A HISTORICAL REVIEW OF EPHEMEROPTERA SYSTEMATICS IN NORTHEAST ASIA

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Mayfly systematics in Northeast Asia, covering Korea, Japan, Russia (Far East), and China (Manchuria), was reviewed from a historical perspective based on comprehensive bibliographic sources and type information. About 230 species of mayflies (ca. 10% of all known mayflies) have been recorded from this region since 19C (Japan 99, Russia 149, and Korea 56 spp.). Mayflies of Manchuria (15 spp.) and North Korea (36 spp.) have not been intensively investigated since IMANISHI (1940). Regional revisions of most Ephemeroptera taxa, esp. Baetidae, Caenidae, and Heptageniidae, covering all this region, are needed because previous studies have not been inclusive due to various communicational problems. Type materials in earlier Japanese and Russian collections must be checked prior to any revisionary study. Larval and adult associations must be carefully examined among closely related species.

INTRODUCTION

Northeast Asia may be defined as the regions of Far East Russia (East of Baykal: see map in LER, 1986), northeastern China (Manchuria), the Korean peninsula and Japanese islands. This geographical region has been attracted by systematists, ecologists, and biogeographers not only because of its relatively abundant biodiversity but also because of its biogeographical interest. Biota of this region was closely associated with that of northwestern North America through Beringia during the glacial periods (ROSS, 1974). Biogeographical relationships between Holarctic continents have been variously studied with respect to animals and plants in general (see DAVIDSE, 1983), insects (ALLEN, 1983), or such particular insect taxa as Plecoptera (ILLIES, 1965), Trichoptera (ROSS, 1967) or Potamanthidae (Ephemeroptera) (BAE & MCCAFFERTY, 1991).

Northeast Asia possesses a long history of its unique cultural bases coexisting with eastern and western elements. The languages of Northeast Asian countries are diversified as Chinese, Korean, Japanese, and Russian. As in other fields of science, insect systematics in this region has been developed along with cultural and academic interactions between those countries. There have been obstacles as well, e.g., language differences, the World Wars, the Korean War, a political barrier during the cold war in the 1950-70s, etc., in the development of systematic investigations in this region (KIM *et al.*, 1988; LEE *et al.*, 1991).

The purpose of this paper is to review the past history of mayfly systematics in this region by providing the current status of known Ephemeroptera taxa based on comprehensive bibliographic sources and type information. This must take priority over any further systematic studies of mayflies, i.e. regional revisions, in this region.

Major bibliographic sources are based on my own library established over the last fifteen years. Many colleagues from Japan, Russia, China, North America, and Europe have provided useful bibliographic sources and type information related to this region (see Acknowledgements, below).

In Table 2, a checklist of Ephemeroptera of Northeast Asia is provided in terms of their distribution, mainly incorporated with major systematic studies in this region, e.g., TSHERNOVA (1952) and TSHERNOVA *et al.* (1986) in Far East Russia, GOSE (1979-80, 1985) in Japan, YOON & BAE (1988a) and BAE *et al.* (1994) in Korea, and IMANISHI (1940) in Manchuria. Familial classification is based on that of MCCAFFERTY (1991).

HISTORICAL REVIEW

Japan

Late in the nineteenth century, two European scientists described several mayflies from Japan. Those were *Ephemera orientalis, E. japonica, Leptophlebia elongatula* [= *Ephemerella?*], and *Dipteromimus tipuliformis* by MCLACHLAN

(1875), *Bleptus fasciatus* by EATON (1885), and *Ephemera strigata* and *Siphlonurus binotatus* (as *Siphlurus binotatus*) by EATON (1892). MCLACHLAN (1875) and EATON (1885) also reported *Cloeon dipterum* (LINNAEUS) from Japan. These were the earliest mayfly studies in Northeast Asia as well as in Japan.

