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Circulatory System of *Columbicola columbae* Linnaeus (Phthiraptera: Insecta: Ischnocera: Philopteridae) Infesting Blue Rock Pigeon (*Columba livia* Gmelin)

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Abstract: Circulatory system of pigeon slender louse, *Columbicola columbae* (Phthiraptera: Ischnocera) has been studied in greater details. In arthropodan insects, the circulatory system is typically open, with just one closed artery. The heart of *C. columbae* is a straightforward, elongated, and single-chambered organ. At its anterior, middle, and basal regions, it has three pairs of laterally positioned minute ostia. From the body wall to the heart, six sets of alariform muscles—three on the left and three on the right—extend in a fan-like pattern.

Keywords: Circulatory system • *Columbicola columbae* • Phthiraptera • Ischnocera

Introduction

The number and types of haemocytes, developmental stage and physiological state vary with insect species. Haemocytes are blood cells that circulate in a clear fluid, the plasma, within the haemocoel (body cavity) of insects. Seguy (1951) and Eichler (1963) have reviewed the work done on anatomical peculiarities of some mallophagan lice. Anatomy of different organ systems of two amblyceran Phthiraptera *Laemobothrion percnopteri* (Srivastava, 1974) and *Menacanthus eurysternus* (Chandra, 1986) and one ischnoceran poultry louse, *Lipeurus lawrensis tropicalis* (Saxena, 1979) have been studied in greater details.

Morphological features of cerebral and suboesophageal ganglion of *Trimenopon jenninysi* (Stowe, 1943), *Bocivola caprae* (Risler, 1951), *Pseudomenopon pilosum* and *Ornithobius cygni* (Haub, 1967 & 1971) have already been studied. Specific information on digestive and tracheal system of few selected phthirapteran species has been contributed by Haug (1952), Waterhouse (1953), Saxena & Agarwal (1981), Navio*et al.*, (1986), Arya & Singh (2021) and Singh & Arya (2022).

The nature of heart and aorta of few species has been noted by Fulmek (1906) and Saxena & Agarwal (1980a). Only few papers Mayer (1954), Lawrence (1956), Saxena & Agarwal, (1979 & 80b), Agarwal & Saxena, (1981); Singh *et al.*, (1985), Ribeiro & Brehelin (2006), Symmons & Hindle (2010) and Arya (2020) deal with blood cells or circulatory system of phthirapteran ectoparasites.

Workers like, Wigglesworth (1955 & 59), Jones (1962), Vostal (1969), Arnold (1974) and Gupta (1979) have discussed the nature and classification of insect haemocytes.

The present study deals with circulatory system of an ischnoceran pigeon louse, *Columbicola columbae* in greater details.

Material and Methods

Fresh lice were collected directly from experimental hosts (pigeon). In addition, regular supply of lice was secured by maintaining them *in vitro* condition at 35±1^{0}C temperature, 75–90% Relative Humidity and pinfeathers for feeding in incubator. Fine sharp entomological pins (after fabricated by rubbing on fine sandpaper) were used for successful dissection. Both the sexes of lice were dissected under a stereozoom binocular

microscope in Insect Ringer's solution (Ephrussi & Beadle, 1936). To properly differentiate the internal organs, the majority of the fat bodies were removed, and a few drops of aqueous Bouin's fluid were added. Blood films were made from haemolymph drops obtained by cutting the legs or by making an incision in the terga of live, adequately cleaned lice. These drops were used for haemocytological experiments. The films of air-dried blood were either stained directly with Lieshmann's stain, or they were first fixed in methanol before being stained with Giemsa or Wright's stain. However, the smear stained with haematoxylin-eosin and preserved in aqueous Bouin's fluid provided a superior cytological image of the blood cells than the results of using Lieshmann's or Giemsa's stains.

Observations

Circulatory system

Heart: The heart of *C. columbae* is a small, elongated, one-chambered structure that is between 0.16 and 0.18 inches in length and 0.07 and 0.08 inches in diameter. It is located in the last abdominal segment's mid-dorsal area, below the tergum and slightly above the rectum (Fig 1). It continues anteriorly as a long, thin tubular aorta that extends above the gut along the mid-dorsal line and terminates beneath the brain in the head area. Three pairs of laterally positioned minute ostia are found close to the anterior, middle, and basal portions of the heart. From the body wall to the heart, six sets of alariform muscles—three on the left and three on the right—extend in a fan-like pattern (Fig 1).The number of muscle bands in different sets of alary muscles varies from 3-4.

Blood cells: Four types of freely circulating haemocytes viz., prohaemocytes, plasmatocytes, granular haemocytes and oenocytoids (according to the terminology given by Jones, 1965 for *Rhodnius prolixus*) have been identified in smears made from haemolymph of *C. columbae*.

