STATUS OF THE SYSTEMATIC KNOWLEDGE AND PRIORITIES IN EPHEMEROPTERA STUDIES: THE ORIENTAL REGION

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ABSTRACT

Of the 28 families containing about 400 genera and approximately 3,000 species of extant Ephemeroptera, 19 families, 104 genera (47 of these endemic) and more than 535 species have been described from the Oriental region including its transition zones (Afghanistan, Himalaya, China, and Papua-New Guinea). The families Baetidae, Heptageniidae and Leptophlebiidae exhibit the greatest diversity in this region. Mayfly diversity and distribution are briefly reviewed at the generic level based on the literature. However, our knowledge of Oriental mayflies seems to be fragmentary since most species are known only in either the larval (about 35%) or adult stage (about 39%); the total number of species is estimated to be at least 3-4 times higher. With few exceptions (e.g. Sri Lanka, Hong Kong, and the Sunda Islands), there are no detailed data on local faunas, biogeography, ecology and life cycles. Further taxonomic research, association of larvae and adults previously described separately, revision of available type material, detailed revisions of genera or species-groups, studies of faunas of defined regions (however small), biogeographic analysis including definition of the limits of the Oriental region, and intensive study of mayfly biology are the main research priorities discussed in this paper.

INTRODUCTION

Although considerable attention has been paid to mayflies of the Oriental region, our present knowledge is very fragmentary. Besides original descriptions by earlier authors (e.g. Pictet, Eaton, Walker, Hagen, and others) and the extensive monographs concerning the Sunda Islands (Ulmer, 1939, 1940), our knowledge is mostly based on isolated or occasional descriptions of new species and genera collected mostly by expeditions directed to other problems, or by general collectors. Furthermore, many types are lost (cf. Hubbard, 1984a, Alba-Tercedor and Peters, 1985) and subsequent taxonomic treatment of some groups is difficult. Only a few higher taxa, i.e. the Leptophlebiidae, Potamanthidae and Neoephemeridae, have been treated in detail (Peters & Edmunds, 1970; Bae & McCafferty, 1991, 1998) and

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catalogs exist for species of some areas, e.g. Tonkin (Lestage, 1921, 1924), the Indian subcontinent (Hubbard & Peters, 1978), the Philippines (Hubbard & Pescador, 1978), Hong Kong (Hubbard, 1986) or China (Gui, 1985; You & Gui, 1995). Larvae of mayflies of Taiwan are being studied intensively at the present time (Kang & Yang, 1994a-f, 1995, 1996). From the biogeographical point view, only Sri Lanka (Hubbard & Peters, 1984) and the Malaysia Peninsula and the Sunda Islands (Edmunds & Polhemus, 1990) have been discussed and Edmunds (1972, 1975, 1979) gave an extensive discussion of the origin of most Oriental genera.

The principal objective of this review is to briefly summarize knowledge of the diversity of mayflies of the Oriental region emphasizing which taxa should be urgently treated and to suggest the priorities of mayfly studies in this geographical area.

DIVERSITY AND DISTRIBUTION OF THE ORIENTAL EPHEMEROPTERA

In the following discussion, the mayfly taxa discussed are arranged according to the catalog of the families and genera of the world by Hubbard (1990) although this list principally follows the higher classification by McCafferty (1991a). In evaluating individual taxa, I have attempted to follow their original meaning when established to emphasize the needs for further revision. The Oriental region (sometimes called the Indomalayan region), although usually limited by the Thar Desert in Pakistan, the Himalaya's main mountain ridge, southern China and the Wallace's line, is considered here to include transition zones and/or adjacent subareas of neighbor biogeographic regions, i.e. Afghanistan, Pakistan, most of China, Cele-

Table 1. Families, genera and approximate number of species of Ephemeroptera in the Oriental region (* endemic taxa; the genus *Teloganella* of unclear family status not included)

