Ecological Survey of Aquatic Animals in the Stream Yokoshibetsu, Sapporo[1)]

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(With 6 Text-figures)

On lentic animal communities in Hokkaido, there have been published a fair number of works, but only little attention has been paid to lotic communities except for several taxonomic studies on limited groups. The present study was carried out in a small stream, the Yokoshibetsu, from May to October in 1954 at the suggestion of Dr. S. F. Sakagami as a joint work by Misses A. Sato, Y. Toyofuku, and Y. Yuize, and Messrs. S. Hayashi, S. Koiwai, M. Sasaki and the writer working as investigators under the guidance of Professor Tohru Uchinda. The material obtained by them were summarized and compiled by the writer as the present form.

Description of the stream

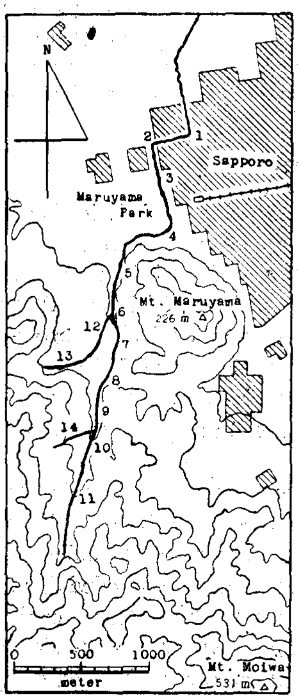
As seen in Fig. 1, the Yokoshibetsu taking its rise in Mt. Moiwa (ca. 500 m above sea level), south west of Sapporo City, runs northwards across Maruyama Park about 3 km, then enters into the city and falls into a creek, the Shinkawa. The survey was confined mainly to the section which ran through the park. The area studied is located on the margin of the deciduous broadleaf forest climax and is characterized by a luxuriant growth of *Cercidiphyllum japonicum* and *Tilia japonica*, though modified secondarily by human interference, e.g. by the mixing of *Quercus crispula* as the secondary element or by the afforestation of *Cryptomeria japonica*.

Eleven stations in the main stream and three (No. 12–14) in branches were chosen as shown Fig. 1; they were numbered from downstream. Various physical and topographical features of each station are shown in Table 1. At most of stations, the stream-bed is covered with sand and non-eroded pebbles of large or medium size. The substrata of St. 1–2 consist of soft mud enriched with organic matter. At these two stations, the stream enters into the city and is gradually contaminated by sewage water. This is indicated by dissolved oxygen contents and a higher value of Cl-ion. Moreover, since considerable bog-water flows in, pH-value shows slight acidity at these two stations. The air and water temperature vary hourly, daily and spatially as shown in Fig. 2. In the syn-

1) Contribution No.353 from the Zoological Institute, Faculty of Science, Hokkaido University, Sapporo, Japan.

Table 1. Topographical features (measured in June)

Condition \ Station	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Width (m)	3	1.5	2-3				1.5				1	less than 0.5		
Depth (cm)	50	20	10				5-10					less than 5		
Current velocity (cm/sec)			10-30			30-50								
Inclination	less than 20/1000					60-80/1000								
Substratum	mud		sand, pebbles									pebbles, plant deteriorated		



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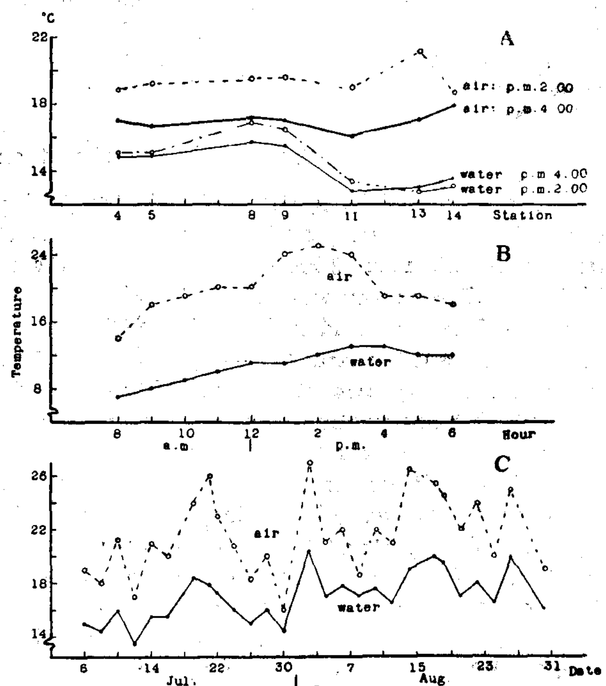

