in the subsequent autumn to feed on plant leaves, stems, and flowers (El-Sheikh and El Kenway, 2023). Cantharidin, a toxic secretion of blister beetles, causes plant damage and poses risks to livestock and domestic animals consuming contaminated crops (Huang et al., 2024; He et al., 2024).

The field biology of *M. proscarabaeus* is complex, with larvae feeding on eggs of locusts and honeybees during specific stages of their development (Shintani et al., 2017; Fu et al., 2023; Zhou et al., 2024; El Kenway et al., 2022). In Egypt's Western Desert, the pest's emergence has been associated with significant economic damage to faba beans, peas, and alfalfa. Given the lack of effective control measures, this study aims to elucidate the biological characteristics and behaviors of *M. proscarabaeus* under field conditions. The findings will inform the development of integrated pest management strategies to mitigate economic losses while conserving biodiversity in agro-ecosystems.

Materials and Methods

Location area: The New Valley Governorate is located in the southwestern part of Egypt's Western Desert, covering 43.6% of the country's total area. This region comprises three administrative oases: Farafra, Dakhla and Kharga (Figure 1). The area receives less than 50 mm of rainfall annually, which is both minimal and unpredictable. Approximately 133,171 acres of land have been reclaimed in this governorate, according to the Egyptian Ministry of Agriculture (Abdelhafez et al., 2021). Faba beans (Vicia faba L.) dominate the cultivated land, accounting for 50% of the crops, followed by alfalfa (Medicago sativa L.) at 33%, and peas at 17%. Crop irrigation in the area relies entirely on artesian groundwater (El-Sheikh and El Kenway, 2023).

Field biology: Studies on the field biology and sexual behavior of M. proscarabaeus (Coleoptera: Meloidae) were conducted in faba bean fields in El-Farafra Oasis. Adult beetles were observed from December to March over two successive seasons. Freshly emerged adults (5 females and 5 males per replicate) were confined in wire-wooden cages (35 × 50 × 50 cm) placed over faba bean plants. Six replicates were set up during the beetles' emergence period. Behavioral observations, including mating, feeding, and oviposition, were recorded. Data on egg deposition, hatchability, and the lifespan of adults were collected under field conditions.

To monitor the development of immature stages, oviposition sites were identified and labeled. These sites were grouped into six categories based on the date of egg-laying, with each group containing three egg masses (Shintani et al., 2017). Wooden cages covered with tulle were installed over these sites, and daily observations were conducted to monitor developmental milestones, including hatching, larval instars, pupation, and adult emergence. Parameters such as mortality rates, sex ratios, fecundity, and longevity were calculated (El Kenway et al., 2024).

Meteorological data: Daily maxi and mini air temperatures (°C), soil temperatures (°C), and relative humidity (%) were recorded using data from the Agricultural Meteorological Station in the New Valley Governorate.

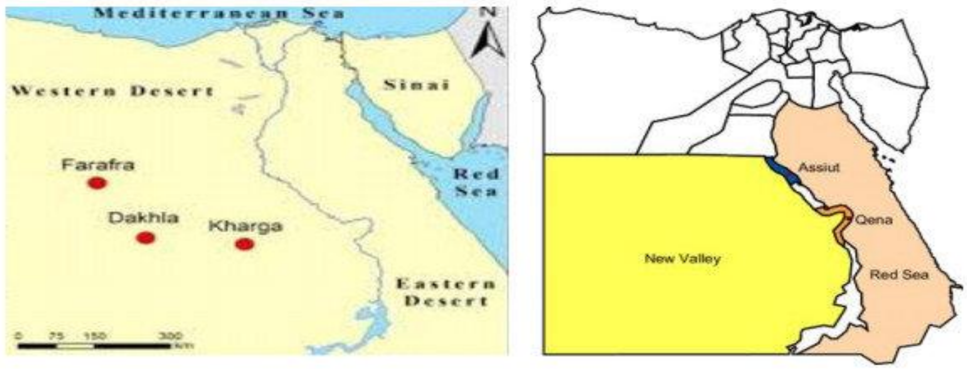

Figure (1): Map of Egypt showing the location of the New Valley Governorate, which includes three main oases it Farafra, Dakhla and Kharga oases.

