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Two reared species of the genus *Aprostocetus* (Hymenoptera: Eulophidae), parasitic on gall forming psylloid *Pauropsylla ficicola* Kieffer infesting *Ficus auriculata* Lour. in Uttarakhand, India

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Abstract

This study was mainly conducted to assess the diversity of Eulophids and their host-parasite relationships. Two species of Genus *Aprostocetus* Westwood (Hymenoptera: Eulophidae: Tetrastichinae) have been discovered from Shitlakhet, Almora, India. Many species of the subgenus *Aprostocetus* are primary parasitoids of hosts in plant galls produced by various gall forming insects. Both the reported tetrastichine wasps were parasitizing to a gall forming psylloid, *Pauropsylla ficicola* Kieffer causing leaf galls on *Ficus auriculata* Lour. *P. ficicola* Kieffer is a very serious pest of this economically important tree. During the taxonomic investigation authors came across with two species of the Genus *Aprostocetus* emerged from the leaf galls in which one species is identified and redescribed as *Aprostocetus ficicolae* Singh and other one is described as *A. Shitlakhetensis* sp. nov. Which is new to Biological Science. This new species was distinguished from other allied species of the Genus *Aprostocetus* by various morphological characters. For the healthy production of fruits and leaves of *Ficus auriculata*, these two species of parasitic wasps could be used to manage the infestation caused by this pest.

Keywords: Hymenoptera, chalcidoidea, eulophidae, tetrastichinae, *Ficus auriculata* Lour

1. Introduction

The Eulophid subfamily Tetrastichinae (Hymenoptera: Eulophidae) is one of the largest and economically important of all parasitic wasps. These are widely dispersed most of the all terrestrial ecosystems. They have very significant roles in insect pest management or biological control of insect pests. Currently the Indian fauna associated to 34 genera and 272 species belongs to Tetrastichinae [1]. Genus *Aprostocetus* Westwood is largest of subfamily Tetrastichinae with 809 species reported worldwide [2].

This study was mainly conducted to assess the diversity of Eulophids particularly Tetrastichinae wasps from leaf galls of *Ficus auriculata* Lour. During the taxonomic investigation authors came across with two species of the genus *Aprostocetus* emerged from the leaf galls in which one species is identified as *Aprostocetus ficicolae* Singh and redescribed, and other one is described as *A. shitlakhetensis* sp. nov., which is new to Biological Science. This new species was distinguished from other allied species of the genus *Aprostocetus* by various morphological characters. Both Tetrastichinae wasps were parasitizing to the gall forming psylloid *Pauropsylla ficicola* Kieffer which was causing leaf galls on *Ficus auriculata*. *Pauropsylla ficicola* is a very serious pest of this economically important tree. For the healthy production of fruits and leaves of *Ficus auriculata*, these two species of parasitic wasps could be used to manage the infestation caused by this pest.

2. Materials and Methods

Infested galled leaves of *Ficus auriculata* were collected from the Shitlakhet (29°33'42.30"E 29°34'50.35" N), Almora, India during May, 2018 and then these infested leaves were brought to the laboratory for rearing and kept in glass containers covered with muslin cloth. Then, the collection was observed for the emergence of parasitoids daily. After emergence, the parasitoids were collected in 70-75% ethanol with the help of aspirator or sharp brush.

Procedure prescribed by Noyes [3] for preparing permanent slides was followed to observe the taxonomic character. Olympus Magnus MSZ-TR (Binocular Stereo Microscope) was used to take various photographs and Olympus Trinocular Research Microscope Model- CX-31-Tr with drawing tube attachment was used for the drawing.

Terminology and abbreviations used in this paper have been adopted from Gibson [4] Abbreviations are: POL, postocellar length; OOL, ocellar length; F1, funicle segment 1; F2 funicle segment 2; F3 funicle segment 3; SMV, submarginal vein; MV, marginal vein; PMV, postmarginal vein; SV, stigma vein. All measurement in millimeter (mm) was used.