Family	N° of genera	N° of species	Larval stage only	Adult stage only	Limited distribution or endemic taxa
Baetidae	23	152	78	55	9 genera*, Tab. 2
Ameletidae	1	5	3	1	Himalaya, Taiwan
Siphlonuridae	1	2	-	2	*Siphluriscus**, China
Oligoneuriidae	2	3	1	1	Chromarcyinae*
Isonychiidae	1	7	2	3	
Heptageniidae	19	114	37	48	7 genera*, Tab. 3
Leptophlebiidae	23	65	10	16	16 genera*, Tab. 4
Behningiidae	1	1+	-	-	Thailand
Euthyplociidae	1	3	-	2	*Polyplocia**
Ephemeridae	2	42	2	24	*Eatonigenia**, subg. *Aethephemera**
Palingeniidae	3	22	-	19	*Plethogenesia**
Polymitarcyidae	2	13	3	7	subg. *Languidipes**
Potamanthidae	2	17	3	6	*Rhoenanthus** and subg. *Stygifloris**
Ephemerellidae	10	39	19	7	4 genera*
Teloganodidae	3	11	3	7	*Teloganodes**, *Macafertiella**
Tricorythidae	1	1+	-	-	
Neoephemeridae	1	5	2	-	*Potamanthellus**
Caenidae	6+	29	17	10	*Caenoculis**
Prosopistomatidae	1	9+	8	1	
Total (19 families + *Teloganella**)	103 (+ 1)	536 (+ 1)	188 (35%)	209 (39%)	141 spp. in both stages (26 %)

bes, Papua-New Guinea and northernmost Australia. The total number of families and genera and the approximate number of species described are listed in Table 1 and reviewed below.

Baetidae. This family represents the most diversified mayfly group within the Oriental region. The approximate number of species described for individual genera are apparent from Table 2. Fourteen genera are classified within the subfamily Baetinae, 7 genera within the Cloeoninae; however, the generic classification of the Baetidae is not still fully understood. Some genera are classified to subgeneric rank (e.g. *Acentrella* and *Baetiella* are considered to be subgenera of *Baetis*) and intergeneric taxonomic shifts are frequent in contemporary literature. For instance, an examination of *Pseudocloeon*-like species showed that only the type species, *P. kraepelini* Klapálek (larva unknown), could be included in the species-rich genus *Pseudocloeon* (cf. Waltz & McCafferty, 1987a); however, the most recent study (Lugo-Ortiz et al., 1999) considered *Pseudocloeon* congeneric with *Labiobaetis* and all species previously assigned to *Labiobaetis* were reassigned to *Pseudocloeon*. Consequently, there are 21 species of *Pseudocloeon* occurring in the Oriental region which were originally described in *Acentrella, Baetis, Labiobaetis* and *Pseudocloeon*, 8 of them known only in the adult stage and 12 described only as larvae. The only species known in both larval and adult stages is *P. fulmeki* (Ulmer).

Detailed study of *Cloeodes*-like species described as *Centroptella* (Braasch & Soldán, 1980) showed that these Oriental species actually belonged to *Cloeodes* (originally considered Neotropical) and *Chopralla* which is endemic to the Oriental region (Waltz & McCafferty, 1987b, c). Distributions of endemic genera are given in Table 2. Larvae of the peculiar genus *Symbiocloeon* live in bivalve molluscs (Müller-Liebenau, 1979). Adults of most endemic species have not been described, except for the adult female of *Echinobaetis* (Lugo-Ortiz & McCafferty, 1997).

The nearly cosmopolitan genera *Baetis* and *Cloeon* are very diverse comprising 43 and 25 species, respectively, in the Oriental region. However, these numbers are probably inaccurate. On one hand, many new species are yet to be described (there are at least 10 unnamed species of *Baetis* in Vietnam); on the other hand some species are probably synonyms named from different life cycle stages. For instance, all species of *Baetis* described from the Philippines (Müller-Liebenau, 1982), West Malaysia and Sabah (Müller-Liebenau, 1984a, b), Taiwan (Müller-Liebenau, 1985, Kang & Yang, 1994a, 1995a) and Sri Lanka (Müller-Liebenau & Hubbard, 1985) are known solely in the larval stage. Species known as both larvae and adults are very rare within *Baetis* (e.g. *B. lahauensis* Kaul & Dubey, *B. javanicus* Ulmer, altogether only 3 species) or *Cloeon* (e.g. *C. marginale* Hagen, *C. fluviatile* Ulmer or *C. exiguum* Navás, altogether 7 species). In some species, revision is difficult because the species is known only from the adult female (e.g., *Baetis seragruis* Dubey).

Predominantly Palaearctic genera extending into the Oriental region include: *Alainites* from China, Malaysia and Taiwan; *Nigrobaetis* from West Malaysia (one species) and Taiwan (8 species); *Acentrella* from Taiwan; *Procloeon* from India, Sri Lanka, Thailand, Malaysia, Hong Kong and Taiwan; and *Baetiella* from the Himalaya and Taiwan. *Alainites pekingensis* (Ulmer), *Baetiella bispinosa* (Gose), and *B. ladakae* Traver are the only species of these genera known in the adult stage. *Centroptilum* occurs in India and China and larvae of an undescribed species have been found in Vietnam. The Nearctic genus *Fallceon* is represented by a single species, *F. candidus* (Kang & Yang, 1995a) in Taiwan.

