



Taxonomic Morphological Study of the Stink Bug *Bagrada hilaris* (Burmeister, 1835) (Hemiptera: Pentatomidae) in Some Regions of Central Iraq

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Received: 21 May 2023

Accepted: 25 June 2023

Published: 20 October 2024

doi.org/10.30526.37.4.3508

Abstract

We conducted a taxonomic and phenotypic study on *Bagrada hilaris*, collected from various regions in central Iraq such as Baghdad, Diyala, and Babel governorates, between the end of May and October 2022. The study showed that the third segment of the antennae is the longest of all segments, and the head contains a pair of simple brown eyes. The rostrum extends to the end of the hind leg coxa, and each abdominal ring contains a pair of spiracles. The tarsus consists of three segments and bears a pair of claws. The phallus and paramere, representing male genitalia, consist of two parts: a medium-thick basal part known as the stem and a broad apical part known as the blade. The blade consists of two protrusions of unequal length. The genitalia of the female are attached to the eighth and ninth abdominal rings. The dorsal tergates of these rings are folded ventrally on each side to make the ventral part of the side of the dorsal plates.

Keywords: *Bagrada*, antennae, scutellum, prothorax, rostrum.

1. Introduction

Suborder Heteroptera is the most diverse group of insects, with about 40,000 species described worldwide [1, 2]. The Pentatomidae family is the largest of the Heteroptera families, estimated at 36,100 described species [3]. *Bagrada hilaris* is a species of shield bug known by the common name bagrada bug [4]. It belongs to the Strachiini clan of the family Pentatomidae, order Hemiptera [5]. It is native to much of eastern and southern Africa, parts of southern Europe and Asia [6], and more recently, South America [7]. India, Pakistan, Afghanistan, Sri Lanka, Myanmar, Iran, Iraq, and some parts of Russia are home to this pest, which has the potential to spread to other locations [8]. It has also been identified as an introduced species in other places [9]. In 2008, researchers first reported this type of insect in California and parts of Arizona, where they found it feeding on over 15 plant families [10-12]. It also infects a wide range of crops, including many vegetables, oilseeds [13, 14], and other bagrada weeds. On piercing This insect's feeding behavior, which uses piercing-sucking mouthparts to ingest plant leaf and stem juices, can sometimes cause wilting and damage to plant leaves [15-17]. Insects are in the same



family, but they are two different species [18]. *Bagrada* is smaller in size and has a different color pattern [19, 20].

2. Materials and methods

2.1. Specimens collection

The samples of *Bagrada* insects were collected from different regions of Iraq (Al-Taji Baghdad, Al-Rashidiya Baghdad, Al-Madaen Baghdad, Diyala Khan Bani Saad, and Babel Dulaimi Village) for the period from May to October 2022. We collected samples from the surfaces of the main stem, branches, and leaves of *Eruca vesicaria* ssp., *Raphanus sativus*, and *Capparis spinosa* using the hand and air net [21] and the previously used sweeping method [22].

2.2. Sampling and storing samples

Insects were killed using one of the killing jars containing alcohol with a concentration of 70% or killed by freezing [23, 24] and were patiently used using pins of appropriate lengths and sizes. All information about the samples was written on them, such as the place, date of collection, and the plant host from which the insects were collected, and finally samples were preserved in insect collection boxes [25].

2.3. Examination and diagnosis of samples

Specimens were examined using a dissecting and a compound microscope (Olympus, Japan), using normal light, for the purpose of studying the tiny parts of the insect's body [26]. Dissection and Studying external morphological traits were conducted, including the male and female reproductive organs [27], and recorded phenotypic traits [28]. We separated the various body parts for both sexes in accordance with [29, 30], and used a micrometer to improve all numbers.

3. Results and Discussion

3.1. Body

The body of adults is shield-shaped and ranges in size from 5-7 mm in length and 3-4 mm in width. Females are slightly larger than males. The body color is black with red and yellow markings. The prothorax and shield of adult *Bagrada* insects have clear longitudinal markings down the center (**Figures 1 and 2**).



Figure 1. Adult *Bagrada hilaris* A- male B- female dorsal view (1x)

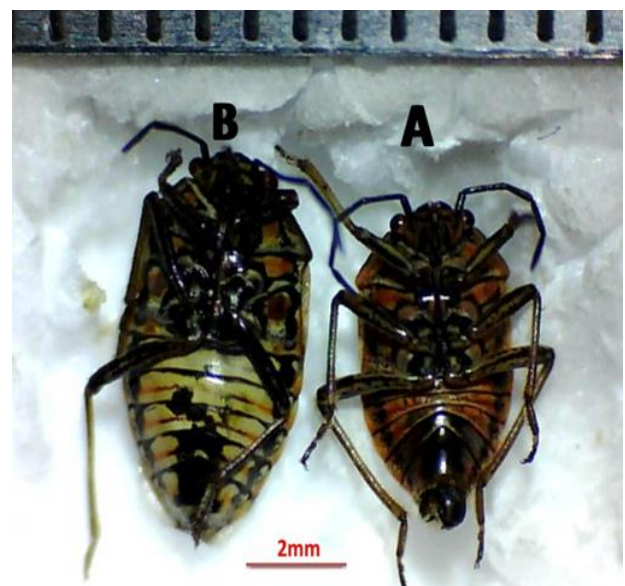


Figure 2. Adult *Bagrada hilaris* A- male B- female ventral view (1x)