3. Results

Aprostocetus Westwood

Aprostocetus Westwood, 1833: 444. Type species, *Aprostocetus caudatus* Westwood, by monotypy.

Description of new species

Aprostocetus shitalakhetensis sp. nov.

(Plate A, Figs. 1-20)

Diagnosis.

Description. Female: Body length about 2.45 mm; body colour black; head black, ocelli yellow and eyes red; antennae scape pale yellow and other part brown; vertex having a yellow crescent shaped spot which is touching to mid ocelli, Thorax black, pronotum black, legs yellow except coxae black and part yellow; gaster black (Plate A, Fig. 9).

Head (Plate A, Fig. 1, 12, 14): Wider than long in frontal aspect (0.535: 0.46), smooth sparsely setose, head frontal grooves present restricted well before the torulus; ocelli arranged in obtuse angled triangle; POL 2X as long as OOL; compound eyes bulged, large and smooth, eyes orbit round, facets uniform in shape and size; antennal toruli situated well above the lower level of eyes margin, prominence between antennal toruli less than the width of frons between eyes (0.06: 0.29); malar sulcus straight, grooved and prominent; malar space smooth longer than eye width (0.17: 0.135); mandibles tri dentate, lower margin of clypeus bilobed.

Antennae (Plate A, Fig. 2): Eight segmented excluding 4 anellus, apical tip of antenna with long spicula, antennal formula 11433; scape cylindrical, 3.7X as long as wide (0.55: 0.15) extending above the vertex; pedicel setose sparsely, 2.1X as long as wide (0.25: 0.12) and less than to the length of FSI, funicle 3 segmented, FS1 to FS3 gradually decreasing in length, FS1 2.6X as long as wide (0.34: 0.13), FS2 2.1X as long as wide (0.30: 0.14), FS3 2X as long as wide (0.28: 0.14), club 3 segmented, 3.6X as long as wide (0.57: 0.16), less than length of preceding two funicle segments combined.

Thorax (Plate A, Fig. 3, 17): Pronotum with a hairy ridge on posterior margin, anterior margin concave in the middle; mesoscutum 1.25X as long as wide (0.55: 0.44); mesoscutum having 4 pairs of adnotaular setae, notauli complete, distinct and deep, median longitudinal grooves present; axilla angulately advanced; scutellum slightly convex and hairy, shorter than mesoscutum, 1.25X wide as long (0.27: 0.34) with median longitudinal grooves and 2 pairs of setae on

scutellum, grooves deep, straight and having outward curvature at anterior margin; dorsellum sculptured, convex and 3X as long as wide; metanotum narrow; propodeum with median carina and without paraspiracular carinae, propodeal spiracles rounded and touching to the anterior margin of propodeum spiracle rim fully exposed.

Fore Wings (Plate A, Fig. 4): 2.7 times as long as wide (2.4: 0.9), densely setose; costal cell long and broad with a row of setae; SMV with 4 Setae directed upwards, SV (0.13) and MV (0.77); PMV rudimentary; SV long (0.135), MV 5.9X longer than the length of SV.

Fore Legs (Plate A, Fig. 5): coxa 2.1X as long as wide (0.29: 0.14), 2.6X longer than fore trochanter; femur 5.8X long as wide (0.41: 0.07), almost equal to tibia in length; fore tarsus shorter than length of tibia (0.35: 0.42), TS1 shorter than next two tarsal segments (0.08: 0.26), TS1 longer than tibial spur length, tarsus pale yellow except TS4 dark brown.

Mid Legs (Plate A, Fig. 6): coxa 1.4X long as wide (0.20: 0.14), 1.4X longer than mid trochanter; femur 5.5X long as wide (0.44: 0.08), shorter to tibia in length; mid tarsus shorter than length of tibia (0.39: 0.635), TS1 shorter than next two tarsal segments (0.1: 0.19), TS1 shorter than mid tibial spur length, tarsus pale yellow except TS4 dark brown.; mid tibial spur longer than fore and hind tibial spur.

