Macroinvertebrate community in a stream flowing through the secondary forest surrounding Nara campus, Kindai University, Japan

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Synopsis

We investigated macroinvertebrate assemblages in a stream flowing through the abandoned secondary and artificial forests in the Nara campus of Kindai University, Japan. The artificial forest was mainly composed of *Cryptomeria japonica*. Surveys conducted in three distinct dates revealed that 31 species belonging to 11 orders inhabited the study site; *Ephemera japonica*, *Amphinemura* sp., and members of Simliidae, Chironominae, and Asellidae accounted for more than 10% of the total number of individuals found at each sampling date. *Amphinemura*, *Nemura* and *Nothopsyche ruficollis* were the shredders observed. Species that prefer a streamlined flow were also identified.

Keywords: riparian forest, Satoyama, stream macroinvertebrate assemblage

1. Introduction

Forested headwater streams have considerable amounts of coarse particulate organic matter (CPOM) such as leaves, twigs, terrestrial insects, fruits, and miscellaneous particles produced in riparian forests [1]. This organic matter is used as food, case-building materials (e.g., for trichopteran larvae), and habitat for stream macroinvertebrate communities [2–7]. An abandoned secondary forest and an artificial forest surround the Nara campus of Kindai University in Japan. There is limited information about the macroinvertebrate assemblages in the streams that flow through these forests, albeit the studies conducted on the biota of some ponds and paddy fields at Nara campus [8, 9]. Here, we present the data obtained in three surveys conducted in the streams of Nara campus forests during 2015–2016, identifying the macroinvertebrate species found and contributing basic data to Kindai University.

2. Materials and Methods

Study site

The study site was a stretch of approximately 250 m along one of the streams flowing through Nara campus, Kindai University, Japan (34° 40′ 24.6″ N, 135° 43′ 42.5″ E). The stream was V-shaped with a mean wetted width of 0.5–1.5 m, and its substrate was mainly composed of pebbles, cobbles, boulders, and considerable amounts of debris such as leaves and twigs. The riparian zone of the study site was mainly composed of broadleaf tree species [10]. Our study site corresponded to sites E1 and F in Okumura et al. study [11] and this is one of the streams in Satoyama where reservoirs were uncared for.

Macroinvertebrates were collected in April 13, 2015 (N = 9), May 23, 2016 (N = 6), and September 27, 2016 (N = 9) using a 25 × 25 cm server net. The mean water depth in the channel on September 27, 2016 was 1.65 ± 0.56 cm (AV ± SD, N = 9) and the water velocity at normal discharge was 16.88 ± 7.81 cm/s (AV ± SD, N = 9). We did not measure the depth and velocity except the above date. The water temperature was 10.3°C on April 13, 2015, 14.9°C on May 23, 2015, and 20.7°C on September 27, 2016. Water temperature was not measured in May 23, 2016,

and we used the data for the same day in 2015. Water depth and velocity were usually low.

Sample collection

Macroinvertebrates and the associated debris were placed in a polyethylene bag with 70% ethanol and brought to the laboratory, where macroinvertebrates were hand sorted using tweezers before being transferred to containers filled with 70% ethanol. They were then identified as described by Kawai and Tanida [12].

3. Results

The species collected at the study site are shown in Table 1. Eleven orders were represented, namely Decapoda, Ephemeroptera, Odonata, Plecoptera, Trichoptera, Coleoptera, Diptera, Hemiptera, Tubificida, Acari, and Hirudinea. *Ephemera japonica*, *Amphinemura* sp., Simuliidae, Chironominae, and Asellidae comprised more than 10% of the total number of individuals at least one sampling date in the three sampling dates. *E. japonica*, *Geothelphusa dehaani*, *Nemoura* sp., and *Mnais pruinosa* inhabited headwater streams and upper streams whereas *Amphinemura* sp. was found in middle streams, *Orthetrum albistylum* in standing water and Asellidae in dirty waters. Thus, the study site is a particular ecosystem in Satoyama with several aquatic environments, from headwater streams to middle streams and standing waters. *Amphinemura* sp. and *Nemoura* sp. are classified as functional feeding shredders [4]. In this ecosystem, they fed on leaves and functioned as decomposers. The species identified in the present study are listed below.

Fig. 1. *Geothelphusa dehaani*
サワガニ

Geothelphusa dehaani inhabits the middle and upper reaches of streams, and spaces below stones, or burrows in the wetlands around it [13]. In the present study individuals' carapace width ranged from 4.65mm to 15.74mm April 13, 2015, May 23, 2016, September 27, 2016.

Fig. 2. *Ephemera japonica*
フタスジモンカゲロウ

Ephemera japonica inhabits muddy sediments in freshwater regions and filter-feed on fine organic substances present in the water [14].

