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REVIEW OF PARASITIC WASP SUBFAMILY EULOPHINAE (HYMENOPTERA: EULOPHIDAE) WITH SPECIAL REFERENCE OF THE TRIBE CIRROSPILINI

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Abstract

The Cirrospilini LaSalle, 2000, belongs to the Eulophinae, along with Eulophini and Elasmini. This tribe consists of about 17 genera and almost 300 species, which are ectoparasitoids, mainly on Diptera, Lepidoptera and Coleoptera in semi-concealed situations. Some species may act as obligate or facultative hyperparasitoids and a few species are gall-formers. Historically, the genera included in the Cirrospilini have been placed in the Eulophinae and the Elachertinae *sensu* Ashmead, 1904. However, the relationships and the placement of genera into subfamilies or tribes have always been problematical. Based on the current evidence, it appears that the Cirrospilini is a monophyletic taxon and the sister-group of the Eulophini plus Elasmini. This paper summarizes the current taxonomic status and systematic background of the Cirrospilini.

Key words: Hymenoptera, Chalcidoidea, Eulophidae, Eulophinae, tribe Cirrospilini, taxonomical review

INTRODUCTION

Since eulophids were first established as a family by Westwood (1840), the definition and recognition of the Eulophidae has been relatively straightforward. However, the relationship of the Eulophidae to other groups (e.g. Aphelinidae, Trichogrammatidae, Tetracampidae and Elasmidae) has remained unresolved. Most early chalcidologists (Walker, 1833, 1834; Förster, 1856) focused on two main groups within the Chalcidoidea: Tetrameri-group (members having four-segmented tarsi) and Pentameri-group (member having five-segmented tarsi). The Eulophidae were placed in the tetramerous group along with the Aphelinidae, the Tetracampidae, the Signiphoridae, the Trichogrammatidae and the Elasmidae. Due to the large size of the Eulophidae,

many new species and genera were described by early authors (e.g. Förster, 1856). In this rapidly growing family the classification became controversial among authors in term of status, composition and relationships of subfamilies, tribes and genera.

Ashmead (1904) was the first person who tried formally to classify the Eulophidae into a series of subfamilies and tribes. This classification was mostly based on forewing venation, parapsidal furrows (= notauli), and numbers of tarsal and antennal segments. Ashmead treated Elasmidae as a separate family due to several obviously distinct characters of the hind legs, thorax, forewing, and abdomen. However, he included the present Aphelinidae as a subfamily and he recognized a further four other subfamilies: Entedoninae, Tetrastichinae, Elachertinae and Eulophinae (Table.1). He also placed the present family Tetracampidae as a tribe under the subfamily of Entedoninae. However, the Tetracampini was raised to family level by Domenichini (1953) based on its 5-segmented tarsi, and this decision was followed by Bouèek (1958, 1988) and Yoshimoto (1984) who explained that in several genera of tetracampid only the males have 4 segmented of tarsi.

Peck *et al*. (1964) and Bouèek & Askew (1968) recognized five subfamilies the Eulophidae: Elachertinae, Eulophinae, Entedontinae, Tetrastichinae, and Euderinae. However, they also excluded Elasmidae from Eulophidae. Riek (1967) treated the Elasmidae as a subfamily under Eulophidae, and this was followed by Burks (1979) and Yoshimoto (1984). Until recently the position of elasmids was debated by several authors (Bouèek, 1988, Coote, 1997, Gibson, 1999) who retained the Elasmidae as a valid family which they considered to be closed to the Eulophidae. LaSalle *et al*. (1997) discussed several characters which indicated a similarity between Elasmidae and *Euryischia* (Aphelinidae) and suggested that elasmids might be more closely related to that taxon than Eulophidae. Their arguments seemed to a large extent to be based on morphological similarity, but without any cladistic analysis. However, a molecular phylogenetic analysis of Eulophidae made by Gauthier *et al*. 2000 indicated that Elasmidae not only belongs in the Eulophidae but in the subfamily Eulophinae (Table 1).

Although the classification at the subfamilial level has been relatively stable since Peck *et al*. (1964), the placement of the genera and tribes within the subfamilies has been uncertain. Bouèek (1959, 1988), and Bouèek & Askew (1968) suggested that Elachertinae and Eulophinae should be united. Burks, (1979) in his catalogue of North American Eulophidae, followed the previous authors and placed the tribe Elachertini in Eulophinae. However, he recognized

only three subfamilies within Eulophidae: Eulophinae, Entedoninae and Elasminae.