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Fig. 1. Locality of the Yokoshibetsu and position of various stations.
Fig. 2. Records of measurement of air and water temperature.
A. Synchronous measurement of temperature at various stations on Jun. 22nd.
B. Hourly change of temperature at St. 5 on Jul. 16th.
C. Daily change of temperature at noon at St. 5.

chronous examination at each station on June 22nd, the water temperature indicated the lowest at St. 11 and 13, that is, at the uppermost and branch stations. From St. 9 downwards the temperature showed no marked spatial difference. Generally, the temperature gradient seems to be relatively gentle within the limits of measured season both spatially and temporally. Though not determined quantitatively, attention must be given to the seasonal change of the volume and velocity of water. From December to March, the area and even the stream are covered with a thick snow layer. Then, spring flood increases the volume and velocity of water from April into May. Thereafter the volume and velocity of water decreases gradually until autumn. It may be assumed that such changes affect directly or indirectly the life and distribution of animals.

Distribution of animals

The present paper deals mostly with the faunistic aspects of the stream based upon the results obtained during the investigations. In spring (May-June) and autumn (Sept.-Oct.), all fourteen stations were visited three to five times respectively. In summer (Jul.-Aug.), however, only St. 5, 9 and 11 were surveyed due to various unavoidable circumstances. Owing to different natures of stream-bed, it was not always possible to employ the same sampling method at all the stations. For example, at St. 1 and 2, about 150 cc of bottom mud was taken to the laboratory to count the macroscopic animals involved. At the other stations, unfortunately, due to the limited observation time, it was necessary to employ sampling during a definite time interval, instead of quadrate sampling. At first all specimens, larger than about 2 mm, discovered around stones on bottom were collected over a period of 45 minutes. Then, during 20 minutes the sampling was based on all the species observed, irrespective of individual number.

Table 2. List of animal species collected.

Coelenterata
- *Hydra vulgaris attenuata*

Turbellaria
- *Dendrocoelopsis* sp.
- *Dugesia gonocephala*
- *Polycelis sapporo*

Nematoda
- Gen. sp.

Nematomorpha
- *Gordionus* sp.
- *Gordius* (?) sp.

Annelida
- Hirudinea
  - *Herpobdella lineata*
  - *Glossiphonia complanata*
  - Gen. sp.
- Oligochaeta
  - *Tubifex hattai*
  - *Limnodrilus socialis*
  - Lumbricidae Gen. sp.

Mollusca
- Bivalvia
  - *Pisidium japonicum*
- Gastropoda
  - *Semisulcospira libertina*
  - *Gyraulus albus*
  - *Fossaria truncatula*

Acarina
- *Lebertina (Pilolebertina) leioderma* (?)
- *Sperchon plumifer plumifer*
- *Atractides* sp.
- *Kongsbergia* sp.
- *Hygrobates calliger*
- *Torrenticola* sp.

Insecta
- Plecoptera
  - Nemouridae
    - *Nemoura (Nemoura)* sp.
    - *Nemoura (Amphinemura)* sp.
  - Perlidae

