

Mayfly (Ephemeroptera) Fauna of North Korea (1)

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Abstract Comprehensive mayfly samplings were taken from five major localities in North Korea (Pyongyang, Kaesong-Haeju, Myohyangsan, Kungangsan, and Paektusan) by a Czech collecting expedition in 1986. Fifty-nine species of mayflies (including 13 undetermined) are recognized from the localities including *Labiobaetis atrebatinus* (Eaton), *Ephemerella (Serratella) ignita* (Poda), *E. (S.) zapetkinae* (Bajkova), *Ephemerella sahalinensis* Matsumura, *Cinygmula kurenzovi* Bajkova, *Rhithrogena binotata* Sinitshenkova, *Metretopus borealis* Eaton, and *Siphonurus palaearticus* Tshernova which are recorded from Korean peninsula for the first time. Habitats of the localities and microhabitats of 28 collecting sites are described. Some aspects of distributional and taxonomic remarks are provided.

Key words Mayflies, Ephemeroptera, systematics, fauna, habitat, North Korea

INTRODUCTION

Over 230 species of Ephemeroptera have been known from Northeast Asia, including Far East Russia (149 spp.), Japan (99 spp.), Korea (56 spp.), and Northeast China (15 spp.) (for list of species and their distribution see Appendix 1 in Bae, 1997). Fifty-two species of mayflies have been recorded from South Korea (Bae *et al.*, 1994). In North Korea, on the other hand, 36 species of mayflies were recorded by Imanishi (1940), who elaborated the materials collected by some Japanese expeditions to Northeast Asia in 1930s (for fully referenced list and synonymy see Bae *et al.*, 1994). Since then the faunal composition of mayflies of North Korea have been investigated only exceptionally. Braasch and Soldán (1988) published some data on the Heptageniidae from North Korea, including descriptions of two new species and eight species new to North Korea. Based on a collection by a Hungarian expedition to North Korea in 1988, Bae and Adrikovics (1997) presented a comprehensive study on the mayfly fauna of North Korea which has been conducted independently and has submitted for publication simultaneously with this study.

In a Czech expedition to North Korea in 1986, the junior author of this study had an opportunity to collect mayfly materials from five major localities in North Korea (see below). We herein present all those species and locality records although part of the species left undetermined for further studies.

MATERIALS AND METHODS

All together more than 15,000 individuals of larvae, subimagos and adults of mayflies were collected from May 15 to July 27 in 1986 from five major localities in North Korea, which include 28 collecting sites. All materials were collected by T. Soldán and M. Tonner, determined by Y.J. Bae and T. Soldán, and deposited at Seoul Women's University in Seoul and at Institute of Entomology in České Budějovice.

Larvae were collected individually from submerged stones and with a metal pan using "washing" technique from stony bottom and sandy sediment. To estimate rough quantitative or semiquantitative presentation of individual occurrence, two workers (T. Soldán and M. Tonner) collected larvae intensively at each collecting site for 30 minutes, except at the site of Hyangsan creek which was based on 8-days' collecting effort.

Physico-chemical data were taken by usual hydrological methods. However, characteristics of habitats such as size of water course and bottom composition were estimated. The scale of substrate particles was referred to Hynes (1970) to estimate percentages of granule (boulder, cobble, pebble, gravel), sand (very coarse sand, coarse sand, medium sand, fine sand, very fine sand), and mud (silt, clay), respectively. To estimate water quality, the classification of saprobity (e.g., Sládeček, 1973) was used. Geographical, climatic, and floral data are referred variously to other studies conducted from the country.

Description of Localities and Collecting Sites

A. Pyongyang

All the collecting sites are situated near Pyongyang city (39° 00' N, 125° 35' E) (Fig. 1) at the altitude of 50~100m above sea level (a.s.l.). Some hills, e.g., Yongaksan(Mt.), reach up to 150-250 m a.s.l. The earth is composed of metamorphic sediments, particularly sandstone, of the Pyongwon massifs. Islands of granite gneiss are present here and there. January temperature (long-term mean temperature) is -8°C; July temperature is 24°C; July precipitation (long-term mean precipitation) is 200-250 mm. Wide neighborhood of Pyongyang (Fig. 2) is cornered by the fields of mainly rice, corn, soya, and cabbage. Secondary growth of deciduous oak forest, i.e. *Pinus densiflora* and *Juniperus rigida*, are predominant on the hill slopes. The following sites were investigated.

A1: Taedong river, Pyongyang: Collecting dates May 15 & June 26, 1986.

Large lowland river at Pyongyang city (Fig. 1); width 300-500m; depth variable; depth (mean depth) at collecting site 50-100 cm; current velocity 10~50 cm/s; transparency 30 cm; water temperature 18°C; pH 7.6. Substrate composition cobble 20%, pebble 40%, gravel 40%; medium sand 50%, fine and very fine sand 25%, silt 25%, clay negligible. Estimated saprobity betamesosaprobic at its lower limits.

A2: Small brook near Sangwon, Pyongyang: Collecting date June 21, 1986.

