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Isolation and morphological study of ecologically-important insect "*Hermetia illucens*" collected from Roorkee compost plant

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ABSTRACT: Certain species of *Hermetia illucens*, also known as the Black Soldier Fly (BSF), were found in a compost plant in Roorkee located in Northern India. Its larvae are voracious eaters of organic waste, hence can play an ecologically-important role in solid waste management. Morphological analysis of various stages of BSF life cycle by SEM showed that its body along with its wings is densely covered with hair. The identified species of BSF were black in color and oviposited into the composted material. The larvae grew up to 30 mm long in 12 days from an initial length of only 6mm, gaining almost 200% of its initial weight after voraciously feeding on organic waste. The mouth of the *H. illucens* showed a well-developed mandibular-maxillary complex that had similar characteristics of scavengers, making the insect a suitable candidate for organic waste consumption.

Keywords: black soldier fly, Fe-SEM, *Hermetia illucens*, morphology, waste manager.

INTRODUCTION

Black Soldier Fly (BSF) was first reported in 1930 in Hillo sugar companies in Hawaiian Islands (Duponte & Larish, 2003). Scientifically known as *Hermetia illucens*, it belongs to the phylum Arthropoda, class Insecta, order Diptera and family Stratiomyidae and is spread in tropical and warmer climatic regions around 45°N to 40°S latitude (Üstüner et al., 2003); however, it is believed that it originated from America (Callan, 1974). This fly is seen quite rarely in North India (Ashuma et al., 2007). There have been many studies around the globe, on the utilization of BSF larvae for the treatment of organic waste on which voraciously (Sheppard et al., 1994; Li et al., 2011a; Li et al., 2011b; De Marco et al., 2015; Diener et al., 2011a; Diener et al., 2011b).

Traditional landfill composting takes years to decompose organic waste, whereas vermiculture reduces it to 3 months; nonetheless, BSFL can decompose and valorize organic waste in a week, thus reducing the overall process time significantly. Various researchers have found these larvae in composts (Gujarathi & Pejaver, 2013). BSFs lack chewing organs in their mouth, only posses a sucking tube, which is the reason they only drink water during their adult stage and survive on their own fat

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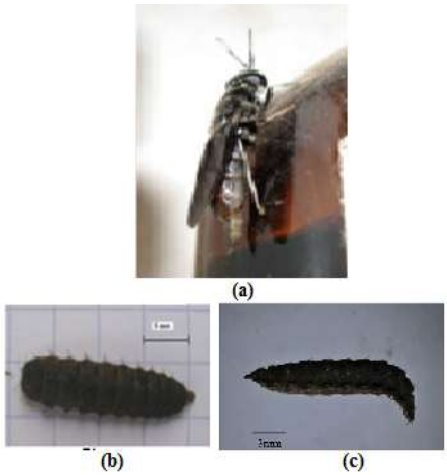

Fig. 1. Images of BSF at various stages of its life cycle reported by other researchers: (a) Adult (b) Larvae (Gujarathi & Pejaver, 2013) (c) Pupae (Li et al., 2016)

and protein, stored from their larval stage. Figure 1 shows the photographs of adult fly and larvae as reported by other researchers.

The larvae develop through 6 larval instars, usually growing to 18-20 mm in size (Rozkosny, 1997). Artificial breeding of BSF has been reported to be quite challenging and requires controlled temperature, humidity and light intensity for each stage of its life for successful completion of its life cycle. The present study reports for the first time sighting of BSF at Roorkee in the state of Uttarakhand, India, located in the foothills of Himalayan mountains. We also report morphological images of BSF larvae, pupae, and adult, using Field Emission Scanning Electron Microscopy (Fe-SEM).

MATERIALS AND METHODS

BSF pupae were recovered from an old batch of compost in a bushy area. Afterwards, a compost trap, made up of food waste, cow dung, and saw dust, was set in the area from which a sum of 200 BSF larvae were recovered (Fig. 2). The collected larvae were fed on Gainesville diet and reared in the insect-rearing unit located indoor. After 12 days of organic waste feeding, the larvae turned into pupae, about 30mm in size, from an initial length of 6 mm. The average temperature and humidity was 30±2°C and 60±5%, respectively during the entire experiment and the flies emerged from about 30% of the total pupae. In a similar manner, BSF larvae are still being harvested through setting up of compost traps and further trials are being carried out for waste reduction. Figure 2 shows the life cycle of the BSF as observed in our laboratory and also an enlarged image of larvae feeding on organic substrates.

