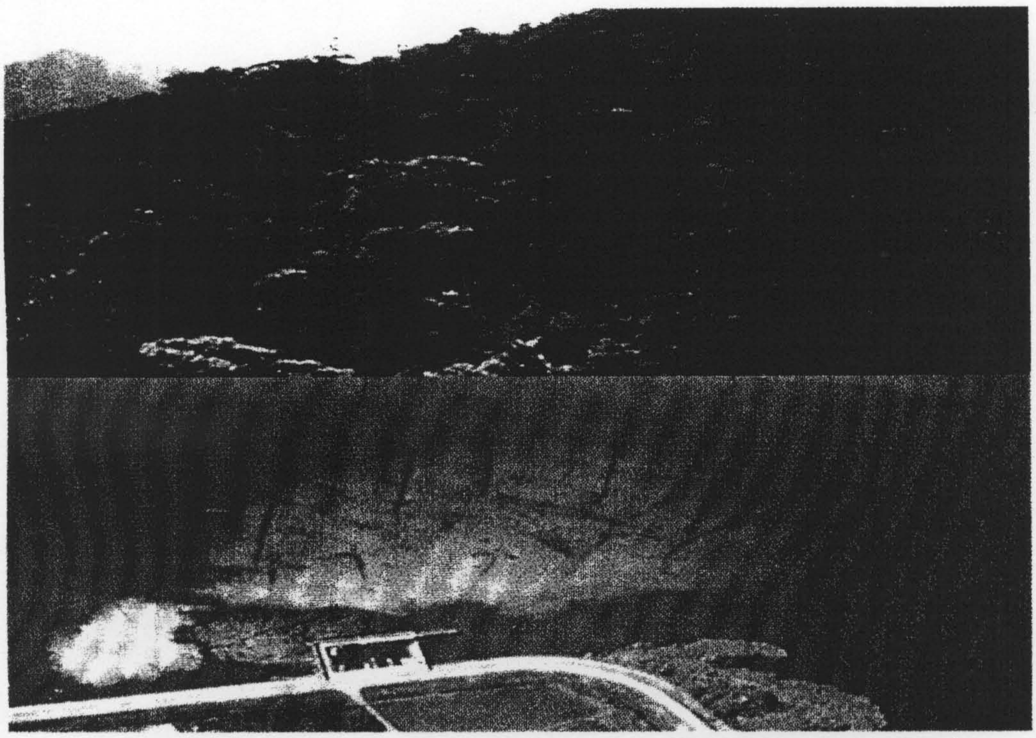
CGER-REPORT

ISSN 1341-4356
CGER-I031-'98

Long-Term Ecological Research in the East Asia-Pacific Region: Biodiversity and Conservation of Terrestrial and Freshwater Ecosystems

Proceedings of the 2nd East Asia-Pacific Regional Conference on Long-Term Ecological Research, 3-5 March 1997, National Institute for Environmental Studies, Tsukuba



Edited by Toshio Iwakuma
1998

Center for Global Environmental Research

National Institute for Environmental Studies
Environment Agency of Japan

Long-Term Research of the Small Salmon Rivers of the Far East of Russia

T. M. Tiunova, V. A. Teslenko, S. L. Kocharina and L. A. Medvedeva

Institute Biology and Soil Sciences,
Far East Branch of the Russian Academy of Sciences,
Vladivostok, Russia

Abstract: For the past 25 years, researches have been conducted in the Kedrovaya River, flowing from the eastern slopes of the East-Manchurian Mountains into Amursky Bay (the Sea of Japan). The Kedrovaya River is located in the monsoon climate zone, where a seasonal fluctuation of water level is conspicuous as compared with the other regions in the Far East of Russia. In spite of extreme environmental conditions such as drought, spate and freezing of the stream bed within a year, species diversity and composition of benthic communities, number of functional trophic groups and number of species in these groups are very stable during 1972 to 1993.