Small brook near Sangwon; width 0.5-1.5 m; depth shallow, 20-50 cm; current velocity 40-60 cm/s; transparency to the bottom; water temperature 20°C; pH 6.9. Substrate composition pebble 20%, gravel 50%, coarse to medium sand 30%. Water polluted (green algae abundant); estimated saprobity

betapolsaprobic at its lower limits.

A3: Small brook near Yongaksan, Pyongyang: Collecting date June 21, 1986.

Small brook located at the west of Pyongyang city; width 1.0-2.0m; depth swallow, 10-40cm; current velocity 10-30cm/s. Stream bed artificially covered by concrete plates; granule absent; coarse to medium sand 50%, silt 50%; overgrown with submerged plants. Water regulated and polluted.

A4: Sandam lake, Pyongyang: Collecting date May 20, 1986.

Eutropic and swallow pond with muddy bottom, partially regulated; width about 100 m across; transparency 10-20 cm; water temperature 25°C; pH 8.2; phytoplankton (Cyanophyta) abundant.

A5: Small artificial pond in zoopark, Pyongyang: Collecting date May 19, 1986.

Width about 30m across, swallow, with well preserved littoral vegetation; water temperature 22°C; pH 8.5; phytoplankton scarce.

B. Kaesong-Haeju

Pagyon national reserve (38° 10' N, 126° 30' E) is a small mountain range (about 200km² and more than 700m a.s.l.) which consists of granite gneisses and metamorphic schists. January temperature is -6 °C; July temperature is 24°C; July precipitation is more than 300 mm. Oaks (*Quercus dentata*, *Q. mongolica* and *Q. serrata*) are predominant, and *Prunus yedoensis*, *Populus davidiana*, *Ulmus propinqua*, *Acer mono*, and *Rhododendron schippenbachii* are also common. Common herbaceous plants are *Lilium concolor*, *Rubia cordifolia*, *Aristolochia concolorata* and *Artemisia anua*.

B1: Pagyon-pokpo (waterfall), Kaesong: Collecting date June 11, 1986.

Waterfall on compact rock; width 3-6 m; depth 30-100 cm; current velocity 40-110 cm/s; transparency total; water temperature 15.5°C; pH 7.6. Substrate composition boulder 30%, cobble 20%, pebble 30%, gravel 20%; very coarse sand 50%, medium sand 50%; silt negligible. Estimated saprobity oligosaprobic at its upper limits.

B2: Kaepung river near Kaepung, Kaesong: Collecting date June 12, 1986.

Foothill river near Kaepung; width 20-25 m; depth 20-60 cm; current velocity 20-45 cm/s; transparency 50cm; water temperature 19°C; pH 7.9. Substrate composition cobble 25%, pebble 40%, gravel 35%; very coarse & coarse sand 40%, medium and fine sand 60%; silt 80%, clay 20%. Estimated saprobity betamesosaprobic at its upper limits.

B3: Yesong river near Kaesong, Kaesong: Collecting date June 11, 1986.

Some habitat characteristics as in Kaepung river (B2); transparency 35cm; water temperature 23°C; estimated saprobity betamesosaprobic at its lower limits.

B4: Kou creek near Kou (tributary of Yesong river), Kaesong: Collecting date June 10, 1986.

Small tributary stream of Yesong river; width 1-2m; depth 10-30 cm; current velocity 10-30 cm/s;

transparency total; water temperature 17°C; pH 7.5. Substrate composition pebble 20%, gravel 80%; coarse sand 50%, medium and fine sand 50%; silt negligible. Water polluted (green algae abundant); estimated saprobity betamesosaprobic at its lower limit.

B5: Taegok river near Haeju, Hwanghae-do: Collecting date June 7, 1986.

Foothill river near Haeju; width 25-30 m; depth 50~100 cm; current velocity 20-50 cm/s; transparency 35 cm; water temperature 18.5°C; pH 7.9. Substrate composition cobble 15%, pebble 50%, gravel 35%; coarse and medium sand 60%, fine and very fine sand 40%; silt 70%, clay 30%. Estimated saprobity betamesosaprobic at its upper limits.

B6: Tributary of Taegok river near Haeju, Hwanghae-do: Collecting date June 6, 1986.

Tributary stream of Taegok river; width 50-100 cm; depth 10-30 cm; current velocity 5-15 cm/s; transparency total; water temperature 22°C; pH 7.2. Substrate composition pebble 40%, gravel 40%; coarse sand 30%, medium and fine sand 70%; silt 60%, clay 40%. Estimated saprobity oligosaprobic at its lower limits.

B7: Kwangsek canal at Haeju, Hwanghae-do: Collecting dates June 6-7, 1986.

Artificial canal with prefabricated plate substrate, mostly covered with gravel and coarse to medium sand; width 2 m; current velocity 30-50 cm/s; water temperature 18°C; estimated saprobity betamesosaprobic at its upper limits.

B8: Suyang-pokpo (waterfall) at Suyangsan near Haeju, Hwanghae-do: Collecting date June 7, 1986.

Waterfall on compact rock; depth 2~5 m; current velocity 1-1.5 m/s; water temperature 15.5°C; pH 7.9. Substrate composition boulder 80%, gravel and very coarse sand 20%; bottom covered with aquatic moss.

