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ORIGINAL ARTICLE

STRUCTURE OF PYGIDIAL GLAND AND NOZZLE OF THE BOMBARDIER BEETLE, *Pheropsophus hilaris* (COLEOPTERA: CARABIDAE).

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ABSTRACT

Among invertebrates, especially in arthropods, insects have received much attention in the study of morphology and behavior.In recent years, the functional aspects of insect have attracted more attention the great complexity of morphology and physiology of insects renders then an interesting group of investigation Individually, each insect exhibit an unique way of behavior. Physiology and behavior of insects is a complicated phenomenon and it deals with the structure and functions of various tissue components of the systemThe secretion of *Pheropsophus hilaris* is pungent, volatile and highly suffocative when spelled on the human skin, it causes a burning sensation followed by the formation of blisters and leaves a yellow stain on the skin. In view of this, it has been programmed to study the abdominal structure of *Pheropsophus hilaris.*

Keywords: Suffocative, Pungent, Volatile, *Pheropsophus hilaris,* Complex Morphology, Physiological Behavior, Arthropods.

1.INTRODUCTION

Pheropsophus hilaris is a bombardier beetle of the order Coleoptera and is in the family Carabidae. It is the representative species of its genus. They are often found around on sandy flood plains, rotting wood, stones, bricks, wooden logs, bricks and debris. The adults are nocturnal and primarily carnivores that prey on other insects, particularly crickets (wickler, 1965). They also fed on some plant matter and fruits as well. Dyeing the day they hide under debris such as rocks and logs. Their body and legs appear to be well adopted for the mode of running life. Body is large and elongated black in colour with yellow bands. Head including eyes narrower than Pronotum. Head is rectangular glabrous and shiny (Turner, 1977; 1984). Antennae eleven segmented and inserted between eyes and base of mandibles. Pronotum is graduate yellow and black stripes both in anterior and posterior sides. In male the Proximal three Prostarsal segments are dilated and appear relatively larger than distal segments. In female, all the Prostarsal segments are comparatively of uniform size. The Ovipositors become visible in the female, normally the adult female with a broad abdomen is slightly larger than the male. (Brower et al., 1967; Brower, 1984).

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2.MATERIALS AND METHODS

Adult *Pheropsophus hilaris,* of both sexes, collected from the fields in the vicinity of Annamalai nagar, were used throughout the present investigation. The adult male and female insects are collected from the field were reared in wooden cages measuring 30x33x45 cm in the laboratory at the room temperature 28 ± 2^0c The bottom of the cages was filled up with sand of about 10-15 inches. Since these beetles are living in crevices, brick stones are kept in the cages. To keep the moisture of the soil, water was sprayed regularly at equal intervals of every 12 hours. In order to provide sufficient aeration, the sides of the cages are fabricated with meshes. To allow sufficient light, one side of the cage is covered with glass. *Pheropsophus hilaris* was fed with wet Prawn, Fish meat, Larvae, eggs of pest insects, organic waste matters, dead and decay materials.

Pygidial glands were dissected and dried in vacuum for getting good moisture free specimen was needed. Then the samples were coated-gold with full deposition for 3 minutes using polaron SC 500 sputter coater. Few tungsten line coating was given this coating has given primary to prevent charging samples and clarity of pictures. Then the samples were mounted in stereo scan 440-model electron microscope UK.

The ascertaining voltage given was 20kw and the beam current used was in between 18-25 p.a (pica amperes) notching distance was between 39mm to 1mm. The secondary electron images were taken for all the samples with varied magnifications from 50 x 10,000 (Kotze and Soley, 1990).

3.OBSERVATION AND DISCUSSION

The structure of the defense system of *Pheropsophus hilaris* is complex structure, consisting of two sets of secretary lobes, collecting canals, collecting reservoir, one way valve, sphincter muscles, reaction chamber and nozzles (Eisner et al., 2000). Glands opening in the pygidial or posterior tip of the abdomen of insects are called pygidial glands. This beetle posses paired pygidial glands located posterior – dorsally in the abdomen. These glands open on to the eigth abdominal legume and have no connection with the rectum. The paired secretary lobes connect via long tubes to collecting reservoir, each of which are surrounded by a thin layer of muscle, and joined to a reaction chamber by means of a one – way valve controlled by a sphincter muscle (Behesti and Mecintosh, 2007). The valve itself oscillates Passively, in an automatic fashion it maintains that the collection reservoir, the valve, and the reaction chamber function together to work as a pulse jet , with the spray emitted in pulses.