3.2. Head (Figures 3 and 4)

The head is small in size, almost triangular in shape. The mouth parts extend to the back, indicating that the head belongs to the posterior category, specifically opithagnathous. The length of the front part of the head without the compound eyes is 0.5 mm, the length of its posterior part with the compound eyes is 1 mm, and the width of the head is 1.5mm. The head's upper surface is black. The compound eyes are medium in size, brown in color, and spherical in shape. They contain a large number of lenticels, and the distance between them is 1 mm. There is a pair of simple eyes with small ocelli that are spherical in shape and brown in color. The hind part of the head is located at the base of the head, and the distance between them is 0.7 mm. The presence of mouthparts and antennae distinguishes the head. And the throat, Gula.

3.2.1. Antennae

The antennae of the head arise from a small, swollen structure called the antennaiferous tubercle. The antennae are of the type Filiform, have a black color, and consist of five pieces. The first piece, known as the scape, is thick. The second piece, known as the pedicle, is the longest of all; the flagellum refers to the remaining three segments; and a scattering of villi covers the antennae.

3.2.2. Mouth parts

The dark brown, three-segmented rostrum, representing the piercing sucking mouth parts of the *Bagrada hilaris* insect, extends to the coxa of the hind legs.

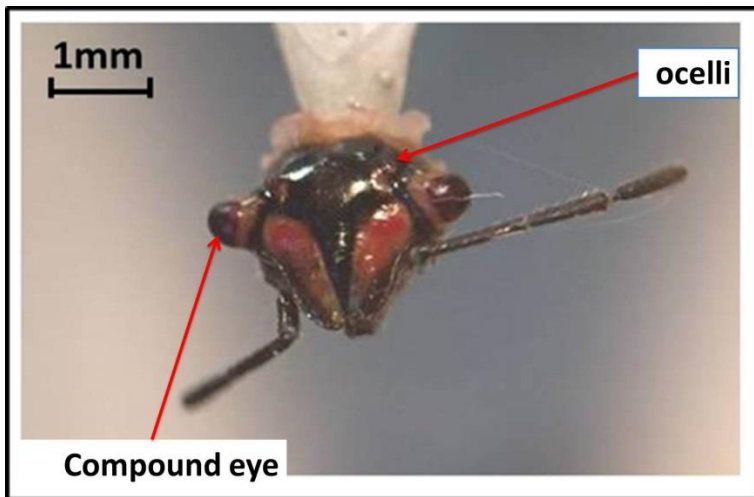


Figure 3. Head facial view.

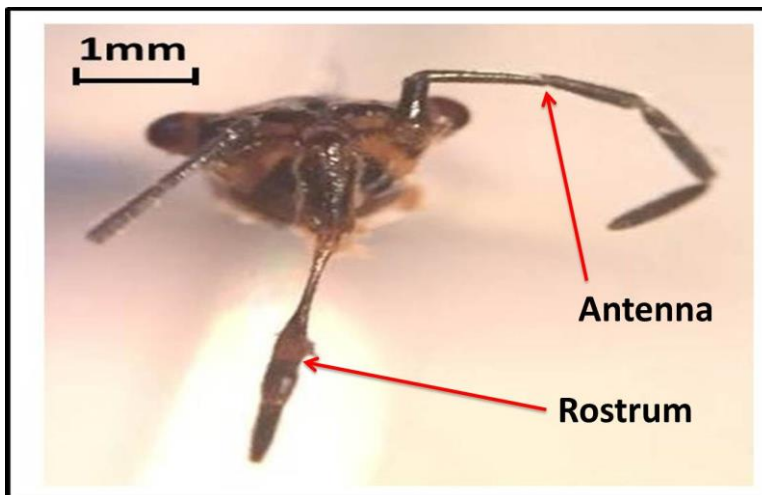


Figure 4. Head ventral view.

3.3. Thorax (Figure 5)

3.3.1. Prothorax

On the dorsal side, it consists of the anterior pronotum, which is yellowish with orange spots and black bands and has shallow punctures. It is relatively large in width, twice its length, width (3.5) mm, and length (1.5) mm. Its anterior margin is concave, and the posterior margin is convex. The anterolateral margins are straight; the posterolateral margins curve inward; the anterior and posterior angles are obtuse; and the humeral angles are acute. The prosternum, a narrow sternal plate with yellow and black bands, composes the anterior thorax on the ventral side.