C. Myohyangsan

Hyangsan town (40° 05' N, 126° 12' E) is situated in the valley of the Chongchon river (about 400 m a.s.l.) and on the foot of the Myohyang mountains (Fig. 3) which creates the boundary between the stratigraphic regions, Pyongnam fold belt and western Kaema-Pyongbuk massifs. It consists of gray granite gneisses (Fig. 3) that strike from west-southwest to east-northeast direction. There are abundant metamorphic rocks of various petrographic nature. Those rocks are intruded by granites which are probably originated quite recently. Mixed climax maple forest is preserved in the lower and mid-elevation regions, and the brown soil type is predominant. January temperature is -12°C; July temperature is 24°C; July precipitation is 200~300 mm. Dominant phanerophytes are maple trees (*Acer mono*, *A. ginnala*, *A. pseudosieboldianum*, *A. tegmentosum*, *A. barvinerve*) mixed with *Ulmus laciniata*, *Quercus mongolica*, *Castanea crenata*, *Pinus densiflora*, *P. koraiensis*, *Abies nephrolepis*, *Magnolia sieboldii*, *Rhododendron mucronulatum*, etc. Common herbaceous plants are *Asler scaber*, *Adenophora remoliflora*, *Plantago asiatica*, *Artemisia asiatica*, *Astilbe chinensis*, etc.

C1: Chongchon river near Hyangsan, Pyonganbuk-do: Collecting date June 2, 1986.

Submontane river (Fig. 4) located at mouth of Hyangsan creek; width 30-60 m; depth 40-160 cm; current velocity 40-100 cm/s; transparency 50 cm; water temperature 13.5°C; pH 6.9. Substrate composition cobble 10%, pebble 60%, gravel 30%; very coarse and coarse sand 60%, medium sand 40%; silt and clay negligible. Estimated saprobity oligosaprobic at its lower limits.

C2: Hyangsan creek, Pyonganbuk-do: Collecting date May 25-June 4, 1986.

Montane stream located at about 5 km upstream from Hyangsan, 480 m a.s.l.; width 3-5 m; depth 20-50 cm; current velocity 25-60 cm/s; transparency total; water temperature 12-14.5°C; pH 7.6. Substrate composition boulder 20%, cobble 20%, pebble 40%, gravel 20%; very coarse & coarse sand 60%, medium & fine sand 40%; silt negligible except in still water pools (50%); littoral vegetation densely overgrown. Estimated saprobity xeno- to oligosaprobic at its upper limits.

C3: Chonsin creek (tributary of Hyangsan creek), Pyonganbuk-do: Collecting date May 31, 1986.

Medium sized montane stream located at Myohyang Mts., 520 m a.s.l.; width 2-3 m; depth 20-50 cm; current velocity 20-40 cm/s; transparency total; water temperature 13.5°C; pH 7.0. Substrate composition boulder 20%, cobble 20%, pebble 30%, gravel 30%; coarse sand 40%, medium sand 60%; waterfall and still water pools filled with abundant leaf litter. Estimated saprobity xenosaprobic.

C4: Yuson creek (tributary of Hyangsan creek), Pyonganbuk-do: Collecting date May 29, 1986.

Headwater stream located at Myohyang Mts., 850 m a.s.l.; width 50-100 cm; depth 20-50 cm; current velocity 30-50 cm/s (100 cm/s at waterfalls); transparency total; water temperature 12°C; pH 6.8. Substrate composition boulder 30%, cobble 20%, pebble 20%, gravel 30%; very coarse & coarse sand prevailing; silt negligible except in still water pools with leaf packets. Estimated saprobity xenosaprobic.

C5: Habiro creek (tributary of Hyangsan creek), Pyonganbuk-do: Collecting date May 30, 1986.

Headwater stream located at Myohyang Mts., 925 m a.s.l.; some habitat characteristics as in Yuson creek without still water pools; water temperature 10.5°C; pH 6.5.

D. Kumgangsan

Kumgangsan (Mt.) (38° 40' N, 128° 15' E, altitude about 200-500 m a.s.l.) is a national reserve whose crystalline schists and granites are typical (as in Fig. 3). Brown forest soil is most common. January temperature is -4°C; July temperature is 24°C; July precipitation is 200-250 mm. Characteristic plant formation of the Okryu valley is the *Sasamorpha*-oak forest (virgin forest) of a southern type with some evergreen, e.g., bamboo and *Sasamorpha gracilis*. Common trees are *Quercus serrata*, *Q. acutissima*, *Q. mongolica*, *Pinus densiflora*, *Acer mono*, *A. pseudosiboldianum*, *Fraxinus mandshurica*, *Prunus leveillana*, etc. Characteristic herb forms are *Cacalia crameri*, *Boehmeria tricuspis*, *Commelia communis*, and *Clematis dividiana*.

D1: Oudjion river near Kumgangsan (Okryu valley), Kangwon-do: Collecting date June 15, 1986.

