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An updated key to the Identification of the genera of Euphorinae (Braconidae: Hymenoptera) of Khyber Pakhtunkhwa province of Pakistan

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Abstract
Euphorinae is a moderately diverse subfamily of Braconidae. Euphorines are important parasitoids of adult hemimetabolous and Holometabolous insects. The present research is based on the euphoria specimens present in the entomological collection of The University of Agriculture, Peshawar. The specimens were collected from different areas of Khyber Pakhtunkhwa province during 1994-2013. The study revealed the existence of 11 genera in the province. These genera are: *Aridelus* Marshall, *Centistes* Haliday *Dinocampus* Foerster, *Ecclitura* Kokujev, *Microctonus* Wesmael, *Peristenus* Foerster, *Streblocera* Westwood, *Cosmophorus* Ratzeburg, *Leiophron* Nees, *Marshiella* Shaw and *Wesmaelia* Foerster. An illustrated key to the identification of these genera is presented.

Keywords: Hymenoptera, Braconidae, Euphorinae, Taxonomy, Key.

1. Introduction
The braconid subfamily Euphorinae is cosmopolitan in distribution. These wasps are generally yellow, yellowish brown or black in colour. Euphorines are small in size ranging from 1 to 6 mm. The petiolate metasoma, short marginal cell, two to three cubital cells (usually 2), the open brachial cell in the forewing and the presence of a single subapical row of setae on metasomal terga will readily separate euphorines from other braconidae [1].
Euphorinae is a moderately diverse group with 54 (sub) genera [2] and 1000 valid species in the world [3]. Members of the subfamily are koinobiont endoparasitoids of adults and immature stages of Coleoptera, Diptera, Hymenoptera, Lepidoptera, Neuroptera, Psocoptera and Heteroptera thus making it a subfamily with a very broad host range as compared other braconidae [1-4]. The broad host range and the behaviour of parasitizing the adult insects make euphorines better dispersers [5].
Euphoria wasps have been used for the biological control of plant feeding bugs [1] and beetles [6]. Several species of *Peristenus, Leiophron* and *Microctonus* have been used for the control of lygus bugs [7], mirid bugs [8] and Sitona weevils [9].
Important contribution to the systematics of Euphorinae includes [1] who conducted a comprehensive phylogenetic study and recognized nine tribes. He also provided key to the identification of world genera of Euphorinae. Achterberg [10] recognized four tribes while [11] classified the group in to 14 tribes [1, 4]. Recognized Meteorinae, Neoneurinae and Blacinae as separate subfamilies, however some authors [12, 13] broadly characterized Euphorinae and place *Meteorus, Blacus* and neoneurine genera under Euphorinae.
Knowledge on the taxonomy of Euphorinae of Pakistan, especially from Khyber Pakhtunkhwa province is limited. Work on euphorines started when [14] discovered the first euphoria genus *Microctonus* from the province. In [5] reported six genera: *Aridelus* Marshal, *Centistes* Haliday, *Dinocampus* Foerster, *Ecclitura* Kokujev, *Microctonus* Wesmael and *Peristenus* Foerster and presented the first key to the euphorine genera of Khyber Pakhtunkhwa. [15] Discovered another genus *Streblocera* Westwood thus raising the number of genera to seven and presented a revised key [16]. During her study on euphorines recorded four more genera: *Cosmophorus* Ratzburg, *Leiophron* Nees, *Marshiella* Shaw and *Wesmaelia* Foerster raising the number of genera to 11, but did not present a revised key. The discovery of four more genera necessitates the construction of a revised key to facilitate insect taxonomists, museum workers and biocontrol specialists working on euphorines. In the present paper an illustrated and updated key to all the known euphorine genera of Khyber Pakhtunkhwa province and adjoining areas is presented.

Materials and Methods

The study is based on the euphorine specimens present in the entomological collection of The University of Agriculture, Peshawar. These specimens were collected by sweep net, malaise traps and rearing of hosts during 1994-2013. All the Hymenoptera collection was sorted out and euphorines were separated. Fresh collection from different areas of the province was also done.

