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Taxonomy & Inventories

Additions to the fauna and biology of stoneflies (Plecoptera) in Taizi River Basin, Liaoning, with seven new species records to China

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Abstract

Background

An investigation report of stonefly fauna in Benxi Manchu Autonomous County, Liaoning Province, northeast China (used to be called Manchuria, now includes Liaoning, Jilin, Heilongjiang Provinces and parts of Inner Mongolia, which are adjacent to the Russian Far East and the Korean Peninsula). Materials were studied with field observation in 2018 and 2019.

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New information

This paper records five families, nine genera and 14 species of stoneflies from Taizi River, Liaoning Province. Nine species have been recorded for the first time in China and the biology of several common species is also reported for the first time.

Keywords

Plecoptera, Liaoning, Leuctridae, Nemourinae, Chloroperlidae, Perlidae, Perlodidae, northeast China

Introduction

Taizi River is located in northeast China and is the largest freshwater river in Liaoning Province. Its source is located in the Benxi Manchu Autonomous County to Huanren County in the east of Liaoning, belonging to the Changbai Mountains. There are multiple hills and branches of streams on both sides of Taizi River, with mixed broadleaf-conifer forest (Wu and Tian 2017), of which water quality is suitable for the habitat of aquatic insects, especially stoneflies (Yu et al. 2019). However, the sampling rate of stonefly fauna in Liaoning Province has been low for a long time and few species have been recorded before (Wu 1938, Wu 1973, Du 1999, Yang and Li 2018).

Zheng (2011) has collected only two stonefly genera (*Oyamia* sp., *Suwallia* sp.) from the southern tributary of Taizi River, but found no stonefly in its northern part. Yu et al. (2019) have further recorded more EPT species in the southern Taizi River (Yanghugou Village) and provided part COI sequences, including four families and four genera of Plecoptera, including Nemouridae (*Amphinemura*), Chloroperlidae (*Alloperla*), Perlidae (*Kamimuria*) and Perlodidae (*Stavsolus*), but unfortunately, no species have been identified.

From 2018 to 2019, more localities of Taizi River Basin including Xiaodonggou (near Yanghugou Village), Tianguan Virgin Forest and Daomugou (Fig. 1) have been further investigated. So far, five families, nine genera and 14 species of Plecoptera have been recorded, including seven new species records to China. In this paper, we also provide a checklist and high-definition colour photos of these stoneflies, with the biology of several common species for the first time, which will be helpful for further biodiversity monitoring and conservation of the local fauna.

Materials and methods

Specimens were collected by hand, sweep net and light trap and preserved in 75% ethanol. Abdominal segments of specimens were examined and illustrated by KEYENCE VHX-5000. Photographs were taken with a Canon camera (EOS 5D Mark III & PowerShot

SX730 HS) and optimised by Adobe Photoshop CS6. The materials are deposited in the Insect Collection of Yangzhou University, Jiangsu Province, China.

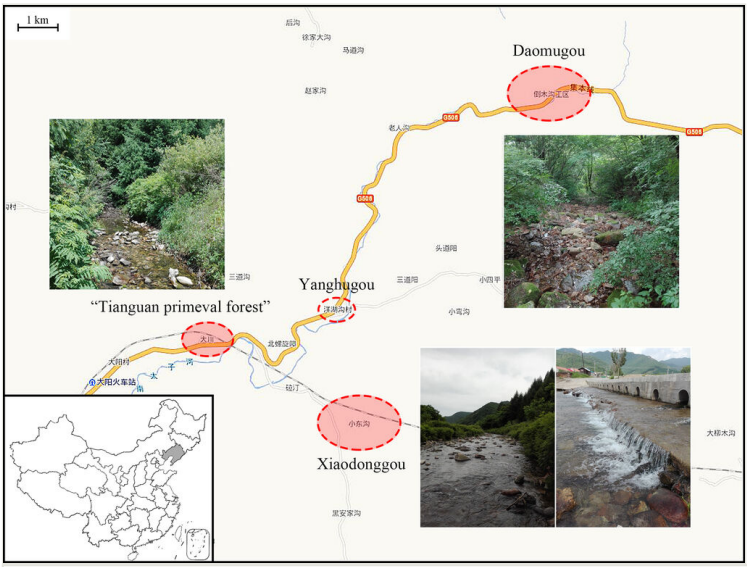


Figure 1. doi

The map of the sampling localities in Taizi River (map provided by www.tianditu.gov.cn).

