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INTRODUCTION

Encyrtidae is an economically important family in the superfamily Chalcidoidea, with 3,702 species (Noyes, 2002). Undoubtedly, the encyrtids play a crucial rule in the maintenance of a natural equilibrium. As natural enemies, the species of Encyrtidae parasitize on the eggs, larvae, pupae, or adults of various insects, some ticks and eggs of spiders. In the past century, species of Encyrtidae are most frequently used in the biological control of the insect pests, especially the scale insects (Homoptera: Coccoidea).

China is a vast territory stretching across the Palearctic and Oriental regions with complicated topography and various climatic conditions. The encyrtid fauna of China is among the richest in the world. Unfortunately, little taxonomic work in China has been done on these potential biocontrol agents. The current work attempts: 1) to delineate the characters defining the each genus; 2) to provide an illustrated key to the Chinese genera; 3) to summarize the available biological and distributional data for the genera; and 4) to synthesize the nomenclatural and taxonomic data.

BIOLOGY AND ECONOMIC IMPORTANCE

Like other families in Chalcidoidea, Encyrtidae also shows a range of biological diversity. Almost all known species of Encyrtidae are primary internal parasitoids of other arthropods or hyperparasites through other hymenopterous parasitoids. About one third of the known species were reported from Pseudococcidae (Homoptera). The remaining species are reported from other families of Homoptera, from Neuroptera, Coleoptera, Lepidoptera, Orthoptera, Diptera, as well as ticks, spider eggs. Many species are hyperparasitoids through other species of Encyrtidae, Aphelinidae, Pteromalidae, Braconidae, Dryinidae, Ichneumonidae, etc (Noyes et al, 1997). Most encyrtids reveal a high degree of specialization in their host relationship. Some encyrtids, such as *Leptomastix dactylopii*, *Ageniaspis fuscicollis*, have been reared from different hosts. Other than solitary and gregarious species in Encyrtidae, some encyrtids (e. g. *Copidosoma* spp.) are polyembryonic parasitoids of the larvae of Lepidoptera. The biology of Encyrtidae was generally presented by Clausen (1940). The host-parasitoids relationships of Encyrtidae were generally discussed by Trjapitzin (1972) and summarized by Tachikawa (1974, 1981). Noyes & Hayat (1994) have discussed on the biology of Tetracneminae. It should be noted that our knowledge on biology of Encyrtidae is quite poor, though many specific literatures on biology of species are published in the past century. In China, biologies of some species were reported by several authors and are noted in the text.

Obviously, encyrtids are effective agents that help to control mealy bugs, coccids, psyllids and many other insect pests infecting farm and fruit plants. So far, many species have been successfully used

in classical biological control programmes throughout the world, particularly in warmer climates. This is no doubt due to the predominance of their hosts in Homoptera, because Homoptera have historically proven to be good candidates for biological control (Greathead, 1989). Examples and descriptions of successful biological control were given by Clausen (1978). Noyes & Hayat (1994) have summarized the worldwide use of Encyrtidae in biological control and listed the hosts of Tetracneminae.

TAXONOMIC REVIEW

The family Encyrtidae was erected by Walker (1837a) based on the genus *Encyrtus*, which was established by Latreille (1809) and redescribed by Dalman (1820). Other earlier prominent contributors to the taxonomy of Encyrtidae were as follows: Förster (1856), Mayr (1876) and Thomson (1876). Two American hymenopterists, Howard (1881) and Ashmead (1900a, b) made notable contributions to Encyrtidae taxonomy. In the early years of the 20thcentury, Girault erected nearly 200 genera from Australia, Southeast Asia, and Nearctic region, while most descriptions are very short and brief. Timberlake (1920) and Ishii (1928) described many species from Hawaii and Japan, respectively.

Mercet (1921) set a landmark in the history of Encyrtidae taxonomy. His valuable work could be regarded as the earliest truly classification of Encyrtidae and greatly improved the taxonomy of Encyrtidae. After Word War Two, more and more hymenopterists paid attention to this economically important family. Among them are Hoffer (1955), Erdös & Novicky (1955), Compere & Annecke (1960, 1961), Tachikawa (1963), Kerrich (1967), Hayat et al (1975).