Specimens were examined under a stereo-zoom trinocular microscope (SMZ 745 M) with 300X magnification. Images were taken with a 5.01MP camera fitted on microscope. Line drawings were also drawn where needed.

Identification of the specimens was done with the help of keys and descriptions [1, 2, 4, 15]. Terminology followed in this paper is that of [4].

All the identified specimens have been deposited in Insect Museum of the Department of Entomology, The University of Agriculture, Peshawar.

Results

The proposed key is constructed for the identification of *Aridelus* Marshall, *Centistes* Haliday *Dinocampus* Foerster, *Ecclitura* Kokujev, *Microctonus* Wesmael, *Peristenus* Foerster, *Streblocera* Westwood, *Cosmophorus* Ratzeburg, *Leiophron* Nees, *Marshiella* Shaw and *Wesmaelia* Foerster. The specimens were collected from different ecological zones of Khyber Pakhtunkhwa Province and the adjoining areas. The key will work for the euphorines of Khyber Pakhtunkhwa and the adjoining areas.

Key to the known genera of Euphorinae of Khyber Pakhtunkhwa and adjoining areas

1 Vein r-m on fore-wing present, thus second submarginal cell present (Fig. 1); terminal flagellomere apically with a spine, ovipositor shortly exerted ……..…….. ***Aridelus*** Marshall

1’ Vein r-m on fore wing absent, thus second submarginal cell absent (As in Figs. 2, 3, 4, 5); ……..…..…..…..… 2

2 (1’) Scape more than 7X longer than its greatest width (Figs. 8,13) ….…….…….…….…… 3

2’ Scape 3X or less than 3X longer than its greatest width (as in Fig. 9) ...…….……..…… 4

3 (2) Antenna raptorial, geniculated twice, scape with a basal blunt horn, flagellum filiform (Fig.13).....…***Streblocera*** Westwood

3’ Antenna not raptorial, scape without a basal blunt horn, flagellum not filiform, but gradually becoming clubbed apically (Fig. 8) .....…… ***Ecclitura*** Kokujev

4 Petiole broad basally, basal width more than half propodeum width (as in Fig. 14) ……..……..…… 5

4’ Petiole narrow basally, basal width less than half propodeum width (as in Figs. 12, 15) ….....……. 6

5 (4) Each antennal base raised in to two rounded projections (Fig. 7); mandibles enormous (Fig. 6), with oral opening between mandibles and clypeus even when mandibles are closed resulting in pseudo-cyclostome depression (Fig. 6); marginal cell open distally …...……. ***Cosmophorus*** Ratzeburg

5’ Antennal bases without such projections, mandibles normal, no pseudo-cyclostome depression; radial cell long, reaching wing apex and closed distally (Fig. 5) .…… ***Centistes*** Haliday

6 (4’) Vein (Rs+M)a (Cubitus) absent thus first submarginal and first discal cell confluent (Figs. 2,4,5) ….……..….. 7

6’ Vein (Rs+M)a (Cubitus) present, first submarginal and first discal cell separated (as in Figs. 1, 3), if Cubitus absent then marginal cell very short, less than stigma length……..… 8

7 (6) Basal four flagellomeres of female slightly broad, flattened, heart shaped and densely setose, setae flattened at tips (Fig. 16); occipital carina complete ..….. ***Marshiella*** Shaw

7’Basal flagellomeres of female cylindrical, not densely setose. Occipital carina absent dorsally; wings (Fig 2) ……. ***Microctonus*** Wesmael

8 Petiole rugose (Fig. 17); ovipositor longer than petiole, body robust...……..... ***Dinocampus*** Foerster

8’ Petiolar sculpture variable; ovipositor shorter than petiole …… 9

9 (8’) Petiole tube like, entirely fused ventrally and as long as remaining metasoma (Fig. 15) ……..... ***Wesmaelia*** Foerster

9’ Petiole not tube like, not fused ventrally or fused only at base and shorter than remaining metasoma ……...…10