Hind Legs (Plate A, Fig. 7): coxa 1.3X as long as wide (0.25: 0.19), 1.9X longer than hind trochanter; femur 4.2X as long as wide (0.55: 0.13), less than to tibia in length; hind tarsus shorter than length of tibia (0.45: 0.65), TS1 shorter than next two tarsal segments (0.125: 0.22), TS1 longer than tibial spur length, tarsus pale yellow except TS4 dark brown.

Gaster (Plate A, Figs. 8, 19, 20): Gaster large, surface smooth, sparsely setose at the posterior end of gaster, sessile, longer than mesosoma; ovipositor sheath slightly exerted; first valvifer semicircular, anterior margin of basal part of second valvifer much curved; third valvulae movably articulate with second valvifer, more than 14.25 times as long as wide (0.59: 0.04), less than 1.9X the length of second valvifers (1.15).

Etymology: Species "*shitalakhetensis*" is named after place of collection "Shitalakhet" Almora Uttarakhand.

Male: Known but not described.

Holotype: ♀ (after taking photographs dissected and mounted on a slide under cover slip). INDIA: Almora, Shitalakhet 24.iv.2018: Vishal Kumar (from galled leaves sent by Vibha Bisht); ex psyllid *Pauropsylla ficicola* (Hemiptera: Trioziidae) forming leaf galls on *Ficus auriculata*. Holotype. Hym. Eulo. Nr AS 2001 (Vishal Kumar).

Paratype: 28 ♀♀ same data as Holotype. Hym. Eulo. Nr AS 2001 (Vishal Kumar).

Remarks: The current species i.e. *A. shitalakhetensis* is allied to *A. malloticalae*, but distinguished in various characters viz.

	<i>A. shitlaketensis</i>	<i>A. mallocticolae</i>
Dorsellum	Black or light brown (Plate A, Fig. 10)	Pale yellow
Ocelli	Pale yellow (Plate A, Figs. 11, 13)	Red
Setae	4 adnotaular setae on mesoscutellum (Plate A, Fig. 3, 17)	6 adnotaular setae on mesoscutellum
Callus	With 3 long setae	With 4 long setae
Submarginal vein of forewing	With 4 setae (Plate A, Fig. 4)	With 6-7 setae
Funicle segment	First funicle segment longest (Plate A, Figs. 2, 15, 16)	Second funicle segment longest
Paraspiracular carina	Not well developed (Plate A, Figs. 3, 18)	Well developed
Scape	3.7X as long as wide (Plate A, Fig. 2)	5X as long as wide
Forewing	2.7X long as wide (Plate A, Fig. 4)	2.27X long as wide
Scutellum	Hairy scattered sparsely (Plate A, Fig. 3)	Sculptured

Redescription of species

Aprostocetus ficicolae Singh (Plate B, Figs. 1-20)

Diagnosis. The current species is belongs to the subgenus *Aprostocetus* as per Graham ^[5]. The species is *Aprostocetus ficicolae* as per Singh ^[6].

Female: Body length about 4.75 mm; body colour black; head black, ocelli pale yellow and eyes red; antennae scape pale yellow, other parts brown; Thorax black, legs yellow except coxae black; gaster black (Plate B, Fig. 9).

Head (Plate B, Fig. 1, 10, 11, 12, 13): Wider than long in frontal aspect (0.55: 0.62), sparsely setose, head frontal grooves present inverted Y in shape; vertex setae short sparse; ocelli arranged in obtuse angled triangle; POL 1.7X as long as OOL; compound eyes bulged, large, smooth, eyes orbit round; antennal toruli situated well above the lower level of eyes margin; malar sulcus straight, prominent malar space smooth; mandibles 3 dentate; lower margin of clypeus bilobed.