Results and Discussion

(A) Adult Stage

1-Adult Emergence: Beetles began to emerge from the areas where they spent undergoes into aestival diapause, emerging in successive waves. In 2022/2023, first emergence of the M. proscarabaeus beetles was in the first week of December to approximately end of March. Number of emerged adults increased gradually reaching maximum level in the last week of January (150 adults / 100 plants) after which it decreased reaching the minimum level (20 beetles / 100 faba bean plants) in the third week of April. Swarming of beetles was air and soil temperature dependent. Under the conditions of 15-22 oC, 10-20 oC, air, and soil temperatures, about 50.5 % of adult population was emerged from the soil (Table 1 and Figure 2). In the second season, 2023/2024, beetles emergence followed the same aforementioned trend with slightly low number of emerged beetles. Similar patterns were observed during the 2023/2024 season, though beetle populations were slightly lower. These findings align with earlier studies on Meloe rugosus, which reported synchronized emergence during specific periods (Whitehead, 1991; Sharma and Singh, 2018; El-Sheikh and El-Tokhy, 2020).

2-Mating: Pairs of blister beetles were showed mating several times during our periodic inspection of infested faba bean fields. Mating occurred during the day. Blister beetles that reached sexual maturity (30 days after emergence) showed evidence of mating. It is true that males are attracted to females by the sex pheromone secreted by females. Males were observed to seek out females in the early morning and when they meet each other, courtship may begin first, with the male touching the antennae of the female partner, facing her side and when the female shows a response, the male touches her abdomen with his antennae. Repeated touches may occur until the female calmly stops; this continues for about 10 minutes (Table 1).

The male jumps on the dorsal side of the female quickly and grabs the female by the fore-thorax legs while the male grabs the abdomen of the female with his middle and hind legs (Figure 3). Because the female's abdomen is longer than that of the male, the female retracts her abdominal segments (telescopic motion) to accommodate the end of the male's abdomen. The male's abdominal apex is folded below the female's abdominal apex, and the chitin-rich male genitalia protrude, much of it inside the female's body, opening the female's genital opening widely for the entrance of the fleshy apical portion of the testis. The male then turns in the opposite direction (tail-to-tail position) and mating occurs (Figure 3). The maximum duration of copulation lasts about an hour. Horsfall (1941), Ward (1985), Joshi and Gaur (2019), Numata and Shintani (2023) found similar sexual behavior in *M. proscarabeus* and M. violaceus when the courtship period was always short, but the subsequent dorsal phase was long; during this phase, males touched the antennae of their partners, and the cuticular pore areas on the antennae of these males appear to be associated with contact pheromone emission.

3- Pre-oviposition period: Results in Table (1) observed that duration of the pre-oviposition may vary according to emergence time of aestivated beetles and prevailing environmental conditions. Beetles emerged in 1st week of December started egg laying 30 days post emergence, while about 40 – 45 (av. 34.8 days) days was acquired to beetles emerged from mid-January to nearly late February for oviposite. Climatic factor conditions prevailed in December averaged 22 °C, 18 °C, 50 % while in January these values lowered to 11.0 °C, 10.0 °C, & 70 % for Mean Temp., soil Temp., & Rh. %, respectively (Table 1).

So, it could be stated that prevailing Temp., particularly soil Temp., pronounsly affected the emergence time of beetles and consequently the duration of pre-oviposition. Inspection of six groups of beetles differing in emergence dates and confined in field cage (one pair / cage) showed that duration of preoviposition ranged between 30 and 45 days with an average of 34.8 ± 0.5 days (Figure 2). These results in agreement with Whitehead (1991), Demir and Kabalak (2023) & Fu et al. (2023) that the Pre-oviposition period depends on the time of insect emergence, air and soil Temp., and Rh. %, as these are influential factors.

Table (1): Effect of climatic factors on the time of emergence of beetles, the time of laying eggs and Pre-oviposition (days).