Ameletidae. Only the genus *Ameletus* of this exclusively Holarctic family extends to the Oriental region or, more precisely, to its transition zones. Three species known only in the larval stage have been recently described from Taiwan (Kang & Yang, 1994a). *Ameletus primitivus* Traver (larva and female) was described from Kashmir (Kyam) (Traver, 1939) and larvae closely related to the Central Asian species *A. alexandrae* Brodsky were collected in Nepal Himalaya (Braasch, pers. comm.). A new subgeneric classification of *Ameletus* is presented in these proceedings (Zloty, in press).

Table 2. Genera and approximate number of species of the family Baetidae in the Oriental region (* presumably endemic genera/subgenera, § adults unknown).

Genus	N° of species	Larval stage only	Adult stage only	Distribution of endemic genera
Acentrella	1	-	-	
Alainites	4	3	1	
Baetiella	9	7	1	
Baetis	43	19	22	
Baetopus subg. *Raptobaetopus**	1	1	-	Malaysia
Centroptilum	4	-	4	
Chopralla§	5	-	-	Sri Lanka, Malaysia
Cloeodes	3	3	-	
Cloeon	25	2	17	
Gratia§	1	1	-	Thailand
*Echinobaetis**	1	-	-	Sulawesi
Fallceon	1	1	-	
Indobaetis§	2	2	-	Sri Lanka
Indocloeon§	1	1	-	Sri Lanka
Jubabaetis§	1	1	-	Philippines
Liebebiella§	9	9	-	Nepal, Sri Lanka, Malaysia, Philippines
Nigrobaetis	8	8	-	
*Platybaetis**	4	3	-	Nepal, Malaysia, Borneo, Vietnam, Philippines
Procloeon	4	3	-	
Pseudocentroptiloides subg. *Psamonella* *§	1	1	-	Sri Lanka
Pseudocloeon	21	12	8	
Symbiocloeon§	1	1	-	Thailand
Takobia	2	-	2	
Total (23 genera)	152	78	55	19 spp. in both stages

Siphlonuridae. This predominantly Holarctic family is represented in the Oriental region by the genus *Siphluriscus*. Originally assigned to Acanthametropodidae (cf. McCafferty & Wang, 1994), it is found in the Tsayin Mts., China (*Siphluriscus chinensis* Ulmer, known only from adult male and female subimago). *Siphluriscus davidi* Navás described from Chusan (China) represents an unclear species and the type material is probably lost (cf. Alba-Tercedor & Peters, 1985).

Oligoneuriidae. Except for *Oligoneuriella kashmirensis* (Ali) (Oligoneuriinae) known in the larval stage from the transition zone in Pakistan (Ali, 1971) and Afghanistan, only the monotypic Chromarcyinae are present in the Oriental region. *Chromarcys feuerborni* (Ulmer) is known from Sumatra (Ulmer, 1939, 1940); other species of this genus were found in Thailand, Srí Lanka (Hubbard & Peters, 1984), and Vietnam. *Chromarcys magnifica* Navás is known from the female adult from China (Demoulin 1967).

Isonychiidae. This monotypic family widespread in the Holarctic region includes 7 described species from the Oriental region. Only *I. formosana* (Ulmer) (Japan and Taiwan) and *I. kiangsinensis* Hsu (China) are known in both larval and adult stages; larvae of other species from the Greater Sunda Islands [*I. grandis* (Ulmer), *I. sumatrana* (Navás), *I. winkleri* Ulmer] and Hainan (*I. hainanensis* She & You) remain unknown (Ulmer, 1940, Zhou, et al., 1997). Larvae of several species have been found in Indochina (e.g. in Laos, Vietnam and Thailand). *Isonychia khyberensis* Ali, known only in the adult stage, occurs in Pakistan (Ali, 1971).