10 (9’) Petiole with tergum and sternum fused ventrally at base of the segment; occipital carina complete; face covered with moderately long silky setae, setae obscuring sculpture (Fig. 9) …..…….…..….. ***Peristenus*** Foerster

10’ Petiole not fused, tergum and sternum entirely separated (Fig. 10); face not covered with setae occipital carina incomplete dorsally, wings (Fig. 11) …..... ***Leiophron*** Nees

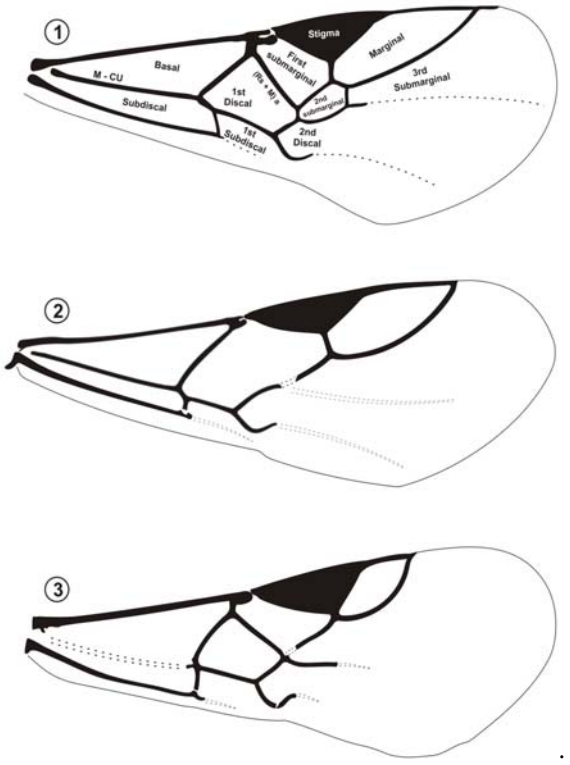


Fig 1-3: Forewings. 1, *Aridelus* sp., showing veins and cells. 2, *Microctonus* sp.
3, *Peristenus* sp.

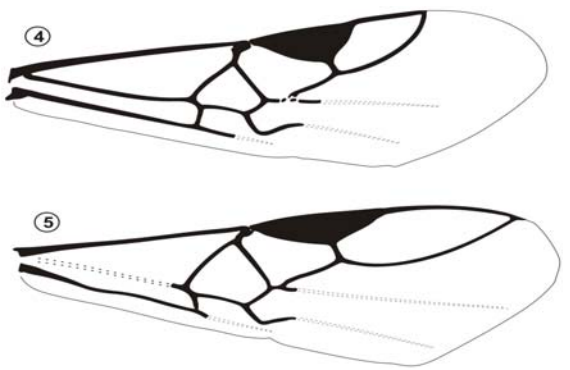


Fig 4, 5: Forewings; 4, *Dinocampus* sp. 5, *Centistes* sp. vein (Rs+M)a present.

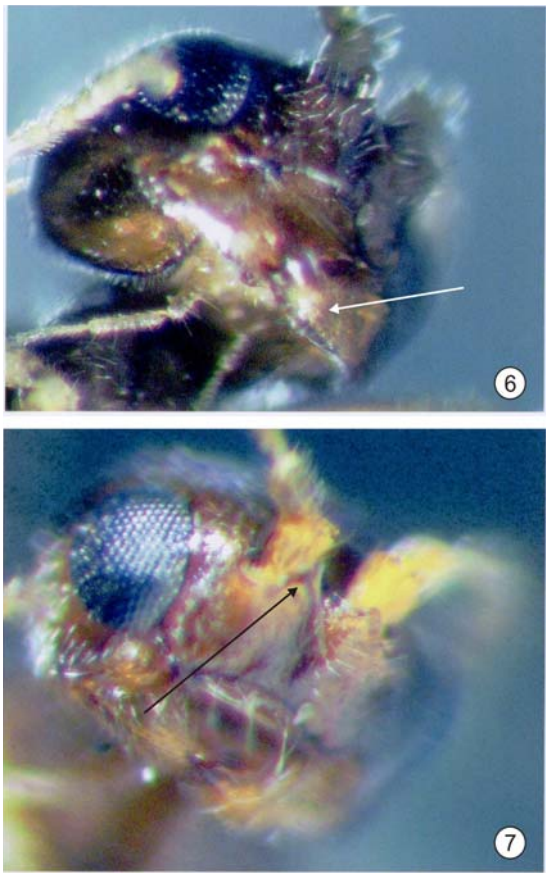


Fig 6, 7: 6, *Cosmophorus* sp. arrow pointing to enormous mandible. 7, *Cosmophorus* sp., arrow pointing to raised area below antennal socket.