Early in this century, especially in the 1920-30s, Japanese scientists intensively studied mayfly fauna from Japan. MATSUMURA (1904, 1907) reported five species: *Ephemera strigata, E. japonica, Siphlonurus sapporensis* MATSUMURA (as *Siphurulus sapporensis*), *Baetis binoculatus* LINNAEUS, and *Cloeon dipterum*. MATSUMURA (1911) also described *Ephemera sachalinensis* from Sakhalin. He (MATSUMURA, 1931) later described 40 species, including 36 new species, in his book, «6000 illustrated insects of the Japanese Empire», but only a part of them have been redescribed or synonymized by other mayfly researchers (e.g., IMANISHI, 1933) while most of them have not been verified up to date. In that period, the Europeans, NAVÁS (1915) and ULMER (1919), described *Ameletus aethereus* (as *Chimura aetherea*) and *Isonychia japonica* (as *Chirotonetes japonicus*), respectively. For larvae, KAWAMURA (1918) illustrated six species of mayflies for the first time. Those were later determined as *Ephemera japonica, Paraleptophlebia* sp. (?), *Ecdyonurus yoshidae* TAKAHASHI, *Epeorus latifolium* UÉNO, *Ephemerella basalis* IMANISHI, and *Isonychia japonica* by IMANISHI (1940).

UÉNO (1928, 1931a, 1931b) conducted the first comprehensive systematic study of mayflies from Japan, especially for larvae, providing detailed descriptions, illustrations, and keys. IMANISHI (1930, 1932, 1933, 1934, 1935, 1936, 1937a, 1937b, 1938, 1941) also conducted a series of revisionary studies of Japanese mayflies, «Mayflies from Japanese Torrents (I-X)», with detailed descriptions of many more species, including 26 new species. Some other Japanese scientists, e.g., TAKAHASHI (1924, 1929), HORASAWA (1929, 1931a, 1931b), etc., worked in this period additionally describing species.

IMANISHI (1940) published the first inclusive mayfly fauna of Northeast Asia, covering Japan, Korean peninsula, Manchuria, and Inner Mongolia, based on a good series of larval materials collected by Japanese expeditions to that regions in the late 1930s. In that work, he described 55 species, but over a half of them (35 species) were not named because he was somewhat reluctant to determine the species by only larvae. Those undetermined larvae were later verified in part by other workers (e.g., TSHERNOVA, 1952; ALLEN, 1971; GOSE, 1979-80; BAE *et al.*, 1994), although many of them, in particular those from Manchuria and Inner Mongolia, have not been studied since then.

After a blank period of systematic study in the 1940-50s, GOSE described more species (GOSE, 1963a, 1963b, 1965, 1981), provided larval and adult keys in a series (GOSE, 1979-80), and larval keys for texts (GOSE, 1962, 1970, 1985). KIMMINS (1960) provided type information on the collections of McLachlan and Eaton in the Natural History Museum in London (previously British Museum), including five Japanese species. DEMOULIN (1965) redescribed *Ephemera orientalis* with its type information. UÉNO also published an illustrated book for larvae (UÉNO, 1973) and larval identification key for a text (UÉNO, 1980). Recently, Ishiwata published a synopsis of the genera of Ephemerellidae (ISHIWATA, 1987) and a checklist of the Ephemerellidae of Japan, Far East Russia, and Korea (ISHIWATA, 1993).

There have been 99 nominal species, 32 genera, and 12 families of Ephemeroptera reported from Japan (Tables 1, 2).

Russia (Far East)

NAVÁS (1912) described *Ephemera amurensis* (later synonymized with *Ephemera orientalis* by TSHERNOVA, 1973), *Ecdyonurus levis* (as *Epeorus levis*), and *Siphlonurus grisea* (as *Andromina grisea*) and reported *Anagenesia sibirica* (MCLACHLAN) and *Ephemera orientalis* EATON from the Amur river basin. ULMER (1927) described *Paraleptophlebia curvata, Ameletus camtschaticus, Cinygmula malaisei* (as *Cinygma malaisei*), and *Cinygmula cavum* (as *Cinygma cavum*) from Kamchatka. TSHERNOVA (1930, 1934, 1948) also described *Siphlonurus palaearcticus* (as *Onyscigaster palaearcticus*), *Ephoron nigrodorsum* (as *Eopolymitarcys nigrodorsum*), and *Acanthametropus nikolskyi*, respectively, from this region. The mayfly fauna from Far East Russia has been investigated since the 1950s centering

around the Amur river basin and neighbouring regions. Tshernova, who worked at Moskva University and pioneered mayfly systematics in Russia, conducted a comprehensive systematic study of mayflies in the Amur river basin (TSHERNOVA, 1952). In her monographical study (TSHERNOVA, 1952), she described 68 species (59 nominal and 9 undetermined) of Ephemeroptera, including 30 new species from the region. She also presented some distributional features of far eastern mayflies (TSHERNOVA, 1958) based on her previous studies, and subsequently described and revised various taxa of Ephemeroptera (TSHERNOVA, 1972, 1973, 1974, 1976, 1978a, 1978b, 1979, 1980, 1981, 1985, etc.), sometimes in collaboration with her colleagues (TSHERNOVA & BELOV, 1982; SINITSHENKOVA & TSHERNOVA, 1976; etc.).