Heptageniidae. Genera and species of the subfamily Heptageniinae from the Oriental region are listed in Table 3. The generic classification of this family is still not satisfactory, although individual genera or species groups mostly representing natural clades have been

defined at different (and sometimes arbitrary) levels by various authors. There is little doubt that the Oriental region is the most important center of biodiversity for this family, and revision of genera in this region should resolve many of the problems in the rest of the world. The former genera *Ororotsia* and *Nixe* are generally considered to be congeneric with *Cinygmula* and *Ecdyonurus*, respectively, or to be subgenera. Similarly, the genera *Belovius* and *Iron* are frequently considered to be subgenera of *Epeorus*. Undoubtedly natural, monophyletic groups of *Ecdyonurus*-like genera consist of closely related taxa with weakly defined differential diagnoses and/or distributional types (McCafferty, 1991b). Consequently, original genera are often subjected to taxonomic shifts and Kluge (1988) even synonymized the genera *Thalerosphyrus, Afronurus, Cinygmina, Notacanthurus, Electrogena,* and *Asionurus* with *Ecdyonurus*.

Endemic genera and their distribution are given in Table 3. At the generic level, larval stages are known for all genera except *Epeorella.* Adults of *Asionurus* and *Trichogenia* have not been described. Description of larval stage and revision of the genus *Atopopus* were published by Wang & McCafferty (1995).

As with the Baetidae, Palaearctic and Holarctic genera are found mostly within transition zones. *Belovius* reaches the southern slopes of the Himalaya and China. The Holarctic genus *Iron* has a similar distribution with the southernmost limits in India (Punjab) or Nepal; the only exception is *I. martius* Braasch & Soldán from Vietnam. *Epeorus* reaches to Vietnam and West Malaysia (Gombak Riv.). The predominantly Holarctic *Rhithrogena* (only 8 species described in the Oriental region, more than 120 Holarctic species) also reaches its southern limits in Nepal and Kashmir, with an isolated distribution of *R. diehliana* Braasch & Soldán in Sumatra (Braasch & Soldán, 1986a). *Cinygmula* enters the Oriental region only

Table 3. Genera and approximate number of species of the family Heptageniidae in the Oriental region (* presumably endemic genera/subgenera, § adults unknown, §§ larvae unknown).

Genus	N° of species	Larval stage only	Adult stage only	Distribution of endemic genera
Afronurus	10	3	4	
*Asionurus**§	2	2	-	Vietnam
*Atopopus**	3	-	-	Borneo
Belovius	6	2	2	
Cinygma	3	-	-	
*Cinygmina**	9	3	4	India, Vietnam, China
Cinygmula	2	1	1	
incl. *Ororotsia** and	1	-	1	Himalaya
Compsoneuria	5	1	2	
Ecdyonurus	23	1	15	
incl. *Nixe* and	3	3	-	
Notacanthurus	2	2	-	
Electrogena	1	1	-	
Epeorus	5	4	1	
*Epeorella**§§	1	-	1	Borneo
Heptagenia	11	2	8	
Iron	8	3	2	
*Paegniodes**	1	-	-	China
Rhithrogena	8	4	3	
*Rhithrogeniella**	2	1	1	Sumatra, Tonkin
Thalerosphyrus	7	2	4	
*Trichogenia**§	1+	1	-	Vietnam, Sulawesi
Total (19 genera)	114	36	49	29 spp. in both stages

in India and southern China. *Cinygmina* is endemic to the Oriental region with 3 species described from the Indian subcontinent and 6 species from Vietnam and China.

There are two groups of genera that are widely distributed, but no genus is cosmopolitan. The genera *Compsoneuria* and *Afronurus* have an Ethiopian-Oriental distribution. *Compsonueria cingulata* (Navás) is described from Chusan Prov., China (type material lost), and 4 species are known from Southeast Asia (Braasch & Soldán, 1986b). Eleven species of *Afronurus* are described from the Oriental region (India to the Philippines); *Thalerosphyrus* displays a similar distribution (India and China to the Sunda Islands).

Twenty-three species of the predominantly Palaearctic *Ecdyonurus* have been reported from the Oriental region, most of them from the foothills of the Himalaya and China. Southernmost records include *E. illotus* Navás (the Philippines) and 3 other species described by Navás (e.g., *E. pallescens, E. pichoni, E. radialis*); none of the type material of any of these species has been studied. Three species of *Nixe* are reported from Taiwan (Kang & Yang, 1994b) and 2 species of *Notacanthurus* are described from the Himalaya in the larval stage (Braasch 1986). The material of *Electrogena fracta* Kang & Yang appears to belong to some other genus (cf. Kang & Yang, 1994c). The genus *Heptagenia* has the largest distribution within the Oriental and Nearctic regions with 8 species from the Sunda Islands, one from China (*H. limbata* Navás) and one from Assam, India (*H. nubila* Kimmins).