For Scanning Electron Microscope (SEM) imaging, individual samples of larvae, pupae, and fly were stored at -20°C, later to be taken out and washed with 70% ethanol solution, and the samples received no other treatment. The specimens were coated with gold, using a sputter gold coater, and were examined with FE-SEM (Field Emission Scanning Electron Microscope Quanta 200 FEG, Netherlands), the resolution and magnification was <2nm and 12X-1000Kx, respectively, operating in a voltage range of 200V-30kV.

RESULTS AND DISCUSSION

The collected BSF larvae, brought from the compost plant to the insect-rearing unit were fed on Gainesville diet, to grow up to 30 mm long. The larvae in the compost heap consumed the organic waste, developing into pupae (Fig. 3b) in about 20 days. It took them at least 14 days (approx.) to become flies (data not shown). Figures 3, 4, and 5 show FE-SEM images of various life stages of BSF.

(a) **(b)**

Fig. 2. (a) Life cycle of BSF, (b) Black Soldier Fly Larvae at IIT Roorkee rearing unit

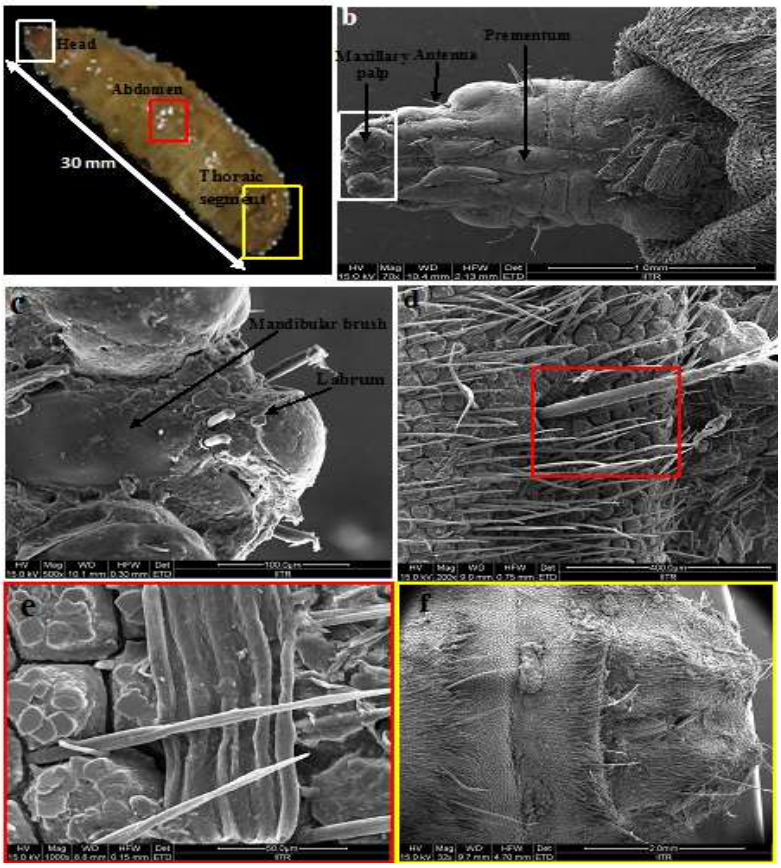

Fig. 3. SEM image of various body parts of wild BSF larvae (a) the lavae, (b) the head, (c) the mouth part, (d) the skin with dense hair cover, (e) hair folicles in the hair-covered body, and (f) the thoraic segment

The SEM images of the BSF larvae show dense hair cover throughout the larva body. The head is hemicephalic. As already reported by Kim et al. (2010), *H.illucens*' mouth possesses scavenger features. It has a very well-developed mandibular-maxillary complex with a pointed labrum. SEM images of the head and the mouth clearly show the mandibular brush, maxillary palp, the antennae, and the prementum. The external skin, i.e. the exoskeleton, appears to be hard and porous with visible hair follicles (Fig. 3). It was also observed that the exoskeleton is quite resistant to acidic atmosphere, allowing the larva to survive in pH conditions as low as 5.

SEM images of BSF pupae are almost similar to BSF larvae, with the only visible difference being that the larvae have a denser hair cover in its body than the pupae (Fig. 4).

In this study it was observed that the head of the BSF is composed of dense hair cover. Also the head of the *H. illucens* is very tightly connected to its thorax, while the mouth is not retracted into the thorax.