3.3.2. Mesothorax

It is large in size compared to the posterior thorax. It consists, on the dorsal side, of the precostal plate, Precosta, Prescutum, Scutum, and Scutellum.

3.3.3. Metathorax

Small compared to the medial thorax. The posterior thorax is covered by the two wings, which are divided into carapaces. The posterior edge of the carapace is connected to the axillary cord of the hind wing.

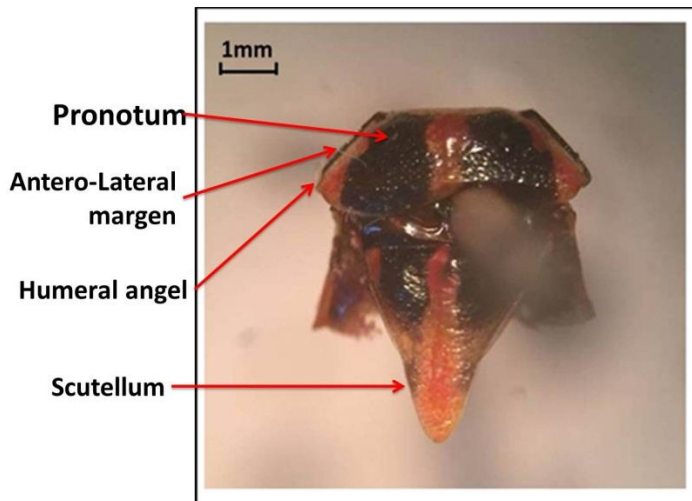


Figure 5. Pronotum and scutellum Dorsal view.

3.4. Abdomen (Figures 6)

Broad yellowish-orange with large black dots on both sides of the abdominal rings, represented by the Pregenital Segmentes, which are seven rings: the longest and widest part in the abdomen for each ring is the Tergate, the Sternat, and the lateral margins Connexiva, the abdomen consists of seven Pregenital plates on the dorsal side. Tergates are dark red with wavy dorsal sutures.

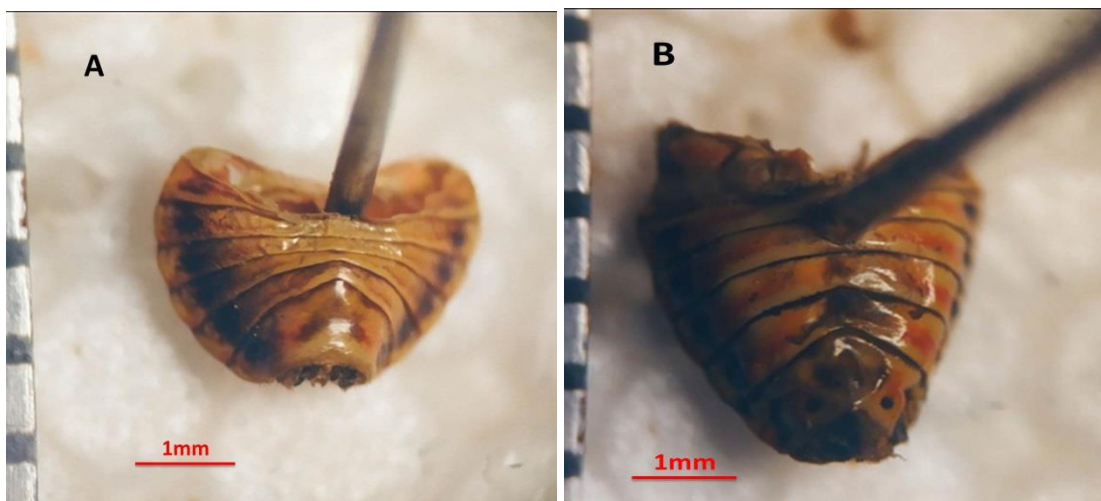


Figure 6. Ventral view abdomen A- Male B-female (2X)

3.5. Wings (Figure 7 and 8)

3.5.1. Fore wing

The fore wing consists of two parts: a corium-thick basal part and a membranous apical part separated by a seam called the membranal suture. The color of the wing is yellowish with dark black bands and an orange spot that contains punctures.

3.5.2. Hind wing

It is a membranous wing divided by grooves and folds into easily recognizable regions. There are four distinct areas on the rear wing:

1-Costal area: A large area extending between the costal margin and the median furrow. It contains the following veins:

a.Costal vein: It extends from the base of the wing, and runs along the anterior margin of the wing, and connects to it after the middle distance.

b.Subcostal vein: Solitary, fused to the radial vein at the apical quarter of the wing.

c.Radial vein: Unbranched, curves upward at a short distance and fuses with the subcostal vein, then curves downward and fuses with the medial vein M1+2.

d.Mediat vein: Branched, consisting of veins M2 and M1, not joined at the base.