Montane stream in the Okryu valley, 500 m a.s.l.; width 10-15 m; depth 30-100 cm; current velocity 20-60 cm/s; transparency total; water temperature 14°C; pH 7.8. Substrate composition boulder 10%, cobble 10%, pebble 50%, gravel 30%; very coarse & coarse sand 40%, medium sand 40%, fine and very fine sand 20%; silt 80%, clay 20%. Estimated saprobity oligosaprobic at its lower limits.

D2: Nam river near Kungangsan, Kangwon-do: Collecting date June 18, 1986.

Small, submontane river, 300 m a.s.l.; width 9-12 m; depth 20-80 cm; current velocity 10-40 cm/s; transparency 50 cm; water temperature 15.5°C; pH 7.9. Substrate composition boulder 20%, cobble 30%, pebble 30% gravel 20%; coarse sand 20%, medium to fine sand 80%; silt 80%, clay 20%; organic debris abundant. Water moderately polluted; estimated saprobity betamesosaprobic at its lower limits.

D3: Tributary of Nam river near Kungangsan, Kangwon-do: Collecting date June 16, 1986.

Small tributary stream of Nam river; width 1-2 m; depth 20-40 cm; current velocity 10-30 cm/s; transparency total; water temperature 17°C; pH 7.6. Substrate composition cobble 20%, pebble 60%, gravel 20%; medium sand prevailing; silt negligible. Estimated saprobity oligosaprobic at its lower limits.

D4: Kosong, Kangwon-do: Collecting date June 19, 1986.

Small stream near Kosong at sea coast, about 40 m a.s.l.; width 30-50 cm; depth 10-20 cm; current velocity 5-25 cm/s; transparency total; substrate composition boulder 20%, cobble 30%, pebble 30%, gravel 20%; fine to very fine sand prevailing; silt 70%, clay 30%; pools with leaf packets very abundant. Estimated saprobity oligosaprobic at its lower limits.

E. Paektusan

Main collection for mayflies was made near Samjiyon (41° 52' N, 128° 23' E) and Mupyonggu (42° 00' N, 128° 35' E) at altitude of 1000-1500 m a.s.l. In eastern Kaema Plateau and Paektusan region, late Tertiary and Quarternary extrusive basalts are predominant. Acidic and basic eruptions alternated many times and covered most of the ancient bedrock. In the southern part of this region, Archeozoic rocks are widely distributed. These metamorphic limestones play an important role, along with mica schists and amphibolites. Podzolic soil is widely distributed in taiga, whereas brown mountain soil is rare. The climate of this region is extremely cold with frequent snowfall in mid-winter and not very warm in summer. Icebergs are present until late June or sometimes early July in the mountain top volcanic lake, Chonji (lake) (Fig. 5). January temperature is -18~-16°C; July temperature is 20~22°C. The upper part of the Amnokgang (R.) (Fig. 6) and Tumangang (R.) basin is characteristic with conspicuously low precipitation (July precipitation 50-100 mm).

Montane larch-spruce taiga is unique in the region (Fig. 7), and the larch, *Larix olgensis*, is most abundant. Other common trees are *Alies nephrolepis*, *Pinus koraiensis*, *Picea koraiensis*, *Betula ermani*, *Sorbus amurensis*, *Coryllus heterophylla*, and *Acer tegmentosum*. Common shrubs are *Lonicera coerulea*, *Rosa dahburica*, *Ledum palustre*, *Vaccinium uliginosum*, and *Rhododendron parvifolium*. The liana, *Tripterygium regelii*, is also abundant. Montane *Sphagnum* peat-bogs with poor and typical flora are very characteristic.

E1: Karim river near Hyesan: Collecting date June 24, 1986.

Large montane stream at 780 m a.s.l.; width 8-12 m; depth 40-150 cm; transparency 40 cm; current velocity 30-60 cm/s; water temperature 10.5°C; pH 6.5. Substrate composition boulder 10%, cobble 40%, pebble 40%, gravel 10%; coarse and medium sand 80%, fine sand 20%; silt negligible. Estimated saprobity oligosaprobic at its upper limits.

E2: Li Huong Su river near Samjiyon: Collecting date June 24, 1986.

Montane stream at 1000 m a.s.l.; width 5-6 m across; depth 20-50 cm; transparency 30 cm; current velocity 20-60 cm/s; water temperature 9.0°C; pH 6.1. Substrate composition cobble 25%, pebble 50%, gravel 25%; very coarse and coarse sand 50%, medium sand 40%, fine sand 10%; silt scarce. Estimated saprobity xenosaprobic at its lower limits.

E3: Chonwon creek and waterfalls near Li Myong Su: Collecting date June 24, 1986.

Montane stream at 1000 m a.s.l.; width 2-4 m; depth 20-70 cm; current velocity 40-70 cm/s (more than 100 cm/s at waterfalls); transparency 50 cm; temperature 8°C; pH 5.9. Substrate composition boulder 30% (at waterfalls 100%), cobble 50%, pebble 20%, gravel negligible; coarse sand 80%, medium sand 20%; silt negligible. Estimated saprobity xenosaprobic.

E4: Sobak river near Samjiyon: Collecting date June 26, 1986.