Leptophlebiidae. Two subfamilies of Leptophlebiidae are known from the Oriental region. Genera and the approximate number of species are listed in Table 4. Contrary to the families Baetidae and Heptageniidae, the generic classification of Leptophlebiidae (or, more precisely, that of the Eastern Hemisphere genera) seems to be well-understood thanks to the extensive revision by Peters & Edmunds (1970). The subfamily Leptophlebiinae includes 5 genera. Species of the Nearctic *Leptophlebia* and *Paraleptophlebia* occur in China, northern India, Nepal and Taiwan. The Nearctic and Oriental genus *Habrophlebiodes* contains 4 species from Sumatra, Java, China, and Hong Kong. The monotypic *Dipterophlebiodes sarawacensis* Demoulin is restricted to Borneo and West Malaysia and *Gilliesia hindustanica* (Gillies) seems to be endemic to northern India (Peters & Edmunds, 1970).

Most genera of the Oriental Leptophlebiidae belong to the subfamily Atalophlebiinae. The genus *Choroterpes* appears to be African in origin and *Choroterpes* s. str. may have given rise to the subgenus *Euthraulus;* both are widespread throughout the Oriental and Ethiopian regions and 18 species are described from tropical Asia. *Choroterpides* is known from Nepal, Thailand, Indochina, Java and Sumatra. One species of *Cryptopenella* known from Hong Kong may be a synonym of *Choroterpes* (Kluge, 1984). Species of *Thraulus* are known from India, Thailand, Vietnam, Hong Kong, and Taiwan. Other endemic genera are listed in the Table 4. The genera *Kimminsula*, *Petersula*, and *Nathanella* (southern India and Sri Lanka) represent a true Gondwanian derivative and share a common ancestry with genera living in Madagascar; *Sulawesia haema* Peters & Edmunds occurs in Sulawesi (Celebes) and is a member of the ancient Gondwanian *Atalophlebioides* lineage which is widespread in Australia, New Zealand, South America, Madagascar, Srí Lanka and Southern India (Peters & Edmunds, 1990).

Behningiidae. Only one species of this largely Holarctic family, *Protobehningia merga* Peters & Gillies (male imago and larval exuviae collected in the river Kwai in Thailand), is known from the Oriental region (Peters & Gillies, 1991; Hubbard, 1994). Based on the known distribution, *Protobehningia* seems to be Oriental in origin (Peters & Gillies, 1991). Another undescribed species of *Protobehningia* has been recently collected in Sumatra (Peters, pers. comm.).

Euthyplociidae. The genus *Polyplocia* is represented by 3 species in the Oriental region. Adults of *P. crassinervis* and *P. campylociella* were described by Ulmer (1939, 1940) from Borneo. Lestage (1921, 1924) described adults of *P. vitalisi* from Tonkin. Larvae of this genus were described by Demoulin (1966).

Table 4. Genera and approximate number of species of the family Leptophlebiidae in the Oriental region (* presumably endemic genera/subgenera, § adults unknown).

Genus	N° of species	Larval stage only	Adult stage only	Distribution of endemic genera
*Dipterophlebioides**	1	-	1	Borneo
*Gilliesia**	1	-	1	India (Assam)
Habrophlebiodes	4	1	-	
Leptophlebia	3	-	2	
Paraleptophlebia	2+	-	2	
*Barba**	1	-	-	Papua-New Guinea
Choroterpes	5	1	2	
Choroterpides	3	1	1	
*Cryptopenella**	2	-	-	Thailand, Hong Kong
Euthraulus	14	2	5	
*Indialis**	2	-	-	India (Kerala), China
*Isca** subg. *Isca*	1	-	-	India, Hong Kong
subg. *Minyphlebia*	1	-	-	Thailand
subg. *Tanycola*	1	-	-	Sri Lanka
*Kimminsula**	3	-	-	Sri Lanka
*Magnilobus**	1	-	1	Papua-New Guinea
*Megaglena**	1	-	-	Sri Lanka
*Nathanella**	2	-	-	South India
*Nonnullidens**	2	1	-	Papua-New Guinea
*Notophlebia**	1	-	-	India (Tamil Nadu)
*Petersula**	2	-	-	India (Tamil Nadu)
*Simothraulus**§	1	-	1	Borneo, Sabah
*Sulawesia**	1	-	-	Sulawesi
*Sulu**	2	-	-	Malaysia, Borneo, Mindanao
Thraulus	8	4	-	
Total (23 genera)	65	10	16	39 spp. in both stages