Antennae (Plate B, Fig. 2, 14): 8 segmented excluding 3 anellus, apical tip of antenna with small spicula, antennal formula 11333; scape cylindrical 4.3X as long as wide (0.64: 0.15), scape apex not above the vertex; pedicel sparsely setose, 1.9X as long as wide (0.25 : 0.13) and less the length of the FS1; funicle 3 segment, FS1 to FS3 gradually decreasing in length, FS1 5X as long as wide (0.70: 0.14), FS2 4.4X as long as wide (0.53: 0.12), FS3 3X as long as wide (0.45: 0.15); club 3 segmented, 3.6X as long as wide (0.62: 0.17) less than preceding two funicle segments combined.

Thorax (Plate B, Fig. 3, 15, 17): Mesoscutum 1.2X as wide as long (0.52: 0.42); mesoscutum having 4 pairs of adnotaular setae, notauli complete, distinct, deep, median longitudinal grooves present; axilla angulately advanced; scutellum slightly convex, shorter than mesoscutum, 1.1X times as wide as long (0.32: 0.29) with median longitudinal grooves and 2 pairs of setae situated; scutellum grooves deep straight having outer curvature at anterior margin; dorsellum smooth, convex and 2.3X as long as wide; metanotum narrow; propodeum with median carina and without paraspiracular carinae, propodeal spiracles rounded, large and touching to the anterior margin of propodeum.

Fore Wings (Plate B, Fig. 4): 2.6X as long as wide (2.84: 1.09); costal cell long, broad with a row of setae; SMV with 4

setae directed upwards, SV (0.13) and MV (1.21); PMV rudimentary; MV 9.3X longer than the length of SV.

Fore Legs (Plate B, Fig. 5): 2.9X as long as wide (0.41: 0.14), 3.1X longer than fore trochanter; femur 6.3X as long as wide (0.57: 0.09), less than to tibia in length; fore tarsus shorter than length of tibia (0.44: 0.67), TS1 shorter than next two tarsal segments (0.135: 0.22), TS1 longer than tibial spur length, tarsus pale yellow.

Mid Legs (Plate B, Fig. 6): coxa 1.1X as long as wide (0.21: 0.19), 1.4X longer than mid trochanter; femur 7.4X as long as wide (0.67: 0.09), less than to tibia in length; mid tarsus shorter than length of tibia (0.55: 0.97), TS1 shorter than next two tarsal segments (0.18 : 0.28), TS1 longer than tibial spur length, tarsus pale yellow except TS4 brown; mid tibial spur much longer than fore tibial spur but shorter than hind tibial spur.

Hind Legs (Plate B, Fig. 7): coxa 2.2X as long as wide (0.495: 0.225), 2.9X longer than hind trochanter; femur 5.5X as long as wide (0.77: 0.14), less than to tibia in length; hind tarsus shorter than length of tibia (0.63: 1.055), TS1 shorter than next two tarsal segments (0.22: 0.3), TS1 longer than tibial spur length tarsus pale yellow except TS4 brown.

Gaster (Plate B, Figs. 8, 19, 20): Gaster large, smooth sparsely setose at the posterior end of gaster; sessile, metasoma longer than mesosoma; ovipositor sheaths highly exerted; first valvifer semicircular; anterior margin of basal part of second valvifer much or large curved; third valvulae movably articulate with second valvifer, more than 22.5X times as long as wide (1.8: 0.08), 1.1X the length of second valvifers (1.6); hypopygium reaching to more than half of gaster length.

Male: Known but not described.

Material Examined: 20 ♀♀, (1 ♀ after taking photographs dissected and mounted on a slide under cover slip). INDIA: Almora, Shitlaket 24.iv.2018: Vishal Kumar (from galled leaves sent by Vibha Bisht); ex psyllid *Pauropsylla ficicola* (Hemiptera: Triozidae) forming leaf galls on *Ficus auriculata*. Hym. Eulo. Nr AS 2003 (Vishal Kumar).

Remarks: The species is identified and redescribed as *Aprostocetus ficicolae* Singh but it have some intraspecific variations in characters.

