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# The Morphological Characters of Egg and Relationship of Immature Stages of *Hermolaus modestus* (*Heteroptera*: *Pentatomidae*: *Eysarcorini*)

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**Abstract.** The paper investigates the biology and structure of egg and different developmental stages from 1st instar to 5th instar of *Hermolaus modestus* (Distant) (Pentatomidae: Eysarcorini). The experiment was conducted in the laboratory and the species was recognized as plant-sucking pest and mostly recorded on *Ocimum basilicum* (L.) from different areas of Karachi, Pakistan. The male and female individuals were breed under controlled laboratory condition. The maximum fertility range of *Hermolaus modestus* was observed 10 to 14 eggs per female and eggs were laid singly on the ventral side of plant leaves near the midrib. The incubation period was completed in 4 to 5 days. Newly emerged nymphs were dark red in colour but later colour changed into brown. The nymph passed through five instars progressively to complete the nymphal period. The first instar completed in 2 to 3 days with its specific characters. The second instar took 6 to 7 days with large clypeus. The third instar having scent gland plates and wing pads, completed in 5 to 6 days. The fourth and fifth instars of *H. modestus* completed in 5 to 6 and 8 to 9 days with prominent mesonotal and metanotal wing pads, respectively. The total nymphal period varied from 26 to 31 days. The total life cycle showed variation from 30 to 36 days. The total body length of male *Hermolaus modestus* was recorded as 4.8 mm to 5.0 mm.

**Keywords:** *Hermolaus modestus*, morphology of egg, pentatomidae, bugs, *Ocimum basilicum*

## Introduction

*Hermolaus modestus* (Distant) belongs to superfamily Pentatomoidea, family Pentatomidae and genus *Hermolaus* (Kment and Carapezza, 2017). The Pentatomoidea is the large superfamily of Hemiptera, consisting of 1301 genera and 7182 species and 16 families in all over the world. Family Pentatomidae is the bug family and five antennal segments are the major character of this family. Pentatomids also famous as "stink bugs" which is invasive in nature. The family Pentatomidae consist of 4112 species (Schaefer and Panizzi, 2000), but recently Pentatomidae have 896 genera and 4722 species (Hassan *et al*., 2016). The Pentatomids also described as "shield bugs" due to their body is generally protected by a hard scutellum which covers half of the abdomen (Biswas *et al*., 2014). The *Hermolaus modestus* is closely similar to *Hermolaus ocimumi* and have some common characters like *Eysarcoris inconspicuous* (Heteroptera: Pentatomidae), found in the hills, plains, coastal and sub coastal areas of Pakistan. One of the encroaching member of this group, *Halyomorpha halys* (Stål) (Hemiptera: Pentatomidae) is very invasive species and widely observed in Japan, Korea Taiwan, eastern China and was also collected from the USA in 20th century, from Pennsylvania and Allentown in 2001 (Zhu *et al*., 2012). The isolated population of *Halyomorpha halys* (Stål) was collected from the west coast of the USA (Leskey *et al*., 2012a). *Halyomorpha halys* (Stål) was recorded on many host plants in all over the world especially in the US and China, they demolished the huge variety of economically valuable agricultural crops (Lee, 2015; Leskey *et al*., 2012b). Pentatomids are mostly phytophagous and severe pests of main crops. *Halyomorpha halys* was studied as polyphagous and herbivore in nature and found on diverse plants, including tree fruits, field crops and vegetables (Bergmann *et al*., 2016) and some species are predator and may be considered beneficial. However, *Hermolaus modestus* mostly recorded from grasses, fodder crops and vegetables.

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*Hermolaus modestus* is vulnerable sucking pests of fodder crops with piercing and sucking mouthparts. The adult and instars of *Hermolaus modestus* mostly recorded on *Ocimum basilicum* and main agricultural crops, like *Solanum melongena* (brinjal) *Hibiscus esculantus* (Okra Okra) and damage them (Hussain and Zahid, 2016). *Hermolaus modestus* badly damage the flowers and soft leaves of *Ocimum basilicum* plant by using their piercing and sucking mouthparts. Due to the piercing and sucking habit of pest, the growth of the plant is reduced. It is observed that most of the farmer grown *Ocimum basilicum* plant around the field of vegetables in Karachi, Pakistan. This practice is helpful to farmers for the protection of their main field crops from the attack of *Hermolaus modestus* and other vulnerable pests. Silva *et al*. (2014) studied the nymphal stages of *Euschistus heros* (Fabr.) (Hemiptera: Pentatomidae) and treated them with biological control agent *Telenomus podisi* under controlled environmental conditions. The biological comparison of *Chinavia impicticornis* and *C. ubica* (Hemiptera: Pentatomidae) pests and showed the fecundity table (Silva *et al*., 2015). The duration of development from egg to adult was calculated approximately 30 days for both species. The development of *Hermolaus modestus* was observed 30 to 32 days. The purpose of this study is to mention the similarities and differences of structure and developmental characters of *Hermolaus modestus*.