Baykova, who has worked in Khabarovsk, located in the Lower Amur River, has published very productively from this region covered most of Ephemeroptera taxa (BAYKOVA, 1962, 1965, 1967, 1968, 1970, 1972a, 1972b, 1973, 1974, 1975, 1976a, 1976b, 1977, 1978, 1979, 1980a, 1980b, etc.). Some other workers, e.g., SINITSHENKOVA (1973a, 1973b, 1977, 1978, 1981, 1982), BELOV (1981), NOVIKOVA (1987), etc., also treated the mayfly fauna of Far East Russia.

Since the 1980s, Kluge of St. Petersburg University has intensively worked mayfly fauna in this region describing or revising Ephemeroptera taxa, especially those of Heptageniidae, Baetidae, and Leptophlebiidae (KLUGE, 1982, 1983a, 1983b, 1984, 1985, 1987a, 1987b, 1988, 1989, 1991, 1993, etc.; KLUGE & TIUNOVA, 1989; etc.). TSHERNOVA *et al.* (1986) published the most completed adult identification key based on previous studies. Tiunova works in Vladivostok, and recently published descriptions of some species (TIUNOVA, 1988, 1990, 1991a, 1991b; TIUNOVA & BELOV, 1984; TIUNOVA & LEVANIDOVA, 1989).

There have been 149 species, 47 genera, and 17 families of Ephemeroptera reported from Far East Russia (Tables 1, 2).

Mayflies of the West of Baikal, especially Altai (e.g., BRODSKY, 1930; TSHERNOVA, 1949; etc.), Central Asia (e.g., KAZLAUSKAS, 1963; KUSTAREVA, 1976, 1978; etc.), and Mongolia (BRAASCH, 1982, 1986; LANDA & SOLDÁN, 1983; etc.) have been variously studied, but are not treated in this paper.

Korea

ULMER (1919) reported *Isonychia japonica* (as *Chirotonetes japonicus*) for the first time from Korea. IMANISHI (1940) described 36 species of Ephemeroptera larvae from Korea, 29 species from North Korea and 19 species from South Korea.

ALLEN (1971) described larvae of four new species of Ephemerellidae, *Ephemerella (Cincticostella) castanea, E. (C.) imanishii, E. (Drunella) aculea*, and *E. (Ephemerella) keijoensis*, from Korea, but he (ALLEN, 1975) later synonymized *E. (C.) imanishii* with *E. (C.) tshernovae* BAYKOVA.

Yoon of Korea University in Seoul pioneered mayfly study in Korea; he has investigated aquatic insect fauna, including Ephemeroptera, from various streams and rivers in South Korea since the 1960s (published in various ecological or faunistic literatures in Korea: see BAE, 1985, in ms). YOON & KIM (1981) revised larvae of Ephemerellidae from South Korea.

BAE (1985) studied the mayfly systematics of South Korea based on a good series of materials, mainly larvae, collected over 120 localities in South Korea since 1960's, and described 47 species of Ephemeroptera, including 14 species previously unknown in Korea. That work has been subsequently separated for publications on the Heptageniidae (YOON & BAE, 1984), Ephemeroidea (YOON & BAE, 1985), Ephemerellidae (YOON & BAE, 1988b), and the Ephemeroptera of South Korea in general (YOON & BAE, 1988a).

The mayfly fauna of North Korea has not been fully investigated since IMANISHI (1940). BRAASCH & SOLDÁN (1988), however, reported 12 nominal species, including two new species, and five undetermined species of Heptageniidae larvae from North Korea.

In a revision of the Potamanthidae, BAE & MCCAFFERTY (1991) described four species of Potamanthidae from Korea, including a new species and a new subspecies. BAE *et al.* (1994) published a catalogue of Ephemeroptera of Korea, included all previously known species of South and North Korea with chronological

synonyms, material (type) information, and distribution. BAE (1995) recently described a new species of Ephemeridae, *Ephemera separigata*, from South Korea. YOON (1995) published an illustrated key book of aquatic insects of Korea, including a revised key to genera and species of Ephemeroptera.
There have been 56 nominal and 10 undetermined species, 26 genera, and 11 families of Ephemeroptera reported from Korea (Tables 1, 2).