Group	Time of beetles emergence	Time of egg laying	Pre-oviposition (days)	Weather factors		
				Mean Temp. °C	Soil Temp. °C	R.H %
I.	Dec., 2	Jan., 3	30	22	18	50%
II.	Dec., 14	Jan., 14	31	18	15	55%
III.	Dec., 25	Jan., 24	30	15	12	62%
IV.	Jan., 15	Feb., 23	40	11	10	70%
V.	Feb., 20	Mar., 31	45	14	12	60%
VI.	Mar., 15	Apr., 18	33	20	17	52%

4- Oviposition habits: Egg-laying by *M. proscarabaeus* has been observed January. Females spent three hours excavating an egg chamber of 5 x 5 cm diameter and 4 x 6 cm deep in the closed boundary strips of 10 cm height near to irrigation canals and this time seems to be acceptable since the sediments and soil texture at El-Farafra oasis are sandy requiring minimal excavation labor (Figure 3). A female of M. rugosus spent 30 hours excavating an egg chamber and that long time may be regarded to the soil texture of oviposition sites at Wiltshire (Whitehead, 1991). Female of *M. proscarabaeus* spent two hours searching for the appropriate ovipositing site and used mandibles, fore and hind legs in excavating the oviposition chamber. Oviposition lasted four hours. Eggs are laid in a longitudinal mass.

Female moves after egg lying and continues feeding until death. More than one egg chamber and one egg mass per female have never been witnesses in *M. proscarabaeus*. Similar oviposition habits are characteristic of *Meloe* spp. Selander (1981) found eggs of Meloinae are deposited in masses in the ground or under stones, while beetles belonging to Nemognathina lay eggs on the food plants of adults; however, females of our species never laid eggs on their food plants. Although females of *M. proscarabaeus* lay eggs once during January, females of M. rugosus deposit their eggs once in November and twice in December (Whitehead, 1991). The female of Meloe variegates digs holes between 2 and 3 cm deep in the ground and lays several batches of yellow eggs, (Singh et al., 2021).

Figure (2): Seasonal activity period of blister beetles after emerging from summer hibernation. (a) Site of beetle emergence; (b) adult male; (c) adult female; (d) Cages made of wood; (e) Beetle feeding on faba bean; (f) Beetle feeding on wheat.

5- Fecundity: Females of the blister beetles showed conspicuous variation in the number of eggs laid by the female according to insect spices, locality and environmental factors effects. Females of *M. proscarabaeus* deposited number of eggs varying according to season and thermal conditions. The number of eggs laid by females during January ranged between 2850 and 2920 eggs per female, with an average (2475.8+ 0.8) eggs/female (Table 2 and Figure 4). The minimum and maximum number of eggs laid by females during their active months was a total of 1890 & 2920 eggs per female.

Generally, the Fecundity of *M. Proscarabeus* females seem to be very low if compared with number of eggs laid by M. variegates females (10000 eggs/ female) and that could be attributed to insect spices locality and environmental conditions (Zack et al. 2023; Numata and Shintani, 2023). The vast numbers of eggs laid by spices of necessary to ensure the survival of the species for very few larvae survive to develop into adult beetles (Horsfall, 1941; Ward, 1985).

6-Sexual composition:

Male and female numbers of *M. proscarabaeus* were estimated during the seasonal activity period of the blister beetles in faba bean fields after they emerged from summer estivation. Similarly, monthly total counts of female and male beetles showed higher female number than male with slight differences. There was no difference in the 1st & 2nd season during the study. Female counts constituted 51.4 % - 48.6 % of the total beetle population. Sex ratio was close to 1:1 with a slight predominance of females. So, it could be stated that female composition in blister beetle *M. proscarabaeus* population is approximately equal to males and the general sex ratio is 1 female: 1male (Table 2 and Figure 2).