INTRODUCTION

The Far East of Russia is a mountainous region, where plains and lowlands cover less than one quarter of the territory (Fig. 1). River research in the Far East has traditionally been concerned with salmon rivers, where the salmon genus *Oncorhynchus*, the pride of the land, spawns. The salmon river is a cold-water or moderately warm watercourse with a swift current and rocky bed. These conditions are essential for spawning and development of the fry and fingerlings (Levanidova *et al.*, 1989). Most salmon rivers of the Far East belong to the category of small salmon streams (there are about 55,000 streams in Prymorye alone). Small salmon streams may serve standards for the investigations of salmon ecosystems, so long as comparable streams and reaches are chosen. If so, the entire diversity of salmon rivers or their zones may conform to a limited set of models.

For the past 25 years, our research has been conducted in the Kedrovaya River, a typical small salmon stream which provides the conditions essential for spawning and development of the fry and fingerlings of salmonids. Furthermore, the river flows through the Kedrovaya Pad Reserve territory and thus is free from artificial impacts on the system. The river belongs to the southern Far East subregion (Levanidov, 1977, 1981) and is characterized by a high species diversity and average annual biomass in the rhithron (Kocharina *et al.*, 1988; Vshivkova *et al.*, 1992; Medvedeva, 1995).

The Kedrovaya River is located in the monsoon climate zone, where a seasonal fluctuation of the water level is conspicuous as compared with the other regions in the Far East of Russia. In spite of the extreme environmental conditions such as drought, spate and freezing of the river bed within a year, the species diversity and species composition of the benthic communities, number of functional trophic groups and quantity of species in these groups are very stable throughout a long period (Kocharina, 1996; Tiunova *et al.,* 1997). There might be such a mechanism that will bring back the system to a primary condition even after the energy and the organic matter accumulated as the biomass in macrobenthos were swept away by spates. It is important that stream organisms turned out to be able to recognize the alarm signals arising within the system and leave the dangerous zones beforehand (Bogatov, 1994; Tiunova *et al.,* 1997). Organisms inhabiting rivers located in the monsoon climatic zone, in general, may be adapted to the seasonal and annual fluctuations of the environmental conditions. They might require the fluctuated environmental conditions for their life.

Probably, the regular consequence of low and high water periods as a whole has favorable effect and for a general ecological situation of the rivers. Therefore, extreme natural events represent ultimate conditions for existence of river ecosystems in a monsoon climate zone.

Based on this hypothesis, we have been conducting a long-term study to reveal characteristics of function of different populations and communities in rivers. The results will provide estimation of a role of the extreme environmental events in functioning of river ecosystems.