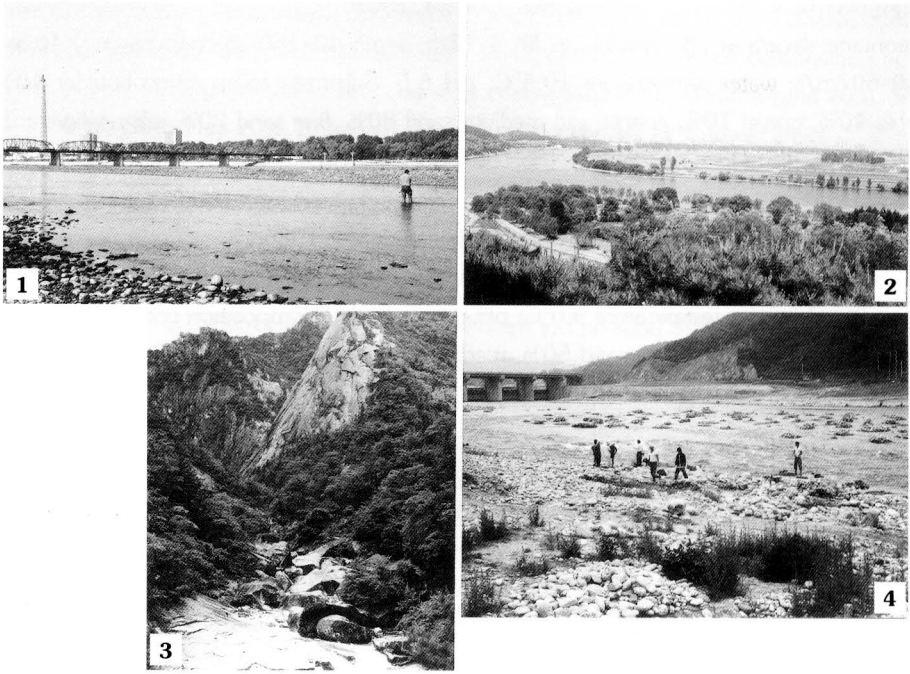
Montane stream at 1200 m a.s.l.; width 3-4 m; depth 30-90 cm; current velocity 40-60 cm/s; transparency 25 cm; temperature 7.5°C; pH 5.8. Substrate composition boulder 20%, cobble 30%, pebble 40%, gravel 10%; very coarse and coarse sand 80%, medium and fine sand 20%; silt negligible; packets of leaves and organic debris 50% in still water pools. Estimated saprobity xenosaprobic.

E5: Kusimuldong river near Samjiyon: Collecting date June 27, 1986.

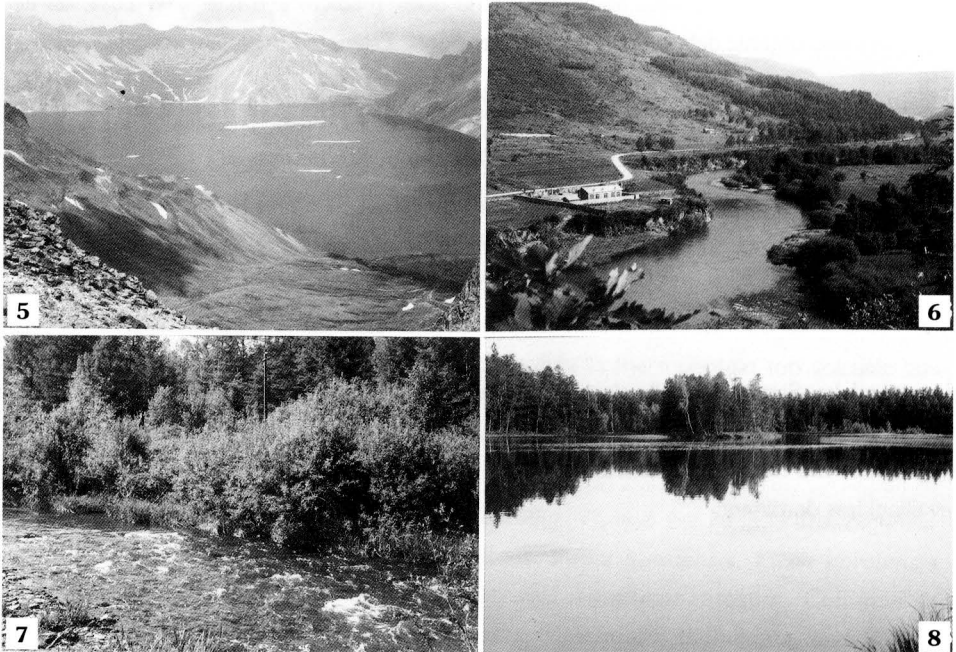
Small montane river at 850 m a.s.l.; width 15-20 m; depth 30-120 cm; current velocity 20-60 cm/s; transparency 50 cm; water temperature 11.5°C; pH 6.5. Substrate composition boulder 20%; cobble 20%; pebble 30%; gravel 30%; very coarse and coarse sand 40%, medium sand 30%, fine and very fine sand 30%; silt nearly 100% at still water places; clay negligible. Estimated saprobity transition between xenosaprobic and oligosaprobic.