Although the problems with understanding relationships in the Eulophidae have been considerable, they are not difficulties unique to this family. Several families within Chalcidoidea have similar challenges and problems. What is somewhat unique about the Eulophidae is the intense historical interest in them taxonomically and biologically. In this paper I agree with most recent authors who have classified the Eulophidae into four subfamilies: Eulophinae, Entedoninae, Tetrastichinae and Euderinae (Graham, 1987; Bouèek, 1988; Gibson, 1993; Schauff *et al*. 1997; Gauthier *et al*. 2000).

Relationships within Eulophidae

Although classification of Eulophidae at the subfamilial level is being widely accepted, the classification and phylogenetic relationships among genera and the placement of several genera (e.g., *Aulogymnus, Dichatomus, Elasmus, Cirrospilus,* and *Zagrammosoma)* is still controversial. Disagreement was based on disagreement amongst pheneticists (Ashmead, 1904; Peck, 1963; Burks, 1979; Bouèek and Askew, 1968; Graham, 1987, 1991; Bouèek, 1988; Schauff and LaSalle, 1993; Storozheva, 1987, 1990; Schauff *et al*. 1997) and the latest study on molecular phylogenetics by Gauthier *et al*. (2000).

Little attempt has been made to hypothesize relationships wthin the Eulophidae. Graham (1987, 1991) discussed relationships in Tetrastichinae. Bouèek (1988) reviewed the subfamilial relationships, and Storozheva (1987, 1990) studied evolutionary trends in the mandibles and antennae of Eulophidae. However, these investigations were little more than arrangement of genera in tribes according to comparison of morphological similarity without comprehensive phylogenetic analysis. The only phylogenetic analysis in the Eulophidae was by Schauff (1991), and that was, unfortunately, restricted to Entedoninae.

Graham (1987) suggested Eulophinae including Elachertinae as the basal clade of the eulophids lineage and a sister group of the other subfamilies. His hypothesis was based on the character of submarginal vein of the forewing connecting smoothly to parastigma. The latter three subfamilies were considered to be a derived group separated by the synapomorphic character that the distal part of submarginal vein is broken. Moreover, he predicted that the Euderinae and the Tetrastichinae are more closed related (Fig. 1). However, he gave no clear picture of relationships among genera and subfamilies.

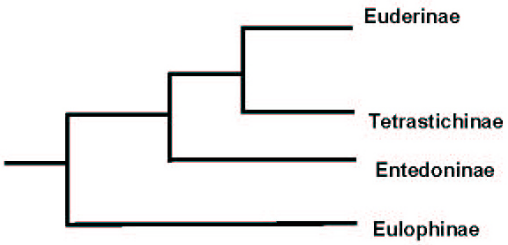

Fig.1. Relationships within Eulophidae from Graham (1987)

Bouèek (1988) suggested that the Eulophinae comprise 6 tribes: Anselmellini, Keryini, Ophelemini, Eulophini, Elachertini and Euplectrini, and that they are the most primitive subfamily and a sister-group to the rest of Eulophidae (Fig. 2). He also suggested that the Ophelimini, Elachertini and Eulophini might be united. The basal taxa of the clade was thought to be Anselmellini and Keryini due to the supposedly plesiomorphic character of phytophagy and also possession of 11 (Anselmellini) or 12 (Keryini) antennal segments.

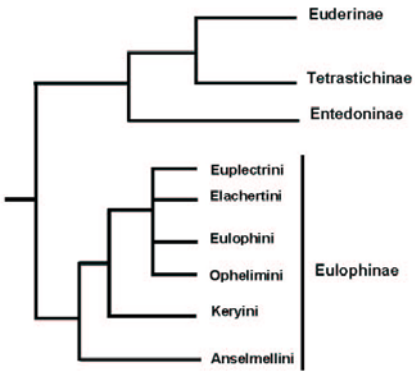

Fig.2. Relationships within Eulophidae from Bouèek (1988)

Taxonomic and systematic of Eulophinae

The subfamilly Eulophinae presently comprises about 1,314 recognised species within 101 genera (Noyes, 2001). Principal classifications of the Eulophinae are those of Ashmead (1904), Peck *et al*. (1964), Bouèek and Askew (1968), Burks (1979), Riek, 1970, Graham (1987), and Bouèek (1988), and these works differ significantly in their treatment of the tribal classification.