China (Manchuria)

HSU (1931-32, 1935-36) described *Ephemera kirinensis* and *Potamanthellus chinensis*, respectively, from Kirin [= Jilin], Manchuria. In IMANISHI's (1940) work, he described 19 species (12 undetermined, part of them verified) of Ephemeroptera larvae from Manchuria: *Baetiella* nX, *Baetis* nla, *Baetis* nlb, *Baetis* nlc, *Caenis* na, *Caenis* nc, *Cloeon dipterum* LINNAEUS, *Ecdyonurus kibunensis* IMANISHI, *E. yoshidae* TAKAHASHI, *Ephemerella* nay [= *Cincticostella levanidovae* (TSHERNOVA)], *Ephemera orientalis* MCLACHLAN, *Ephemerella* naz [= *Serratella zapekinae* (BAYKOVA)], *Ephemerella* nb and *Ephemerella* nbx [= *Ephemerella denticula* Allen], *Epeorus curvatulus* MATSUMURA, *E. latifolium* UÉNO, *Heptagenia* na [= *H. flava* ROSTOCK], *Isonychia* na, *Potamanthus* na and *Potamanthus* naa [= *Potamanthus luteus oriens* BAE & MCCAFFERTY], and *Siphlonurus binotatus* EATON. GUI (1985) prepared a catalogue of the Ephemeroptera of China including three species from Jilin, Manchuria.
Based on these studies, there have been 15 species, 12 genera, and 8 families of Ephemeroptera reported from Manchuria (Tables 1, 2).

Table 1. Number of Ephemeroptera taxa recorded from Northeast Asian countries.

Family	Japan (Far East)	Russia	Korea	China (Manch.)
Acanthametropodidae	0	1	0	0
Ameletidae	8	7	2	0
Ametropodidae	0	1	0	0
Baetidae	23	30	4	1
Behningiidae	0	2	0	0
Caenidae	1	12	0	0
Ephemerellidae	25	20	14	3
Ephemeridae	4	9	3	2
Heptageniidae	24	45	21	5
Isonychiidae	1	2	2	0
Leptophlebiidae	6	6	2	0
Metretopodidae	0	2	0	0
Neoephemeridae	0	1	1	1
Oligoneuriidae	1	1	0	0
Polymitarcyidae	1	2	1	1
Potamanthidae	2	2	4	1
Siphlonuridae	3	6	2	1
Family total	12	17	11	8
Genus total	32	42	26	12
Species total	99	149	56	15
Family grand total		17		
Genus grand total		47		
Species grand total		230		

Table 2. Checklist of nominal species of Ephemeroptera previously recorded from Northeast Asia.

Ephemeroptera taxa	Japan	Russia (Far East)	Korea	China (Manch.)
Family Acanthametropodidae				
Acanthametropus nikolskyi TSHERNOVA		*		
Family Ameletidae				
Ameletus camtschaticus ULMER		*		
A. cedrensis SINITSHENKOVA		*		
A. costalis (MATSUMURA)	*	*	*	
A. croceus IMANISHI	*			
A. gojoensis GOSE	*			
A. kyotoensis IMANISHI	*			
A. metanus IMANISHI	*			
A. montanus IMANISHI	*	*	*	
A. procerus BAYKOVA		*		
A. subalpinus IMANISHI	*			
Dipteromimus tipuliformis MCLACHLAN	*			
Parameletus chelifer BENGTSSON		*		
P. minor BENGTSSON		*		
Family Ametropodidae				
Ametropus eatoni BRODSKY		*		
Family Baetidae				
Acentrella fenestrata KAZLAUSKAS		*		
A. gnom KLUGE		*		
A. sibiricus KAZLAUSKAS		*		
Baetiella bispinosa (GOSE)	*			
B. japonica (IMANISHI)	*		*	
B. tuberculata (KAZLAUSKAS)	*	*	*	
Baetis acuminatus GOSE	*			
B. atagonis IMANISHI	*			
B. bicaudata DODDS		*		
B. chocoratus GOSE	*			

Table 2. Continued.