Fig 10, 11: *Leiophron* sp. 10, ventral view of petiole showing the entirely separated tergum and sternum. 11, forewing.

Fig 8, 9: 8, *Acclitura* sp. showing the long scape. 9, *Peristinus* sp. showing the setae on face.

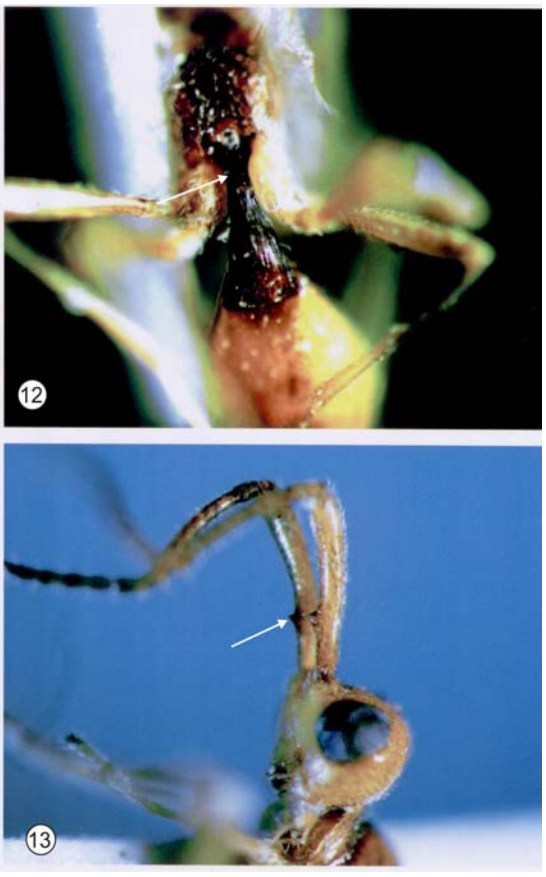
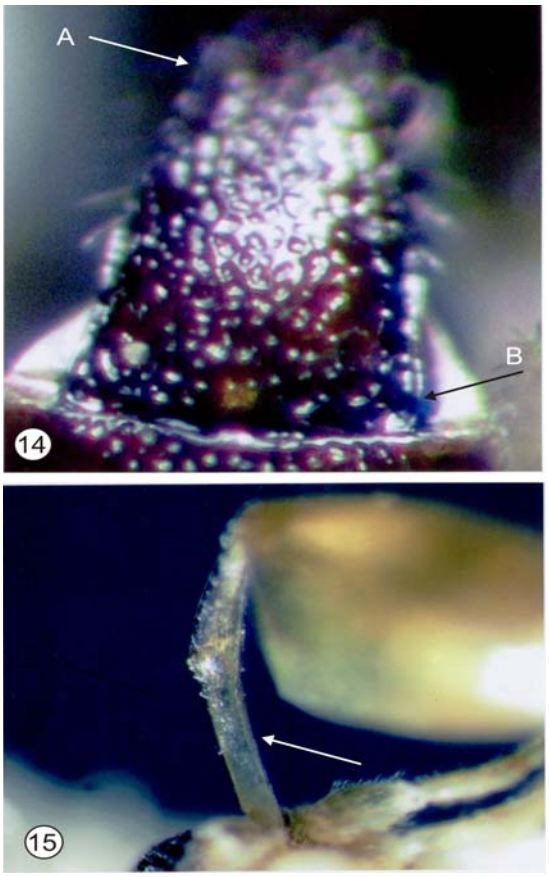


Fig 12, 13: *Streblocera* sp. 12, showing basally narrow petiole. 13, arrow pointing to the tooth present on long scape.