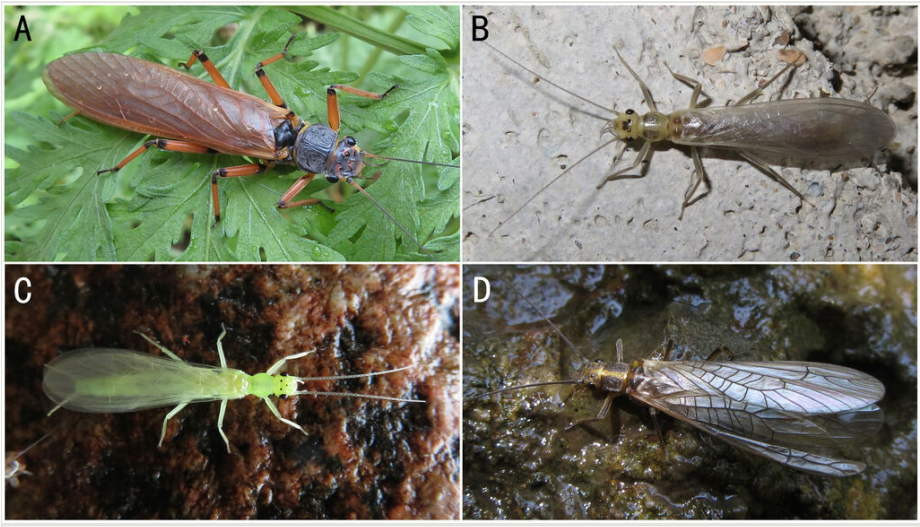


Figure 2. doi

The four most common stoneflies in Xiaodonggou. **A** *Oyamia nigribasis* Banks, 1920; **B** *Isoperla flavescens* Zhiltzova & Potikha, 1986; **C** *Alloperla joosti* Zwick, 1972; **D** *Stavsolus manchuricus* Teslenko, 1999.

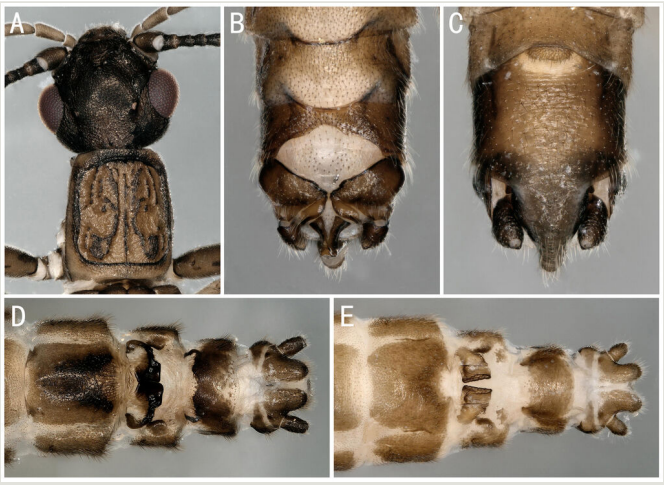


Figure 3. doi

Perlomyia smithae Nelson & Hanson, 1973, *Perlomyia baei* Murányi & Hwang, 2017 and *Perlomyia koreana* Murányi & Hwang, 2017. **A–C** *P. smithae*, male head and pronotum; terminalia, dorsal and ventral view; **D** *P. baei*, female terminalia, ventral view; **E** *P. koreana*, female terminalia, ventral view.

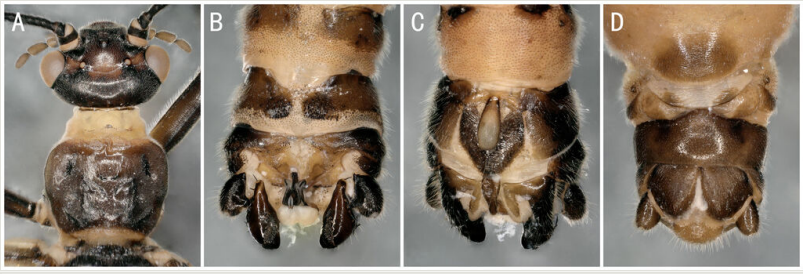


Figure 4. doi

Amphinemura coreana Zwick, 1973. **A** male head and pronotum; **B–C** male terminalia dorsal and ventral view; **D** female terminalia ventral view.