This phenomenon is widely common among coleopterous species (El-Sheikh and El-Tokhy, 2020) however; Whitehead (1991) mentioned that adults of Meloe rugosus located at Broadway (UK) during 1989 are 90.3 % females and 9.7 % are males, which is quite far from our obtained results for *M. proscarabaeus*. Duration of adult survival of the blister beetle *M. proscarabaeus* varied according to sex and emergence time of beetles. Generally, females survived longer than males. Selander and Fasulu (2000) observed that adults of *Nemegnatha plazata* F. (Meloidae) commonly live three months or more which is nearly the same for *M. proscarabaeus* adults that determined in the present study.

7- Food and feeding habits:

Beetles were observed feeding on the leaves, stems, and flowers of faba beans, peas, alfalfa, and wild weeds such as Melilotus indica. Young faba bean plants were particularly susceptible, with severe infestations leading to total crop loss. Feeding activity occurred exclusively during daylight hours. Cantharidin secretion, observed during feeding, poses additional risks to livestock consuming contaminated plants (Huang et al., 2024).

Table (2): Number of eggs per female, hatching rate and sex composition of beetles

Group	On - eggs per female	Hatchability%	Sexual composition	
			Female %	Male %
I.	2850	96.5	51	49
II.	2640	98.6	53	47
III.	2920	94.0	51	49
IV.	2430	92.2	50	50
V.	2125	86.0	52	48
VI.	1890	85.0	51	49
Average ±SE.	2475.8±0.8	92.05±0.3	51.4±0.7	48.6±0.9

(B) Immature stages

1- Egg stage: After mating, the adult female searches for a high place in the field and after preparing a hole to lay eggs, she lays eggs in the form of a cohesive longitudinal mass arranged in an organized and wonderful manner below the surface of the soil. The eggs are cylindrical in shape and we notice that the eggs are bright yellow in colour when laid by the females and turn reddish yellow before hatching (Figure 4). These results are consistent with Horsfall (1941), Selander (1981) and El-Sheikh and El-Tokhy (2020) where beetles lay eggs in groups in the ground, under stones, in soil, or on plants depending on the species.

2- Hatching: The results given in (Table 2 and Figure 4) show that percentage of egg hatching ranged between 85.0% and 98.6% with an average of 92.02%. Variation observed in percentages of egg hatching could be ascribed to variation in environmental temperature. Eggs laid in the Second week of January at air temperature average 18.0 °C gave the highest value of egg hatchability (98.6%) while those deposited at the last week of march (14.0 °C) showed the lowest rate of egg hatchability (85.0%).We notice that the hatching rate of beetle eggs is very high, but in the end a large percentage of the larvae die and only a few of them reach the insect stage, and therefore the hatching rate is high to preserve the species. Ward (1985) and Whitehead (1991) stated that the number of eggs and the hatching rate of blister beetles vary from one insect to another due to changes in climatic factors but noted that the hatching rate is very high due to the death of a large number of larvae.

Figure (3): Observations of sexual behavior of blister beetles. (a) Courtship stage; (b) Mating; (c) Mating position tail to tail; (d) Excavating behaviour; (e) Egg laying holes excavated; (f) Cantharidin fluid excreted by adult beetles.

3- Larval stage: The larval development of *M. proscarabaeus* follows a hypermetamorphic pattern, with seven instars divided into three distinct phases:

• First Phase (Triungulin Larvae): The active 1st and 2nd instar larvae are predatory, feeding on grasshopper, leafhopper, and honeybee eggs. This phase lasted an average of 4.0 and 4.5 days, respectively (Table 3 and Figure 4). Triungulin larvae displayed strong mouthparts and high mobility, allowing them to efficiently locate prey. These traits align with reports on other Meloidae species (Fu et al., 2023; Ma et al., 2024).

• Second Phase (Active Larvae): The 3rd and 4th instars exhibited rapid growth, lasting 6.0 and 7.3 days, respectively. During this phase, larvae transitioned from predatory feeding to consuming decomposing organic matter as they moved into the soil (Table 3 and Figure 4).

• Third Phase (Inactive Larvae): The 5th and 6th instar larvae remained in soil chambers, with durations averaging 13.6 and 17.0 days, respectively. The 7th instar larvae entered aestivation, lasting approximately 95.3 days, to survive harsh environmental conditions. These findings highlight the species' adaptability to desert climates (Shintani et al., 2017; Numata & Shintani, 2023).