Kamimuria quadrata
Haploperla japonica
Alloperla abdominalis
Alloperla sp.
Caroperla sp.
Perlodidae
Hydroperla japonica
Perlodes sp.
Ephemeroptera
Ephemeridae
Ephemera strigata
Leptophlebiidae
Paraleptophlebia chocorata
Paraleptophlebia cincta
Ephemerellidae
Ephemerella trispina
Ephemerella nigra (?)
Ephemerella sp.
Caenidae
Caenis sp. *nc*
Baetidae
Baetis sp.
Baetiella sp.
Siphlonuridae
Ameletus montanus
Ecdyonuridae
Epeorus latifolium
Epeorus curvatulus
Ecdyonurus sp.
Cinygma sp.
Odonata
Calopterygidae
Mnais strigata
Epiophlebiidae
Epiophlebia superstes
Gomphidae
Davidius moiwanus
Sieboldius albardae
Cordulegasteridae
Anotogaster sieboldii
Hemiptera
Gerridae
Gerris lacustris
Aquarius palludum
Neuroptera
Corydalidae
Protohermes grandis
Osmylidae
Osmylus sp.
Trichoptera
Rhyacophilidae
Rhyacophila brevicephala
Rhyacophila shikotsuensis (?)
Rhyacophila sp. RH
Rhyacophila sp. RF
Rhyacophila spp. (ca. 4 species)
Mystrophora sp.
Agapetus sp.
Philopotamidae
Dolophilodes sp.
Stenopsychidae
Stenopsyche griseipennis
Polycentropidae
Polycentropus sp.
Psychomyidae
Psychomyia sp.
Arctopsychidae
Arctopsyche sp.
Hydropsychidae
Hydropsyche ulmeri (?)
Hydropsychodes brevilineata
Diplectrona sp.
Leptoceridae
Leptocerus sp.
Phryganeidae
Neuronia maxima
Phryganea (*Phryganopsis*) *latipennis*
Limnophilidae
Platyphylax yokouchii
Apatania sp. HA
Apatania sp. HB
Apatania sp.
Sericostomatidae
Goera japonica
Micrasema sp.
Dinarthrodes japonica
Coleoptera
Gen. sp.
Hymenoptera
Agriotypidae
Agriotypus gracilis
Diptera
Blepharoceridae
Bibiocephala infuscata
Bibiocephala japonica (?)
Bibiocephala sp.
Blepharocera japonica
Philorus longirostris

Philorus ezoensis
Philorus sp.
Limoniidae
Antocha sp.
Eriocera sp.
Tipulidae
Tipula spp. (2 species)
Doxidae
Dixa sp.
Simuliidae
Prosimulium hirtipes
Prosimulium yezoense
Eusimulium uchidai
Chironomidae
Tanypus (?) sp.
Tanytarsus (?) sp.
Rheotanytarsus spp. (2 species)
Tendipes sp. (*thummi*-group)
Gen. spp. (ca. 4 species)
Rhagionidae
Atherix spp. (2 species)
Crustacea
Amphipoda
Anisogammarus (*Eogammarus*) *annandalei*
Isopoda
Asellus nipponensis
Decapoda
Cambaroides japonicus
Vertebrata
Cyclostomata
Lampetra reissneri
Pisces
Oreias oreas
Cottus nozawae
Pungitius pungitius
Pungitius tymensis
Amphibia
Hynobius retardatus
Rana temporaria temporaria

A list of the species[1] collected by the various methods mentioned above is given in Table 2. A glance at the table reveals that 88 species of aquatic insects supply the greater portion of the fauna of the stream. Moreover, all these insects except water-striders are aquatic only in immature stages. The absence of true water-bugs or aquatic beetles may perhaps be explained by the combination of two factors : habitat of resricted size and high velocity of current.

Seasonal and spatial change in species and individual number: As seen in Fig. 3, A, no remarkable seasonal change was found in the total species number. From spring to autumn the number of species was always higher in the upper main-stream (at St. 4–11, about 30–40 species) than in the lower section and also in branches. This tendency is also generally found on the two dominant groups, Trichoptera and Ephemeroptera, with the exception of the decrease in the former group at St. 7 (Fig. 3, B & C).

Contrary to the species number, the total individual number varies considerably by seasons. The seasonal change is expressed by higher population in spring than in autumn (Fig. 3, D). The result is caused mainly by the change of population number of caddis-worms, especially of *Agapetus* sp., a dominant species in spring (cf. Fig. 5, A, B & C). For example, at St. 10, more than 400 individuals in spring have decreased to less than 50 individuals in autumn (Fig. 3, E). The seasonal change in Ephemeroptera was also clear but not so remarkable as in Trichoptera.