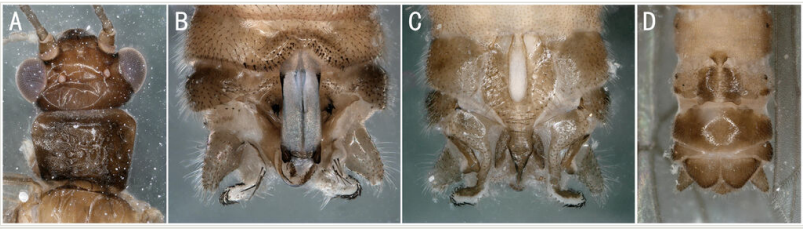


Figure 5. doi

Amphinemura verrucosa Zwick, 1973. **A** male head and pronotum; **B–C** male terminalia dorsal and ventral view; **D** female terminalia ventral view.

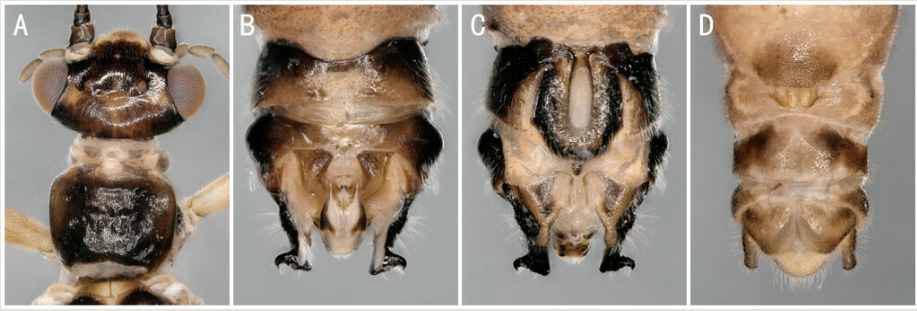


Figure 6. doi

Nemoura papilla Okamoto, 1922. **A** male head and pronotum; **B–C** male terminalia, dorsal and ventral view; **D** female terminalia, ventral view.

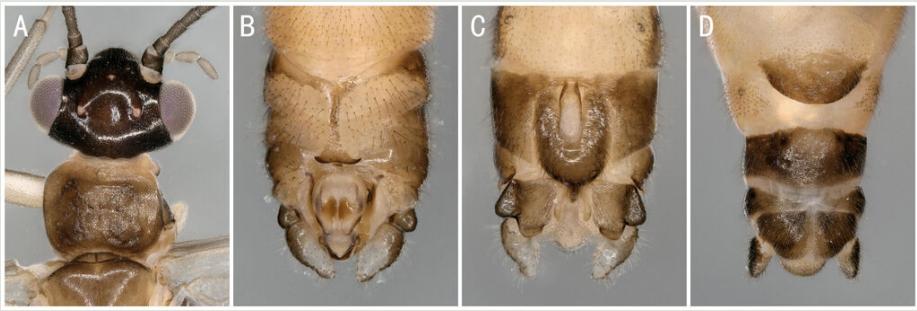


Figure 7. doi

Nemoura tau Zwick, 1973 **A** male head and pronotum; **B–C** male terminalia, dorsal and ventral view; **D** female terminalia, ventral view.

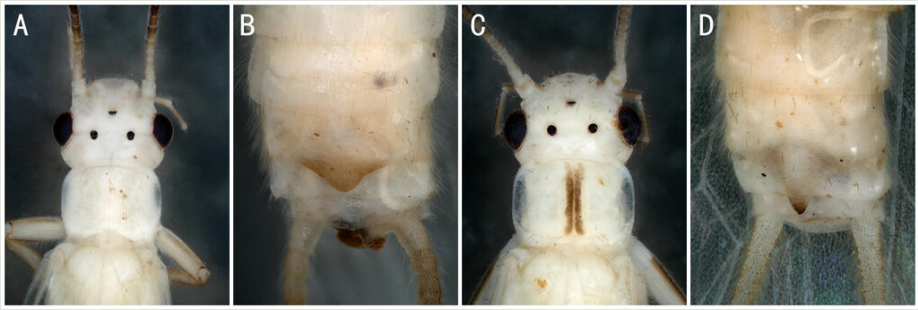


Figure 8. doi

Alloperla joosti Zwick, 1972 and *Alloperla mediata* (Navás, 1925) females. **A–B** *A. joosti* head and pronotum; terminalia ventral view; **C–D** *A. mediata*, head and pronotum; terminalia ventral view.