2-Medial area: A medial triangular region located between the costal region and the medial humeral furrow. It contains the following veins:

-The third medial race, M3, and the fourth race, M4, merge with each other in a V-like manner.

3-Cubital area: This area is located between the medial humeral groove and the anal fold and contains the following veins:

- The humeral vein is unbranched, attached to the first posterior vein A1 at the base of the wing.

- The first posterior vein Solitary attached to the humeral vein at the base of the wing.

4-Anal area: It contains a single vein, the posterior vein A, which is curved and extends from the base of the wing to near the tip of the wing.

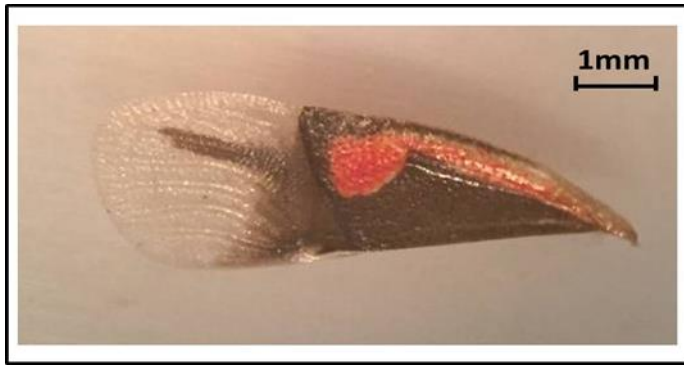


Figure 7. Fore wing.

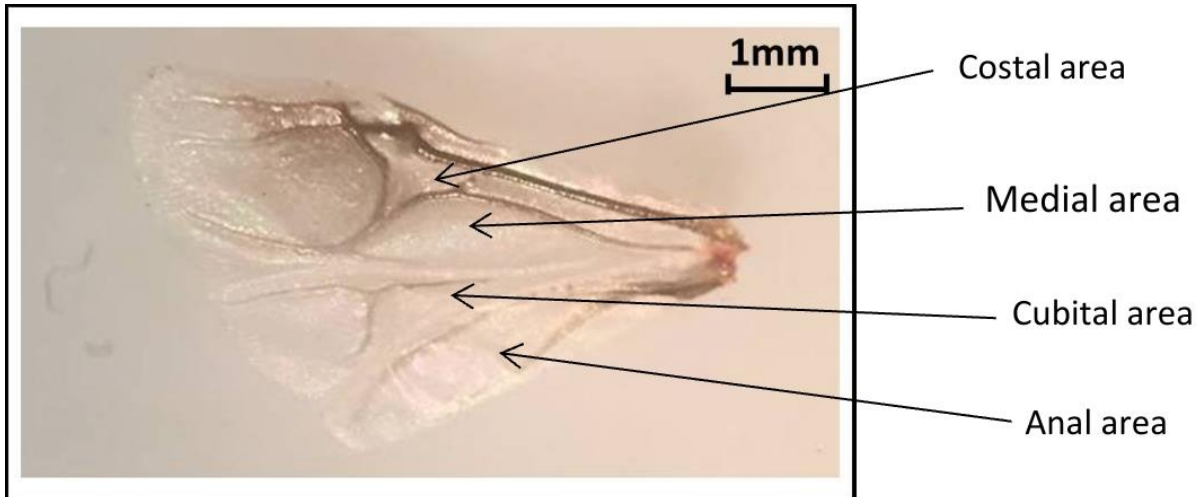


Figure 8. Hind wing.

3.6. Legs (Figure 9)

3.6.1. Fore legs

As is the case in other insects, they consist of the following parts:

1-Coxa: a smooth, oval-shaped piece of yellow color with black areas.

2- Trochanter: A small, smooth, triangular piece located between the coxa and the thigh.

3- Femur: The largest part of the front legs is cylindrical in shape. Its part close to the base is narrow and gradually widens towards the top of the leg. Longitudinal black lines compress the thigh on both sides. Its surface contains short, weak, low-density spines.

4-Tibia: tubular in shape, slightly longer than the thigh, but less wide. Weak, medium-density spines are spread on the stalk's surface. Denser and thicker spines surround the stalk at its connection to the wrist.

5-Tarsus: It consists of three pieces: the first, called Metatarsus, is rectangular in shape, slightly longer than the third piece; its outer surface is convex; the second piece is small, square in shape; and the third piece is oval in shape, shorter and higher than the first piece, carrying a pair of short claws located under each Pulvillus cushion claw. The outer surface of the wrist pieces contains medium-density short hairs, whereas the inner surface contains more dense short hairs.

3.6.2. Middle legs

Similar to the fore legs, but a little longer.

3.6.3. Hind legs

Similar to the fore legs but differ from them by being much longer.