Ephemeroptera taxa	Japan	Russia (Far East)	Korea	China (Manch.)
B. clecus IMANISHI	*			
B. diversicolor TSHERNOVA		*		
B. flexifemora GOSE	*			
B. florens IMANISHI	*			
B. fuscatus LINNAEUS		*		
B. hyugensis GOSE	*			
B. iriomotensis GOSE	*			
B. mongolicus TSHERNOVA		*		
B. obscuriventris TSHERNOVA		*		
B. obtusiceps TSHERNOVA		*		
B. pseudothermicus KLUGE		*		
B. rhodani PICTET		*		
B. sacishimensis UÉNO	*			
B. sahoensis GOSE	*			
B. silvaticus KLUGE		*		
B. takamiensis GOSE	*			
B. thermicus UÉNO	*		*	
B. totsukawensis GOSE	*			
B. tsushimensis GOSE	*			
B. uenoi GOSE	*			
B. ursinus KAZLAUSKAS		*		
B. ussuricus KLUGE		*		
B. vernus CURTIS		*		
B. yamatoensis GOSE	*			
B. yoshinensis GOSE	*			
B. (Labiobaetis) atrebatinus orientalis KLUGE		*		
B. (L.) tricolor TSHERNOVA		*		
B. *(Nigrobaetis) acinaciger* KLUGE		*		
B. (N.) bacillus KLUGE		*		
Baetopus wartensis KEFFERMÜLLER		*		
B. (Raptobaetopus) tenellus ALBARDA		*		
Centroptilum kazlauskasi KLUGE		*		
C. luteolum MÜLLER		*		
C. rotundum TAKAHASHI	*			
Cloeon dipterum (LINNAEUS)	*	*	*	*
C. ryogokuensis GOSE	*			
C. simile EATON		*		
Cloeoptilum albisternum NOVIKOVA		*		
C. maritimum KLUGE		*		
C. pennulatum EATON		*		
Procloeon bifidum BENGTSSON		*		
Family Behningiidae				
Behningia tshernovae EDMUNDS & TRAVER		*		
Protobehningia asiatica TSHERNOVA		*		
Family Caenidae				
Brachycercus japonicus GOSE		*		
B. magnus TSHERNOVA		*		
B. minutus TSHERNOVA		*		
B. tubulatus TSHERNOVA		*		
Caenis amurensis KLUGE		*		
C. cornuta (TSHERNOVA)		*		
C. horaria (LINNAEUS)		*		
C. macronyx KLUGE		*		
C. macrura STEPHENS		*		
C. maculata (TSHERNOVA)		*		
C. miliaria (TSHERNOVA)		*		
C. rivulorum EATON		*		
C. robusta EATON		*		
Family Ephemerellidae				
Acerella longicaudata (UÉNO)	*	*	*	
Cincticostella castanea (ALLEN)	*		*	
C. ezoensis (GOSE)	*			
C. levanidovae (TSHERNOVA)	*	*		*
C. nigra (UÉNO)	*	*		
C. okumai (GOSE)	*			
C. tshernovae (BAYKOVA)	*	*	*	
Drunella aculea (ALLEN)		*	*	
D. basalis (IMANISHI)	*	*		
D. bicornis (GOSE)	*			
D. bifurcata (ALLEN)	*			
D. cryptomeria (IMANISHI)	*	*	*	
D. kohonoi (ALLEN)	*			
D. lepnevae (TSHERNOVA)		*	*	
D. solida (BAYKOVA)		*		
D. triacantha (TSHERNOVA)		*	*	
D. trispina (UÉNO)	*	*		
D. trispina ezoensis (GOSE)	*		*	
Ephemerella atagosana IMANISHI	*	*		
E. aurivillii BENGTSSON		*	*	
E. cornutus GOSE	*			
E. denticula ALLEN	*			*
E. imanishii GOSE	*		*	
E. ishiwatai GOSE	*			
E. keijoensis ALLEN			*	
E. kozhovi BAYKOVA		*		
E. maxima ALLEN	*			
E. mucronata BENGTSSON		*		
E. notofascia YOON & BAE			*	
E. taeniata TSHERNOVA	*			
Serratella ignita (PODA)		*		
S. setigera (BAYKOVA)	*	*	*	
S. thymalli (TSHERNOVA)		*		
S. zapekinae (BAYKOVA)		*		*
Torleya japonica (GOSE)	*			
Uracanthella chinoi (GOSE)	*			
U. rufa (IMANISHI)	*	*	*	
Family Ephemeridae				
Subfamily Ephemerinae				
Ephemera formosana ULMER	*			
E. japonica MCLACHLAN	*	*		

Table 2. Continued.