Fig. 3. *Mnais pruinosa*
アサヒナカワトンボ

Mnais pruinosa inhabits mountain or small streams, which are surrounded by forests in hill or mountain areas [15].

Fig. 4. *Orthetrum albistylum*
シオカラトンボ

Orthetrum albistylum is widely found in standing water regions such as ponds, wetlands, paddy fields, and stagnation zones in rivers from plain to mountain areas [15].

Fig. 5. *Nemoura* sp.
オナシカワゲラ属の 1 種

Although many *Nemoura* species are still undescribed, *Nemoura fulva* is found on fallen leaves in slow current areas and *Nemoura longicercia* is found on the riffle of streams [16]. They are classified as shredder [17].

Fig. 6. *Amphinemura* sp.
フサオナシカワゲラ属の 1 種

To date, only 16 *Amphinemura* species have been recorded and described from Japan, but many local or endemic species inhabiting in a particular region still lack identification [16]. They are classified as shredder [17].

Fig. 7. *Nothopsyche ruficollis*
ホタルトビケラ

Nothopsyche ruficollis inhabits headwater streams in flatlands and spring valleys. In addition, species that live on land during their larval stage were known as terrestrial species. Two types of this species are known, one that uses gravel to build nests and the other that uses vegetative pieces [2, 18]. They are classified as shredder [17].

Fig. 8. *Diplectrona* sp. DA

Fig. 9. Dryopidae sp.
ドロムシ科の 1 種

Dryopidae and Elmidae larvae are very similar; however, the body of the latter is slightly wider. Both larvae and adults live in clear streams [19].

Fig. 10. Tipulinae sp.
ガガンボ亜科の 1 種

Tipulinae adults are found in various environments such as wet grasslands and forests, while larvae are found in the soil of wet forests (Nephrotoma, Tipula), decayed trees (Ctenophora, Tanyptera, Dictenidia, Phoroctenia, Pselliophora, Tipula), bryophytes (Dolichopeza, Tipula), mud of paddy fields or wetlands (Indotipula, Tipulodina, Tipula), water-impregnated soils around swamps

(Indotipula, Holorusia, Tipulodina, Tipula), and in the gravel bottom of streams (Tipula) [20]. In Europe and America, Tipulinae larvae are frequently used as fishing baits due to their tough skin [20].

Fig. 11. Limoniinae sp.
ヒメガガンボ亜科の 1 種

Limoniinae adults inhabit various environments, and many species are found in humid places such as wetlands, grasslands, forests, and around swamps. Larvae are found in various environments such as the soil of wet forests, decayed trees, fungi, bryophytes, mud of paddy fields or wetlands, water-impregnated soils around swamps, the gravel bottom of streams, wet escarpments, and bedrocks with water splash [20].

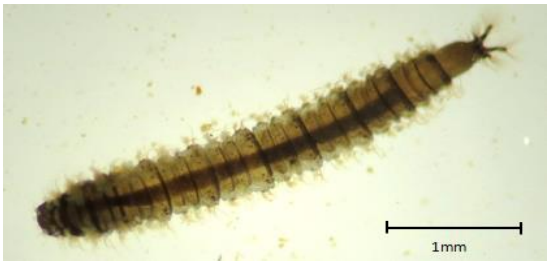

Fig. 12. Psychodidae sp.
チョウバエ科の 1 種

The habitats of Psychodidae include drains and cesspools, although they also inhabit saturated areas near steep streams. Adults belonging to 31 species in eight genera and three subfamilies have been described; however, there is limited information about the larvae [21].

Fig. 13. Bittacomorphinae sp.
ヒメコシボソガガンボ亜科の 1 種

Bittacomorphinae adults fly in a unique manner, with their legs apart, as if they were drifting in the wind [22].

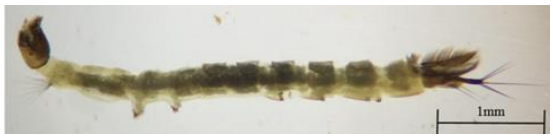

Fig. 14. Dixidae sp.
ホソカ科の 1 種

Larvae of Dixidae inhabit not only on rock under the water but also on moist part of rock or plants above the water [23].

Fig. 15. Simuliidae sp.
ブユ科の 1 種

Adult Simuliidae feed on blood from homoeothermic animals such as birds or mammals and adults feeding on poikilothermic animals such as reptiles or amphibians are not known. The blood is sucked from the animal by pushing hair aside, after perforating the skin with their mandibles [24].