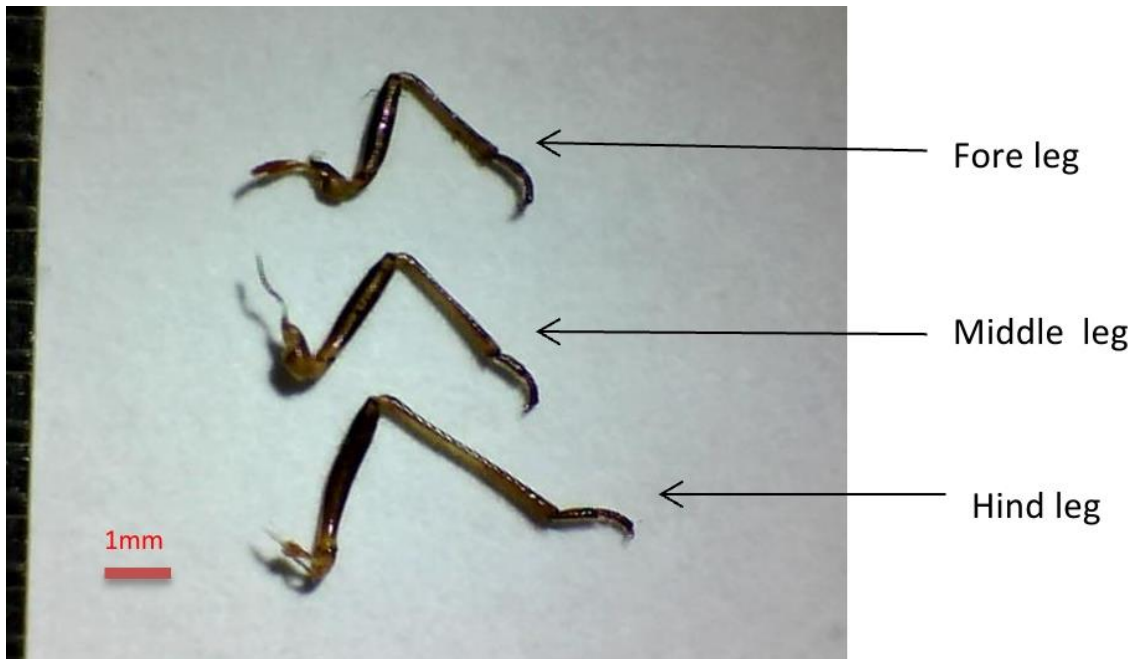


Figure 9. Legs.

3.7. Male genitalia: (Figure 10)

The ninth abdominal ring gives rise to the male seed, attaching a pair of gonopods known as pseudophallic organs. The true penile organs, known as the euphallic organs, comprise the phallus and the two lateral pieces known as the paramere. The eighth ring is a membranous ligament that connects the seventh abdominal ring and the ninth ring. In this species, the ninth abdominal ring is short.

3.7.1. Phallus

The basal plate represents the proximal part of the penis, and the distal part is known as the thecal appendages, which surround a structure called the conjunctiva appendages.

3.7.2. Paramere

It is represented by a pair of structures that are attached to the basal plate of the penis and consists of two parts: a basal part of medium thickness called the stem, and a broad apical part called the blade. The blade consists of two protrusions of unequal length.

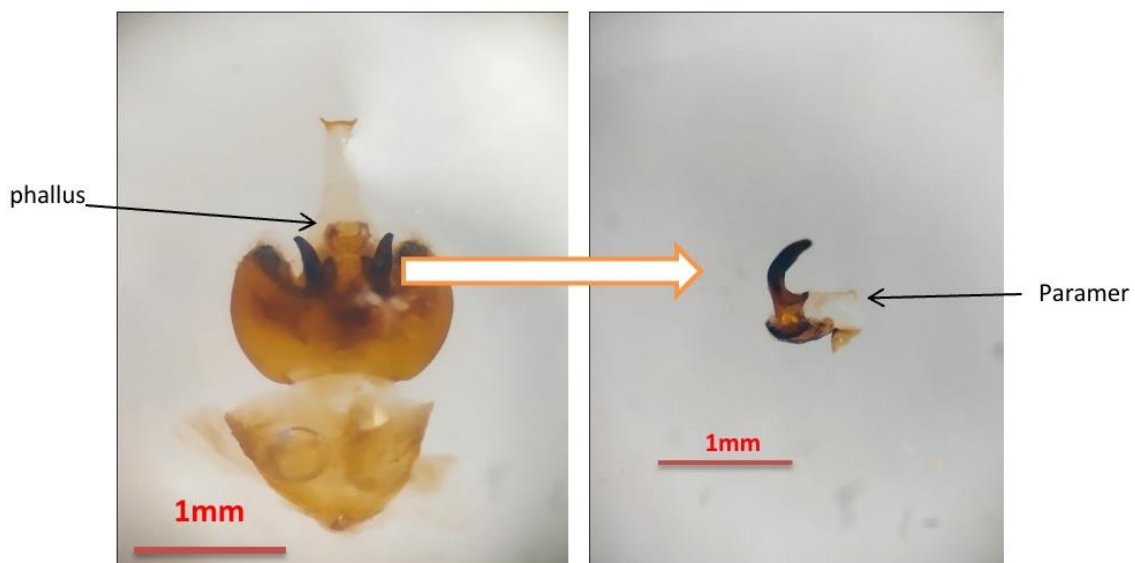


Figure 10. Male genitalia (4X)