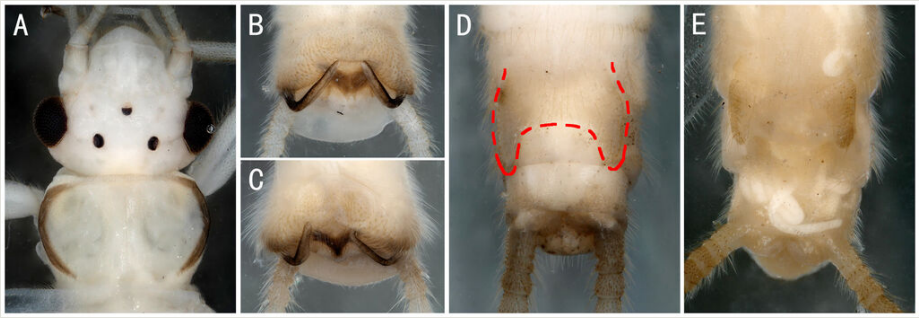


Figure 9. doi

Suwallia asiatica Zhiltzova & Levanidova, 1978. **A** male head and pronotum; **B–C** male terminalia with the shapes of epiproct slightly different dorsal view; **D–E** female terminalia with the subgenital plate slightly/heavily sclerotised ventral view.

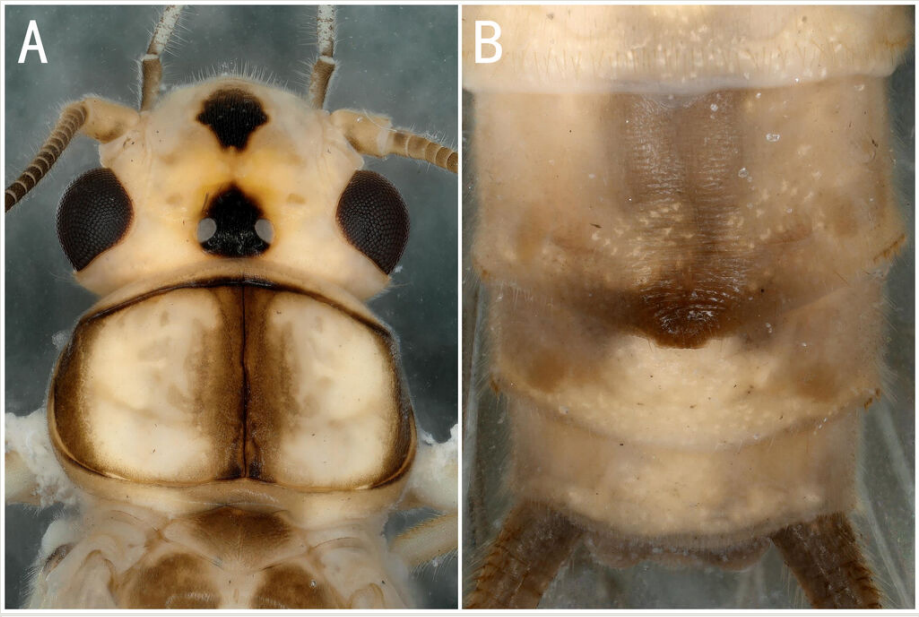


Figure 10. doi

Neoperla coreensis Ra, Kim, Kang & Ham, 1994, female **A** head and pronotum; **B** terminalia ventral view.

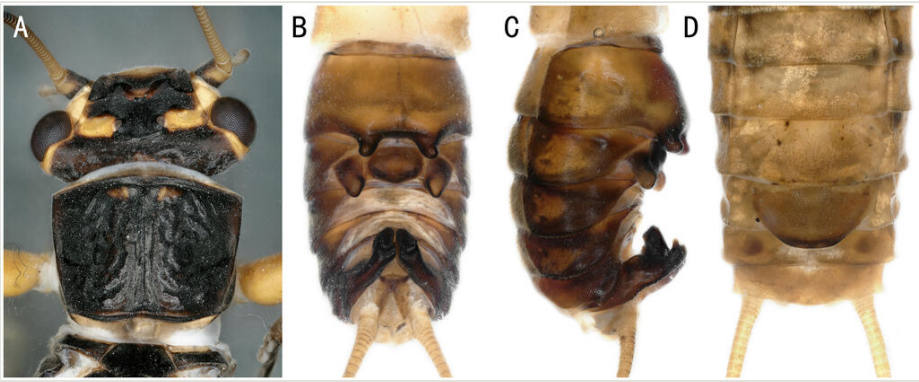


Figure 11. doi

Oyamia nigribasis Banks, 1920. **A** male head and pronotum; **B–C** male terminalia dorsal and ventral view; **D** female terminalia ventral view.