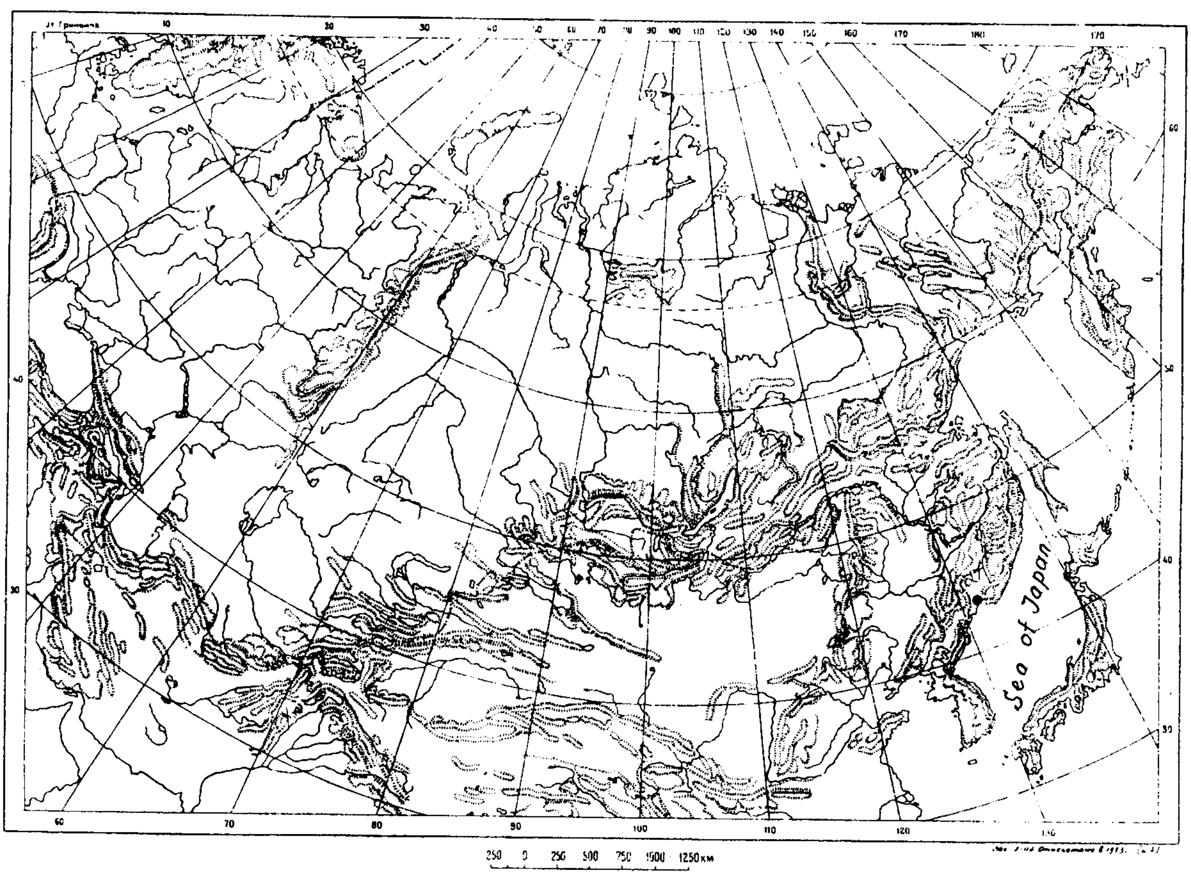


Fig. 1. Map showing the region of investigation.

STUDY AREA

The Kedrovaya River flows from the eastern slopes of the East-Manchurian Mountains into Amursky Bay (the Sea of Japan) (Fig. 2). The river length is about 28 km, the upper reaches are of mountainous, the lower portion flows through the foothills to a considerable extent.

The bottom is composed of pebbles and stones. Stones are often overgrown with algae and mosses. The average depth is 25–35 cm and the current velocity is 0.5–1.0 m s^{-1}. Ice cover during winter months is open over spring, but in shallow reaches, the river water is frozen to the bottom. The mean water temperature for the summer period is about 13°C, with daily fluctuations reaching 4–6°C.