The beetle does not squeeze the collection reservoir or the sphineter muscle rapidly, but that the beetle applies even, steady pressure on the collection reservoir. Once the muscle around the reservoir squeeze the first amount of reactants through the valve into the reaction chamber, the resulting explosion causes the pressure to rise, rapidly in the reaction chamber, forcing shut the one-way valve (Gullan and Cranston, 2010). The products of the reaction then exit the chamber with a pop and a puff, and the pressure inside the reaction chamber lowers again, falling below the pressure of the collection reservoir, which is still being squeezed by the reservoir muscles. The cycle then repeats itself the valve thus oscillates passively. The pygidial secretion of *pheropsophus hilaris* is pungent, volatile and highly suffocative when spelled on the human skin, it causes a burning sensation and deep stain (Eisner et al., 2006).

The pair of defensive organs consisted of many small synthetic lobes, large reservoirs, collecting ducts from lobes to reservoirs and secretary ducts from reservoirs. The paired duct opened at the last sterna inter segmental membrane (Carton et al., 2008); Strand, 2008; Beckage, 2008). There was species specificity in the reservoir shape, synthetic lobe shape and entering site of the collecting ducts into reservoirs. The spherical shaped lobes produced benzoquinones and short chain fatty acids (Fig – 1).

The paired secretary lobes connect via long tubes to collecting reservoirs, each of which are surrounded by a thin layer of muscle, and joined to a reaction chamber by means of a one-way valve controlled by a sphincter muscle (Gillespie et al., 1997). The valve itself oscillates passively, in an automatic fashion, the collection reservoir, the valve, and the reaction chamber function together to work as a 'pulse jet', with the spray emitted in pulses. Using a microphone, force transducer (piezoelectric crystal), and high-speed cinematography, workers discovered that each discharge (lasting 2.6 to 24.1 ms) consists of 2 to 12 individual pulses, and that they are in reality individual micro-explosions repeating at 368 to 735 pulses per second within the reaction chamber. The beetle does not squeeze the collection reservoir or the sphincter muscle rapidly, but that the beetle applies even, steady pressure on the collection reservoir (Smilanich et al., 2009). Once the muscles around the reservoir squeeze the first amount of reactants through the valve into the reaction chamber, the resulting explosion causes the pressure to rise rapidly in the reaction chamber, forcing shut the one-way valve (God fray, 1994). The products of the reaction then exit the chamber with a pop and a puff, and the pressure inside the reaction chamber lowers again, falling below the pressure of the collection reservoir, which is still being squeezed by the reservoir muscles.

The secretory lobes secrete aqueous hydrogen peroxide and hydroquinones, which are stored in large quantity in the collecting reservoirs. The same cells actually synthesize and separate both the hydrogen peroxide and the hydroquinones (Edmunds, 1994; Evans and Schmidt, 1991). The stored liquids remain in the full reservoirs until needed. When the Beetle is threatened (such as with a bite on the limb) it contracts its collection reservoirs, moving the hydrogen peroxide and hydroquinones into the reaction chamber through the valves (Martin et al., 1989). The reaction chamber is said to be lined with enzyme-secreting structures which produce peroxidases and catylases, although some studies state that oxidases and other enzymes are secreted and stored in the reaction chamber. When the hydrogen peroxide and hydroquinones come into contact with the enzymes, an explosive reaction takes place, yielding water, quinones, heat and gaseous oxygen. The pressure of the free oxygen propels the mixture out of the reaction chamber through the spray nozzle, directed to the target by way of ranges line grooves or spray deflectors (Devries, 1997).

The overall structure of the secretary lobes and collecting canals is said to resemble a cluster of grapes (Fig -1). The stalk being the final collecting canal leading to the collecting reservoir. These authors state that each lobe is essentially a ball of cells which all face inward, aligned radially around a central collecting lumen (Schmidt, 1974; Epstein et al., 1994). Each secretary cell has an elongate secretory vesicle which is almost as long as the cell itself and is centrally located with a 'coated membrane' crowded with microvilli. An efferent cuticular tubule, or duct, leads out of the end of the vesicle towards the center of the secretory lobe. The duct extends past the end of the cell, and through a duct-carrying cell. A duct-carrying cell surrounds the duct, having its plasma membrane between it and the duct, which in turn is surrounded by its own vesicular membrane. Finally, the duct terminates into the central collecting lumen in the middle of the secretory lobe. Subsequent to the collecting lumen, the secretion travels through the collecting canal to the 'stalk', or the main collecting canal of the 'grape bunch,' which will then take the secretion to the collecting reservoir.