Paramer (4X)

3.8. Female genitalia: (Figure 11)

The female ovary attaches itself to the eighth and ninth abdominal rings. The dorsal tergates of the eighth and ninth rings fold ventrally on each side, forming the abdominal part adjacent to the dorsal plates. The dorsal plate side of the eighth ring is large and nearly triangular, housing a pair of respiratory openings. The first pair of gonocoxites that are connected from the inside with the first pair of valves, the first genital spire, is triangular in shape and covered with short, dense bristles, and the side of the dorsal plate of the ninth ring is oval in shape; its lower part is narrow and its top is round, and it is covered with short and dense bristles.

3.8.1. Spermatheca

It is an inflated installation consisting of the following parts:

- 1- **Spermathecal bulb:** an elongated structure with a broad, flat base and a pointed apex, without lateral processes.
- 2- **Spermathecal pump:** a long funnel-shaped structure with a funnel-shaped top and a cylindrical base.
- 3- **Distal spermathecal duct:** a short, narrow tubular structure that connects to the upper apex of the seminal repository.
- 4- **Proximal spermathecal duct:** duct A tubular structure, longer than the distal duct of the seminal repository, and attached to the lower side of the seminiferous repository.

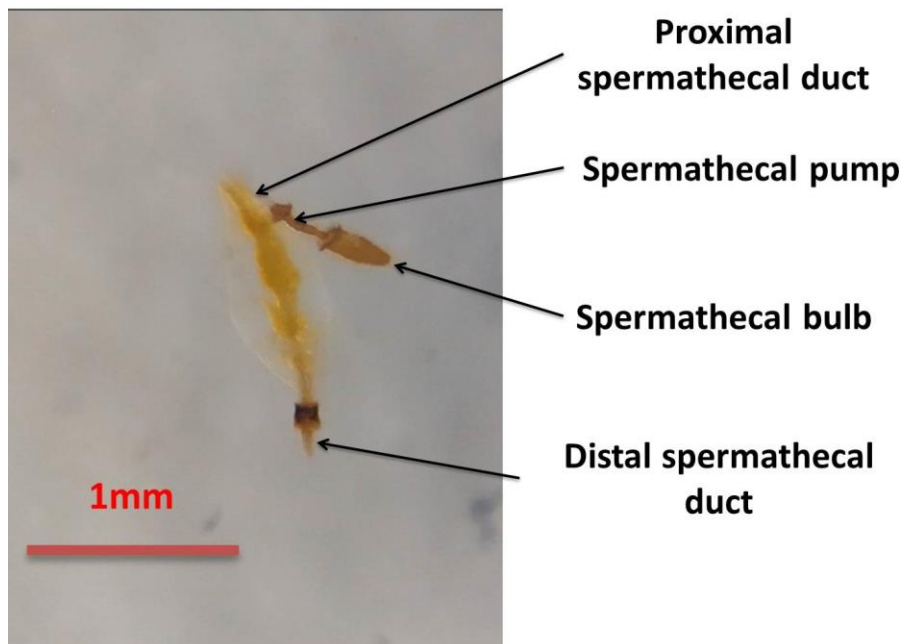


Figure 11. Female genitalia – Spermatheca (4X)

4. Conclusions

The body of *Bagrada hilaris* is small in size, black in color, with orange and yellowish spots. The head is almost triangular; the antennae consist of five segments; the abdominal side is yellowish or orange in color; the scutellum is triangular in shape. The front wing is of the semicircular type; the rostrum extends into the coxa of the hind legs; and the paramere consists of two parts: a basal part of medium thickness called the stem and a broad apical part called the blade. The spermathecal bulb is an elongated structure with a broad, flat base and a pointed apex, but no lateral processes.

Acknowledgment

Many thanks to the Department of Biology at the College of Education for Pure Science (Ibn-Al-Haitham), University of Baghdad, for their invaluable assistance in facilitating the practice sections of this article.

Conflict of Interest

There is no conflict of interest.

Funding

There is no funding for the article.