4- Pupal stage: In October and November, the 7th aestivated larva resumes activity, and with ecdysis, the larva becomes again scarabaei form and transforms to pupa free in the soil, after the improvement of air and soil temperatures. The duration of the pupal stage ranges on average from 43.3 days (Table 3 and Figure 4). When planting faba bean and winter crops, blister beetles start to emerge from the places where they spent the summer. During this period, newly emerged insects are voracious in feeding and destroying crops while they are in the seedling stage. The results agreed with Singh et al., (2021) that the blister beetle emerges in August and continues until December. The beetles were most active in the morning.

Table (3): Mean durations of immature stage of *M. proscarabaeus* developed under field conditions.

Group	Incubation period	Mean duration in-days							Total	Pupa
		1st	2nd	3rd	4th	5th	6th	7th		
		Triungulin larvae		Active larvae		In-active larvae				
I.	22.0	3.0	4.0	5.0	7.0	10.0	16.0	110	177	25
II.	23.0	3.0	4.0	6.0	7.0	11.0	17.0	105	176	30
III.	22.0	4.0	5.0	6.0	8.0	16.0	17.0	94	172	35
IV.	25.0	5.0	5.0	7.0	8.0	17.0	17.0	90	174	40
V.	27.0	6.0	6.0	8.0	9.0	18.0	20.0	88	182	60
VI.	21.0	3.0	3.0	4.0	5.0	10.0	15.0	85	146	70
Average	23.3	4.0	4.5	6.0	7.3	13.6	17.0	95.3	171	43.3