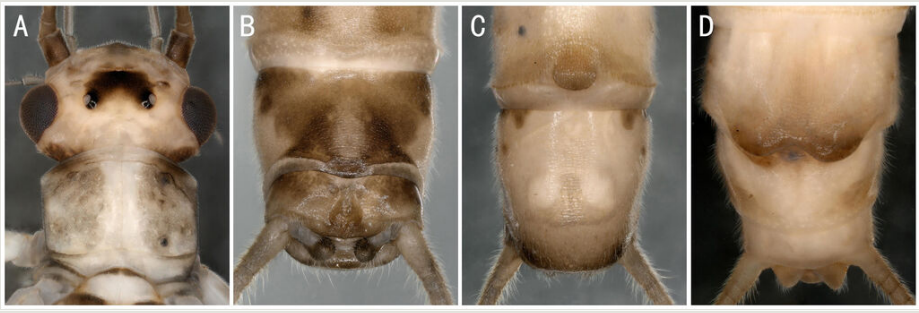


Figure 12. doi

Isoperla flavescens Zhiltzova & Potikha, 1986. **A** male head and pronotum; **B–C** male terminalia dorsal and ventral view; **D** female terminalia ventral view.

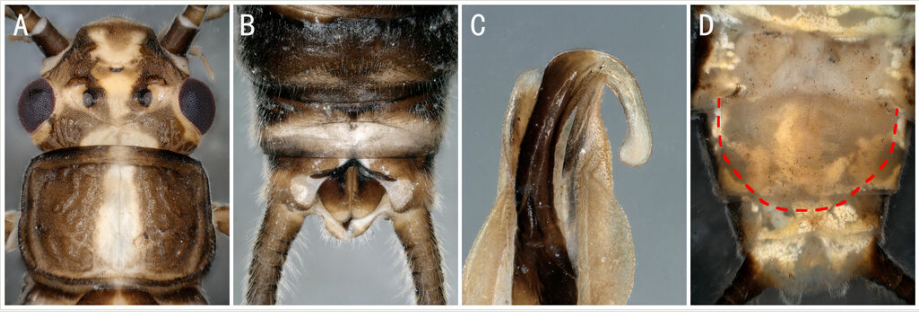


Figure 13. doi

Stavsolus manchuricus Teslenko, 1999. **A** male head and pronotum; **B** male terminalia, dorsal view; **C** apical epiproct; **D** female terminalia, ventral view.

Materials examined are from these localities: **Site A1**: Xiaodong Gou Village (Painter's Village), Benxi County, Liaoning Province, 3-5-VII-2018, 705 m alt., 41°10.589′N, 124°39.438′E, leg. Huo Qing-Bo, Gao Peng. **Site A2**: Xiaodonggou Village, Benxi Autonomous County, Liaoning Province 9-10-VI-2019, 589 m alt., 41°10.806′N, 124°40.148′E, leg. Huo Qing-Bo, Yang Yu-Ben. **Site B**: "Tianguan Virgin Forest", Benxi County, Liaoning Province, 4-VII-2018, 575 m alt., 41°13.893 ′N, 124°37.353′E, leg. Huo Qing-Bo, Gao Peng. **Site C**: "Daomugou Industrial Area", Benxi County, Liaoning Province, 5-VII-2018, 705 m alt., 41°15.508′N, 124°43.318′E, leg. Huo Qing-Bo, Gao Peng.

A checklist of stoneflies from Taizi River

Order Plecoptera

Analysis

Taxa

The identification of the stonefly fauna is based on previous taxonomic literature including Teslenko and Zhiltzova (2009), Judson and Nelson (2012), Murányi et al. (2015), Murányi and Hwang (2017). Species names are listed in Table 1, with their distributions revised according to the records by Kim et al. (1998), Teslenko and Zhiltzova (2009), Hwang et al. (2016) and DeWalt et al. (2022). Photos of each species are shown in the figures below.

Table 1.

A checklist of stoneflies from Taizi River.