Ephemeridae. Only the genera *Eatonigenia* and *Ephemera* of this widely distributed family are recorded in the Oriental region. Previous records of *Ichthybotus* and *Hexagenia* from India seem to be obvious errors (cf. e.g., McCafferty, 1973a, b; Hubbard, 1990). There are 6 described species of the endemic genus *Eatonigenia*: *E. chaperi* (Navás) is known from Borneo, Java, Thailand and China (cf. Zhang, et al., 1995), larvae of *E. indica* (Chopra), *E. trirama* McCafferty (India), *E. seca* McCafferty (Thailand) and *E. philippina* (Navás) (Philippines) are unknown, and *E. chinei* (Dang) (Vietnam) is described only in the larval stage (McCafferty, 1973b, 1991a). More than 25 species of the genus *Ephemera* have been described from the Oriental region. *Ephemera nadinae* McCafferty & Edmunds (Thailand) belongs to the subgenus *Aethephemera* (McCafferty & Edmunds, 1973), but most species are placed in the subgenus *Ephemera* s.str. This genus is known from Taiwan, Sri Lanka, the Indian subcontinent and China. but evidently does not cross Wallace's line. It shows a relative high diversity here from whence it probably dispersed to the Ethiopian region (Edmunds, 1979). Many species are known only from the type series, and some types are lost. This genus requires a detailed revision.

Palingeniidae. Three genera of this family are known from the Oriental region, *Palingenia*, *Anagenesia* and *Plethogenesia*. The last two are endemic to the Oriental region while the distribution of the first includes the Palaearctic region as well. *Palingenia orientalis* Chopra is recorded from Iran and India. Besides the doubtful species *Anagenesia leucoptera* Navás recorded from Tonkin, 11 species of this genus have been described from the Sunda Islands; *A. lontona* Hafiz occurs in Burma and in Assam, and *A. robusta* (Eaton), *A. minor* (Eaton) and *A. birmanica* Navás were collected in India and Burma. All five

species of *Plethogenesia* are endemic to Papua-New Guinea (Demoulin, 1965). With the exception of species of *Palingenia*, *Anagenesia robusta* (Eaton) and *Plethogenesia papuana* (Eaton) are the only species known in the larval stage.

Polymitarcyidae. Two genera of this family have been found in the Oriental region — *Ephoron* (Polymitarcyinae) and *Povilla* (Asthenopodinae). Of the former, 5 species are known from the Indian subcontinent including Sri Lanka, all described from adults. Recently *E. hainanensis* Gui & Zhang was described in adult stage from Hainan (Gui & Zhang, 1997). An uncertain record on the occurrence of the European species *E. virgo* from China was published by Hsu (1935). The genus *Povilla,* comprises a single Afrotropical species and 7 Oriental species, was revised by Hubbard (1984b). *P. andamanensis* Hubbard (South Andaman Island), *Povilla junki* Hubbard (Thailand), and *P. (Languidipes) taprobanes* Hubbard (Sri Lanka), are known in the larval stage only. Both genera have probably dispersed from the Oriental to the Ethiopian (Edmunds, 1975, 1979).

Potamanthidae. Detailed revision of this originally Laurasian family including a detailed analysis of distributional patterns has been completed by Bae & McCafferty (1991). All genera of this family except for the Nearctic *Anthopotamus* occur in the Oriental region. The subgenus *Rhoenanthus s. str.* comprises two allopatric species: *R. distafurcus* Bae & McCafferty (south India and South East Asia, larva unknown), and *R. speciosus* Eaton occurring in the Sunda Islands and southern Malaysian Peninsula. Species of *Rhoenanthus* (*Potamanthindus*) occur in Southeast Asia and China [*R. obscurus* Navás, *R. magnificus* Ulmer —larvae unknown, *R. youi* (Wu & You)]; only a single species [*R. coreanus* (Yoon & Bae)] extends past the borders of the Oriental region. Within *Potamanthus*, the monotypic subgenus *Stygifloris* seems to be endemic to Borneo (Sabah) and 10 species of the subgenus *Potamanthodes* are distributed in a relatively narrow belt-like area from central Japan to southernmost Malaysia. One doubtful species *P. subcostalis* Navás, originally described from adults, is recorded from southern India. Much of Southeast Asia is inhabited by the common *P. formosus* Eaton. On the other hand, *P. idiocerus* Bae & McCafferty seems to be endemic to Taiwan (Bae & McCafferty, 1991, Kang & Yang, 1994e) There are also several species of uncertain taxonomic position described on the basis of adult material from China (e.g., *P. macrophthalmus* You, *P. kwangsiensis* Hsu, *P. sangangensis* You, *P. yunnanensis* You et al.).

