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Biology and Distribution of *Palaeolindbergiella simlae* (Crawford, 1912) (Hemiptera: Psyllidae) along with its Associations with Ants from Pothwar Region of Pakistan

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ABSTRACT

Psyllids (Hemiptera: Psylloidea) are small *insects* and belong to sucking group of insects. *Palaeolindbergiella simlae* (Crawford, 1912) belongs to this group and is a serious pest of *Bauhinia variegate* Linn. The Genus *Palaeolindbergiella* Heslop-Harrison, 1961 has only 3 species records from the world. Immature stages of this species are 5 which have been described with the help of coloured micro-graphs. Male and female genitalia have been described using line drawings and coloured drawings. Main diagnostic characters, brief description, morphometrics, distribution and illustrations are provided. Biology, trophic associations with 4 ant's species namely, *Camponotus parius, Camponotus compressus*, *Tapinoma melaocephalum, Lepisiota fraunfeldi* have been discussed. Four natural enemies; two species of syrphid flies namely, *Allobaccha apicalis* (Loew, 1858), *Allobaccha sapphirina* (Wiedemann, 1830), two species of Coccinellid beetles, *Coccinella septempunctata* (Coleoptera: Coccinellidae), *Menochilus sexmaculatus* (Fabricius, 1781) and *Chrysoperla carnea* (Stephens, 1836) (Chrysopidae: Neuroptera) were found to be the bio-control agents of *P. simlae*.

INTRODUCTION

Psyllids or jumping plant-lice (Hemiptera: Sternorrhyncha) are phloem-feeding tiny insects belonging to superfamily Psylloidea and can be further classified into eight families: Aphalaridae, Carsidaridae, Calophy-idae, Homotomidae, Liviidae, Phacopteronidae, Psyllidae and Triozidae according to new classification (Burckhardt and Ouvrard, 2012). These tiny creatures are phytophagous pests being sucking insects resulting in galling making, leaf curling and sooty mould development. On other side they are also considered as vectors of many diseases in various crops like citrus, pear, apple, plum, potato, and tomato (Aubert, 1987; Hodkinson, 2009). They have also been used as bio-control agents of mosquitoes and various alien plant species especially against weeds in various parts of the world like mosquito psyllids in Australia (van Klinken *et al*., 2003; Donnelly, 2002) and *Melaleuca* psyllid is being used against its host plant, *Melaleuca quiquenervia* (Paper bark tree, native to Australia but a serious invasive weed tree in Florida). Both adult and immature (Nymph) of pysllids are phytophagous, nymphs secrete honey dew which is feed by various species of bees, ants and wasps (Mathur, 1975). Psyllid species are most common in forest areas and over 100 species have been recorded as feeding on trees and vegetation growing in forest areas (Mathur, 1975). Up till now, 4000 species have been described throughout the world (Li, 2011) and this number has doubled now according to Burckhardt and Ouvrard (2012) but as far as Pakistan is concerned only a little work has been done on exploration of these entities in Pakistan Bodlah *et al*. (2017a, b), Mathur (1973, 1975).

Genus *Palaeolindbergiella* Heslop-Harrison, 1961 was proposed as a subgenus of genus *Lindhergiella* by Heslop-Harrison (1961). Genus *Palaeolindbergiella* Heslop-Harrison, 1961 can be recognized by the combination

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of following characters: Pterostigma of the wing longer and narrower, labium much longer than other member of psyllinae; legs long, well developed and metatarsus with two basal spines (Heslop-Harrison, 1961). According to Ouvrard (2019) 3 species of genus *Palaeolindbergiella* Heslop-Harrison, 1961 has been reported from the world. Out of these, *Palaeolindbergiella primitiva* Heslop-Harrison, 1961 is a type species reported from African region (Heslop-Harrison, 1961). Other two namely, *P. simlae* (Crawford, 1912) and *P. thakrei* (Mathur, 1973) are reported from India (Crawford, 1912; Mathur, 1973). *Palaeolindbergiella simlae* (Crawford, 1912) has been classified under the genus *Psylla*. Currently Burckhardt (2018) revised this species with new combination under genus *Palaeolindbergiella*. Here we report this species for the first time from Pakistan with the description of immatures and adult, trophic associations with ants and natural enemies.