The *Ocimum basilicum* is commonly used for essential oil production. Hussain *et al*. (2008) studied the essential oil of *Ocimum basilicum* and found linalool component in abundant, which has antimicrobial and antioxidant properties. *Ocimum basilicum* has medicinal properties for heart asthma and blood diseases. This plant is antipyretic, carminative and expectorant in nature (Eftekhar *et al*., 2018). *Ocimum basilicum* is one of the most important limiting agent fodder crop for our livestock production. This enhancement research evaluates the fodder pest information for the betterment of good production of our livestock. The achievement of this study is to find out the new comprehensive information about invasive fodder pest. The knowledge of such information helps to develop the best understanding in the research field.

## Materials and Methods

**Site and climatology.** The collection of *Hermolaus modestus* was performed in the early morning on different days from Karachi, Pakistan. For the purpose of insect collection, Faisal Cantonment and Gadap, Gulshan-e-Iqbal, Landhi, and Malir towns of Karachi were visited. It is observed that the population of *Hermolaus modestus* depends upon different environmental factors such as temperature, relative humidity and rainfall. Two major environmental factors temperature and relative humidity play a very important role in the successive development of immature stages of *H. modestus*.

**Host plant.** *Hermolaus modestus* (Distant) mostly collected from the plant, *Ocimum basilicum* (L.) and this species sometimes found on (Lucerne) *Medicago sativa* (L.) from different areas of Karachi Pakistan. *Ocimum basilicum* is one of the important fodder crops among genus *Ocimum* and mostly recorded from Indo-Pakistan. *Ocimum basilicum* is commonly called sweet basil and belong to family Lamiaceae. *Ocimum basilicum* has medicinal and economic importance.

**Sampling.** The beating method was used for the collection of *Hermolaus modestus* (adult). Beating method is the very significant and effective method for the collection of bugs and beetles (Metspalu *et al*., 2015) and generally adopted for the different insects' collection. Searching and picking method was applied for the collection of copulated pairs, eggs and instars from *Ocimum basilicum* plant. This technique was used by McCravy (2018). The study of *Hermolaus modestus* was performed in the laboratory at the Department of Zoology, Federal Urdu University Karachi. Temperature and relative humidity ranged from 20 to 32 °C and 35 to 75% respectively during the laboratory experiment.

**Test management.** The category of eggs, instars and copulating pairs of *Hermolaus modestus* was arranged in the laboratory after collection. Three washed Petri-dishes of 9 cm were arranged for experiment and 8 to 10 eggs and instars kept separately in each Petri-dish. The 10 pairs of adults arranged in each 12" × 16" sized chimneys. Chimneys washed and covered with a dull white clean muslin cloth. The leaves of *Ocimum basilicum* supplied as food adults and instars in alternative days. The temperature and relative humidity maintained from 20 to 32 °C and 35 to 75% respectively by a table lamp, small-sized motor fan, and wet cotton balls. Binocular microscope (Nikon SMZ-1) and cannon camera (A4000 IS) were used for the observation and taking photographs of adults, eggs and different larval stages of *Hermolaus modestus*.

## Results and Discussion

**Mating behaviour.** Sometimes a male and female *Hermolaus modestus* were observed in the copulated condition in the laboratory. Male take initiates for copulation and reaches to the female. Both insects move and touch their antennae in very slow motion. The male turns around to the female and contact in the end to end position and then insert its pygophore in the female genital hole. It was observed that female remains motionless during all process. The eggs were laid 10 to 14 in numbers per female.

**Egg.** The egg of *H. modestus* was observed milky white when freshly laid and then gradually changed into dark red. Sixteen bright micropyles and horizontal lines observed in mature egg. The length and width of the egg were measured 0.6 mm and 0.4 mm respectively (Fig. 1). The varied incubation period of *H. modestus* was observed from 4 to 5 days. The newly hatched instars were collected and shifted carefully by using a wet camel hairbrush on host plant fresh leaves in the Petri dishes.