Trjapitzin (1973a, 1973b, 1989) classified the Palearctic Encyrtidae and proposed to divide Encyrtidae into two subfamilies, Tetracneminae and Encyrtinae. This practical system is followed and accepted by more and more encyrtid taxonomists. Trjapitzin (1989) recognized 11 tribes in Tetracneminae and 36 tribes in Encyrtinae. In a more recent comprehensive classification of Tetracneminae, Noyes & Hayat (1994) reduced it into 6 tribes.

For the Chinese fauna, some species was described by Howard (1898b) and Girault (1915a). The earlier Chinese contributors are as follows: Wu Chen-fu (1941), Ru-zuo Zhu and Xue-liu Li. A significant contribution to knowledge of Chinese Encyrtidae was made by Ding-xi Liao, who included 23 genera and 40 species of Chinese encyrtids in the book *Hymenoptera*: *Chalcidoidea* (1) (Liao et al, 1987). Several authors, such as Zhen-ya Shi, Zhi-hong Xu, etc., recently reported more species of Chinese Encyrtidae.

CONTENTS

MATERIALS AND METHODS

SPECIMENS

Most of the material used in this study was in the collection of Institute of Zoology, the Chinese Academy of Sciences (IOZ, CAS). For the remaining part, some were borrowed from the Natural History Museum, London, and some from Henan Agricultural University and Zhejiang University. Many specimens in IOZ, CAS preserved in alcohol were critical-point dried to prevent collapsing. Material include in this paper had been collected using various techniques (see Noyes, 1982), but generally by sweeping and rearing. All of the voucher specimens are deposited in the collection of Institute of Zoology, the Chinese Academy of Sciences (IOZ, CAS).

We have not seen the specimens of *Baeocharis* and *Erencyrtus* (recorded by Xu, 2003), and several genera mentioned in Si et al's (1994) checklist, such as *Cheiloneurella*, *Copidosomyia*, *Metaphaenodiscus*, *Neastymachus* and *Pseudococcobius*, so that these genera are not treated in this work.

MORPHOLOGY AND TERMS

Drawings were done from card-mounted material using a drawing tube attached on a Leica microscope. Scanning electron micrographs were given to show detailed characters.

In this book, 'body' refers to the composite of head, thorax (= mesosoma) and gaster (= metasoma) but excludes the appendages (antennae, wings, legs).

Head(Figs 1, 2)

Head height is measured the vertical length of the head in frontal view. **Head length**, if not specified, indicates the median length of the head in dorsal view. **Frontovertex** refers to the combined vertex and upper face above the antennal scrobes. **Frontovertex width**, if not specified, indicates the minimum width between eyes. **Antennal scrobe** is applied to the vertical depression above torulus. **Interantennal prominence** is the region between the antennal scrobes, which is usually convex. **Malar sulcus** is the sulcus joining the lower eye margin and mouth margin at the base of mandible. **Mandible** is usually tridentate or bidentate, but sometimes developed into one or two teeth and a truncation, one acute tooth, four teeth or truncated.

Antenna (Figs 99, 100)

Torulus is a ring-like sclerite surrounding the area where antenna attached to head. **Scape** means

the part of antenna attached to the head by a basal constriction (radicle), which is subcylindrical, or slightly to greatly expanded and flattened. **Pedicel** is the segment connecting flagellum to scape. **Funicle** consists of the segments between the pedicel, or anelliform segments if present, and clava. **Flagellum** is often composed of funicle and clava, rarely of one or more anelliform segments basally. **Clava** refers to the apical part of antenna and composed of one to three segments. **Scale-like structures** usually indicate the structures on apical segments of antennae of males of Anagyrini.