E6: Samjiyon lake, Samjiyon: Collecting date June 24-26, 1986.

Large montane lake (600 × 600 m) at 1500 m a.s.l. (Fig. 8), deep, oligotrophic; transparency more than 2 m; littoral zone with numerous packets of leaves, logs, and other organic debris; sandy areas (coarse sand prevailing) less dominant.



Figs 1-4. Habitat photos: 1. Taedong river in Pyongyang city. (Chuche tower is shown over the bridge); 2. Taedong river in the suburb Pyongyang; 3. Myohyangsan; 4. Chongchon river near Hyangsan town, below dam.



Figs 5-8. Habitat photos: 5. Paektusan Chonji, a mountain top (2744m) volcanic lake; 6. Upper stream of Amnokgang (R.), below Chonji; 7. A small montane stream of Paektusan; 8. Samjiyon lake in Paektusan.

LIST OF SPECIES

Family Ameletidae

1. *Ameletus costalis* (Matsumura)

Materials examined: C2: 85 L; C3: 38 L & 1 M; C4: 3 L.

2. *Ameletus montanus* Imanishi

Materials examined: B1: 3 L & 2M; C2: 13 M; C4: 32 L; C5: 6 L; D3: 6L.

3. *Ameletus* sp. A

Materials examined: E1: 6 L; E4: 2 L.

Family Baetidae

4. *Baetiella tuberculata* (Kazlauskas)

Materials examined: B1: 10 L; B8: 28 L; C2: 3 M & 3 F.

Remarks. This is a widely distributed and abundant species and previously known from Far East Russia (Irkutsk, Khabarovsk, Primorye, Sakhalin), Japan, South Korea, and North Korea (Imanishi, 1940). Larvae are strongly rheophilic.

5. *Baetis fuscatus* (Linnaeus)

Materials examined: B3: 20 L.

Remarks. This is a widespread species from Europe to East Asia, previously known as "Baetis nla" in South Korea (see Bae *et al.*, 1997).

6. *Baetis* sp. A

Materials examined: C2: 12 L; E4: 13L.

Remarks. This is a common baetid species in Korea, previously known as *Baetis thermicus* Uéno by Imanishi (1940) and Yoon & Bae (1988). Similar species, *Baetis pseudothermicus* Kluge was described from Primorye, Far East Russia, near Russia-North Korea border. The family Baetidae of Korea is currently revised by Bae and Park (see Park *et al.*, 1996).

7. *Baetis* sp. B

Materials examined: B1: 12 L; E3: 11 L.

8. *Baetis* sp. C

Materials examined: C5: 2 L; E1: 2 L.

9. *Cloeon dipterum* (Linnaeus)

Materials examined: A4: 2 L.

10. *Labiobaetis atrebatinus* (Eaton), 1885

Materials examined: B1: 16 L; D1: 5 L.

Remarks. This species was known from Europe to Far East Russia (Khabarovsk and Primorye). Larvae of this species were especially abundant in Kaesong and Haeju area where streams are moderately polluted (betamesosaprobic). European populations of this species occur at similar biotopes in larger rivers.

11. *Nigrobetis* sp. A

Materials examined: C2: 15 M; C5: 4 L; E2: 4L.

12. *Procloeon* sp. A

Materials examined: B1: 2L; B5: 2L; D1: 5L.

13. *Procloeon* sp. B

Materials examined: B1: 2 L; B5: 2 L.

Family Caenidae

14. *Caenis* KUa

Materials examined: B2: 216 L.

Remarks. This species was collected only at a single locality but in a mass occurrence. Larvae of this species occurred in somewhat polluted (betamesosaprobic) waters.

15. *Caenis* sp. A

Materials examined: E6: 5 L.

Remarks. Larvae of this species were found from a high montane lake, Samjiyon lake.

Family Ephemerellidae

16. *Ephemerella* (*Cincticostella*) *levanidovae* Tshernova

Materials examined: B1: 56 L; C2: 151 L; C3: 48 L & 4 F; C4: 8 L; D4: 1 L.

Remarks. This species is widely distributed and abundant in clean water montane streams. This species was previously known as *Cincticostella castanea* (Allen) (see Bae *et al.*, 1997).

17. *Ephemerella* (*Cincticostella*) *tshernovae* Bajkova

Materials examined: C2: 119 L, 2 M & 16 F; E1: 6 L & 16 F; E5: 1 L.

18. *Ephemerella* (*Drunella*) *aculea* (Allen)

Materials examined: C2: 119 L, 4 M & 51 F; E1: 16 L; E4: 28 L; E5: 2 F.

19. *Ephemerella (Drunella) criptomera* (Imanishi)

Materials examined: B1: 1 M; B5: 12 L; C2: 45 L; D1: 2L; D3: 1 L; E1: 10 L; E5: 4 L.

20. *Ephemerella (Drunella) lepnevae* (Tshernova)

Materials examined: B8: 2 L; C3: 5 L; E3: 25 L; E4: 32 L; E5: 18 L.