Earlier attempts at a classification maintained the Eulophinae as distinct from the Elachertinae (Ashmead 1904; Riek, 1970). The Eulophini was based on their incomplete notauli and articles of the male funicle having branching, while the Elachertinae have complete notauli and the male funicle is without branches. However, Graham (1987) and Bouèek (1988) pointed out that these characters were not sufficiently consistent, and placed the Elachertini as a tribe in the Eulophinae.

Although there was some variation in the delimitation of tribes, this subfamily generally included any taxon with the following combination of characters: antenna 10 -12 segmented, scutellum with 2 pairs of setae, sometimes with additional hairs, postmarginal vein well developed, usually longer than stigmal vein, dorsal surface of the submarginal vein with 3 or more setae, submarginal vein joining smoothly to parastigma. This classification has generally been followed by subsequent authors (LaSalle & Schauff, 1992; Schauff & LaSalle, 1993; Schauff *et al*. 1997)

However, Gauthier *et al*. (2000) provided some new ideas on Eulophidae classification. They proposed a concept of Eulophinae classification based on molecular and morphological evidence comprising three tribes the Eulophini (including Elachertini + Euplectrini), Elasmini and the Cirrospilini which they erected as new (see Table 1). Unfortunately, phylogenetic relationships of genera within these remained largely unresolved and sensitive to phylogeny reconstruction protocol.

The placement of the genera allied to Cirrospilus in Eulophinae

The genera allied to *Cirrospilus* (e.g. *Ascotolinx, Cirrospilus, Cirrospiloidelleus, Diaulinopsis, Dichatomus, Diglyphus, Gallowayia, Gattonia, Semielacher, Meruana, Naumanniola, Oxycantha, Pseudiglyphus* and *Zagrammosoma*) share a number of morphological features: face with a transverse groove, antenna mostly with two segmented funicles, propleura separated distally, scutellum with distinct submedian grooves, and submarginal vein dorsally with 3 or more setae. These genera were previously placed under Hemiptarsini *sensu* Ashmead, 1904 (*Diglyphus*) and Elachertinae *sensu* Ashmead, 1904 (*Zagrammosoma, Cirrospilus*), Ophelimini *sensu* Bouèek 1988 (*Cirrospiloidelleus, Semielacher, Zagrammosoma, Cirrospilus, Diglyphus, Diaulinopsis, Meruana*) and Elachertini *sensu* Bouèek, 1988 (*Gattonia, Ascotolinx, Pseudiglyphus, Naumanniola, Gallowayia*) (Table 1).

Gauthier *at al*. (2000) found that 28S DNA D2 info supported a grouping that is recognizable morphologicaly and as there was no available family group name for it, they erected the Cirrospilini type genus *Cirrospilus*.

Table 1. Classification of Eulophidae through the years, with emphasis on Eulophinae. Bold letters indicated the members of Cirrospilini

Ashmead, 1904 Morphology based Classification	**Burks, 1979 Morphology based Classification**	**Bouček, 1988 Morphology based Classification**	**Gauthier *et al.* 2000 Molecular phylogeny**
EULOPHINAE	**EULOPHINAE**	**EULOPHINAE**	**EULOPHINAE**
Hemiptarsenini	**Euplectrini**	**Anselmellini**	**Elasmini !**
Hemiptarsenus	*Euplectrus*	**Keryini**	*Elasmini*
Necremnus	**Elachertini***	**Ophelimini**	**Cirrospilini**
Diglyphus	*Elachertus*	*Aulogymnus*	*Aulogymnus*
Eulophini	*Diaulinopsis*	*Cirrospiloidelleus*	*Cirrospiloidelleus*
Sympiesis	*Cirrospilus*	*Semielacher*	*Semielacher*
Eulophus	*Zagrammosoma*	*Zagrammosoma*	*Zagrammosoma*
Diaulus	*Aulogymnus*	*Cirrospilus*	*Cirrospilus*
Diaulomorpha	*Paraolinx*	*Diglyphus*	*Diglyphus*
Dimmockia	*Hyssopus*	*Diaulinopsis*	*Diaulinopsis*
Microlycus	*Apterolophus*	*Meruana*	*Meruana*
Microplectron	*Peckelachertus*	**Elachertini**	*Gattonia*
Cratrotrechus	**Eulophini**	*Gattonia*	*Ascotolinx*
Dicladocerus	*Diglyphus*	*Ascotolinx*	*Pseudiglyphus*
Pentacladia		*Pseudiglyphus*	*Naumanniola*
(placed to Eupelmidae by Graham, 1993)		*Naumanniola*	*Gallowayia*
		Gallowayia	**Eulophini**
		Eulophini	
		Sympiesis	
		Euplectrini	
ENTEDONINAE	ENTEDONINAE	ENTEDONINAE	ENTEDONINAE
Tetracampini	Euderini		
Entedonini	Tetrastichini **		
Omphalini	Entedontini		
Pediobiini			
TETRASTICHINAE	**tribeTetrastichini	TETRASTICHINAE	TETRASTICHINAE
Ceratoneurini		*Peckelachertus*	
Tetrastichini			
ELACHERTINAE	*tribe Elachertini	EUDERINAE	EUDERINAE
Euplectrini			
Zagrammosoma			
Aulogymnus			
Cirrospilus			
Elachertus			
Ophelimini			
Elachertini			
APHELININAE ***			
Aphelinini			
Pteroptricini			
Family ELASMIDAE	**ELASMINAE**	**family ELASMIDAE**	**EULOPHINAE**
*****APHELININAE**	***Elasmus***	**Family**	**! Elasmini**
Aphelinini	**Family**	**APHELINIDAE**	**Family**
Pteroptricini	**ENCYRTIDAE**		**APHELINIDAE**
	Aphelininae		