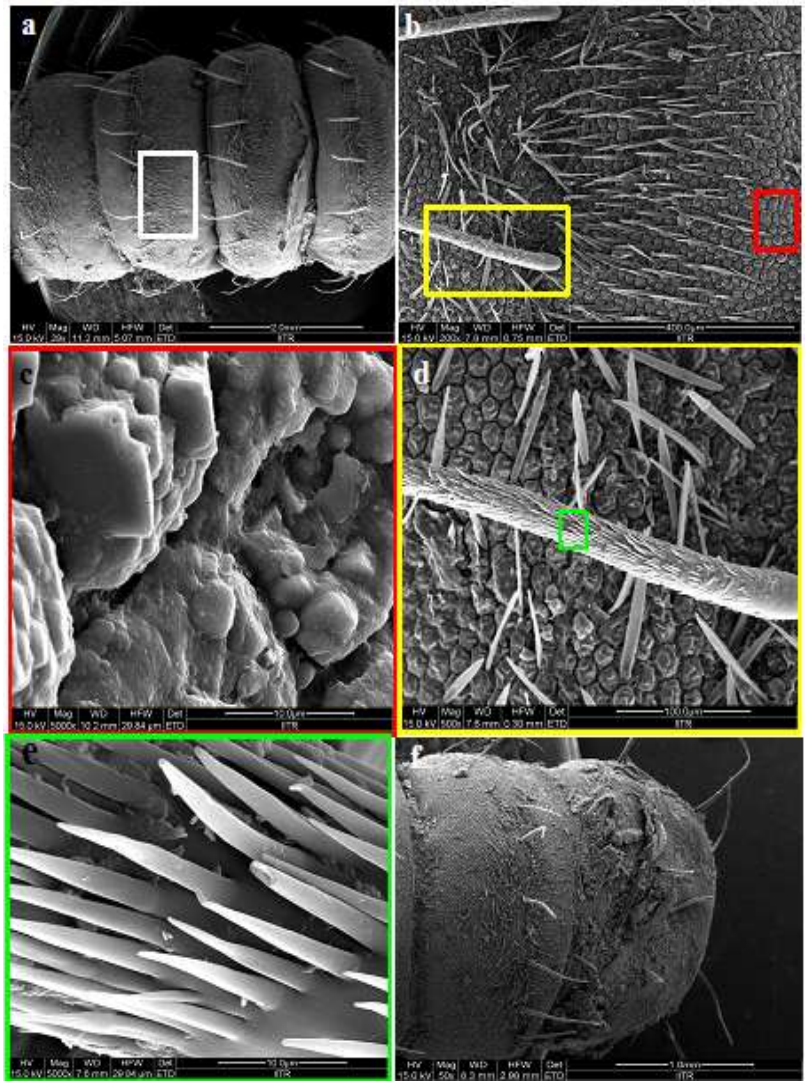

Fig. 4. SEM picture of Wild BSF pupae (a) the Thoraic segments; (b) the hair, covering the thoraic segments; (c) the porous exoskeleton; (d) magnified view of the hair; (e) magnified hair, showing dense hairy cover; and (f) the Thoraic segment