Remarks. This species is widely distributed in East Palaearctic region and previously recorded from Yenisey basin, Mongolia, Zabaykal region, Amur basin, Khabarovsk, Primorye, Altay Mts., and Korean peninsula. Larvae prefer strong current, and often found in waterfalls. In North Korea, this species was collected mainly at localities of higher altitude.

21. *Ephemerella (Drunella) triacantha* (Tshernova)

Materials examined: E3: 12 L.

22. *Ephemerella (Ephemerella) aurivillii* (Bengtsson)

Materials examined: E3: 158 L; E4: 209 L.

Remarks. This species was originally recorded from Scandinavia. In Northeast Asia, this species was known from Okhotsk, Angara, Altay, Amur, Ussuri, Kamchatka, Sakhalin, and North Korea (Imanishi, 1940), and lacking from South Korea.

23. *Ephemerella (Ephemerella) dentata* Bajkova

Materials examined: C2: 5 L; E1: 58 L; E2: 32 L; E5: 16 L.

Remarks. This species was previously known as *Ephemerella keijoensis* Allen (see Bae *et al.*, 1997).

24. *Ephemerella (Ephemerella) kozhovi* Bajkova

Materials examined: D2: 54 L; E1: 5 L.

Remarks. This species was previously known as *Ephemerella notofascia* Yoon & Bae (see Bae *et al.*, 1997).

25. *Ephemerella (Serratella) ignita* (Poda)

Materials examined: B4: 1 M & 1 F; D3: 21 L & 2 M; E2: 16 L.

Remarks. This species was previously unknown to Korean peninsula.

26. *Ephemerella (Serratella) setigera* (Bajkova)

Materials examined: A1: 4 L; B2: 22 L; B4: 115 L; B5: 85 L; B7: 3 L; D1: 15 L.

27. *Ephemerella (Serratella) zapetkinae* (Bajkova)

Materials examined: B2: 35 Ms & Fs; B4: 51 L; B5: 18 L; B6: 76 L.

Remarks. This species was previously unknown to Korean peninsula.

28. *Ephemerella (Uracanthella) rufa* (Imanishi)

Materials examined: A1: 3 L; A3: 2 L; B2: 86 L; C1: 5 L; C2: 189 L, 4 M & 45 F.

29. *Ephemerella (Uracanthella) sp. A*

Materials examined: E2: 4 L.

Family Ephemeridae

30. *Ephemera orientalis* McLachlan

Materials examined: A1: 8 L, 12 M, 3 F & 115 Ms & Fs; B2: 6 L; B3: 15 L; B5: 25 L; B6: 45 L; B7: 223 F; C2: 26 L, 15 M & 19 Ms & Fs; E1: 6 L.

31. *Ephemera sahalinensis* Matsumura

Materials examined: A1: 12 F, 5 Ms & 10 Fs; B7: 1 M, 5 Ms & 4 Fs.

Remarks. Adults of this species resemble to *E. orientalis*, but differ slightly in genitalia (see Tshernova *et al.*, 1986). This species is distributed in southern Sachalin, East Kazakhstan, eastern Siberia, Altay, Khabarovsk, and Primorye.

32. *Ephemera separigata* Bae

Materials examined: C2: 15 L; C4: 3 L.

Remarks. Larvae of this species occur in the uppermost section of a stream among Korean *Ephemera* spp. (see Bae, 1995).

33. *Ephemera strigata* Eaton

Materials examined: A1: 3 L, 13 M, 29 F & 86 Ms & Fs; B1: 6 M; B6: 1 F; B8: 2 F; C2: 22 L, 126 M, 15 F & 28 Ms & Fs; C4: 3 L; E5: 1 L.

Family Heptageniidae

34. *Cinygmula grandifolia* Tshernova

Materials examined: E3: 3 L.

Remarks. This species was previously known as *Cinygmula* KU_b by Yoon & Bae (1988) from South Korea (see Bae *et al.*, 1994) and as *Cinygmula* sp. I by Braasch & Soldán (1988) from North Korea.

35. *Cinygmula kurenzovi* Bajkova

Materials examined: E1: 4 L.

Remarks. This species was previously unknown to Korean peninsula.

36. *Cinygmula* KU_a

Materials examined: E1: 22 L; E3: 16 L; E4: 85 L.

37. *Ecdyonurus bajkova* Kluge

Materials examined: B1: 52 L; B3: 1 M & 4 F; B5: 18 L; C2: 283 L, 100 M, 165 F & 58 Ms & Fs; D1: 12 L.

Remarks. *Ecdyonurus subspinosus* (Braasch and Soldán) was synonymized with *E. bajkova* Kluge by Bae *et al.* (1997).

38. *Ecdyonurus dracon* Kluge

Materials examined: C2: 2 L & 1 M; E1: 5 L.

39. *Ecdyonurus joernensis* (Bengtsson)

Materials examined: B1: 210 L, 10 M & 14 F; B5: 13 L; B6: 22 L; C1: 16 L; C2: 325 L, 128 M, 215 F & 52 Ms & Fs.