References

1. Weirauch, C.; Schuh, R.T. Systematics and evolution of Heteroptera: 25 years of progress. *Annual Review of Entomology* **2011**, *56*, 487–510. <https://doi.org/10.1146/annurev-ento-120709-144833>
2. Augul, R.S. Revision of the family Sphecidae (Hymenoptera, Apoidea) in Iraq. *Bulletin of the Iraq Natural History Museum* **2019**, *15*(4), 491-504. <https://doi.org/10.26842/binhm.7.2019.15.4.0491>.
3. Pal, E.; Allison, J.D.; Hurley, B.P.; Slippers, B.; Fourie, G. Life History Traits of the Pentatomidae (Hemiptera) for the Development of Pest Management Tools. *Forests* **2023**, *14*, 861. <https://doi.org/10.3390/f14050861>.
4. EFSA Panel on Plant Health (PLH); Bragard, C.; Baptista, P.; Chatzivassiliou, E.; Di Serio, F.; Gonthier, P.; Jaques Miret, J.A.; Justesen, A.F.; Magnusson, C.S.; Milonas, P.; Navas-Cortes, J.A.; Parnell, S.; Potting, R.; Reignault, P.L.; Stefani, E.; Thulke, H.H.; Van der Werf, W.; Civera, A.V.; Yuen, J.; Zappalà, L.; MacLeod, A. Pest categorisation of *Bagrada hilaris*. *EFSA journal. European Food Safety Authority* **2022**, *20*(2), e07091. <https://doi.org/10.2903/j.efsa.2022.7091>.
5. Jadhav, D.D.; Hegde, V. D. On a collection of stink bugs (Hemiptera: Pentatomidae) in and around Pune, Maharashtra. *Journal of Entomology and Zoology Studies* **2018**, *6*(4), 1504-1507.
6. Palumbo J.C.; Natwick, E. T. *The Bagrada bug (Hemiptera: Pentatomidae): a new invasive pest of cole crops in Arizona and California*. Plant Health Progress, **2010**. <https://doi.org/10.1094/PHP-2010-0621-01-BR>.
7. Faúndez, E.I.; Lüer, A.; Cuevas, A.G.; Rider, D.A.; Valdebenito, P. First record of the painted bug *Bagrada hilaris* (Burmeister, 1835) (Heteroptera: Pentatomidae) in South America. *Archivos Entomológicos* **2016**, *16*, 175-179.
8. Carvajal, M.A.; Alaniz, A.J.; Núñez-Hidalgo, I.; González-Céspedes, C. Spatial global assessment of the pest *Bagrada hilaris* (Burmeister) (Heteroptera: Pentatomidae): current and future scenarios. *Pest Management Science* **2019**, *75*(3), 809–820. <https://doi.org/10.1002/ps.5183>.
9. Sonnekus, B.; Slippers, B.; Hurley, B.P.; Joubert, E.; Stiller, M.; Fourie, G. Diversity and Molecular Barcoding of Stink Bugs (Hemiptera: Pentatomidae) Associated with Macadamia in South Africa. *Insects* **2022**, *13*, 601. <https://doi.org/10.3390/insects13070601>.
10. Bundy, C.S.; Perring, T.M.; Reed, D.A.; Palumbo, J.C.; Grasswitz, T.R.; Jones, W.A. *Bagrada hilaris* (Burmeister) in McPherson, J.E. (ed.). In: *Invasive Stink Bugs and Related Species (Pentatomidae): Biology, Higher Systematics, Semiochemistry, and Management*. CRC press, **2018**, 820 pp. <https://doi.org/10.1201/9781315371221>.
11. Motta, C.I.; Luong, J. C.; Seltmann, K.C. Plant-arthropod interactions of an endangered California lupine. *Ecology and Evolution* **2011**, *12*(3), e8688. <https://doi.org/10.1002/ece3.8688>.
12. Butler, C.D.; Trumble, J.T. The potato psyllid, *Bactericera cockerelli* (Sulc)(Hemiptera: Trioziidae): life history, relationship to plant diseases, and management strategies. *Terrestrial Arthropod Reviews* **2012**, *5*(2), 87-111. <https://doi.org/10.1163/187498312X634266>.