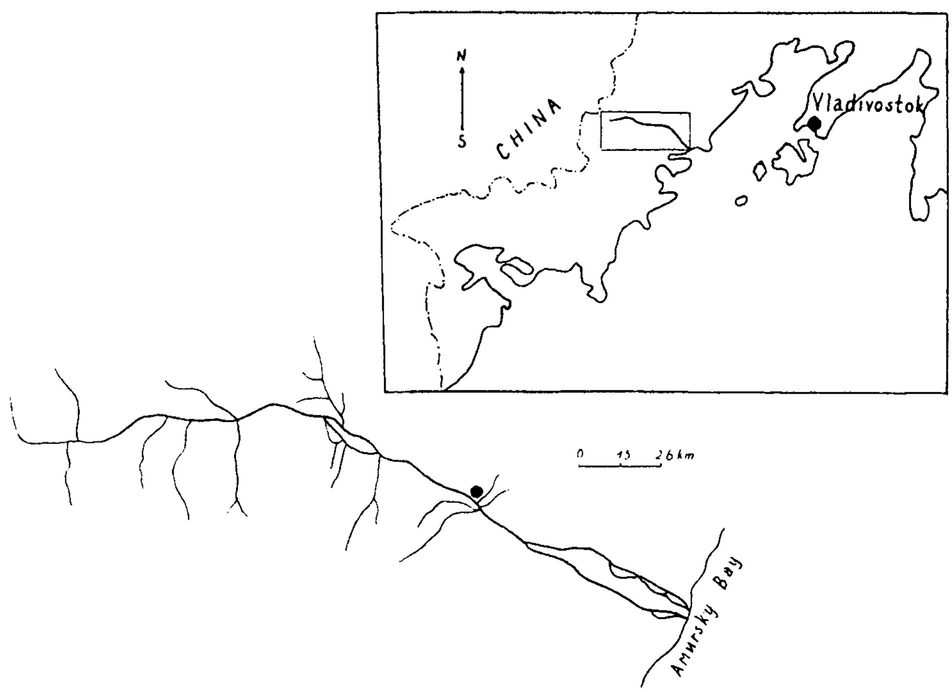


Fig. 2. Map of the Kedrovaya River and sampling site.

METHODS

Quantitative samples were collected during 2 periods:

1) July 1979–November 1980. During this period, 10 stations in the riffles were established on a 6-km section of the river. Two samples of macrobenthos were taken from each station monthly using a benthometer with a bottom area of 0.012 m^2.

2) March 1993–June 1994. A small section of river (about 60 m), including pool and riffle, was investigated. We followed the mapping method of Takemon and Tanida (1993) for surveying the geomorphology of the river and the distributional patterns of organisms. Environmental map of the area was made twice a month using measurements on geomorphology, water depth, current velocity, water temperature, illumination, and substrate types. About 30 benthic samples were collected each time by means of a benthometer with a bottom area of 0.075 or 0.0625 m^2. At each sampling site periphyton and fishes were also collected.

Sessile algae were brushed out from the stone surface completely and a part of collected material was filtrated through the Whatman GF/C glass-fiber filters. This part of sample was used for photosynthetic pigment analysis and another part – for the determination of algal density and standing crop. Density was determined with a calculating camera and the standing crop was calculated by multiplying by mean cell volumes. Therefore the density and standing crop of each species, overall algal standing crop and chlorophylls *a, b, c,* carotenoids and phaeophytin contents were obtained simultaneously.

The classification of Levanidov (1977) was applied to determine benthic community structure: the dominants made up 15% and more, the subdominants 5.0–14.9%, and secondary species from 4.9% and less of the total biomass.

RESULTS AND DISCUSSION

The Kedrovaya River experiences a periodic alternation of low and high waters. However, in spite of frequent occurrences of extreme natural events (drought, river-bed freezing, high water), the structure and species diversity of the benthic communities in this river remain stable throughout a long period. Annual structural characteristics of the benthic community of Kedrovaya River were very similar for 1972–1973 and 1979–1980. In both periods caddisfly larvae of *Stenopsyche marmorata* Navas dominated. The mean annual biomass of this caddisfly for the first period was 28% and that for the second was 35.1% of the whole community biomass. *Gammarus coreanus* Ueno and *Drunella aculea* Allen were classified into the category of subdominants in both periods. The quantitative parameter values of these species did not differ significantly between 2 study periods (Tiunova *et al.*, 1997).

Tables 1 and 2 show comparisons of the faunal data of riffle part of the Kedrovaya River in springs of 1980 and 1993. Caddisfly larvae of *Stenopsyche marmorata* dominated, *Gammarus coreanus* belonged to the subdominants in these years, although the biomass of the other species changed. A large species of a mayfly, *Drunella aculea* dropped out from the category of subdominants and a caddisfly *Arctopsyche palpata* (13.87% of benthos biomass) took its place. Besides 2 caddisfly species, *Neophylax ussuriensis* and *Hydatophylax nigrovittatus* were also classified into the category of subdominants.