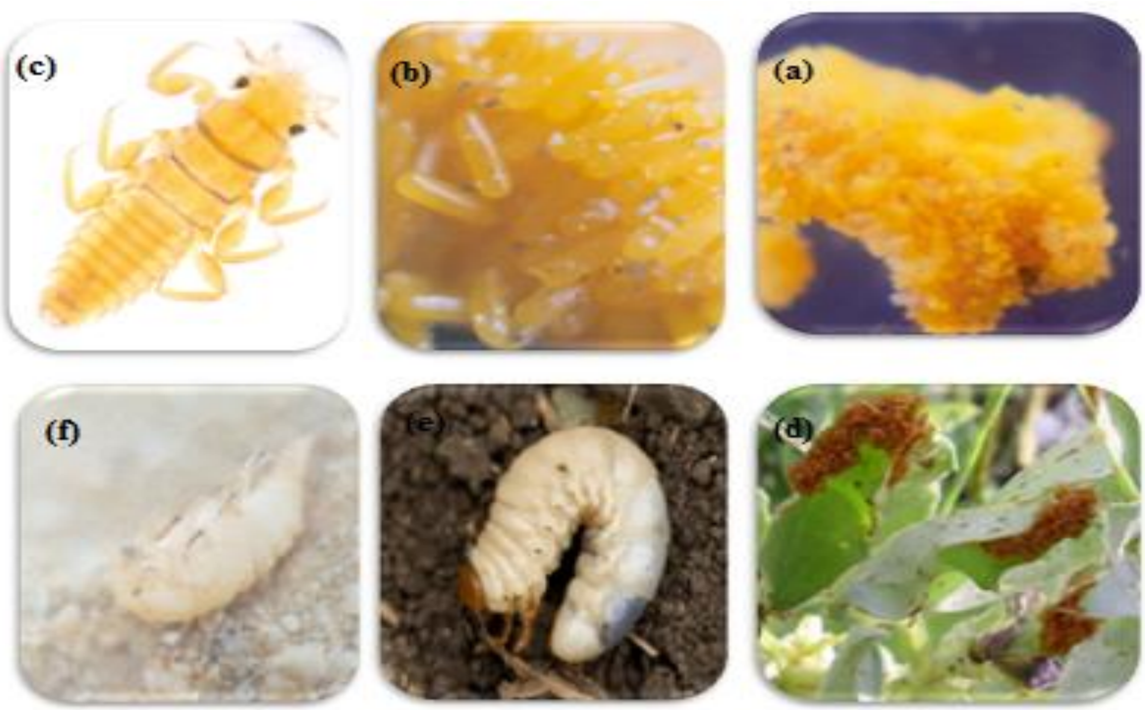

Figure (4): Immature stages of the blister beetle *M. proscarabaeus*. (a) Egg mass of the blister beetle; (b) hatchability of eggs; (c) Triungulin larvae the 1st and 2nd instars; (d) Triangulin larvae clusters on plant leaves.; (e) Inactive larva; (f) pupa stage in the soil.

Conclusions

The study provides valuable insights into the biology and behavior of *M. proscarabaeus* in the Western Desert agro-ecosystem. Key findings include the beetle's single annual generation, hypermetamorphic development, and its significant impact on faba bean crops. The results emphasize the importance of integrating field biology data into pest management strategies. Recommendations include:

1. Developing monitoring techniques to predict emergency patterns.
2. Implementing targeted control measures during the critical early stages of crop growth.
3. Preserving portions of wild vegetation to reduce pest pressure on economic crops.

Maintaining a balance between agricultural expansion and ecological stability is essential to mitigate the threat posed by *M. proscarabaeus* while conserving biodiversity.

Funding (optional)

The author has no relevant financial support to disclose here.

Conflicts of Interest/ Competing interest

No conflict of interest.

References

Abdelhafez, A. A., Abbas, M. H., Kenawy, M. H., Noureldeen, A., Darwish, H., Ewis, A. M., & Hamed, M. H. (2021). Evaluation of underground water quality for drinking and irrigation purposes in New Valley Governorate, Egypt. *Environmental Technology & Innovation*, *22*, 101486.

Demir, M. A., & Kabalak, M. (2023). Blister Beetles (Coleoptera: Meloidae) of Ankara (Türkiye) in Terms of Ecological Properties and Zoogeographical Composition. *Transactions of the American Entomological Society*, *149*(2), 151-168.

El Kenway, A. H., El-Sheikh, W. E. A., & Ali Mohamed, M. (2022). Evaluation of Chrysoperla carnea and Macrolophus pygmaeus as biological control agents of Frankliniella occidentalis on Batavia lettuce under hydroponic cultivation. *Journal of Crop Protection, 11(2), 269-278.*

El Kenway, A. H., Hassan, A., Hamza, M. K. & El-Sheikh, W. E. A. (2024). Impacts of Climate Change on the Number of Days per Generation of the Egg-Parasitoid Telenomus Remus Nixon, 1937 (Hymenoptera: Scelionidae) in Egypt. *Plant Protection, 8 (01), 41-50.*

El-Sheikh, W. E., & El-Kenway, A. (2020). Effect of spatial distribution pattern and field depth on the population dynamic of the blister beetle, Meloe rugosus M.(Coleoptera: Meloidae) adults in wheat fields in El-Bahariya oasis, Western Desert, Egypt. *Egyptian Academic Journal of Biological Sciences. A, Entomology*, *13*(3), 73-82.

El-Sheikh, W. E. A. & El Kenway, A. H. (2023). Effectiveness of pitfall trap colors in monitoring adults of blister beetle *Meloe proscarabaeus* Linnaeus, 1758 (Coleoptera: Meloidae) in faba bean fields at El-Farafra Oasis Egypt. *Plant Protection, 07 (01). 25-32*. DOI: 10.33804/pp.007.01.4508

El-Sheikh, W. E. A. & El-Tokhy, A. I. (2020). The blister beetle *Meloe proscarabaeus* (Coleoptera: Meloidae) a dangerous pest threatens field crops in New Valley Governorate, Egypt. *Egypt Journal Plant Protection Research Institute, 3 (1): 73- 82.*

Fu, Z., Liu, C. & Du, C. (2023). A staged adaptation of the specialized feeding larvae *Hycleus cichorii* (Coleoptera: Meloidae) to the non-preferred food. Acta *Entomologica Sinica, 66(6), 780–787.*

He, T., Duan, C., Feng, W., Ao, J., Lu, D., Li, X., & Zhang, J. (2024). Bibliometric Analysis and Systemic Review of Cantharidin Research Worldwide. *Current Pharmaceutical Biotechnology*, *25*(12), 1585-1601.