Thorax (Figs 3, 5)

Notaular lines are the paired superficial lines on the mesoscutum running from the anterolateral margin of mesoscutum to the center of its posterior margin. These lines are sometimes hard to see in dry material. It is better to adjust the light direction or brightness for a proper view. **Propodeum length** is measured along the mid-line of the propodeum in dorsal view.

Forewing (Fig 162)

Costal cell is the membranous region anterior to the submarginal vein. **Marginal vein** is usually present and slightly to greatly longer than broad, sometimes punctiform, or absent. **Linea calva** is an oblique hairless strip extending from below marginal vein and stigmal vein to posterior margin of forewing. **Filum spinosum** consists of a series of peg-like setae on distal margin of linea calva.

Gaster (Figs 4, 6)

Cerci are plate-like structure on the tergum that bears several long setae. **Hypopygium** refers to the apical, externally visible sternite. **Ovipositor** is female reproductive organ that consists of the protective outer sheaths and stylets. **Exserted part of ovipositor** is measured from the apex of last gastral tergite to the apex of ovipositor sheath in dry-mounted material. **Male Genitalia** is the reproductive organ composed of a phallobase surrounding the aedeagus; the phallobase posteriorly usually differentiated into lateral parameres and median digiti; each digitus has one, two or three digital spines.

KEY

Though Encyrtidae is easy to recognize in the superfamily Chalcidoidea, it is difficult to key to genera level by non-experts, especially within taxonomically difficult groups, such as Anagyrini, Microteryini. Some of the characters used to separate groups in the key are not always reliable. The users should confirm the identification by comparison of the relevant material with the generic diagnosis. Accurate identification of Encyrtidae requires not only high quality specimens but also a good microscope with high magnification.

The males are not keyed out because males of some related genera are very difficult to be separated and generally have fewer taxonomic features than females. Another reason is that males are unknown in a number of genera.

ARRANGEMENT OF THE WORK

The genera are alphabetically arranged. Every genus is accompanied with 1) synonymy list; 2) diagnostic characters; 3) notes including the data of number of species, distribution, list of Chinese species, most useful references, sometimes systematic comments; 4) biology and use in biocontrol.

KEY TO CHINESE GENERA OF ENCYRTIDAE(FEMALES)

1. Tarsi 4-segmented (Fig 115); body length less than 1 mm 2
   Tarsi 5-segmented (Fig 116); body length generally more than 1 mm, sometimes less than 1 mm 3
2. Antennal funicle with 2 to 4 anelliform segments adpressed to clava; clava enlarged and usually longer than the remainder of antenna; marginal fringe of forewing distinctly shorter than forewing width; mandible with one acute tooth ..... ***Arrhenophagus***
   Antennal funicle with 5 to 6 segments which clearly separated from clava; clava distinctly shorter than the remainder of antenna; marginal fringe of forewing about equal to forewing width; mandible somewhat truncated, with truncation serrated (Fig 108) ..... ***Anthemus***
3. Antennal funicle 4 or 5-segmented 4
   Antennal funicle usually 6-segmented, rarely 7-segmented 14
4. Antennal funicle 4-segmented 5
   Antennal funicle 5-segmented 7
5. Forewing hyaline; antennal scape cylindrical or subcylindrical; hypopygium reaching about half along gaster; occipital margin and apex of scutellum sometimes with scale-like setae ..... ***Plagiomerus***
   Forewing infuscate, or with a pattern of infuscation developed by series of enlarged setae; antennal scape distinctly expanded and flattened 6
6. Flagellum more or less cylindrical in cross-section (Fig 75); forewing with several fuscus lines radiating from a longitudinal fuscus line in center of wing; occipital margin and apex of scutellum usually with scale-like setae (Figs 32, 38) ..... ***Caenohomalopoda***
   Flagellum conspicuously expanded and flattened (Fig 74); forewing with a pattern of infuscation developed by series of enlarged setae (Fig 174); occipital margin and apex of scutellum without scale-like setae ..... ***Spaniopterus***
7. Pronotum divided in the middle (Fig 55); flagellum basally with a distinct anelliform segment (Fig 78); marginal vein more than 3 times longer than broad, postmarginal vein and stigmal vein long (Fig 181) ..... ***Oriencyrtus***
   Pronotum entire; flagellum without anelliform segment; marginal vein punctiform or a little longer than broad 8
8. Mandible bidentate; forewing with linea calva broad, area below proximal part of parastigma to apex of stigmal vein nearly completely naked ..... ***Tetracnemoidea***
   Mandible usually tridentate; forewing with linea calva normal, area below proximal part of parastigma to apex of stigmal vein not naked 9
9. Stigmal vein with sensillae arranged symmetrically in a square (Fig 165) ..... ***Copidosomopsis***