Ephemerellidae. Ten genera of this family inhabit the Oriental region. The endemic genus *Ephacerella* (=*Acerella* Allen 1971, nec Berlese, 1909 cf. Paclt, 1994) consists of three species occurring in Southeast Asia and Japan, *E. uenoi* (Allen & Edmunds) in India, and two species (*E. montana, E. glebosa*) described from Taiwan by Kang & Yang (1995b). Four species of *Crinitella* occur mostly in Kashmir, Nepal and Pakistan (a single species known from Malaysia), and most are known in the larval stage only. *Cincticostella* exhibits a disjunctive distribution in the Far East, Japan and the Southeast Asia (Allen, 1980). Three species (all in the subgenus *Rhionella*) occur in the latter area.; two additional species (*C. fusca, C. colossa*) have been recently described from Taiwan by Kang & Yang (1995b). The predominantly Holarctic *Drunella* is represented by 12 Oriental species classified in the subgenera *Drunella* s. str., *Myllonella*, and *Tribrochella*. These species occur mostly in montane streams of the Himalaya, Hindukush [e.g. *D. kabulensis* (Ali), *D. submontana* (Brodsky) and *D. serrata* Braasch] and China; species from China are known in the adult stage only (cf. Su & Gui, 1995). The southernmost extension of *Drunella* is represented by *D. soldani* Allen from southern Vietnam (Allen, 1986). Four species of *Serratella* have been described in adult stage from China (You & Gui, 1995). *Teloganopsis media* Ulmer is widely distributed in Java (Allen, 1980), *Torleya nepalica* (Allen & Edmunds) occurs in the Himalaya, another unnamed species lives in southern Vietnam, and *T. glareosa* Kang & Yang and *T. lutosa* Kang & Yang seem endemic to Taiwan. The monotypic genus *Eburella* (*E. brocha* Kang & Yang), known from the larval stage only, is also endemic to Taiwan, and the monotypic *Hyrtanella christinae* Allen & Edmunds may be endemic to Borneo. In addition a

single species of *Ephemerella* is known from India in the larval stage (Kapur & Kripalani, 1963) and 3 species are described from China in the adult stage (You & Gui, 1995).

Teloganodidae. Three genera of this family (McCafferty & Wang,1997) are known to occur in the Oriental region. *Vietnamella* (subfamily Austremerellinae) is represented by 6 species in Vietnam and southern China. Some [e.g. *V. thani* Tshernova, *V. ornata* (Tshernova)] are known from larvae only; others [e.g. *V. sinensis* (Hsu)] as adults; and *V. dabieshanensis* You & Su from larvae and adults. Within the subfamily Teloganodinae, the monotypic *Macafertiella* is considered endemic to Sri Lanka; however, other species apparently live in south India. *Teloganodes* is widely distributed throughout the whole Oriental region showing relatively high diversity here although only 4 species are named. The most common is *T. tristis* (Hagen) occurring in the Sunda Islands, the Philippines, Southeast Asia, China and Indian subcontinent including Sri Lanka. Other species, like *T. dentata* Navás and *T. major* Eaton, are known only in the adult stage.

The monotypic genus *Teloganella* represents a taxon of uncertain systematic position. *T. umbrata* Ulmer, occurring in the Sunda Islands and Malaysia (Ulmer, 1939, Wang, et al., 1995), is classified either in the Teloganodidae or in the Tricorythidae (Peters & Peters, 1993, Wang, et al., 1995). Further, an unnamed species of the same or closely related genus occurs in southern India.

Tricorythidae. The only species of this family (subfamily Tricorythinae) known from the Oriental region is *Tricorythus jacobsoni* Ulmer. Adults were described by Ulmer in 1924 and larvae in 1940 from South Sumatra and West Java. The relationships of this species to other representatives of the genus from the Ethiopian region are not clear. There are several unnamed species closely related to *T. jacobsoni* collected throughout the Oriental region.

Neoephemeridae. Detailed revision of this family, the distributional patterns of which appear to be most similar to the Potamanthidae, was published by Bae & McCafferty (1998). The only Oriental genus is *Potamanthellus* (= *Neoephemeropsis*) with 4 described species. In addition to *P. chinensis* (Hsu) occurring in northwestern China and the Far East, *P. ganges* Bae & McCafferty (adult unknown) is described from northern India and the 3 other species [(*P. amabilis* (Eaton), *P. caenoides* (Ulmer) and *P. edmundsi* Bae & McCafferty, adults of the latter unknown] are sympatric in Southeast Asia. This genus does not cross Wallace's line.