MATERIALS AND METHODS

Adult psyllid collection and identification:

For collection of adult psyllids, wide range surveys were conducted. Different areas of Rawalpindi and Islamabad were visited during February to May for the collection of *Palaeolindbergiella simlae*. Adults were collected with the help of nylon made insect collection nets and preserved in small glass vial, and then preserved in 75% ethyl alcohol. Temporary slides of collected specimens were made and identified under the Labomed microscope. Measurements were done by using stage microscope. Adult specimens were micro-graphed under Labomed microscope (CZS6, Labo America, Inc. USA). LEICA MS 5 (Leica Microsystems (Switzerland) Ltd) microscope attached with Amscope 18 megapixel camera (Amscope, China) was used also for microphotography.

Immature stages collection and identification

Immatures stages of psyllid were also collected preserved in 75% ethyl alcohol. They were processed for identification by methods used by Bodlah *et al*. (2017a). Slide preparation protocal as described by Bodlah *et al*. (2017b) was used. Permanent slides were prepared and observed under Noif (XSZ-107BN). Stage and ocular meters were used for measurement. Illustrations were processed in Helicon Focus 6 and Adobe Photoshope CS6 (Adobe Inc. USA). Lines drawing of taxonomically important parts were also drawn with the help of ocular grid.

Collection of ants and natural enemies

Those ants were collected which were observed stroking Psyllids immatures with their *antennae*, stimulating them to release the honeydew on *Bauhinia variegata* Linn leaves. Ants were collected with aspirator and through hand picking, were killed and preserved in 75 % ethanol in small glass vials. These specimens were identified by using compound microscope and identification keys by Bingham (1903). Adult syrphids, coccinellids and green lacewing were identified by comparing the reference collection of Museum of Department of Entomology, PMAS-AAUR. For confirmation of their role as predators, heavily infested leaves of *Bauhinia variegata* with the attack of Psyllids were brought to the laboratory and they were reared under laboratory conditions up-till emergence of adults of natural enemies.

Palaeolindbergiella simlae (Crawford, 1912) (Figs. 1 and 2)

First nymphal instar (Fig. 1A)

Body ranges from 0.31 to 0.42 mm. Antennae shorts, two-segmented, with one sensorium, rudiments of wing-pads represented by weak projections bearing one short spatulate seta; abdominal margin with seven pairs of small dagger-shaped setae.

Second nymphal instar (Fig. 1B)

Body ranges from 0.48 to 0.53 mm. Similar to the third instar but with small knob-like wing-pads projecting from the body and bearing single spatulate setae at apex. Antennae 3 segmented with one sensorium on the apical segment. Abdominal margin with three pairs of spatulate and four pairs of dagger-shaped setae.

Third nymphal instar (Fig. 1C)

Body ranges from 0.68 to 0.74 mm. Mostly resembles with resembles the fourth stages excepting antennae 3 segmented having two sensoria on terminal segment.

Fourth nymphal instar (Fig. 1D)

Body ranges from 0.99 to 2.4 mm. This instar is similar to fifth instar excepting following characters: smaller than 5th instar; thoracic and abdomen al sclerites as shown; dorsal derm beset with minute points and ring-based spatulate setae; antennae five-segmented with three sensoria, one on third segment and two simple ring-based setae.