Family	Species	Sites	Number	Figures	Distribution
Leuctridae	*Perlomyia baei* Murányi & Hwang, 2017	A2	10 females	Fig. 3D	South Korea; **China***
	Perlomyia koreana Murányi & Hwang, 2017	A2	2 females	Fig. 3E	South Korea; **China***
	Perlomyia smithae Nelson & Hanson, 1973	A2	5 males	Fig. 3A-C	China; North Korea; South Korea; Russia
Nemourinae	*Amphinemura coreana* Zwick, 1973	A2	6 males, 2 females	Fig. 4A-D	South Korea; Kazakhstan; North Korea; Russia; **China***
	Amphinemura verrucosa Zwick, 1973	B	2 males, 1 female	Fig. 5A-D	Russia; South Korea; China
	Nemoura papilla Okamoto, 1922	A2	3 males, 4 females	Fig. 6A-D	Japan; Russia; South Korea; China
	Nemoura tau Zwick, 1973	A2	2 males, 2 females	Fig. 7A-D	South Korea; **China***

Family	Species	Sites	Number	Figures	Distribution
Chloroperlidae	*Alloperla joosti* Zwick, 1972	A1, B	4 females	Fig. 2C, Fig. 8A-B	Russia; Mongolia; South Korea; **China***
	Alloperla mediata (Navás, 1925)	A1	2 females	Fig. 8C-D	Russia; China; Japan; South Korea; Mongolia
	Suwallia asiatica Zhiltzova & Levanidova, 1978	A1, A2, B	17 males, 20 females	Fig. 9A-D	Russia; China
Perlidae	*Neoperla coreensis* Ra, Kim, Kang & Ham, 1994	A1,	2 females	Fig. 10A-B	South Korea; **China***
	Oyamia nigribasis Banks, 1920	A1, A2, C	25 males, 32 females, 20 nymphs/shed skins	Fig. 2A, Fig. 11A-D	China; Russia; South Korea
Perlodidae	*Isoperla flavescens* Zhiltzova & Potikha, 1986	A1, A2, B	5 males, 3 females	Fig. 2B, Fig. 12A-D	Russia; South Korea; **China***
	Stavsolus manchuricus Teslenko, 1999	A1, A2, B	18 males, 20 females	Fig. 2D, Fig. 13A-D	Russia; China; South Korea

Biology of adults

Emergence and parasite

The emergence sites are located on riverside plants and structures. Only *Oyamia nigribasis* and *Stavsolus manchuricus* always emerge in the broad mainstream of Taizi River, but other smaller-sized species are more common in the tributaries of width less than 3 m. All the Leuctridae, Nemourinae, Chloroperlidae and *Neoperla* there can be collected on grasses or shrubs (height < 3 m) by the river, while *Oyamia nigribasis*, *Stavsolus manchuricus* and *Isoperla flavescens* often fly to the higher tree canopy (height > 4 m).

In addition, *Oyamia nigribasis* is the primary carrier of water mites (Hydryphantidae sp.) and each adult can carry dozens of mites of different instars (Fig. 14). These red mites crawl on stonefly larvae as they emerge. Since the dorsal plate of the thoracic segment appears first during moulting, the mites first reach the junction of the dorsal pronotum and the mesothorax (Fig. 14A and B) and then concentrate on the metathorax and abdominal terga 1 - 3 when the adult wings begin to stretch (Fig. 14C and D). In all the materials, these mites were rarely found in any small-sized stonefly species. We cannot judge whether they have a specific host preference for the time being, but can only speculate that they may prefer to ride on larger and stronger hosts to facilitate the spread of their populations.



Figure 14. doi

Hydryphantidae sp. on the body of *Oyamia nigribasis*. **A** the landing nymph; **B** mites climbing on to the thoracic segment of the emerging stonefly; **C** mites walking to the metathorax and abdomen of the stonefly; **D** multiple mites on terga 1-4 of the stonefly.

Mating and spawning

Most of the above species are ready to mate after eclosion in early June (the emergence date of *Neoperla coreensis* is still unknown) and large numbers of females with egg masses can still be observed by early July (Table 2). All species can mate on riverside plants (on leaves or branches), but only *Oyamia nigribasis* appeared in groups in crevices of rocks or buildings to compete for mates and usually become the mating ball (Fig. 15A). Mate guarding is also only documented in this species between the mature male and newly-emerged female (Fig. 15B).

Table 2.