The relatively constant number of the functional trophic groups, the quantity of the species in these groups and trophic relationships of the individual species also indicated a stability of the Kedrovaya River ecosystem (Table 3). Among the functional trophic groups, the filtering-collectors, predators and shredders dominated in 1980 as well as 1993. The position of scrapers and collectors was not changed through these years.

Table 1. Structure of the bottom community in the Kedrovaya River (% of biomass; 3 April–8 June 1980).

Dominants	%	Subdominants	%	Secondary species	%
Stenopsyche marmorata	27.8	*Drunella aculea*	12.8	*Pteronarcys sachalina*	4.46
		Gammarus coreanus	7.02	Diptera	3.72
				Cinygmula grandifolia	3.52
				Stavsolus sp.n.	3.82
				Arctopsyche palpata	3.17
				Chironomidae	2.55
				Neophylax ussuriensis	2.23
				Taenionema japonicum	2.10
				Amphinemura verrucosa	2.20
				Megarcys ochracea	2.29
				Cincticostella tshernovae	2.29
				Cinygmula latifrons	2.75

Table 2. Structure of the bottom community in the Kedrovaya River (% of biomass, 24 April–10 June 1993).

Dominants	%	Subdominants	%	Secondary species	%
Stenopsyche marmorata	26.7	*Arctopsyche palpata*	13.9	*Stavsolus* sp.n.	4.3
		Neophylax ussuriensis	5.9	*Hydropsyche orientalis*	3.7
		Hydatophylax		*Baetis pseudothermicus*	3.3
		nigrovittatus	6.1	*Kamimuria exilis*	3.0
		Gammarus coreanus	5.2	*Cincticostella levanidovae*	2.7
				Drunella triacantha	1.5
				Rhyacophila retracta	1.4
				Epeorus gornostajevi	1.3
				Drunella aculea	1.2

Table 3. Composition of functional trophic groups of benthos in the Kedrovaya River.

Functional group	Biomass (%)		Number of species	
	1980	1993	1980	1993
Filter-feeders	32.37	44.59	3	4
Predators	30.05	18.35	16	18
Shredders	19.20	15.13	8	7
Scrapers	11.56	14.64	8	11
Collectors	5.75	7.17	9	11

Above results indicate that the community of the Kedrovaya River was in a stable condition in spite of droughts, river-bed freezing and high waters during 13 years (1980–1993). Such long-term investigations of the structure of river communities provides basic information on monitoring, but do not on quantitative changes in the populations and communities as a whole influenced by extreme environmental factors. At the same time temporary extreme natural phenomena have important meaning in organization of river ecosystems (Minshall *et al.,* 1985; Minshall, 1988; Townsend, 1989; Bogatov, 1994).

To collect information about the quantitative spatial and temporary changes in community structure, we used another approach to study structure and function of the multispecies community in the small salmon Kedrovaya River in 1993–1994. A riffle-pool of about 60 m in extent was taken as a structural element of the river system. During the period of our investigations, we recorded 6 low floods, characterized by small rises of water, and 2 high floods, accompanied by flooding of large area of the river valley. Series of samples were taken during early spring before the river bed freezing when only on 30% of the river surface was open. Changes from long low water periods to high water periods were marked.

Changes of the bottom area of the Kedrovaya River during springtime were shown in Fig. 3 and Table 4. The difference between the maximum and minimum bottom areas was about 126 m^2. The total benthos biomass (kg dry weight) normally decreased in the pool and increased in the riffle from April to June. It could be caused by 2 basic reasons: by the flying up of adults of the some large mayfly and caddisfly species from the pool in this period, and also migration of larvae from the pool to the riffle. On May 9 the bottom area was minimum for springtime, whereas the benthos biomass was the highest; 4.62 g m^2 in the pool. Biomass for the whole pool area was less than that in the previous month (1.37 kg).