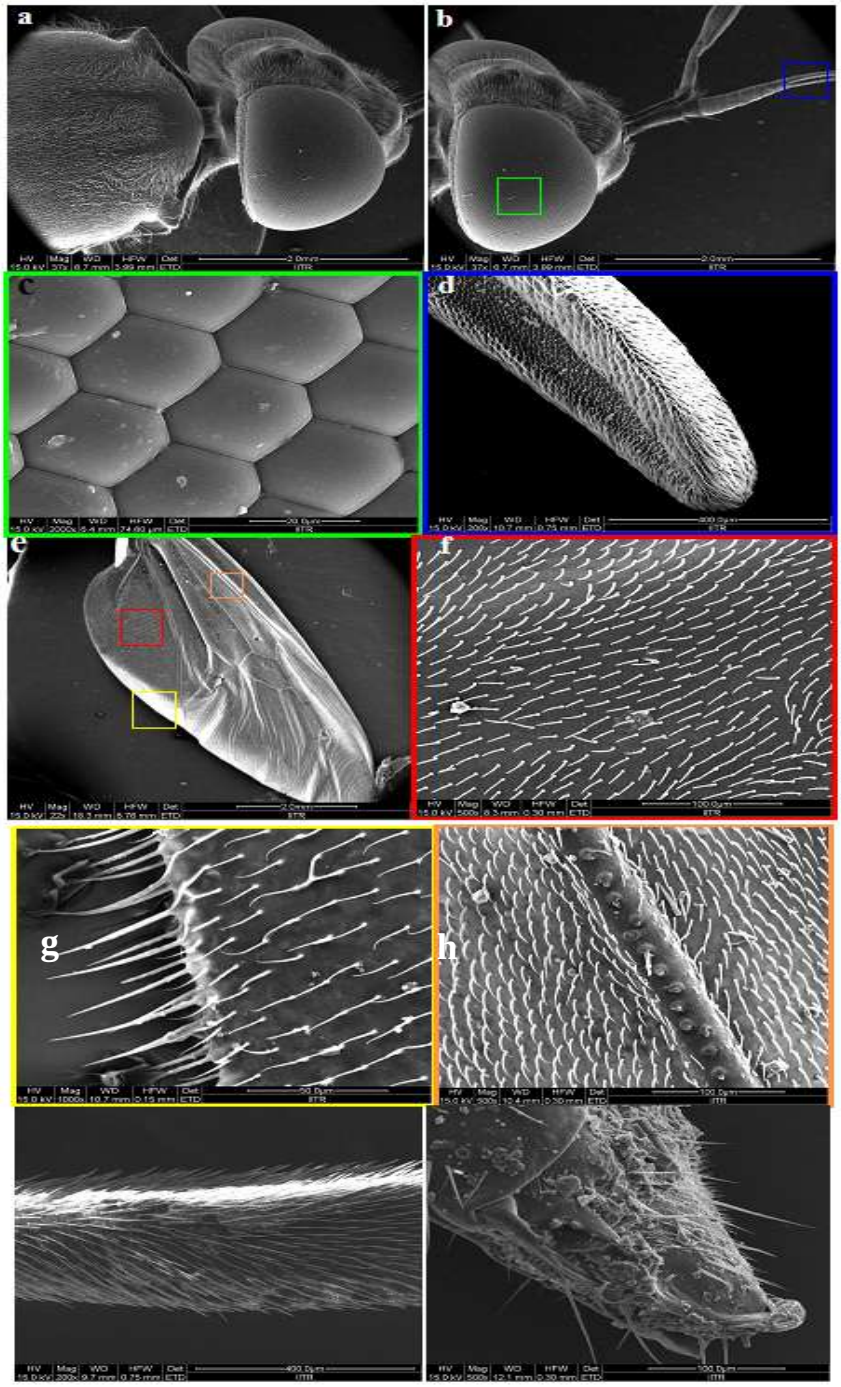

Fig. 5. SEM picture of adult wild BSF (a) the head, compound eye, and Prothorax; (b) compound eye and antannae; (c) magnified view of the compound eye; (d) the antannae; (e) the wings; (f) magnified view of the wings; (g) magnified view of the side edge of wings; (h) magnified view of sub-costa of the wings; (h) magnified view of the legs; and (i) magnified view of female genitalia

Paulk and Gilber (2006) studied the external anatomy and physiological capabilities of Prosternal Organ (PO), i.e. a head posture proprioceptor, located at the base of the neck in *H.illucens* (Fig. 6). They also observed 130 mechanosensory hair sets around the PO, which-they reported- to be determinant in head movement postures of BSF.

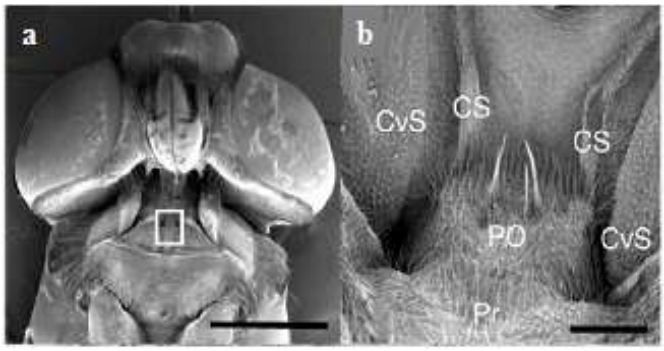

Fig. 6. The prosternal organ in *H.illucens*: (a) SEM of the ventral cervical region of a female *H. illucens*; (b) SEM of the PO region of *H. illucens* (Paulk & Gilber, 2006)

The compound eye showed homogenous hexagons. The magnified image of BSF wings showed dense false hairs on its surface, almost having a curvature in one direction and uniformly distributed throughout the wings. The legs were also found to be extensively covered by long hairs.

CONCLUSION

H. iilucens larvae attained a length of 30mm after 12 days of voracious feeding. The FE-SEM analysis shows that several stages of BSF have a similar attribute of dense hairy morphology. The mouth of the *H. illucens* shows a well-developed mandibular-maxillary complex, resembling the characteristics of scavengers, which makes the insect a suitable candidate for organic waste consumption. The literature describes BSF larvae as a potential agent to turn trash into value added resource in the form of stored protein, fat, and carbohydrate in its body mass. The only challenge in this process is artificial rearing of BSF.

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