Ephemeroptera taxa	Japan	Russia (Far East)	Korea	China (Manch.)
E. kirinensis HSU				*
E. orientalis MCLACHLAN	*	*	*	*
E. sachalinensis MATSUMURA		*		
E. separigata BAE			*	
E. shengmi HSU		*		
E. strigata EATON	*	*	*	
E. transbajkalica TSHERNOVA		*		
Subfamily Palingeniinae				
Anagenesia paradoxa BULDOVSKIJ		*		
Chankagenesia natans BULDOVSKIJ		*		
C. sibirica MCLACHLAN		*		
Family Heptageniidae				
Bleptus fasciatus EATON	*		*	
Cinygma adusta IMANISHI	*			
C. dorosalis IMANISHI	*			
C. peterseni LESTAGE		*		
C. vernalis IMANISHI	*			
Cinygmula cava ULMER		*		
C. grandifolia TSHERNOVA		*	*	
C. hirasana (IMANISHI)	*		*	
C. irina TSHERNOVA & BELOV		*		
C. kurenzovi BAYKOVA		*		
C. latifrons TSHERNOVA & BELOV		*		
C. levanidovi TSHERNOVA & BELOV		*		
C. malaisei ULMER		*		
C. putoranica KLUGE		*		
C. unicolorata TSHERNOVA		*		
Ecdyonurus abracadabrus KLUGE		*		
E. aspersus KLUGE		*		
E. aurarius KLUGE		*		
E. bajkovae KLUGE		*	*	
E. dracon KLUGE		*	*	
E. hyalinus ULMER	*			
E. inversus KLUGE		*		
E. joernensis mongolicus BAYKOVA & VARYCHANOVA		*	*	
E. kibunensis IMANISHI	*	*	*	*
E. levis (NAVÁS)		*	*	
E. rubromaculatus YOU *et al.*		*		
E. scalaris KLUGE		*	*	
E. simplicioides MCDUNNOUGH		*		
E. subspinosa (BRAASCH & SOLDÁN)			*	
E. tigris IMANISHI	*			
E. tobiironis TAKAHASHI	*	*		
E. yoshidae TAKAHASHI	*	*		*
Epeorus curvatulus MATSUMURA	*		*	*
E. ikanonis TAKAHASHI	*			
E. latifolium UÉNO	*	*	*	*

Ephemeroptera taxa	Japan	Russia (Far East)	Korea	China (Manch.)
E. napaeus IMANISHI	*			
E. rautiani SINITSHENKOVA		*		
E. (Belovius) ermolenkoi TSHERNOVA		*		
E. (B.) gornostajevi TSHERNOVA		*		
E. (B.) pellucidus (BRODSKY)		*	*	
E. (B.) sinitshenkovae TSHERNOVA		*		
E. (B.) smirnovi TSHERNOVA		*		
Heptagenia chinensis ULMER		*		
H. flava ROSTOCK		*		*
H. guranica BELOV		*	*	
H. kihada MATSUMURA	*		*	
H. kyotoensis GOSE	*		*	
H. sulphurea MÜLLER		*		
H. (Kageronia) fuscogrisea RETZIUS		*		
H. (K.) orbiticola KLUGE		*		
Iron aesculus (IMANISHI)	*	*	*	
I. alexandri (KLUGE & TIUNOVA)		*		
I. hiemalis (IMANISHI)	*		*	
I. koreanicus BRAASCH & SOLDÁN			*	
I. maculatus TSHERNOVA		*	*	
I. uenoi (MATSUMURA)	*			
Rhithrogena bajkovae SOWA		*		
R. binotata SINITSHENKOVA		*		
R. japonica UÉNO	*		*	
R. lepnevae BRODSKY		*		
R. minazuki IMANISHI	*			
R. parva ULMER	*			
R. quadrinotata SINITSHENKOVA		*		
R. satsuki IMANISHI	*			
R. sibirica BRODSKY		*		
R. tateyamana IMANISHI		*		
Family Isonychiidae				
Isonychia japonica (ULMER)	*	*	*	
I. ussurica BAYKOVA		*	*	
Family Leptophlebiidae				
Chiusanophlebia asahinai UÉNO	*			
Choroterpes (Euthraulus) altioculus KLUGE	*	*	*	
Paraleptophlebia chocolata IMANISHI	*	*	*	
P. cincta (RETZIUS)		*		
P. curvata ULMER		*		
P. lunata TSHERNOVA		*		
P. spinosa UÉNO	*			
P. vladivostokica KLUGE		*		
P. westoni IMANISHI	*			
Thraulus grandis GOSE	*			

Table 2. Continued.