Remarks. This species was originally known from Mongolia as *Ecdyonurus mongolicus* Bajkova & Varychanova (1978), and later as *Ecdyonurus joernensis* (Bengtsson) (Landa & Soldán, 1983). Tshernova *et al.* (1986) recorded this species from Far East Russia as *E. joernensis mongolicus*. Braasch & Soldán (1988) recorded this species as *Nixe mongolica* from North Korea. This species was also previously known from Korea as *Ecdyonurus* KU_B (Yoon & Bae, 1988) (see synonymy in Bae *et al.*, 1997).

40. *Ecdyonurus kibunensis* Imanishi

Materials examined: C2: 215 L, 126 M & 56 F; D1: 5 L.

41. *Ecdyonurus levis* (Navás)

Materials examined: A1: 113 M, 58 F, 215 Ms & Fs; B2: 8 L; B3: 2 F; B4: 95 L; B5: 82 L & 2 M; C1: 4 L; C2: 150 L & 2 M.

Remarks. See Bae *et al.* (1994) for the synonymy.

42. *Ecdyonurus scalaris* Kluge

Materials examined: C2: 86 L, 182 M & 215 F; C5: 4 L; D1: 8 L, 1 M & 3 F.

43. *Ecdyonurus* sp. A

Materials examined: E2: 6 L (BAE-323).

44. *Epeorus curvatulus* Matsumura

Materials examined: D3: 6 L; E4: 15 L.

45. *Epeorus pellucidus* (Brodsky)

Materials examined: A1: 1 L; B1: 51 L; B2: 8 L; B4: 16 L; B5: 9 L, 1 M & 4 F; B6: 1 L; E5: 1 L; C2: 15 L, 189 M, 36 F & 48 Ms & Fs; D1: 12 L, 1 M & 4.

46. *Heptagenia guranica* Belov

Materials examined: A1: 4 L, 21 M, 62 F & 60 Ms & Fs.

47. *Heptagenia kihada* Matsumura

Materials examined: C1: 5 M & 12 F; C2: 16 L, 113 M & 56 F; C3: 8 L; C4: 6 L; D1: 6 L; D4: 15 L.

48. *Iron aesculus* (Imanishi)

Materials examined: B1: 22 L; C2: 115 L; C3: 10 L; D3: 4 L; E3: 115 L; E4: 26 L.

49. *Iron maculatus* Tshernova

Materials examined: D3: 8 L.

50. *Iron* sp. A

Materials examined: D3: 2 L (BAE-325).

51. *Rhithrogena binotata* Sinitshenkova

Materials examined: C2: 2 M & 3 F.

Remarks. This species was previously unknown to Korean peninsula.

Family Leptophlebiidae

52. *Choroterpes (Euthraulius) altioculus* Kluge

Materials examined: B1: 161 L; B5: 4 L & 3 M; C2: 56 L, 17 M & 3 F; D1: 15 L.

53. *Paraleptophlebia chocolata* Imanishi

Materials examined: B1: 8 L; C2: 115 L; D1: 16 L; E1: 1 L.

Family Metretopodidae

54. *Metretopus borealis* Eaton

Materials examined: C2: 1 Ms.

Remarks. This is a Holarctic boreal species distributed in Canada, Scandinavia, Chukotka, Kamchatka, Siberia, and Primorye, and previously unknown to Korean peninsula.

Family Polymitarcyidae

55. *Ephoron shigae* (Takahashi)

Materials examined: A1: 85 L.

Family Potamanthidae

56. *Potamanthus luteus oriens* Bae and McCafferty

Materials examined: A1: 215 L, 16 M & 82 F; B2: 5 L; B4: 16 L; C1: 59 L.

57. *Potamanthus formosus* Eaton

Materials examined: A1: 3 L.

Family Siphonuridae

58. *Siphonurus chankae* Tshernova

Materials examined: E2: 82 L; E5: 28 L; E6: 4 L.

59. *Siphonurus palaearticus* Tshernova

Materials examined: B2: 6 L; B5: 152 L, 1 M & 4 F; B6: 18 L; D4: 11 L.

Remarks. This species was previously unknown to Korean peninsula.

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북한의 하루살이목 분포상 (1)

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1986년 체코 학술조사단에 의하여 북한의 5개 지역(평양, 개성-해주, 묘향산, 금강산, 백두산)에서 하루살이가 집중적으로 채집되었다. 그 결과 59종(미동정종 13종 포함)의 하루살이가 확인되었고, 그 중 *Labiobaetis atrebatinus* (Eaton), *Ephemerella* (*Serratella*) *ignita* (Poda), *E. (S.) zapetkinae* (Bajkova), *Ephemera sahalinensis* Matsumura, *Cinygmula kurenzovi* Bajkova, *Rhithrogena binotata* Sinitshenkova, *Metretopus borealis* Eaton 및 *Siphonurus palaearticus* Tshernova는 한반도에서 처음으로 기록되는 종이다. 채집지의 일반적인 서식환경과 28개 채집지점의 미소서식처를 기술하였고, 어떤 종은 분포 특성 및 분류학적 변동을 논하였다.

검색어 : 하루살이목, 분류, 분포상, 서식처, 북한

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