	Material Examined	<i>A. ficicolae</i>
Setae	4 adnotaular setae on mesoscutum (Plate B Fig. 3, 16).	5 adnotaular setae on mesoscutum
Callus	Callus with 8 setae (Plate B Fig. 3).	With 4-5 long setae
Paraspiracular carina	Paraspiracular carina not developed (Plate B Fig. 3, 18).	Well developed
Spur	Spur of mid tibia is shorter than basitarsus (Plate B Fig. 6).	Spur of mid tibia about 0.7X as long as basitarsus

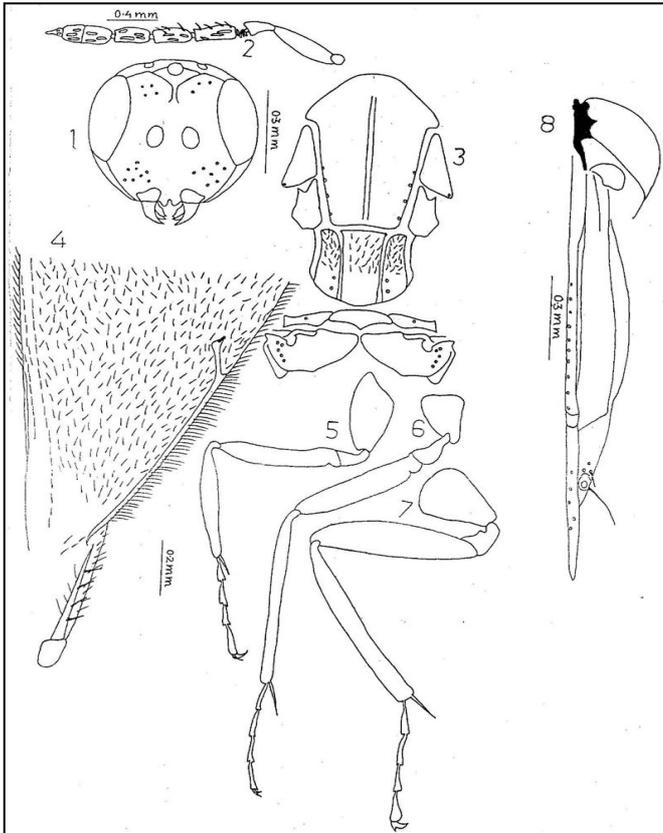


Plate A (Figs. 1-20): 1- Head (dorsal view), 2- Antenna, 3- Thorax (dorsal view), 4- Fore wing, 5- Fore leg, 6- Mid leg, 7- Hind leg, 8- Female genitalia.



Plate A (Figs. 1-20): 9- Female Habitus, 10- Whole body dorsally (without wings), 11- Head frontal vertex (before dissecting), 12- Vertex (after bleaching), 13- Vertex (before dissecting), 14- Head frontal view, 15- Antenna, 16- Head and antenna (after bleaching), 17- Thorax dorsally, 18- Thorax laterally, 19- Abdomen dorsally, 20- Abdomen ventrally.



Fig 21: Leaf galls of *Ficus auriculata*.