Systematic review of Cirrospilini

The Cirrospilini has been assumed to be a monophyletic group (Gauthier *et al*. 2000) based on a combinations of molecular data of D2 region of the 28S rDNA and morphological synapomorphic characters (Ubaidillah *et al*, 2003) such as presence of transverse groove on face; antenna with funicle 2-3 segmented; submedian groove on scutellum distinct and with 2 pairs of setae. Gauthier *et al*. (2000) included in the Cirrospilini most genera of the Ophelimini *sensu* Bouèek, 1988 (however not *Ophelimus*) as well as some genera which Bouèek (1988) placed in Elachertini. They provisionally placed *Aulogymnus* and *Dichatomus* under Cirrospilini, although they realized that there might be problems with this placement. *Aulogymnus* and *Dichatomus* are different from other cirrospilines in having antenna with 3 funicular segments (rather than 2) in females and 3 or 4 segments. In addition Gauthier *et al*. (2000) stated that transverse groove on face and submedian lines on scutellum are good characters for Cirrospilini, but these are absent in all *Aulogymnus* and *Dichatomus*.

Number of species and geographical distribution of Cirrospilini

It is not known exactly how many species there are in the Cirrospilini. However, it appears that the group is moderate in size and currently has 299 described species in 17 genera. Species of Cirrospilini are known from all geographic regions, although they are most abundant in Australia and the Pacific (Table 2). Most genera contain relatively few species, with about two-thirds of genera containing fewer than ten species. The tribe is dominated by a single genus *Cirrospilus* Westwood with 134 described species. The current figure of geographical distribution pattern shown in Figure 1 probably does not reflect a real pattern of diversity or faunistic history of Cirrospilini, but rather the intense study of chalcidoid wasps in these regions. Taken from this figure, and the expected rich fauna in unexplored tropical regions, I would predict that the World Cirrospilini probably contains about a thousand species.

The genus *Cirrospilus* occurs over most of the world. Certain other genera are restricted to a single region such as *Pseudiglyphus* and Semielacher in Australia and Pacific, and *Danuviella* in the Palearctic.

Nomenclatural history for species and genera of Cirrospilini

Most species of Cirrospilini are known from Australia, the Pacific and the Palearctic region (Fig.3) and were described before 1930. Nees, Walker, Mayr, Ratzeburg, Förster and Girault contributed the majority of names between 1771-1939. Species were described predominantly by Girault (35%) and Walker

(9%) with others adding fewer than 5% each. After that period the only substantial contributions were by Bouèek (1958-1994) 4%, Erdös (1951-1958) 2.5% and Graham (1959-1994) 2%. From the total number of those described species, 78 % are still regarded valid at species level.

The Girault period (1913-1916) was spectacular in that he described 103 species and 7 currently valid genera mainly from the Australian region.