Occurrence of adult stoneflies at Taizi River.

Taxon/ Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Leuctridae												
Perlomyia martynovi	-	-	-	-	-	+	-	-	-	-	-	-
Perlomyia secunda	-	-	-	-	-	+	-	-	-	-	-	-
Perlomyia smithae	-	-	-	-	-	+	-	-	-	-	-	-
Nemourinae												
Amphinemura coreana	-	-	-	-	-	+	-	-	-	-	-	-
Nemoura hamulata	-	-	-	-	-	+	-	-	-	-	-	-
Nemoura transversospinosa	-	-	-	-	-	+	-	-	-	-	-	-

Taxon/ Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Nemoura tau	-	-	-	-	-	+	-	-	-	-	-	-
Chloroperlidae												
Alloperla acietata	-	-	-	-	-	+	-	-	-	-	-	-
Alloperla kurilensis	-	-	-	-	-	+	+♀	-	-	-	-	-
Alloperla mediata	-	-	-	-	-	+	+♀	-	-	-	-	-
Suwallia asiatica	-	-	-	-	-	+	+	-	-	-	-	-
Perlidae												
Neoperla coreensis	-	-	-	-	-	+	+♀	-	-	-	-	-
Oyamia nigribasis	-	-	-	-	-	+	+	-	-	-	-	-
Perlodidae												
Isoperla flavescens	-	-	-	-	-	+	-	-	-	-	-	-
Stavsolus manchuricus	-	-	-	-	-	+	+♀	-	-	-	-	-

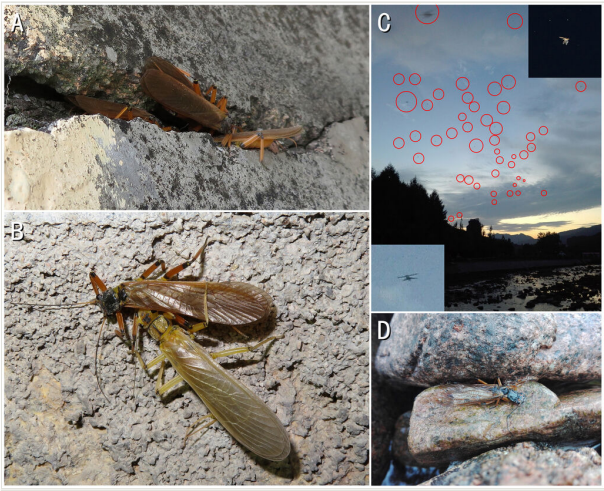


Figure 15. doi

Oyamia nigribasis. **A** mating ball; **B** a couple of mature male and newly-emerged female; **C** multiple females with eggs in the sky; **D** a dead female after spawning.

In June, females of Chloroperlidae will fly to the river to lay eggs before it becomes dark (19:00 - 19:20 h, Beijing time). In early July, when the sun is setting, but the afterglow can still illuminate the entire river surface (19:30 - 19:50 h, Beijing time), *Oyamia nigribasis* females carrying eggs will fly and crash into the river during this time period from the mountains on both sides of the river (Fig. 15C). We used net interception on the bridge and over 50 *Oyamia nigribasis* and a few *Stavsolus manchuricus* were collected. We followed the *Oyamia nigribasis* into the Taizi River, but found nothing on the surface; they probably dived to lay their eggs. During the next day, there are often large numbers of dead *Oyamia nigribasis* females in the rocks where the river turns, with their abdomen empty (Fig. 15D).

Phototaxis

Amongst the above species, Leuctridae, Nemourinae and *Neoperla coreensis* were not attracted and collected by light traps. *Oyamia nigribasis* and *Stavsolus manchuricus* have weak phototaxis, even being photonegative to the extent that females carrying eggs were seldom found under the light (n < 5 per night) and immediately changed flight direction or rushed into the river when illuminated by an electric torch. In addition, *Alloperla* spp. and *Suwallia asiatica* are the most phototactic species there (Fig. 16A–C), either male or female carrying eggs (n > 20 per night), which means that this family may be most vulnerable to human activity along river banks.