Ephemeroptera taxa	Japan	Russia (Far East)	Korea	China (Manch.)
Family Metretopodidae				
Metretopus alter BENGTSSON		*		
M. borealis EATON		*		
Family Neoephemeridae				
Potamanthellus chinensis HSU				*
P. rarus TIUNOVA & LEVANIDOVA		*	*	
Family Oligoneuriidae				
Oligoneuriella pallida HAGEN		*		
O. rhenana IMHOFF	*			
Family Polymitarcyidae				
Ephoron nigridorsum TSHERNOVA		*		
E. shigae (TAKAHASHI)	*		*	
E. virgo OLIVER		*		*
Family Potamanthidae				
Potamanthus (Potamanthodes) formosus EATON	*		*	
P. (P.) yooni BAE & MCCAFFERTY			*	
P. (Potamanthus) luteus oriens BAE & MCCAFFERTY	*	*	*	*
Rhoenanthus (Potamanthindus) coreanus (YOON & BAE)		*	*	
Family Siphlonuridae				
Siphlonurus binotatus EATON	*			*
S. chankae TSHERNOVA		*	*	
S. immanis KLUGE		*		
S. lacustris EATON		*		
S. palaearcticus TSHERNOVA		*		
S. sanukensis TAKAHASHI	*		*	
S. yoshinoensis GOSE	*			
S. zhelochovtsevi TSHERNOVA		*		
S. (Siphlurella) alternatus SAY		*		

DISCUSSION

Prior to the 1920s, when Japanese researchers became predominant in the study of mayfly in Northeast Asia, only a few species of mayflies had been described from Northeast Asia by such Europeans as McLachlan, Eaton, and Navás.

In the 1920-30s, the mayflies of Japan were thoroughly investigated. Those of Southern China and Southeast Asia were also studied in this period by ULMER (e.g., 1919, 1932-33, 1935-36, 1939) and HSU (1931-32, 1935-36, 1936-37, 1937-38).

Few mayfly studies could be carried cut during the World Wars and the Korean War in the 1940s and 1950s. Hsu's important mayfly collections were destroyed during the war (You, pers. comm.), and mayfly investigations in China could not be resumed until the 1980s because of the political situation in the country. In the 1980s You and his colleagues of Nanjing Normal University in Nanjing studied the mayfly fauna from Southern China (e.g., YOU, 1984, etc.). Kang of National Chung Hsing University in Taiwan worked relatively recently in Taiwan (e.g., KANG & YANG, 1994). The mayflies of Far East Russia, relatively less affected by wars, have been investigated continuously since the 1950s.

The systematic studies of mayflies in Russia have been somewhat traditional: adults mayflies were relatively well known and a completed adult key (TSHERNOVA *et al.*, 1986) was prepared in Far East Russia. In Japan and Korea, on the other hand, mayfly studies have often been involved in ecological studies of freshwater ecosystems: larvae have been, thus, relatively well investigated and texts on aquatic insects, including mayflies, or laval identification keys were prepared in preference to any other (e.g., GOSE, 1979-80, 1985; UÉNO, 1980; YOON & BAE, 1988a; YOON, 1995).

Based on my tentative enumeration, about 50-60% of larvae of mayflies of Northeast Asia have been associated with their adults (either male or female) or vice versa. Only a part of the eggs was known by KOSS & EDMUNDS (1974), OKAZAKI (1981, 1982, 1984), BAE & MCCAFFERTY (1991), etc.

As seen in Tables 1 and 2, Far East Russia represents the most abundant species diversity of mayflies among countries of Northeast Asia probably because it covers a relatively wide range of geographical region (see map in LER, 1986). The Japanese mayfly fauna has been relatively well known whereas Manchurian and North Korean faunas have not been studied in detail.