Stigmal vein with sensillae not arranged symmetrically in a square ····· 10

10. Dorsum of thorax with striated reticulations which giving a silky appearance (Fig 39); forewing with postmarginal vein conspicuously long and distinctly longer than stigmal vein ····· ***Ageniaspis***

Dorsum of thorax with polygonal, rectangular or scaly reticulations, if reticulations elongated or striated, they doesn't give a silky appearance; forewing with postmarginal vein short and distinctly shorter than stigmal vein, or absent ····· 11

11. Head or thorax usually dark or dark brown, with metallic sheen; forewing without postmarginal vein; marginal vein punctiform and not reaching anterior margin of forewing (Fig 169); mesoscutum sometimes with notaular lines ····· ***Trechnites***

Head or thorax at least partly yellow or yellow brown; forewing with postmarginal vein very short; marginal vein punctiform but reaching anterior margin of forewing ····· 12

12. Antenna generally uniform in color, yellow or yellow brown ····· 13

Antenna with clava yellowish white, contrasting with the funicle which usually yellow brown or dark yellow brown ····· ***Pseudaphycus***

13. Clava entire or 3-segmented ····· ***Acerophagus***

Clava 2-segmented ····· ***Pseudectroma***

14. Forewing shortened, not reaching apex of gaster ····· 15

Forewing fully developed, extending past or reaching apex of gaster ····· 27

15. Hypopygium reaching apex of gaster; mandible usually bidentate, if tridentate, the upper third tooth very small ····· 16

Hypopygium reaching about half of gaster, at most reaching 4/5 of gaster; mandible not bidentate ····· 24

16. Mesoscutum in lateral view saddle-like; flagellum of antenna distinctly flattened and expanded; mandible tridentate, the upper third tooth very small ····· 17

Mesoscutum in lateral view not saddle-like; flagellum of antenna not flattened and expanded, subcylindrical in cross-section; mandible bidentate ····· 18

17. Antennal scape only somewhat flattened and expanded, more than 4 times as long as broad; propodeum medially at least 1/3 scutellum length ····· ***Sakencyrtus***

Antennal scape strongly flattened and expanded, less than 3 times as long as broad (Fig 67); propodeum medially at most 1/5 scutellum length ····· ***Mira***

18. Scutellum apically with membranous flange (Fig 56) ····· ***Ericydnus***

Scutellum apically without membranous flange ····· 19

19. Pronotum longitudinally divided in middle; body often dorsoventrally flattened; antennal clava two or three segmented ····· ***Rhopus***

Pronotum entire ····· 20

20. Antennal clava entire (Fig 56); occipital margin usually rounded; ovipositor usually distinctly exserted ····· ***Tetracnemus***

Antennal clava 2 or 3-segmented; occipital margin usually sharp; ovipositor not or hardly exserted ····· 21