Horsfall, W.R. (1941). Biology of the black blister beetle (Coleoptera: Meloidae). *Annals of the Entomological Society of America*, *34*(1), 114-126.

Huang, Y., Shen, L., Du, F., Wang, Z., & Yin, Y. (2024). Functional studies of McSTE24, McCYP305a1, and McJHEH, three essential genes act in cantharidin biosynthesis in the blister beetle (Coleoptera: Meloidae). *Journal of Insect Science*, *24(4), 4*.

Joshi, R., & Gaur, N. (2019). First report of Blister beetle, *Mylabris pustulata* Thunberg (Meloidae: Coleoptera) in maize fields from Sarson village of Almora District, Uttarakhand (India). *Journal of Applied and Natural Science*, *11*(3), 752-754.

Ma, J., Fu, Z., Yang, X., Ming, W., Song, X., & Du, C. (2024). Gut microbial changes in a specialist blister beetle larvae and their nutritional metabolic characteristics. *Ecology and Evolution*, *14*(8), e70184.

Numata, H., & Shintani, Y. (2023). Diapause in univoltine and semivoltine life cycles. *Annual Review of Entomology*, *68*(1), 257-276.

Selander, R. B. (1981). Evidence for a third type of larval prey in blister beetles (Coleoptera: Meloidae). *Journal of the Kansas Entomological Society*, 757-783.

Selander, R. B. & Fasula, T. R. (2000): Featured Creatures DPI Entomology Circular 268, 9 pp. *University of Florida, USA.*

Sharma, R. K., & Singh, S. (2018). Host range and abundance of blister beetle [Mylabris pustulata (thunberg)] in sub-mountainous Punjab. *Agricultural Research*, *55*(4), 696-700.

Shintani, Y., Terao, M., & Tanaka, S. (2017). Adaptive significance of precocious pupation in the bean blister beetle, Epicauta gorhami (Coleoptera: Meloidae), a hypermetamorphic insect. *Journal of Insect Physiology*, *99*, *107-112.*

Singh, G., Singh, R., & Singla, A. (2021). Seasonal abundance of Blister Beetle, Mylabrispustulata Thunberg on Pigeonpea and Mungbean. *MAUSAM*, *72*(3), 645-648.

Wagner, L. S., Campos-Soldini, M. P., & Guerenstein, P. G. (2024). Olfactory responses of the blister beetle Epicauta atomaria, a polyphagous crop pest, to host, non-host, and conspecific odors. *Entomologia Experimentalis et Applicata*, *172*(9), 806-817.

Ward. C. R. (1985). Blister beetles in alfalfa Cooperative Exten-sion Service. *College of Agriculture and Home Economics, New Mexico State University, USA. Circular, 536: 1–9.*

Whitehead, P. F. (1991). The breeding population of Meloe rugosus Marsham, 1802 (Coleoptera: Meloidae) at Broadway, Worcestershire, England .*Elytron Supplement, 5 (1): 225-229.*

Zack, R. S., Monzón, J., Huether, J. P., Huether, M. K., & Landolt, P. J. (2023). New country records of blister beetles (Coleoptera: Meloidae) from Guatemala with distributional notes on other meloid species and a record of human blistering caused by Epicauta (Macrobasis) forticornis Haag-Rutenberg, 1880. *The Pan-Pacific Entomologist, 99(3), 169-182***.**

Zhou, Z., Mang, D., Smagghe, G., Liu, Y., Mu, Y., Yang, L., & Chen, X. (2024). A Farnesyl Pyrophosphate Synthase Gene Is Expressed in Fat Body Regulates Cantharidin Synthesis in Male Epicauta impressicornis Blister Beetle. *Journal of Agricultural and Food Chemistry*.