The spatial difference of individual number generally accords with that of

1) With the exception of water-mites no microscopic animals were collected throughout this survey.

species number. But the population number at St. 7 and 11 was relatively small. The fact is due to that population number of caddis-worms is smaller in these stations, though partially compensated by mayfly nymphs which diametrically increased at St. 7.

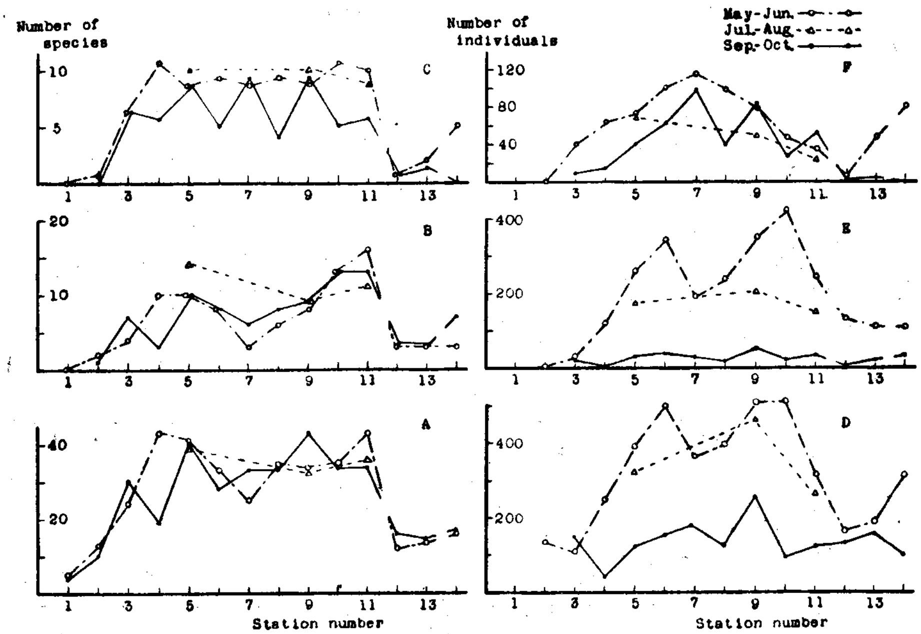

Fig. 3. Number of species and individuals collected at various stations. Species number of total animals (A), Trichoptera (B) & Ephemeroptera (C) ; individual number of total animals (D), Trichoptera (E) & Ephemeroptera (F). Note : Number of individuals are taken the average for several times.

Relative abundance of animals: With regard to the relative abundance of different groups of species (Fig. 4, A & B), the aquatic insects occupied 80%, and two dominant groups, Trichoptera and Ephemeroptera, when counted together, more than 50% of total animals. At St. 1 and 2, however, owing to the scarcity of these two groups, the relative number of *Tubifex* and *Herpobdella* increased conspicuously. This corresponds well to the change of environmental factors as shown in Table 1.

The relative size of individual number is, in general pattern, similar to that of species number, but shows the distinct seasonal change (Fig. 4, C & D). In spring caddis-worms occupy more than 60% of total individuals at St. 5–12. Then, the ratio of aquatic insects is more than 90% at St. 3 to 13. On the other hand, the autumnal composition is generally modified by decrease of Trichopteran individuals, and by that of Ephemeroptera in branch stations (St. 12–14). St. 1 and 2 show a lower individual number of insects in any season. Therefore, the general pattern of relative size is relatively identical in respect to both the species and individual number.