21. Basal segments of clava with similar appearance as funicular segments, thus funicle appearing 7-segmented, clava 2-segmented (Fig 131) ····· ***Anomalicornia***
Funicle 6-segmented, clava 3-segmented or indistinctly 3-segmented ····· 22
22. Mesoscutum without notauli; body usually yellow or yellow brown; funicular segments mostly quadrate or transverse; clava usually white or yellowish white ····· ***Neodusmetia***
Mesoscutum with notauli; body dark or dark brown ····· 23
23. Antennal clava white or yellowish, contrasting with dark funicular segments ····· ***Dicarnosis***
Antennal clava dark or dark brown, concolorous with funicular segments ····· ***Dinocarsis***
24. Antenna with all segments distinctly flattened and expanded; face with transverse margin at top of antennal scrobes ····· ***Cerapterocerus***
Antenna with flagellum and pedicel subcylindrical in cross-section, scape sometimes flattened and expanded; face without transverse margin at top of antennal scrobes ····· 25
25. Antenna with clava strongly obliquely truncated; scutellum usually with a tuft of bristles ····· ***Cheiloneurus***
Antenna with clava more or less transversely truncated or rounded apically; scutellum without a tuft of bristles ····· 26
26. Occipital margin usually rounded; axillae usually distantly separated; mesopleuron posteriorly expanded and touching base of gaster; mandible usually with one tooth and an upper broad truncation ····· ***Ooencyrtus***
Occipital margin sharp; axillae more or less meeting; mesopleuron posteriorly sometimes expanded and more or less touching base of gaster; mandible tridentate or with two teeth and an upper truncation ····· ***Microterys***
27. Scutellum with a tuft of bristles, or apically with two or more scale-like setae ····· 28
Scutellum without a tuft of bristles or enlarged scale-like setae ····· 34
28. Scutellum with two or more scale-like setae apically ····· 29
Scutellum with a tuft of bristles ····· 30
29. Scutellum with two enlarged scale-like setae apically; antenna with flagellum not expanded or flattened; submarginal vein of forewing with a triangular expansion sub-apically ····· ***Lakshaphagus***
Scutellum with 8-14 enlarged setae on posterior margin; antenna with flagellum strongly expanded or flattened (Fig 72); submarginal vein of forewing without a triangular expansion sub-apically ····· ***Pareusemion***
30. Mesoscutum with a tuft of bristles in the middle, and with shallow transverse depression posteriorly ····· ***Diversinervus***
Mesoscutum without a tuft of bristles in the middle, and without shallow transverse depression posteriorly ····· 31
31. Forewing with marginal vein punctiform, both postmarginal vein and stigmal vein longer than 1/4 of submarginal vein; mandible somewhat obliquely truncated (Fig 113) ····· ***Encyrtus***
Forewing with marginal vein usually more or less 3 times longer than broad, postmarginal vein and

stigmal vein short; mandible tridentate or with four teeth ····· 32

32. Forewing hyaline; apex of postmarginal vein and stigmal vein without hyaline, naked streak; mandible with four teeth or with two teeth and an upper truncation (Fig 107) ····· ***Zaomma***

Forewing often infuscate; apex of postmarginal vein and stigmal vein often connected by a hyaline, naked streak; mandible tridentate ····· 33

33. Hypopygium reaching apex of gaster; ovipositor strongly exserted, with exserted part of ovipositor about 1/3 gaster length ····· ***Prochiloneurus***

Hypopygium reaching about 2/3 of gaster; ovipositor at most slightly exserted ····· ***Cheiloneurus***

34. Antennal scape not more than 3 times as long as broad ····· 35

Antennal scape more than 3 times as long as broad ····· 78

35. Antenna with flagellum strongly flattened and expanded (Figs 69, 70, 71, 73) ····· 36

Antenna with flagellum not flattened and expanded, more or less cylindrical in cross-section, if somewhat flattened and expanded, at least basal segments clearly longer than broad ····· 43

36. Mandible bidentate; hypopygium reaching apex of gaster ····· 37

Mandible not bidentate, usually tridentate or with two teeth and an upper truncation; hypopygium at most reaching 3/4 of gaster ····· 38

37. Antennal clava entire; marginal vein of forewing conspicuously long; ovipositor distinctly exserted, with the exserted part about 1/3 gaster length ····· ***Tetracnemus***

Antennal clava 3-segmented; marginal vein of forewing short and more or less twice as long as broad; ovipositor hardly exserted ····· ***Cryptanusia***

38. Forewing with one or two longitudinal infuscate bands or with several stripes radiating from a median longitudinal stripes ····· 39