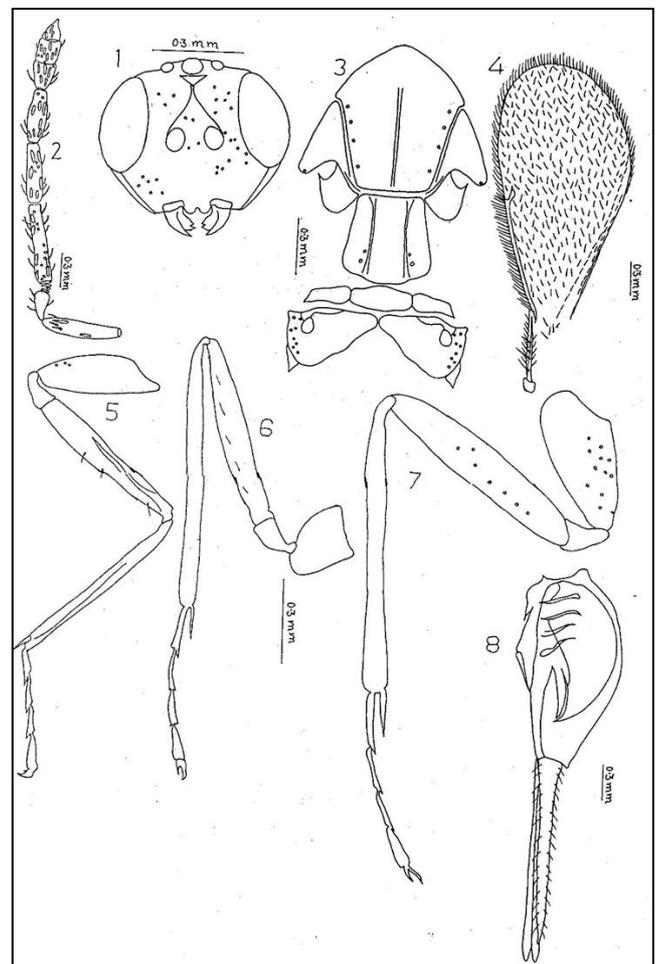


Plate B (Figs. 1-20): 1- Head, 2- Antenna, 3- Thorax dorsally, 4- Forewing, 5- Fore leg, 6- Mid leg, 7- Hind leg, 8- Abdomen laterally.

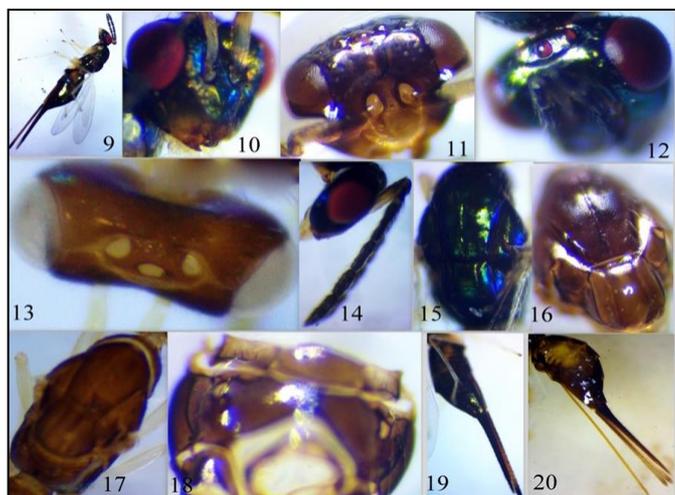


Plate B (Figs. 1-20): 9- Female habitus, 10- Head frontal view (before dissecting), 11- Head frontal view (after dissecting), 12- Vertex (before dissecting), 13- Vertex (after dissecting), 14- Antenna, 15- Thorax dorsally (before dissecting), 16- Thorax dorsally (after dissecting), 17- Thorax dorsally (after bleaching), 18- Propodeum (after dissecting), 19- Abdomen (before bleaching), 20- Abdomen (after bleaching).

4. Conclusion

As per Singh ^[6] nine parasitoids species of genus *Aprostocetus* are defined from psylloids worldwide which are: *Aprostocetus phytolymae* Risbec (1947), *A. salebrosus* Robinson (1962), *A. trichionotus* Robinson (1962), *A. roseveari* Ferriere (1931), *A. indicus* Ozdikmen (2011), *A. gelastus* (Burks 1943), *A. psyllaephagus* (Burks 1963), *A. niger* (Girault 1913) and *A. essugonjaev* Triapitsyn (2015). Two species *A. ficicola* Singh and *A. malloticolae* Singh were recorded from psylloids ^[6]. Another new species *Aprostocetus doonensis* Singh was described from midge ^[2]. In this study authors described the species *Aprostocetus shitalakhetensis* sp. nov. and redescribed *A. ficicola* Singh from psylloids.

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