Caenidae. Five genera of this family have been reported from the Oriental region, i.e. *Brachycercus, Cercobrachys, Caenoculis, Caenis,* and *Clypeocaenis*. Only one species of *Brachycercus* (*B. gilliesi* from Sri Lanka) is described from the Oriental region (Soldán & Landa, 1990), representing an Oriental extension of this largely Holarctic genus. *Cercobrachys* is a widely distributed genus with 2 representatives in the Oriental region (Soldán 1986). On the other hand, *Caenoculis* seems to be endemic to this area; 2 species are known from Vietnam and one from Malaysia (Soldán, 1986) but other unnamed species undoubtedly occur in this region. *Clypeocaenis* is an Oriental-Ethiopian genus which seems to have its center of biodiversity in the Oriental region with 4 species described from India, Sri Lanka, Thailand, Vietnam; its sister-group taxon possessing brush-legged larvae occurs in South Africa. The taxonomy of *Caenis* in the Oriental region is not well studied and there are undoubtedly many species yet to be described. Of the19 species described, most are from the Indian subcontinent and Taiwan (Kang & Yang, 1994d).

Prosopistomatidae. Of the 16 species of this monotypic family, six are known from the Oriental region. In addition to *Prosopistoma wouterae* (Lieftinck) from Western Java, Peters (1967) described 5 further species from India and Sri Lanka (*P. indicum, P. lieftincki*), the Philippines (*P. boreus, P. palawana*) and Papua-New Guinea (*P. sedlaceki).* Two more species were described from Vietnam by Soldán & Braasch (1984) and one (*P. pearsonorum*) from far north Queensland in Australia (Campbell & Hubbard, 1998). The latter species is the only one known in adult stage. Distributional patterns of most species were treated by Koch (1988). However, there are a number of species yet to be described, at least 10 from Southeast Asia (Peters, pers. comm.).

CONCLUSIONS AND RESEARCH PRIORITIES

Of the total number of recent Ephemeroptera (28 families, about 400 genera and approximately 3000 species) altogether 19 families, 104 genera and approximately 537 species have been so far identified in the Oriental region. Contrary to a very high percentage of taxa at the family level, the number of known genera is relatively low. However, this is affected by the absence of most Gondwanian Leptophlebiidae, a highly diversified family. Despite a relatively large number of species described from the Oriental region, mayfly diversity is most probably 3-4 times higher than known since the total known number of species is comparable to that of the Nearctic or West Palaearctic faunas, areas with an original fauna considerably reduced by the last glaciation.

In addition to basic taxonomic research, research priorities of the Oriental Ephemeroptera can be summarized as follows:

(i) Revision of unclear or weakly defined genera, especially those in the families Baetidae and Heptageniidae.

(ii) Proper association of larvae and adults described separately. Some genera (e.g. *Epeorella*) are known in adult stage only and other genera (e.g. *Symbiocloeon, Trichogenia* and *Eburella*) only as larvae. Of about 43 species of the genus *Baetis* known from this area, approximately a half are known only in the adult stage (especially those of the Indian subcontinent) while many remaining species (mostly those in Southeastern Asia) are described in the larval stage.

(iii) Revision of type material scattered in different institutions; however about a third of the type material is lost or missing. Concentration on detailed generic or species-group revision and study of faunas of well defined areas however small.

(iv) Biogeographical analysis of species/genera origins. Considerable attention should be paid to transitory areas and to the definition of the Oriental limits. There is no doubt that the limits as defined on the basis of vertebrate distribution (e.g. Wallace's line) do not match the distribution of Ephemeroptera and invertebrates in general.

(v) Study of life cycle and ecology of individual species or mayfly taxocenes. Only very fragmentary data have been published on biology of the Oriental species. Apart from Ulmer's (1940) summary of seasonal occurrence of the Sunda Island species and Edmunds and Edmunds' (1980) study of adult and subimaginal adaptation, there are few detailed studies on mayfly seasonality and habits in this region. However, valuable data have been collected in the framework of limnological studies especially in Malaysia (Bishop, 1973), Hong Kong (Dudgeon, 1992); see this monograph for further references on mayfly biology), and the Indian part of the Himalaya (Pandit, 1999).

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