Diatoms were most diverse and numerous. *Gomphonema olivaceum* (Hornemann) Brev., *G. angustatum* (Kütz) Rabh., *Cymbella minima* Hilse ex Rabh., *C. silesiaca* Bleisch, *C. turgidula* Grun., *Hannaea arcus* (Ehr.) Patr., *Cocconeis place*ntula Ehr., *Achnanthes minutissima* Kütz. dominated from April to June. The filamentous blue-green alga *Homoeothrix simplex* Woronich. also had high density during the sampling period. Algal species compositions of the riffle and the pool were similar. The density and the standing crop of algae increased from April to June, and were higher in the pool than in the riffle.

Thus, we obtained an example of quantitative biomass changes in the algal and invertebrate communities. These biomass changes depended on the changes of bottom area of the river. We expect that such approach of research on the multispecies community of a small salmon river will enable to provide data of characteristics of function of river populations and communities as a whole under low and high water conditions. With these basic data, it will be possible to reveal a role of extreme natural phenomena on the function of river ecosystems.

ACKNOWLEDGMENTS

This study was supported by the Russian Fund of Fundamental Investigations (Grant N 96-04-51019).

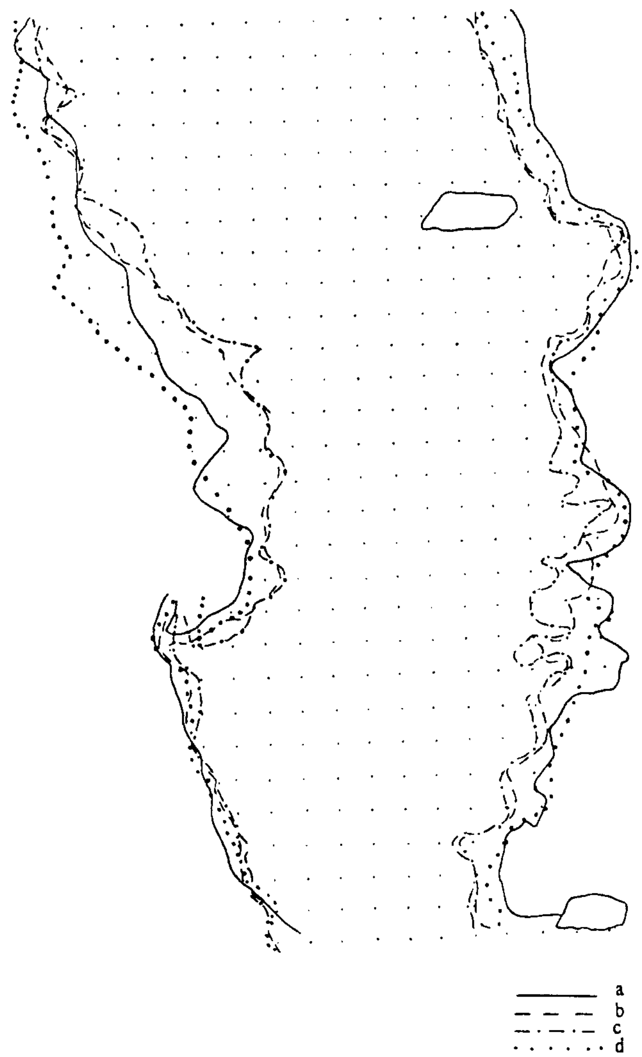


Fig. 3. Map of the observation area in the Kedrovaya River observed in 1993: (a) 24 April, (b) 9 May, (c) 23 May, (d) 10 June.

Table 4. Average biomass of benthos, algae of epilithon and chlorophyll *a* values in a riffle-pool of the Kedrovaya River.