Fifth nymphal instar (Fig. 1E)

Body ranges from 1.47 mm to 1.55mm. The wing pads large, project well beyond the contour of the body. Eyes prominent. Dorsum with the derm membranous over some parts of the body, and the wing-pads, a pair of

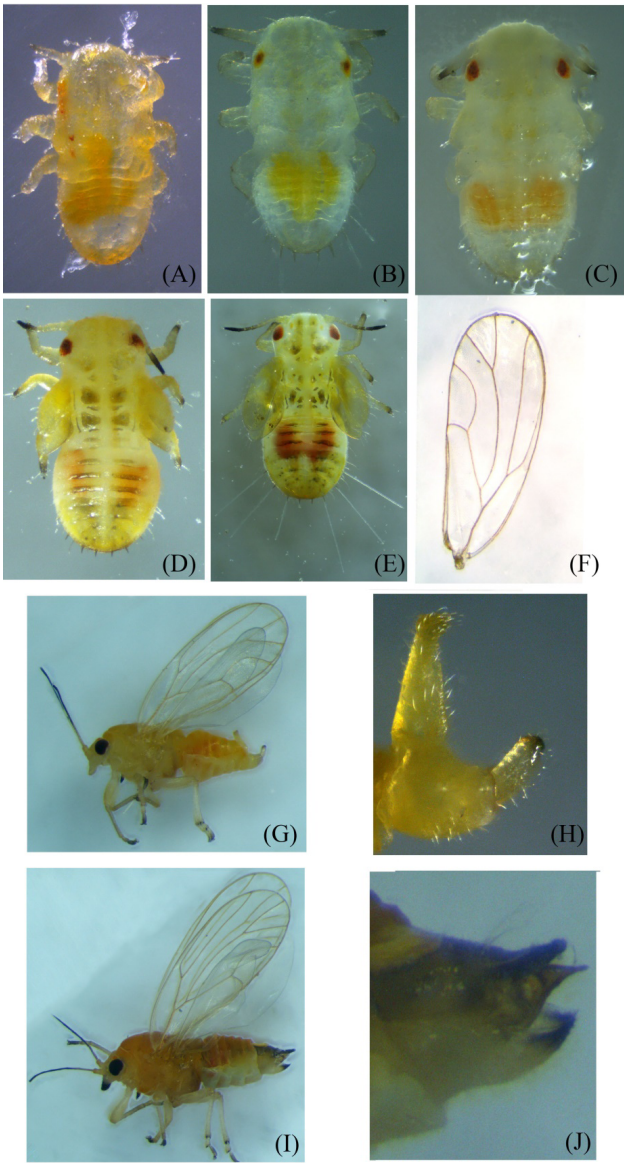

Fig. 1. Morphology of *Palaeolindbergiella simlae;* a, first nymphal instar; b, second nymphal instar; c, third nymphal instar; d, fourth nymphal instar; e, fifth nymphal instar; f, forwing; g, male adult; h, male genitalia; i, female; j, female genitalia.

large head plates between the eyes and almost the whole of the posterior half of the abdomen heavily sclerotized. There are several small sclerites on the thorax and narrow sclerotic plates on the abdominal segments. Derm slightly vermiculate and sparsely beset with minute points which are stouter on the abdomen. Abdomen sclerites and apical plate also bear minute fringed processes. Apical abdomen plates show traces of segmentation, and minute points. Body covered with scattered, simple, ring based setae as well as with spatulate ones, both of various lengths; the latter are also present on the apical margin of head, along the margin of wing-pads and abdomen. Margin of apical plate armed with eight dagger-shaped setae. Wing-pads also bear minute clavate setae. Posterior margins of hind wing-pad with three to four spatulate setae. *Antennae* 0.55 mm long, slender; seven-segmented, bearing simple setae. Four sensoria are present on antennae; one on the 3rd, one on the 5th and two on 7th segment. The 3rd antennal segment has a weak construction at about its middle; the terminal segment imbricate bearing two spines at apex. Legs short and stout, bearing simple setae; without trochanter; with distint tibio-tarsal articulation. Each tarsus with a single golf club seta; claws present. Anal opening set well inside from the apex of abdomen and is surrounded by the outer row of silt-like pores and an inner row of small oval pores.