Massive striated muscle was found, as anticipated surrounding the storage reservoir, abundant musculature often

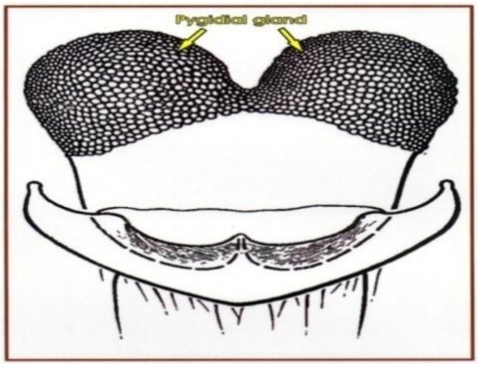

Fig.1 Pygidial gland of *Pheropsophus hilaris*

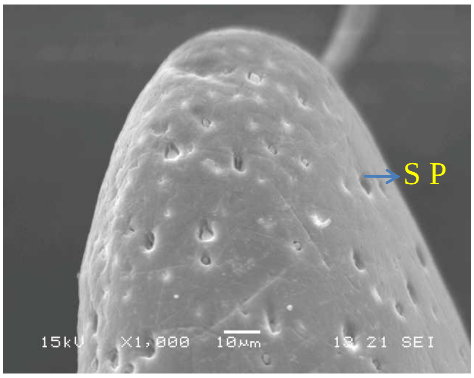

Fig – 2 Nozzle – Dorsal View

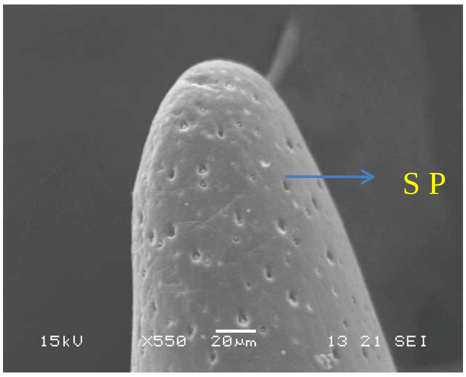

Fig – 3 Nozzle – Dorsal View

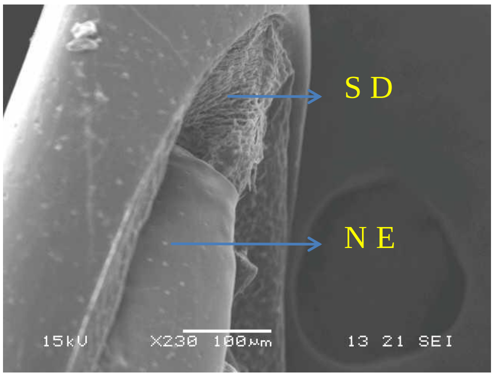

Fig – 4 Nozzle – Ventral View

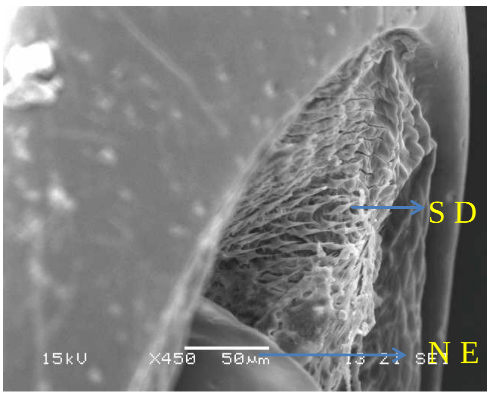

Fig – 5 Nozzle – Ventral View

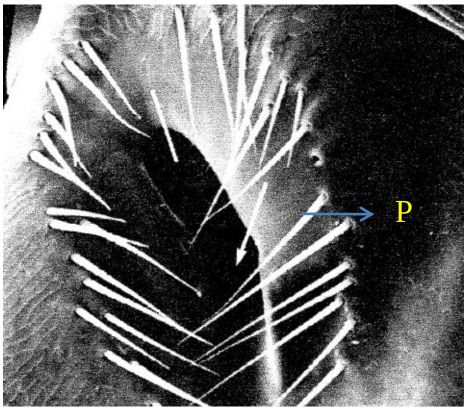

Fig – 6 Nozzle -Ventral View

surrounds various passageways leading from the reaction chamber to the exit nozzle, and these passageways are also very thickly lined with chitin. The abdomen tip was heavily muscled as expected and these muscles extended out to the cuticular deflector plates (Fig – 2 & 3).

Extending from the abdominal tip on either side of the tip are tongue like projections. A large pore is embedded at the tip of the nozzle containing flattened hairs or papillae that extend out of the pores and above the surface of the nozzle (Fig – 6). Additionally, five or more much smaller pores run along the midline of the tongue like nozzle, each with a small papilla extending from the centre of the pore (Fig – 4 & 5

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