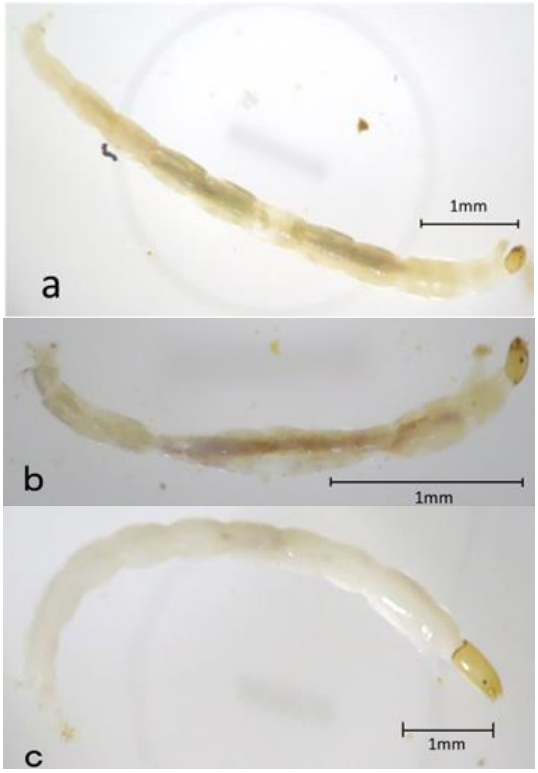

Fig. 16. a : Chironominae sp. ユスリカ亜科の 1 種
b : Orthocladeenae sp. エリユスリカ亜科の 1 種
c : Tanypodinae sp. モンユスリカ亜科の 1 種

The larvae were found in excreta of animals and soil organic matter; however, they were mostly aquatic, living in rivers and lakes. In addition, some were adapted to seawater and were found on the seabed. Tanypodinae and Podonominae larvae are free-living and they wander in muds and mosses; Telmatogetoninae and Chironominae build tube nests and are gregarious [25].

Fig. 17. Asellidae sp.
ミズムシ科の 1 種

Asellidae inhabit dirty water more frequently than pure streams. They feed on organic substances while moving at the river bottom laden with fallen leaves, or can be found and under stones [26].

Fig. 18. Acari sp.
ダニ目の 1 種

Hydracarina inhabit various freshwater environments such as rivers, ponds, ground water, and hot springs, and some species live in brackish water and seawater. Both nymphs and adults are free-living in water [27].

4. Discussion

In the present study, *Nemoura* sp., *E. japonica*, *G. dehaani*, and *M. pruinosa*, which prefer mountain streams, were found in the upper area of the stream. The existence of Plecoptera, Simuliidae, and *G. dehaani* allowed ranking water quality as I. The number of filter feeders (one of the functional feeding groups; Chironominae, *E. japonica*), and shredders (*Nemoura* sp. and *Amphinemura* sp.) were relatively large in the community. *Amphinemura* sp. in particular, played an important role as a decomposer in this Satoyama stream. Only one collector, was found at the study site, indicating that floods or precipitation might cause much fluctuation in the stream bed. Most species were mud-adapted and we did not observe cobble- or pebble-adapted species. Sakai et al. [28] reported that, after the disappearance of forest floor vegetation, a considerable amount of sediment moves along the slope into the stream, filling the stream bed; consequently, the aquatic community that was adapted to cobbles and pebbles decreased along

with species diversity. In the present study, the area surrounding the stream was covered by an abandoned secondary forest, leading to a situation similar to that described by Sakai et al. [28]. Thus, mud-adapted species formed the aquatic community in this study. Our study site was characterized by a lower species diversity and by the absence of fish, when compared to the results obtained from studies at similar locations [29, 30]. We think these results reflected the location characteristics such as shallow water depth and low water volume. Around the study site, juveniles of the salamander *Hynobius nebulosus*, which is a species on the verge of extinction were observed. They inhabit aquatic systems as juvenile, feeding on aquatic insects such as midges [31]. Thus, the species found in the present study might have an important role as a food resource for *H. nebulosus* and the stream might be an important habitat for its juveniles.