Prohaemocytes: Prohaemocytes cells are round and ovoid in shape and have centrally located intensely basophilic large nucleus. These cells occupy the entire cellular space leaving only scanty cytoplasm which is homogenous and basophilic (Figure 2 A & B). The prohaemocytes are the smallest of the four types of haemocytes and do not show much variation in size (3.1 to 4.8µ).

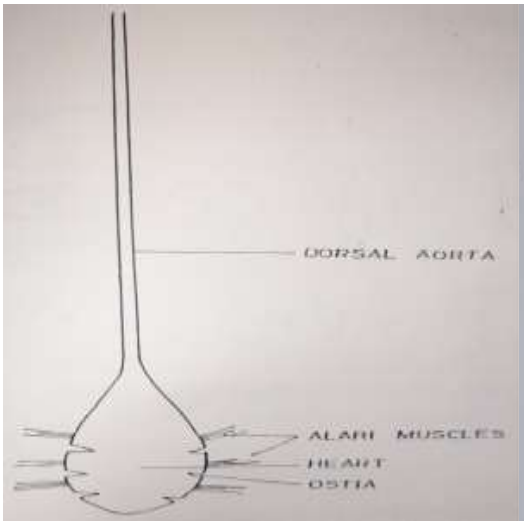

Fig 1

Figure 1: Heart and aorta of *Columbicola columbae,*

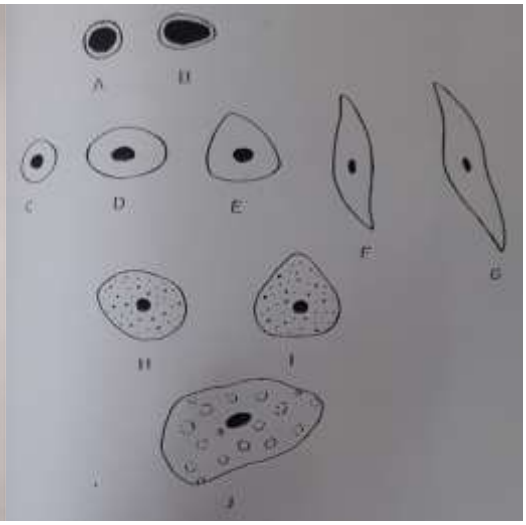

Fig 2

Figure 2: Different types of haemocytes of *Columbicola columbae*

[A – B: Prohaemocytes; C – G: Plasmatocytes; H – I: Granular haemocytes; J: Oenocytoids]

Plasmatocytes: These cells are polymorphic, being round, ovoid pear or spindle shaped. Round to ovoid shaped plasmatocytes outnumber the other types (Figure 2 C to G). Each plasmatocytes has an oval, centrally located, strongly basophilic nucleus and abundant lightly eosinophilic cytoplasm. Sometimes one or two spike-like outgrowths are found extending from the cytoplasm. 2-5 round to oval non refrigerant vacuoles, have also been noticed in the cytoplasm of these cells in some preparations. The size of the plasmatocytes is quite variable (6.8 to 31µ).

Granular haemocytes: Granular haemocytes cells are oval, or pear shaped. Each granular haemocytes have centrally placed, small basophilic nucleus surrounded by eosinophilic cytoplasm that contains prominent basophilic granules (Figure 2 H & I). These cells are smaller than the plasmatocytes and oenocytoids but larger than proheamocytes (4.8 to 9.3µ).

Oenocytoids: The characteristics appearance of oenocytoids is best seen in preparations fixed in acids fixative and stained with haematoxylin and eosin. These cells are more or less ovoid in appearance; contain basophilic nucleus and lightly basophilic cytoplasm which is filled with certain rounded indistinct bodies (Figure 2 J). These cells are comparatively big sized 12-31µ.

Discussion

Columbicola columbae's heart has a rather straightforward bulbous configuration, similar to that of other species studied thus far (Fulmek, 1906; Srivastava, 1974; Saxena & Agarwal, 1980a; Chandra, 1986; Arya, 2020). Six sets of alariform muscles—three pairs in each—support it, but *Menacanthes eurysternus* and *Lipeurus lawrensis tropicalis* are said to have seven sets each (Chandra, 1986). Three pairs of the alariform muscles in *M. gallinae* have been described (Arya, 2020).The nature of prohaemocyte, plasmatocyte, granulocyte of *C. columbae* resemble to that of other species studied so far (Srivastava, 1974; Saxena & Agarwal, 1979; Agarwal & Saxena, 1981; Singh *et al.*, 1985). However, oenocytoids of *C. columbae* differ markedly from that of *L. lawrensis tropicalis* (which are filled with rod shaped crystals) (Saxena & Agarwal, 1980b). The occurrence of adepohaemocytes could not be detected in *C. columbae* (as found in heamolymph of *L. lawrensis tropicalis* (Agarwal & Saxena, 1981). Arya (2020) reported only three types of haemocytes, prohaemocytes, granular haemocytes and plasmatocytes in *M. gallinae*.

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