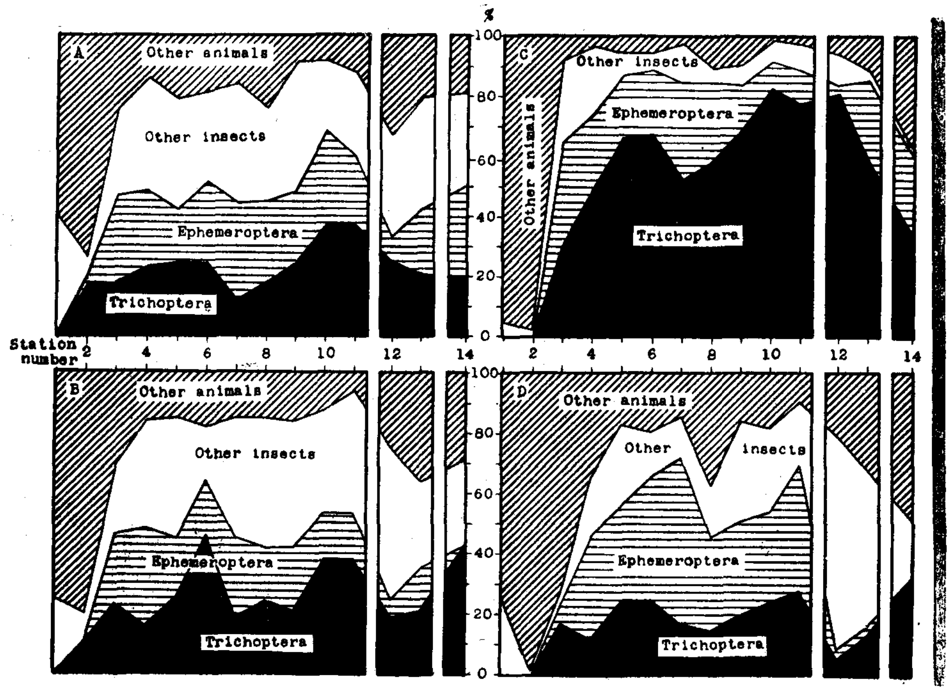

Fig. 4. Percentage of number of each groups at various stations.
Species in May-Jun. (A), Sept.-Oct. (B) ; individuals in May-Jun. (C), Sept.-Oct. (D).

Relative abundance of Trichoptera and Ephemeroptera : From the data above given, it has been shown that Trichoptera and Ephemeroptera play an important rôle in the makeup of the animal community in this stream in any season and also in any station except St. 1 and 2. Therefore, the relative abundance of these two groups was analysed further as follows :

Based upon the form and life-type, the collected caddis-worms were divided into the following four types, and their relative abundance is illustrated in Fig. 5, A, B & C.

1. *Agapetus* type : Larvae campodeiform, using small pebbles to build portable larva-cases. *Agapetus, Mystrophora.*

2. *Goera* type : Larvae eruciform, larva-cases built of small pebbles. *Goera, Apatania* and *Leptocerus.*

3. *Rhyacophila* type : Larvae campodeiform, having neither cases nor nets or weaving a snare of silken secretion. *Rhyacophila, Polycentropus, Dolophilodes, Hydropsyche, Hydropsychodes, Diplectrona, Arctopsyche* and *Stenopsyche*.

4. Other caddis-worms.

Comparing three histograms in Fig. 5, it is immediately found that *Agapetus* type caddis-worms are overwhelmingly abundant in spring at any station. They take more than half of the total population at any station, and more than 90% at five stations. But two species belonging to this type, *Agapetus* sp. and *Mystrophora* sp. emerged mostly in July and in August respectively. Consequently, as shown above, autumnal caddis-worms decreased conspicuously in the individual number and are dominated relatively (not absolutely) by *Goera* type.

Nextly, the relative abundance of *Rhyacophila* type shows a peculiar spatial but not temporal pattern. From spring to autumn the species belonging to this