**First instar.** The first instar lasted for 2 to 3 days. The body of the first instar impunctate and oval in shape; pronotum dark brown; abdomen light brown; clypeus generally longer than paraclypeus; labium passing the third coxae; antennae four segmented, 1stand 2nd segments of antenna being fused, thick, pinkish-red (Fig. 2).

**Second instar.** This stage almost the same in shape with 1st instar; colour comparatively lighter than 1st instar. This stage was completed in 6 to 7 days. The mesonotal wing pad was starting to develop; clypeus long and deflexed; antenna dark brown (Fig. 3).

**Third instar.** The third instar was also occupied 5 to 6 days. Abdominal turga of the third stage was lighter in colour than thoracic turga; scent gland plates dark brown; wing pads extending to cover at least first abdominal segment; antennal segment having a ratio of 1=2=3=4<5 (Fig. 4).

**Fourth instar.** The fourth stage of larvae completed in 5 to 6 days. Body colour lighter than previous; meso and metanotal wing pads almost equal in length and reached to third abdominal segment; the ratio of antennal segment size in the order of 1= 2 < 3 = 4 < 5 (Fig. 5).

**Fifth instar.** The fifth larval period consisted of 8 to 9 days. The meso and metanotal wing pads clearly observed in this stage. Mesonotal wing pad longer than metanotal wing pad and antennal segments ratio was 1 = 2 < 3 < 4 < 5. The legs were ochraceous and hairy (Fig. 6).

**Fig. 1.** Egg of H. modestus.

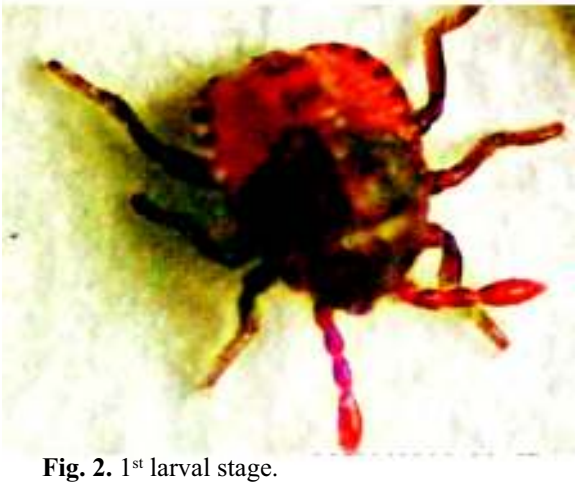

**Fig. 2.** 1st larval stage.

**Fig. 3.** 2nd larval stage.

**Adult.** Body, dark brown punctate and ochraceous; head length (1.07 mm) slightly smaller than length of pronotum (1.12 mm), pronotum width 2.5 mm; scutellum long as 1.6 mm and 1.8 mm in width; antennal formula is 1< 2 = 3 < 4 < 5. The range of length in adult males was 4.8 to 5.0 mm. (Fig. 7, Table 1).

Key to the various immature stages of *Hermolaus modestus*:

1. Mesonotal wing pad present in the initial stage; clypeus almost deflexed and long; antenna dark brown ..... 2
   Wing pads developed and reaching to first abdominal segment; scent gland plates developed .... 3
2. Colour lighter than the previous stage; mesonotal wing pad developed to appear ..... 2nd stage.
   Pronotum dark brown than abdomen and body almost oval in shape; 1st and 2nd antennal segment fused ..... 1st stage.
3. Thoracic turga dark in colour; scent gland plates dark brown; all antennal segments equal in size except 5th segment, which is slightly larger than 4th segment ..... 3rd stage.
   Body-colour lighter than previous stages; meso and metanotal wing pads different in size and clearly observed; 1st and 2nd antennal segments equal in size ..... 4
4. Abdominal and thoracic turga almost light in colour; mesonotal and metanotal wing pads equal in size and reached to 3rd abdominal segment; 1st, 2nd antennal segments, and 3rd, 4th antennal segments equal in size ..... 4th stage.
   Mesonotal wing pad larger than metanotal wing pad; 1st and 2nd antennal segments same in size; 3rd, 4th and 5th antennal segments larger in sequence ..... 5th stage.