Figs 14, 15: 14, *Cosmophorus* sp. petiole basally broad, A, petiole base, B, petiole apex. 15. *Wesmaelia* sp, arrow showing the tube-like and entirely fused tergum and sternum.

Fig 16: *Marshiella* sp. antennae, basal four flagellomeres with setae.

Fig 17: *Dinocampus coccinale*, showing sculpture on propodeum and petiole.

Discussion

During the course of the study it was found that *Meteorus* Haliday, *Zele* Curtis (Subfamily Meteorinae), *Blacus* Nees (Subfamily Blacinae), *Elasmosoma* Ruthe and *Neoneurus* Haliday (Subfamily Neoneurinae) are also occurring in the area. These genera are placed by [12] [13] under Euphorinae. [2] placed *Meteorus* and *Zele* under Euphorinae and have excluded *Blacus*, *Elasmosoma* and *Neoneurus* from their key to the genera of Euphorinae of China. [1] included *Meteorus* in his key to euphorine genera of the world, but favoured placement of *Meteorus* under subfamily Meteorinae. In the present study we followed [1] [4] and excluded these genera from the key to euphorine genera.

[1] using 68 morphological characters, conducted phylogenetic analysis of world Euphorinae and came up with *9* tribes. Out of these, representatives of 6 tribes occur in Khyber Pakhtunkhwa province. The highly represented tribe in the area is Euphorini with 4 genera: *Wesmaelia*, *Aridelus*, *Peristenus* and *Leiophron*. This is followed by tribe Microctonini with 3 genera: *Microctonus*, *Streblocera* and *Ecclitura*. Tribes Townesilitini, Dinocampini, Cosmophorini and Centistini are represented by single genus each: *Marshiella* .*Dinocampus*, *Cosmophorus* and *Centistis* respectively.

The placement and validity of some euphorine genera are still debated in literature. Worth to mention is the status of *Leiophron*, *Peristenus*, *Microctonus* and *Perilitus.* Genus *Leiophron* was synonymized with *Peristenus* which according to [17] dates back to [18]. [19] removed *Peristenus* from synonymy with *Leiophron*. [1][2] also considered these genera as valid. The main morphological characters that separate these two genera are the complete occipital carina and the ventrally fused petiole in *Peristenus*, while the occipital carina is effaced dorsally and petiole is open in *Leiophron*. [12] however considers the species group with these characters insufficient and recognizes the group of species with complete occipital carina and ventrally fused petiole as a subgenus of *Leiophron*. [17] studied these two genera in detail. They also studied the genitalia of *Leiophron* and confirmed the findings of [19]. At the same time they argued for more data on both the genera before reaching a conclusion.

We also suggest that more material be studied from different geographical areas before reaching a final classification. For convenience the complete occipital carina and basally fused petiole in *Peristenus* are sufficient characters for treating the two genera as distinct.

The validity of *Microctonus* as a genus is also in question. [12] puts *Microctonus* as subgenus of *Perilitus*. Genus *Perilitus* was described by [20] and *Microctonus* by [21]. The two genera differ on the bases of separation or confluence of first submarginal and first discoidal cells in the fore wing. [22] stated that "the two genera do not make a natural group and that the separation of the two genera on the bases of separation or confluence of first cubital (submarginal) and first discoidal cell is artificial, but since the species arrange themselves so conveniently into two groups by this character, it has been considered advisable to consider both names as valid". [1] argued that the separation of the cells in *Perilitus* is plesiomorphic and confluence in *Microctonus* is apomorphic. [1] Analysis places these genera in different tribes which show the wide difference between the two genera. He stated that the monophyly of *Perilitus* is in question and will need to be dismembered in to monophyletic groups. We are in agreement with Shaw's analysis and conclude that both *Microctonus* and *Perilitus* are distinct and separate entities. However, study of specimens of these genera from different regions of the world

may further clarify the validity of both the genera.

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