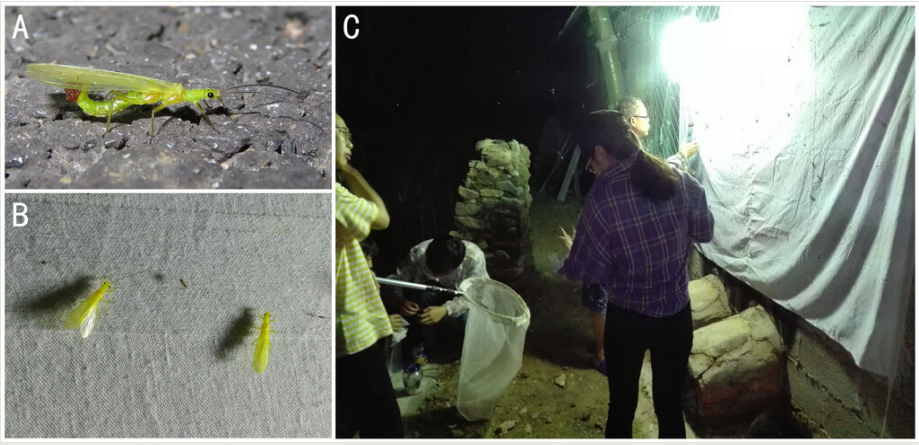


Figure 16. doi

Photographs in the field. **A** *Alloperla* sp. with egg mass; **B** *Suwallia asiatica* on the curtain; **C** the light trap set in Xiaodonggou.

Remarks

Most of the stonefly species mentioned in this article were originally recorded only in the Russian Far East, Korea Island or Mongolia. The Changbai Mountains is on the border with North Korea and close to the Russian border. Therefore, this study presents the potential local diversity of stonefly species and more neighbouring species may be discovered in northeast China in the future.

Acknowledgements

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References

- DeWalt RE, Maehr MD, Hopkins H, Neu-Becker U, Stueber G (2022) Plecoptera species file. Version 5 (0/5.0) URL: http://Plecoptera.SpeciesFile.org
- Du YZ (1999) A taxonomic study on Plecoptera from China. Zhejiang University, Hangzhou, 324 pp pp.
- Hwang, Jeong M, Dávid M, Bae YJ (2016) New records of Plecoptera from Korea. Entomological Research Bulletin 32 (2): 176-178.
- Judson SW, Nelson CR (2012) A guide to Mongolian stoneflies (Insecta: Plecoptera. Zootaxa 3541: 1-118. https://doi.org/10.11646/zootaxa.3541.1.1
- Kim JS, Bae YJ, Zhiltzova L (1998) Bibliographic review, systematic status, and biogeographic notes on Korean and Far East Russian stoneflies (Insecta: Plecoptera) with their new Korean records. Korean Journal of Biological Sciences 2 (4): 419-425. https://doi.org/10.1080/12265071.1998.9647440
- Murányi D, Li WH, Jeon MJ, Hwang JM, Seo HY (2015) Korean species of the genus *Neoperla* Needham, 1905 (Plecoptera: Perlidae. Zootaxa 3918 (1): 113-127. https://doi.org/10.11646/zootaxa.3918.1.5
- Murányi D, Hwang JM (2017) Four new species and further contributions to the Leuctridae (Plecoptera) of the Korean Peninsula. Zootaxa 4282 (1): 43-61. https://doi.org/10.11646/zootaxa.4282.1.2
- Teslenko VA, Zhiltzova LA (2009) Key to the stoneflies (Insecta, Plecoptera) of Russia and adjacent countries. Imagines and nymphs. Dalnauka, Vladivostok. Russian Academy of Sciences, Far Eastern Branch, 381 pp.
- Wu CF (1938) The stoneflies of China (Order Plecoptera). Bulletin of the Peking Society of Natural History 13 (1): 53-87.
- Wu CF (1973) New species of Chinese stoneflies (Order Plecoptera. Acta Entomologica Sinica 16 (2): 97-118.
- Wu HB, Tian ZQ (2017) Study of the influences of watershed landscape patterns on the community structure of macrozoobenthos- a case of the mountain area of Taizi River. Environmental Protection Science 4: 95-101.
- Yang D, Li WH (2018) Insecta (III), Plecoptera. In: Chen Y (Ed.) Species catalogue of China. Animal 2. Science Press, 71 pp.
- Yu D, Wang JF, Liu YS, Wang j (2019) Identificatioin of aquatic insects in Yanghugou Based on DNA barcode. Journal of Anhui Agricultural Sciences 47 (11): 56-59.
- Zheng WH (2011) Researches on the community characteristics and habitat preferences of macroinvertebrates in the Taizi River. Liaoning University, Shenyang, 67 pp.