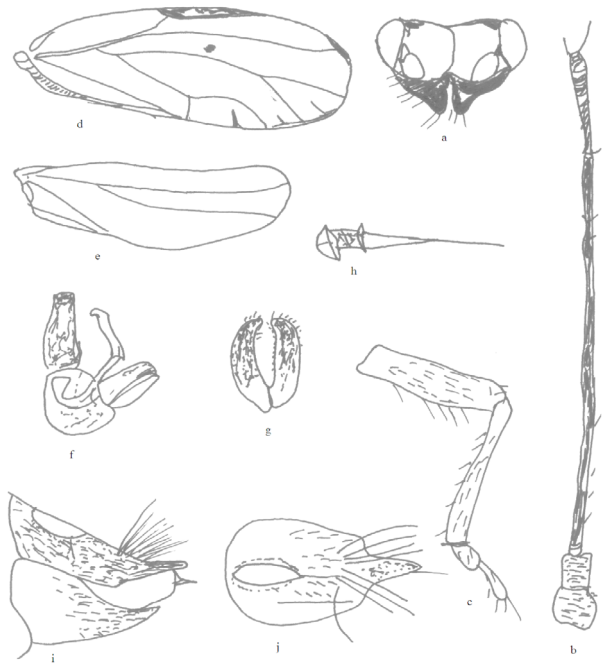

Fig. 2. Morphology of *Palaeolindbergiella simlae;* a, head, frontal view; b, antennae; c, hind leg; d, forewing; e, hind wing; f, male genitalia, lateral view; g, parameres; h, sperm pump; i, female genitalia, lateral view; j, dorsal plate.

Identification characters of adult

Coloration

Body brownish generally, having light brown appearance on head, legs and antennae, however antennal segments black from apex-terminal segments. Genae of head black. Forewing hyaline, clavus with black spot apically.

Structure

Body smaller, head width almost equal to thorax, entirely rugulose, slightly deflexed with sparsed pubescent. vertex of head distinctly broader, median suture slightly swollen, having short foveae laterally, triangular lobes present at posterior-middle, frontal part weakly rounded, posterior margin angulate, having swollen post ocellar region, emarginated anteriorly, genal cone 0.2 mm longer, almost equal to the length of vertex, with longer setae, subacute apically, weakly pubescent along with sparsed hairs allover. Eyes prominent, backwardly directed to thorax.

Antennae longer, 10 segmented with robust segments at base, segment 3rd longest than remaining, two unequal setae present on terminal segments. Thorax more or less arched, reticulate, having sparsed and fine pubescent; prothorax smaller, backwardly sloped, dorsum of prescutum broader, anterior margin narrow, angular at lateral and posterior margin; scutum almost equal to prescutum in length, dorsum more broader than other, lateral and posterior margin angular. Legs having minute lines arranged smoothly, having fine and sparsed setae throughout, tibiae of legs having irregular setae apically, small basal spure present at hind femur, both sides having a pair of spine, apex of hind tarsal having a pair of black spine at basal face. Fore wing hyaline, transparent, membranous, having broad pterostigma, vein R smaller than basal, Cu smaller, about more than ½ longer than R, cells of marginal area are sub equal, 2nd cell shorter and narrow than 1st cell, veins having small setae throughout. Hindwing somewhat longer, having few setae at costal margin. Abdomen small, pubescent, long setae present at sternite.

Male genitalia

Male terminalia in profile quit smaller than abdominal part, straight anteriorly, weakly convex, slendrical, dorsum of terminalia somewhat as pear shaped, paramere longer about 0.20 mm, sparsed setae present at outer face, hypandrium with few setae sparsely, outer face of aedagus small than inner face, having spoon like structure apically.