As also seen in Table 2, mayfly faunas between Northeast Asian countries have not been comparatively studied, especially between those of Japan and Russia. For instance, there

have been few regional revisions of Ephemeroptera covering whole this region after IMANISHI (1940), although certain groups reviewed recently (e.g., KLUGE, 1988; BAE & MCCAFFERTY, 1991). Furthermore, although geographically adjacent, only 24 species of mayflies were reported from Japan and Russia in common, and only 16 species were reported from Japan, Russia, and Korea in common. In particular, few baetids, caenids, and heptageniids have been recorded inclusively from those countries together. This may have been due to various communication problems between mayfly researchers in those countries.

To solve these problems, closely related species of certain groups must be revised carefully by examining materials (i.e., types) brought together from those countries. Type information has not been provided in detail in most earlier Japanese and Russian literatures. Primary type materials in certain important Japanese and Russian collections (e.g., UÉNO, 1928, 1931b; MATSUMURA, 1931; IMANISHI, 1930s, 1940; TSHERNOVA, 1952) must be checked prior to any further descriptive studies.

In Japan, McLachlan's and Eaton's type materials have been deposited in the Natural History Museum in London (KIMMINS, 1960). Matsumura's materials, consisting of dried specimens, have been at Hokkaido University (Entomological Institute) in Sapporo, but part of them were lost (S. Takagi, pers. comm.; Y. Takemon, pers. comm.). Most of Imanishi's materials were at Kyoto University (Center for Ecological Research, previously Otsu Hydrobiological Station) in Kyoto (Takemon, pers. comm.; Ishiwata, pers. comm.). Kobayashi and Ishiwata (in ms) prepared a list of Imanishi's type specimens, in part, deposited at Kyoto University (Takemon, pers. comm.). Takahashi's materials have not been preserved at any of the places he worked: National Institute of Agriculture and Environment, Mie Prefectural Institute of Agriculture, Institute of Ecology at Kyoto University, and Hokkaido University (Ishiwata, pers. comm.). According to various sources, Uéno's materials, if preserved, may be at Kyoto University, but have not been checked (Takemon, pers. comm.). Most of Gose's materials may be at Nara Women's University in Nara.

In Russia, most of the type specimens of Tshernova, Sinitshenkova, Baykova, Belov, and Kluge have been deposited in the Zoological Institute in St. Petersburg. Part of Tshernova's and Sinitshenkova's materials may be at Moscow University and part of Baykova's materials may be in Khabarovsk (D.J. Chun, pers. comm.). Part of Kluge's materials are currently at St. Petersburg University, but will be deposited in the Zoological Institute in St. Petersburg in the future (Kluge, pers. comm.). KLUGE (1995) prepared a catalogue of Ephemeroptera type specimens deposited in the Zoological Institute in St. Petersburg.

In Korea, major Ephemeroptera collections, including Yoon and Bae's type specimens, are currently at Seoul Women's University in Seoul. Korea University in Seoul, Chonnam National University in Kwangju, and Pusan National University in Pusan also hold collections of aquatic insects, including mayflies. Although Hsu's collections in Nanjing were destroyed during the war, a part of old collections from China, including Ulmer's collection, Needham's collection, etc., may be in the Museum of Hamburg, Museum of Berlin, Museum of Paris, Natural History Museum in London, Cornell University, etc. (see HSU, 1936-37). These important collections have not been generally checked so far. Large Ephemeroptera collections from Southern China since the 1980s are currently at Nanjing Normal University (You, pers. comm.; Gui, pers. comm.), but those may not include materials from Northern China.

Larval and adult relationships should be also matched for previously unassociated species (e.g., IMANISHI, 1940; YOON & BAE, 1988a). A revisionary study of Potamanthidae conducted by BAE & MCCAFFERTY (1991) indicated that certain related species from Japan, Russia, and Korea, which were known in part by adult or larval stage only from each country, were virtually conspecific. This must be the same for in other groups of mayflies which finally may produce numerous synonyms.

There has been a somewhat conservative attitude about naming new species only from larvae (e.g., IMANISHI, 1940; YOON & BAE, 1988a). This is out of date because there is a

tendency that any life stage of insects, and other animals as well, is significant as long as it represents conceivable evolutionary novelty. Some workers (e.g., MATSUMURA, 1931; GOSE, 1979-80), however, have named many new species without any detailed descriptions or type information. This, of course, may create serious taxonomic problems unless those species are redescribed shortly by revisionary workers. Joint projects of revisionary studies of mayfly taxa are therefore desirable among mayfly workers in Northeast Asian countries to solve these taxonomic problems.

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