Forewing more or less evenly infuscate, or with hyaline lunate band apically or subapically ··· 41

39. Forewing with one or two longitudinal infuscate bands ····· ***Comperiella***

Forewing with one or two longitudinal infuscate bands or with several stripes radiating from a median longitudinal stripes ····· 40

40. Antenna with scape more or less triangular; submarginal vein without a triangular expansion subapically ····· ***Cerapteroceroides***

Antenna with scape more or less rectangular; submarginal vein with a triangular expansion subapically ····· ***Cerapterocerus***

41. Face without a transverse ridge at top of antennal scrobes; marginal vein of forewing punctiform; antennal clava entire (Fig 71) ····· ***Leurocerus***

Face with a transverse ridge at top of antennal scrobes; marginal vein of forewing clearly longer than broad; antennal clava 3-segmente (Figs 69, 70) ····· 42

42. Frontovertex with distinct punctures giving an appearance of thimble; body usually dark brown and with some metallic sheen ····· ***Eusemion***

Frontovertex without distinct punctures, if present, only sparsely scattered; body usually yellow or yellow brown, sometimes partly dark ····· ***Anicetus***

43. Forewing infuscate or with a distinct infuscate pattern, sometimes developed by contrasting dark

and white setae 44

Forewing generally hyaline 59

44. Antennal calva apically strongly obliquely truncated, the truncated part about as long as the ventral surface of the remainder part (Figs 68, 101) 45

Antennal calva apically more or less transversely truncated or rounded, if obliquely truncated, the truncated part clearly shorter than the ventral surface of the remainder part 51

45. Mandible bidentate; linea calva of forewing usually interrupted or closed posteriorly 46

Mandible not bidentate; linea calva of forewing not interrupted or closed posteriorly 48

46. Pedicel of antenna shorter than first funicular segments; forewing with distinct infuscate bands ..... ***Yasumatsuiola***

Pedicel of antenna longer than first funicular segments; forewing without distinct infuscate bands 47

47. Frontovertex narrow, usually less than 1/4 head width, covered with distinct piliferous punctures giving an appearance of thimble or golf-ball (Fig 30); marginal vein clearly longer than broad; dorsum of thorax without striated reticulations (Fig 57) ..... ***Aenasius***

Frontovertex more or less 1/3 head width, without distinct piliferous punctures (Fig 28); marginal vein of forewing punctiform (Fig 182); dorsum of thorax with striated reticulations giving a silky appearance (Fig 59) ..... ***Grandiclavula***

48. Marginal vein of forewing punctiform, or forewing without marginal vein, stigmal vein and postmarginal vein developed directly from submarginal vein (Fig 156) 49

Marginal vein of forewing punctiform conspicuously longer than broad, at least three times longer than broad; stigmal vein and postmarginal vein developed from marginal vein 50

49. Scutellum with a median longitudinal ridge; clava conspicuously shorter than funicle ..... ***Pentelicus***

Scutellum without a median longitudinal ridge; clava about as long as funicle ..... ***Zozoros***

50. Hypopygium reaching apex gaster; ovipositor strongly exserted, exserted part at least 1/3 gaster length ..... ***Prochiloneurus***

Hypopygium reaching about half of gaster; ovipositor not or at most slightly exserted ..... ***Cheiloneurus***

51. Costal cell of forewing strongly incised apically; head with distinct piliferous punctures which giving an appearance of thimble or golf-ball ..... ***Eugahania***

Costal cell of forewing not or hardly incised apically; head at most with sparse piliferous punctures and not giving an appearance of thimble or golf 52

52. Mandible bidentate; forewing with linea calva interrupted on dorsal surface posteriorly; hypopygium more or less reaching apex of gaster 53

Mandible not bidentate; forewing with linea calva open posteriorly, or interrupted on dorsal surface by one line of setae in posteriorly 1/3; hypopygium not reaching apex of gaster, at most reaching 4/5 along gaster 57

53. Forewing with postmarginal vein usually longer than stigmal vein 54