Female genitalia

Female terminalia pubescent, smaller, dorsum longer than ventral, descending at caudal region, eight hairs present at middle of genital, whilst peg like setae present apically, ovipositor acute tip.

Measurements

Body length, male, 1.43mm; female, 1.50; length of forewings, male,1.96mm; female 1.51; width of head with eyes, 1.97mm; Width of vertex between eyes, 0.38; length of antennae, 1.20mm.

Material examined

Islamabad, 2-iii-18, 17♂ and 12♀; Rawalpindi, 23-iv-18, 7♂ and 5♀; Kahuta,14-iii-18, 7♂ and9♀; Sihala, Islamabad, 27-iv-18, 10♂ and 12♀; Ayub National Park, 8-iv-18, 6♂ and 7♀; Rawalpindi, 10-iii-18, 11♂ and 8♀; Morgah Biodiversity Park, 22-iii-18, 8♂ and 12♀; Rawalpindi, 9-iii-18, 5♂ and 10♀; Nawaz Sharif Park, 30-iii-18, 4♂ and 9♀; Rawalpindi, PMAS AAUR, 5-iii-18, 7♂ and 9♀; Shahdra Valley, 20-iv-18, 16♂ and 9♀; Islamabad, F-9 Park, 23-iv-18, 7♂ and 5♀; Islamabad, Kachnar Park, Islamabad, 20-iii-18, 8♂ and 4♀.

Host plant

On young and fresh leaves and inside flower buds of *Bauhinia variegata* Linn.

Distribution

India (Hodkinson, 1983, 1986): Meghalaya (Lahiri and Biswas, 1990), West Himalaya (Mathurn, 1975) and Pakistan (Current studies as new record from Pothwar region of Pakistan).

Trophic association with ants

Kachnar Park, Islamabad, 20-iii-18, 8♂ and 4♀ (*Camponotus compressus*, *Tapinoma melaocephalum*); Islamabad, F-9 Park, 23-iv-18, 7♂ and 5♀ (*Lepisiota fraunfeldi*, *Camponotus compressus*); Ayub National Park, 8-iv-18, 6♂ and 7♀ (*Camponotus compressus*, *Tapinoma melaocephalum, Lepisiota fraunfeldi*); Rawalpindi, PMAS AAUR, 5-iii-18, 7♂ and 9♀ (*Camponotus parius, Camponotus compressus*, *Tapinoma melaocephalum, Lepisiota fraunfeldi*).

Bio-control agents

Two species of syrphid flies namely, *Allobaccha apicalis* (Loew, 1858), *Allobaccha sapphirina* (Wiedemann, 1830), two species of Coccinellid beetles, *Coccinella septempunctata* (Coleoptera: Coccinellidae), *Menochilus sexmaculatus* (Fabricius, 1781) and *Chrysoperla carnea* (Stephens, 1836) (Chrysopidae: Neuroptera) were found to be the bio-control agents of *P. simlae*.

Biology

This species found to be infesting fresh young buds, leaves and flowers. Leaves became sickly and eventually succumb to the attack. Flowers shriveled and drop to the ground. Leaves and flowers shrivel. Heavy infestation resulted in dwarf and stunted young plants.

DISCUSSION

Specimens collected from Pakistan were compared with published description by Mathur (1973) and found to be similar.

Various aphid species have been reported in association with *Camponotus compressus* (Mortazavi *et al*., 2015). Shiran *et al*. (2013) mentioned *Lepisiota fraunfeldi* to be in mutualistic associations with various aphid species. *Tapinoma melaocephalum* have been renowned as to be in association with aphids (Zhang *et al*., 2012; Mortazavi *et al*., 2015). Mortazavi *et al*., 2015 reported *Camponotus parius* as to be in mutualistic association with aphids. Here we report four species of ants in association with *Palaeolindbergiella simlae* (Crawford, 1912).

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Statement of conflict of interest

The authors have declared no conflict of interest.

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