13. Schaefer, C.W.; Panizzi, A.R. *Heteroptera of Economic Importance*. CRC press, Boca Raton, Florida, USA, 2010, 856. [http://dx.doi.org/10.1653/0015-4040\(2002\)085%5b0400:HOEI%5d2.0.CO:2](http://dx.doi.org/10.1653/0015-4040(2002)085%5b0400:HOEI%5d2.0.CO:2)
14. Zheng, X.; Koopmann, B.; Ulber, B.; von Tiedemann, A. A global survey on diseases and pests in oilseed rape—current challenges and innovative strategies of control. *Frontiers in Agronomy* 2020, 2, 590908. DOI: <https://doi.org/10.3389/fagro.2020.590908>.
15. Hori, K.; Schaefer, C.W.; Panizzi, A.R. Possible causes of disease symptoms resulting from the feeding of phytophagous Heteroptera. In: *Heteroptera of Economic Importance*. 2020, 11-35. DOI: <http://dx.doi.org/10.1201/9781420041859.ch2>.
16. Stafford, C.A.; Walker, G.P.; Ullman, D.E. Hitching a ride: Vector feeding and virus transmission. *Communicative & Integrative Biology* 2012, 5(1), 43–49. <https://doi.org/10.4161/cib.18640>.
17. Palumbo, J. C. 2016. Biology, Ecology, and Management of an Invasive Stink Bug, *Bagrada hilaris*, in North America. *Annual Review of Entomology* 2016, 61, 453–73. <https://doi.org/10.1146/annurev-ento-010715-023843>.
18. Grazia, J.; Panizzi, A.R.; Greve, C.; Schwertner, C.F.; Campos, L.A.; de A. Garbelotto, T.; Fernandes, J.A.M. Stink bugs (Pentatomidae). In: *True bugs (Heteroptera) of the Neotropics*. 2015, 681-756. <http://dx.doi.org/10.1201/9781420041859.ch13>.
19. Halbert, S.E.; Eger, J.E. *Bagrada bug (Bagrada hilaris)(Hemiptera: Pentatomidae) an exotic pest of cruciferae established in the Western USA*. Pest Alert, Fl. Dept. Agr. Consumer Services, Division of Plant Industry, 2010. <http://www.freshfromflorida.com/pi/pest-alerts/pdf/bagrada-bug-pest-alert.Pdf>.
20. Reed, D.A.; Palumbo, J.C.; Perring, T.M.; May, C. *Bagrada hilaris* (Hemiptera: Pentatomidae), an invasive stink bug attacking cole crops in the southwestern United States. *Journal of Integrated Pest Management* 2013, 4(3), C1-C7. <https://doi.org/10.1603/IPM13007>.
21. Al-Asady, H.S.; Aga, M.M. External Morphological Study of *Pieris rapae* (Linnaeus, 1758), (Lepidoptera: Pieridae) Mid and North of Iraq. *Ibn AL-Haitham Journal For Pure and Applied Sciences* 2015, 28(1), 205-217. <https://jih.uobaghdad.edu.iq/index.php/j/article/view/205>.
22. Aljaf, M. M.; Sabr, A. J., Salman, Z. H. and Fezea, M. A. Review and Description for *Theretra alecto* Boisduval 1827, (Lepidoptera: Sphingidae) in Iraq. *Journal of Pharmaceutical Sciences and Research* 2019, 11(6), 2327-2332. <https://doi.org/www.researchgate.net/publication/331483385>.
23. Abdul-Rassoul, M.S.; Augul, R.S.; Al-Saffar, H.H. Seasonal Abundance of Adult Fly Species on the Exposed Carcasses in Baghdad City. *Ibn AL-Haitham Journal For Pure and Applied Sciences* 2009, 22(4), 1-10. <https://www.iasj.net/iasj/download/6a86a487f5207f79>.
24. King, J.R.; Porter, S.D. (2004). Recommendations on the use of alcohols for preservation of ant specimens (Hymenoptera, Formicidae). *Insectes Sociaux* 2004, 51, 197-202. <https://doi.org/10.1007/s00040-003-0709-x>.
25. Mawlood, N.A.K. A New Species of *Sarcophaga* Meigen 1826 (Diptera: Sarcophagidae) From Iraq. *Ibn AL-Haitham Journal For Pure and Applied Sciences* 2006, 19(1), 12-21. <https://jih.uobaghdad.edu.iq/index.php/j/article/view/1530/1240>.
26. Sabr, A.J.; Aljaf, M.M. External Morphological Study of *Tabanus nemoralis* Meigen 1820 (Diptera: Tabanidae). *Ibn AL-Haitham Journal For Pure and Applied Sciences* 2017, 03(1), 11-19. <https://doi.org/10.30526/30.1.1055>.
27. Salman, Z.H.; Aljaf, M.M.; Sabr, A.J. External Morphological Study of *Aporiacrataegi* (Linnaeus, 1958) (Lepidoptera: Pieridae). Northern Iraq. *Journal of Global Pharma Technology* 2018, 10(7), 71-76.
28. Sabr, A.J. Seasonality And Relative Abundance Of Deer And Horse Flies (Diptera : Tabanidae) From Three Farms In Al-Anbar, Iraq. *Biochemical and Cellular Archives* 2018, 18(2), 1915-1920.
29. AL-kiasy, R.J.H. Description of a new species of leafhopper *Cicadella lataeilla* nov. (Hemiptera: Cicadellidae) from Iraq. *Baghdad Science Journal* 2010, 7(4), 1331-1337. <https://doi.org/10.21123/bsj.2010.7.4.1331-1337>.

30. Alwaily, D.S.; Kader A.A.; Tohma A.J. Studying the efficacy of some insecticides and sporophyte suspension of *Beauveria bassiana* (Balsam) Vuil. fungus in controlling nymphs and adults of *Bagrada hilaris* (Burmeister) (Hemiptera: Pentatomidae) on radish crop (*Raphanus sativus* L.) *in vitro* and field. *Euphrates Journal of Agriculture Science* **2020**, *12*(2), 530- 541.