Table 2. Approximate numbers of extant, described Cirrospilini species by geographic region. Regions follow Noyes (1998) and are abbreviated as follow: Afrotropical (Afr), Australian/ Pacific (Aus/Pac), Europe (Eur), Holarctic (Hlt), Nearctic (Nrt), Neotropical (Ntr), Palaearctic (Plr), Oriental (Ort)

Genus	Afr	Aus/Pac	Eur	Hlt	Nrt	Ntr	Plr	Ort	Total
Ascotolinx Girault	-	2	-	-	-	-	-	-	2
Aulogymnus Förster	-	4	2	-	7	-	22	1	27
**Danuviella* Erdos	-	-	-	-	-	-	1	-	1
Diaulinopsis Crowford	-	1	-	-	3	1	2	-	4
Dichatomus Förster	1	-	-	-	-	-	1	-	1
Diglyphus Walker	2	3	4	1	7	7	16	9	29
Cirrospiloidelleus Girault	-	1	-	-	-	-	-	-	1
Cirrospilus Westwood	12	65	8	-	27	3	30	13	134
Gallowayia Bouček	-	1	-	-	-	-	-	-	2
Gattonia Bouček	-	2	-	-	-	-	-	-	2
Maruana Delucchi	3	1	-	-	-	-	-	-	4
**Melittobiopsis* Timberlake	-	1	-	-	-	-	-	-	1
Naumanniola Bouček	-	2	-	-	-	-	-	-	2
**Oxycantha* Surekha &Ubaidillah	-	-	-	-	-	-	-	1	1
Pseudiglyphus Girault	-	2	-	-	-	-	-	-	2
Semielacher Bouček	-	2	-	-	-	-	1	-	2
Zagrammosoma Ashmead	-	-	-	-	9	6	1	1	14
Total species	**18**	**87**	**14**	**1**	**53**	**17**	**74**	**24**	**229**

* not in Gauthier, *et al*, 2000

After Girault, there was a progressive tendency for several of his genera to be synonymized, especially in the work of Bouèek (1988). Most nomenclature changes in Cirrospilini have been connected the genus *Cirrospilus*, with 14 genera synonymized under it between 1950 and1990 (see Bouèek, 1988 and Noyes, 1998). Six genera (*Achrysocharelloidea, Austrolynx, Gyrolasella, Cirrospilomella, Parzagrammosoma* and *Pseudochrysocharis)* described by Girault (1913-1916) from Australian region were synonymized by Bouèek (1988), and 41 species required new combinations. Bouèek (1988) reviewed the

nomenclatural problems in the *Cirrospilus* complex and divided *Cirrospilus* into 5 groups. However, the nomenclature of *Cirrospilus* remains ambiguous and is one focus in the present study. The second major problem was recognition of *Aulogymnus,* which now has 8 different genera synonymised with it (*Olynx, Chinipoctonus, Olinx, Ophelonoideus, Scotolinx, Pseudiglyphella, Mirolynx* and *Pseudolynx*). Bouèek (1988) synonymized four of these.

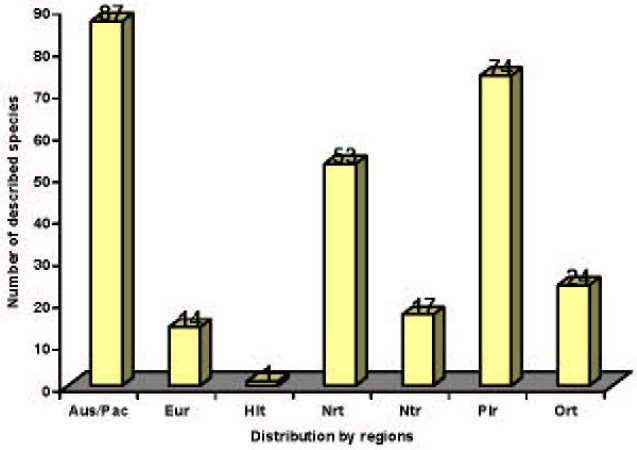

Fig.3. The geographical distribution of Cirrospilini. The explanation of the regions system see Table 2

CONCLUSIONS

This recent sense of the paper follows the classification of Eulophidae proposed by Bouèek (1988) as modified by Gauthier *et al.* (2000). The Cirrospilini is considered as a tribe within the subfamily of Eulophinae. However, a few genera such as *Aulogymnus, Dichatomus,* and *Trichospilus* need further study to clarify their placement. Study of the generic level classification within Eulophinae is still far from complete and there remains some ambiguity, even between those chalcidologists who are concentrating in Eulophidae, as to the placement of some of the genera. Despite previous works, the limits of Cirrospilini are still rather vague, and one purpose of this review was define to properly and characterize this tribe within Eulophinae.

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