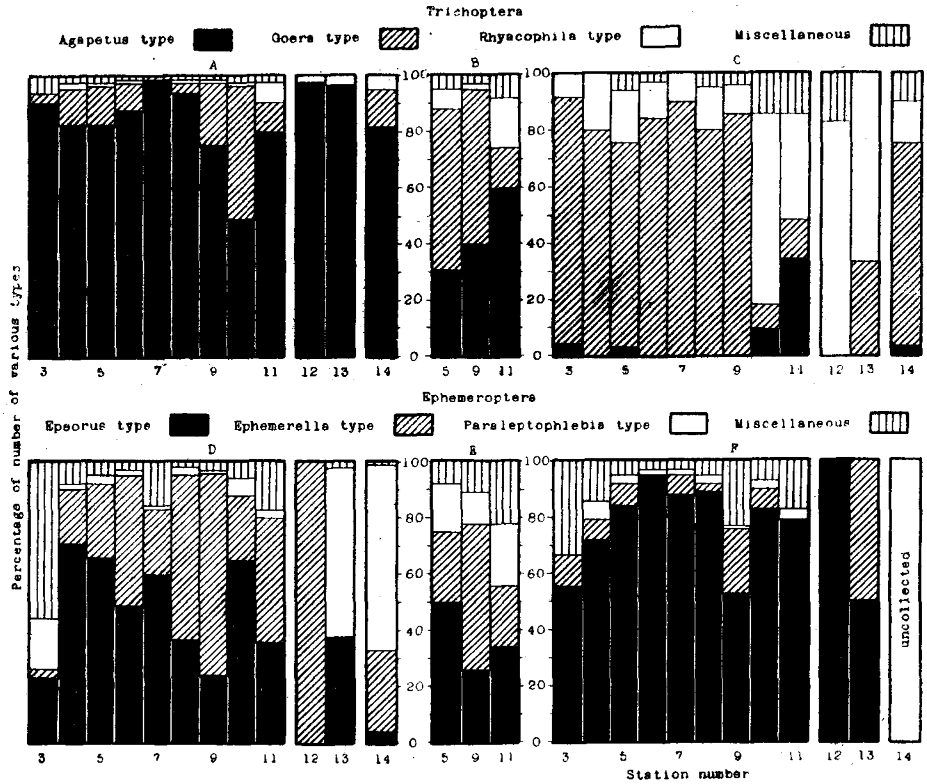

Fig. 5. Percentage of individuals in Trichoptera and Ephemeroptera.
Trichoptera in May-Jun. (A), Jul.-Aug. (B) & Sept.-Oct. (C) ; Ephemeroptera in May-Jun. (D), Jul.-Aug. (E) & Sept.-Oct. (F).

type was found mostly at St. 10–14, namely, the uppermost or branch stations characterized by the lower value of depth and the higher current velocity.

The mayfly nymphs can be divided into the following four types, of which the relative abundance is illustrated in Fig. 5, D, E & F.

1. *Paraleptophlebia* type: Body slender and gradually tapering backwards, gills 2-leaved and linear acuminate. *Paraleptophlebia*.

2. *Epeorus* type: Body strongly flattened and intimately contacted to substrata, eyes dorsal. *Epeorus*, *Ecdyonurus* and *Cinygma*.

3. *Ephemerella* type: Body somewhat flattened, eyes lateral. Gills double, posterior lobe cut into many small lobelets. *Ephemerella*.

4. Other mayfly nymphs.

Different from the case of caddis-worms no clear tendencies were found in the relative abundance of mayfly nymphs, either spatially or seasonally, except the abundance of *Paraleptophlebia* type in branches during spring. The distribution of mayfly nymphs of *Epeorus* type, possessing a most adapted form for high current velocity, shows, as far as this stream is considered, a relatively clear pattern. Their decrease at St. 6–9 in spring and at St. 9 in summer and autumn can neither be explained at present by the environmental conditions nor by the distribution of conhabitants. But it may be premature to explain this distribution pattern only as accidental.

In respect to seasonal change, there occur the increase of *Epeorus* type and decrease of *Ephemerella* and *Paraleptophlebia* types in autumn. These changes are, however, not so conspicuous as in the case of caddis-worms of *Agapetus* type. Therefore, it may be assumed that the distribution of mayfly nymphs in the stream is rather even and not so differentiated in the case of caddis-worms.[1]

Animal distribution zones: Judging from the facts above described, this stream may be divided into three main distribution zones, namely, St. 1–2, 3–11, 12–14, or, lower contaminated section, main brook section and branches. These three zones are indicated in Fig. 3–5 and also in Fig. 6. The difference of St. 1–2 from 3–11 is distinct. At the former section, the stream enters into the city and is contaminated gradually by sewage water. This difference will be shown also by the abundance of certain bio-indicators of polluted water, such as *Tubifex*, *Herpobdella*, *Pisidium* and *Tendipes*. The occurrence of the two species of stickleback at St. 2, which can live in relatively polluted water, but not in the brook, supports further the above distinction.