5. Acknowledgement

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6. References

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Table 1 Species found in the stream at Kindai University, Japan. (Individuals / 25cm×25cm)

出現生物＼調査日			2015.4.13			2016.5.23			2016.9.27		
	学名	和名	Average	SD	percentage	Average	SD	percentage	Average	SD	percentage
Decapoda（エビ目）	*Geothelphusa dehaani*	サワガニ	0.0	0.0	0.0%	1.2	1.5	2.2%	0.3	0.7	4.3%
Ephemeroptera（カゲロウ目）	*Ephemera japonica*	フタスジモンカゲロウ	1.2	3.5	8.7%	0.7	0.8	1.2%	0.8	1.1	10.1%
	Baetidae	コカゲロウ科	0.0	0.0	0.0%	0.0	0.0	0.0%	0.1	0.3	1.4%
Odonata（トンボ目）	*Mnais pruinosa*	アサヒナカワトンボ	0.0	0.0	0.0%	0.0	0.0	0.0%	0.2	0.6	2.8%
	Orthetrum albistylum	シオカラトンボ	0.2	0.4	1.6%	0.0	0.0	0.0%	0.0	0.0	0.0%
Plecoptera（カワゲラ目）	*Nemoura* Latreille	オナシカワゲラ属	0.7	1.6	4.8%	3.5	3.1	6.5%	0.0	0.0	0.0%
	Amphinemura Ris	フサオナシカワゲラ属	3.4	4.3	24.8%	18.8	19.6	35.2%	0.3	0.7	4.3%
Trichoptera（トビケラ目）	*Diplectrona* sp. DA	*	0.2	0.4	1.6%	0.0	0.0	0.0%	0.1	0.3	1.4%
	Nothopsyche ruficollis	ホタルトビケラ	0.1	0.3	0.8%	0.0	0.0	0.0%	0.0	0.0	0.0%
Coleoptera（コウチュウ目）	Dryopidae	ドロムシ科	0.0	0.0	0.0%	0.0	0.0	0.0%	0.2	0.4	2.8%
	Dryopomorphus nakanei	ヒメハバヒロドロムシ	0.0	0.0	0.0%	1.2	0.9	2.2%	0.0	0.0	0.0%
Diptera（双翅目）	Tipulidae	ガガンボ科	0.1	0.3	0.8%	0.0	0.0	0.0%	0.0	0.0	0.0%
	Tipulinae	ガガンボ亜科	0.0	0.0	0.0%	0.0	0.0	0.0%	0.1	0.3	1.4%
	Limoniinae	ヒメガガンボ亜科	1.0	1.5	7.2%	1.7	1.5	3.1%	2.2	1.5	28.6%
	Psychodidae	チョウバエ科	0.0	0.0	0.0%	0.0	0.0	0.0%	0.1	0.3	1.4%
	Bittacomorphinae	ヒメコシボソガガンボ亜科	0.1	0.3	0.8%	0.0	0.0	0.0%	0.0	0.0	0.0%
	Dixidae	ホソカ科	0.0	0.0	0.0%	3.7	3.8	6.9%	0.0	0.0	0.0%
	Simuliidae	ブユ科	0.3	0.9	2.4%	15.2	9.4	28.4%	0.0	0.0	0.0%
	Chironominae	ユスリカ亜科	1.9	4.0	13.6%	4.0	3.9	7.5%	2.2	2.6	28.6%
	Orthocladeenae	エリユスリカ亜科	0.0	0.0	0.0%	1.3	1.1	2.5%	0.2	0.4	2.8%
	Tanypodinae	モンユスリカ亜科	0.8	1.2	5.6%	2.0	1.5	3.7%	0.0	0.0	0.0%
Isopoda（等脚目）	*Hesperocorixa distanti*	ミズムシ	3.1	5.5	22.4%	0.2	0.4	0.3%	0.7	1.2	8.5%
Tubificida（イトミミズ目）	Naididae	ミズミミズ科	0.7	1.9	4.8%	0.0	0.0	0.0%	0.0	0.0	0.0%
Acari（ダニ目）	Acari	ダニ目	0.0	0.0	0.0%	0.0	0.0	0.0%	0.1	0.3	1.4%
Hirudinea（ヒル綱）	Hirudinea	ヒル綱	0.0	0.0	0.0%	0.2	0.4	0.3%	0.0	0.0	0.0%
	Total		13.9	26.2	100.0%	53.5	47.8	100.0%	7.8	10.8	100.0%

* There is no Japanese name.

近畿大学農学部里山林内を流れる細流における水生生物相

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要　約

本研究では、近畿大学奈良キャンパスにおける森林内の細流において、水生無脊椎動物群集を調査した。人工林は主にスギ *Cryptomeria japonica* で構成されていた。3 回行った調査データから、調査地において 11 目の無脊椎動物群集の分類群が確認され、フタスジモンカゲロウ *Ephemera japonica*、フサオナシカワゲラ属 *Amphinemura*、ブユ科 Simliidae、ユスリカ亜科 Chironominae、ミズムシ科 Asellidae がいずれかのサンプリング日において全体の出現個体数の 10%を超えた。本調査では破砕食者に該当する分類群として、フサオナシカワゲラ属、オナシカワゲラ属、ホタルトビケラが確認された。また、細流を好む種も確認された。

キーワード：河川大型無脊椎動物群集、里山、河畔林