Date	24 April 1993		9 May 1993		10 June 1993	
	pool	riffle	pool	riffle	pool	riffle
Site area, m^2	366	326	296	282	388	316
Average biomass (dry weight):						
Benthos, g m^{-2}	4.53	3.82	4.62	5.87	2.69	7.19
Algae, g m^{-2}	2.0	0.6	5.6	2.2	45.0	12.75
Chlorophyll *a*, mgC m^{-2}	1.3	1.2	2.4	2.5	7.7	3.84
Total biomass (dry weight):						
Benthos, kg	1.66	1.18	1.37	1.65	1.04	2.27
Algae, kg	0.73	0.19	1.67	0.62	17.46	4.03
Chlorophyll *a*, gC	0.47	0.39	0.71	0.71	2.99	1.21

REFERENCES

Bogatov, V. V., 1994. *Ecology of River Communities of Russian Far East.* Dalnauka Vladivostok, 210 p.

Kocharina, S. L., 1996. Structural characteristics of caddisfly community from a little salmon river, South Primorye, Russian Far East. *Proceeding of the 8th Int. Symp. on Trichoptera.* Ohio Biological Survey, pp. 256-264.

Kocharina, S. L., E. A Makarchenko, M. A Makarchenko, E. V. Nikolaeva, T. M. Tiunova and V. A. Teslenko, 1988. Bottom invertebrates in ecosystems of salmon streams of the southern Far East USSR. *Fauna, Systematics and Biology of Freshwater Invertebrates.* FEB AS USSR Vladivostok, pp. 86-108.

Levanidov, V. Ya., 1977. Biomass and structure of bottom biocenoses of the Kedrovaya River. *Freshwater Fauna of <Kedrovaya Pad> Reserve.* FESC AS USSR Vladivostok, pp. 126-159.

Levanidov, V. Ya., 1981. Ecosystems of salmon streams of the Far East. *Invertebrate Animals on Ecosystem of Salmon Rivers of the Far East.* FESC AS USSR, Vladivostok, pp. 3-21.

Levanidova, I. M., T. I. Lukyanchenko, V. A. Teslenko, M. A. Makarchenko and A. Yu Semenchenko, 1989. Ecological study of fashion rivers of the soviet Far East. *Systematics and Ecology of River Organisms.*FEB AS USSR, Vladivostok pp. 74-111.

Medvedeva, L. A., 1995. Sessile algae of the Kedrovaya stream and its tributaries (Primorye Far East). In: K. Tanida (ed.), *Report of the Studies on the Structure and Function of River Ecosystems of the Far East, No. 3.* pp. 13-19.

Minshall, G. W., 1988. Stream ecosystem theory: a global perspective. *J. N. Am. Benthol. Soc.*, **7:** 263-288.

Minshall, G. W., Cummins, K. W., Petersen, R. C., Cushing, C. E., Bruns, D. A., Sedell, J. R. and R. L. Vannote, 1985. Developments in stream ecosystem theory. *Can. J. Fish. Aquat. Sci.,* **42:** 1045-1055.

Takemon, Y and K. Tanida, 1993. Environmental elements for recovery and conservation of river in nature. In: M. Anpo (ed.), *Proceeding of the International Symposium on Global Amenity.* University of Osaka Prefecture, Osaka, pp. 349-356.

Tiunova, T. M., 1993. *Mayfly of the Kedrovaya River and their Ecologo-Physiological Chracteristics.*Dalnauka, Vladivostok, 194 pp.

Tiunova, T. M., V. A. Teslenko, L. A. Medvedeva and S. L. Kocharina, 1997. The ecosystem of a small river in the Far East of Russia. *Proceeding of the International Workshop on New Scope on Boreal Ecosystems in East Siberia.* Scientific Publishing Center of the UIGGM SB RAS, Novosibirsk. Vol. 2: 99-105.

Townsend, C. R., 1989. The patch dynamics of stream community ecology. *J. N. Am. Benthol. Soc.*, **8:** 36-50.

Vshivkova, T. S., S. L. Kocharina, E. A. Makarchenko, M. A. Makarchenko, V. A. Teslenko and T. S. L. M. Tiunova, 1992. Fauna of Water Invertebrates of the <Kedrovaya Pad> Reserve and Adjacent Territories. *Modern State of Flora and Fauna <Kedrovaya Pad> Reserve.* FEB RAS USSR, Vladivostok, pp. 48-88.