The branches St. 12–14 differ from the main brook section in both the faunal composition and environmental conditions, though differentiation is not so sharp as that between St. 1–2 and 3–11. In this section, the stream is not polluted artificially; it has shallow water of slow current velocity, together with

1) The relative abundance of mayfly nymphs at St. 12 in spring and St. 13–14 in autumn (Fig. 5, D & F) is due mostly to the lower individual number and is almost without significance (cf. Fig. 3, F).

abundant deposition of deteriorated plant material. Therefore, branches are fairly different from the main stream in these points.

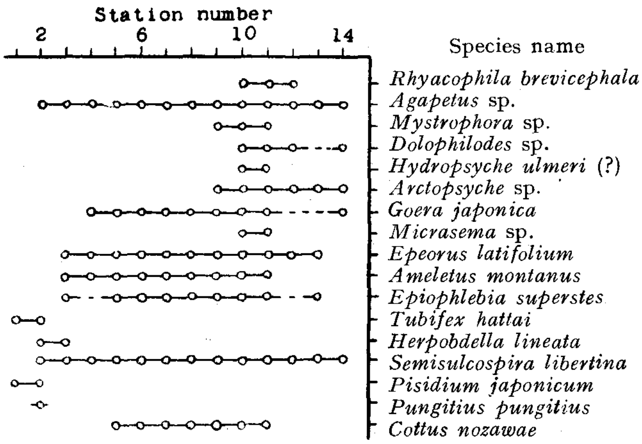

Fig. 6. Distribution of some important animals at various stations.

The brook section (St. 3–11) is relatively uniform in both the distribution of animals and the environmental factors. Indeed, a slight transition seems to occur between St. 3–8 and 10–11. As seen in Fig. 6, caddis-worms of *Rhyacophila* type (except *Stenopsyche griseipennis*) and *Mystrophora* sp. are found only at St. 10–11. Their relative abundance in number is also significantly high in both spring and autumn (Fig. 5, A & C) at these uppermost stations. Nevertheless, this main brook section is quite uniform in general features. It is characterized as a narrow, shallow, consequently unstable brook. This section possesses essentially most of the peculiarities of a brook, and moreover, a relatively rich fauna for small scale of water-system.

Summary

1. The animal community of a small brook stream in Sapporo, the Yokoshibetsu, was studied from May to October in 1954 and about 120 species of macroscopic animals belonging to seven phyla were collected.

2. Upon the basis of seasonal and spatial changes of fauna, especially of Trichoptera and Ephemeroptera, it was concluded that the stream can be divided into three ecological sections, namely, lower contaminated section, main brook section and branches.

Acknowledgements

Finally the writer wishes to express most sincere gratitude to Professor Tohru Uchida and Dr. Shoichi F. Sakagami for very helpful suggestions and criticisms through the course of and completion of the present study, and to Assistant Professor Eizo Asahina for his kind advice with respect to limnology. Further, the writer takes opportunity to experss his heartiest thanks to Misses A. Sato, Y. Toyofuku and Y. Yuize, and Messrs. S. Hayashi, S. Koiwai and M. Sasaki, for their kind assistance in field work and in numerous other ways. The writer is also indebted to the following persons for identifying the specimens : Professor Atsuhiko Ichikawa (Triclada), Dr. Iwao Inoué (Nematomorpha), Professor Hideji Yamaguchi (Oligochaeta), Dr. Tadashige Habe (Mollusca), Professor Taiji Imamura (Hydracarina), Dr. Shoziro Asahina (Insecta); Professor Matsunae Tsuda (Insecta), Mr. Teizi Kawai (Insecta), Dr. Tamotsu Ishihara (Insecta), Dr. Hiroshi Takahashi (Insecta), Dr. N. Wang (Crustacea) and Professor Shin-ichi Sato (Pisces).

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