**Table 1.** Measurements of the body parts of adult *Hermolaus modestus* (♂)

| Body parts | Male (♂) (mm) |
|---|---|
| Body length (BL) | 4.8 |
| Head length (HL) | 1.07 |
| Head width across eyes (HW) | 1.9 |
| Length of 1st antennomere (A1) | 0.23 |
| Length of 2nd antennomere (A2) | 0.3 |
| Length of 3rd antennomere (A3) | 0.3 |
| Length of 4th antennomere (A4) | 0.46 |
| Length of 5th antennomere (A5) | 0.63 |
| Pronotum length (PL) | 1.12 |
| Pronotum width (PW) | 2.5 |
| Scutellum length (SL) | 1.6 |
| Scutellum width (SW) | 1.8 |
| Abdomen of length (ABL) | 1.2 |
| Abdomen of width (ABW) | 2.02 |

**Fig. 4.** 3rd larval stage.

**Fig. 5.** 4th larval stage.

**Fig. 6.** 5th larval stage.

The structure of egg and developmental stages of *Hermolaus modestus* was the same as in other species of Eysarcorini. Ali and Rizvi (2010) determined the development of *Coocinella septempunctata* at specific temperature and humidity. Aziz *et al*. (2013) studied

**Fig. 7.** *Hermolaus modestus* (adult).

the life cycle of *Trilocha virescence* and estimated 33 days of development. *Hermolaus modestus* was showed variation and completed the life cycle in 30 to 32 days, under controlled laboratory conditions. The mortalities were gradually decreased from early to late stages during development. The temperature and relative humidity were observed as important factors which influenced the egg hatching time and developmental activities of *H. modestus*. Haye *et al*. (2014) studied the phenology and life table of *Halyomorpha halys*. The populations of *H. halys* evolved within 33.2, 42.3 and 75.8 days from egg to adult under controlled temperatures of 30, 25 and 20 °C, respectively. Many researchers described the importance of temperature and relative humidity for developmental activities in different species and agreed that the effect of temperature speed-up the development process in species. Rastogi and Pandey (2008) observed the effect of different constant temperature on the life-history of *Zygogramma bicolorata*. Michels and Flanders (1992) described the larval development of aphid and observed the importance of temperature influence. The *H. modestus* showed comparatively variation than *Eysarcoris inconspicuus* (H. Sch.) (Heteroptera: Pentatominae). The egg length and width in *Eysarcoris inconspicuus* were 0.9 mm and 0.5 mm respectively and micropyles were invisible in *Eysarcoris inconspicuus* (Koppel *et al*., 2009). The egg of *H. modestus* was dark red in colour with 16 visible micropyles and barreled in shape. The egg size of *Hermolaus modestus* was observed 0.6 mm and 0.4 mm in length and width respectively. The operculum and sixteen visible bright micropyles distinctly observed on the anterior side in the egg of *Hermolaus modestus*. The length of paraclypeus was small than clypeus with the prominent labium reaching to third coxae in the first instar of *H. modestus*. In the second instar, the development of mesonotal wing pad was almost going to start and clypeus prominently large in size. In later stages, scent gland plates were developed and wing pads reached to the first abdominal segment. The sizes of mesonotal and metanotal wing pads were the same in length. The width of scutellum slightly short than broad in adult *H. modestus*. This character was different as compared to *Hermolaus capitatus* (Distant). The length of head comparatively less than the length of pronotum in *H. modestus* and showed the similarity with *Hermolaus ishurdiensis* (sp. nov). The 2$^{nd}$ antennal segment was larger than 1st antennal segment in *H. modestus*. The 3rd antennal segment was equal to 2nd antennal segment and 4th antennal segment was larger than the 3rd antennal segment. The 5$^{th}$ antennal segment was larger than 4$^{th}$ in the adult of *H. modestus*. The total length of the antenna in the adult male of *H. modestus* was almost 1.92 mm.

## Conclusion

The biological characters of *Hermolaus modestus* showed somewhat variation with the other member of this group. The female laid eggs singly near the midrib of plant leaf in 10 to 14 numbers. The emergence of the first instar in 4 to 5 days. The first instar occupied 2 to 3 days having small paraclypeus than clypeus and large labium toward the third coxae. The second instar developed in 6 to 7 days with prominent large clypeus. The third instar having scent gland plates and wing pads, accomplished in 5 to 6 days. The fourth instar of *H. modestus* completed in 5 to 6 days with the character of equal size mesonotal and metanotal wing pads. The fifth instar took 8 to 9 days with long mesonotal wing pad. The total nymphal developmental period showed variation from 26 to 31 days. The total life cycle of *Hermolaus modestus* was completed in 30 to 36 days. The body of an adult male was dark brown and punctate with 1.07 mm, 1.12 mm and 1.6 mm of head, pronotum and scutellum length respectively. The total body length of an adult male was 4.8 to 5.0 mm.

**Conflict of interest.** The authors declare no conflict of interest.

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