An Ecological Study of Temporary Pools after Thawing[1)]

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(With 7 Text-figures)

One of the most noticeable contributions by modern ecology may be the establishment of the concept of ecological succession in the dynamic aspect of communities. Most of so-called succession studies are, however, indirect estimations of the temporal processes from the spatial distribution of various communities. Direct observation is rather difficult and can be effectively executed during a relatively short period only on simple communities with the replacement of constituents, such as hay infusion (Woodruff 1912, 1913, Allee 1932), carrion (Fuller 1913, Holdaway 1930, Borenemissza 1957), logs and stumps (Shelford 1913, Blackman and Stage 1924, Savely 1939) and cattle droppings (Mohr 1943).

The western region of Hokkaido is one of the districts in Japan to have a very heavy snowfall. Annually, many puddles and pools are found after thawing, in which certain unstable aquatic communities offer the most suitable material for the direct study of succession. Succession studies in such environments were made by Mozley (1932) and Kenk (1949), but still there is need of further researches. So far as the writer is aware, there have been no studies in Japan, especially in Hokkaido.

For this reason the present writer carried out on ecological investigation on temporary pools after thawing during the spring seasons of 1957 and 1958 and obtained some results as reported herewith.

Topography

The temporary pools studied were located near the coast of Zenibako-Ishikari, being about 16 km distant northwestward from Sapporo. The area is covered with shelter woods of an oak, *Quercus mongolica* Firch., mixed with a maple, *Acer Miyabei* Maxim..

The shrub layer mainly consists of the Sasa bamboo, *Sasa paniculata* Makino et Shibata, the wild grape, *Amelopsis hetelophilla* Sieb. et Zucc., the zebra-grass, *Miscanthus sinensis* Anderss, and the mugwort, *Erigeron* sp., as dominant species.

The surface of the ground is undulating and the wave-like ridges run in parallel with the tidal line. The pools are formed in the hollows between these

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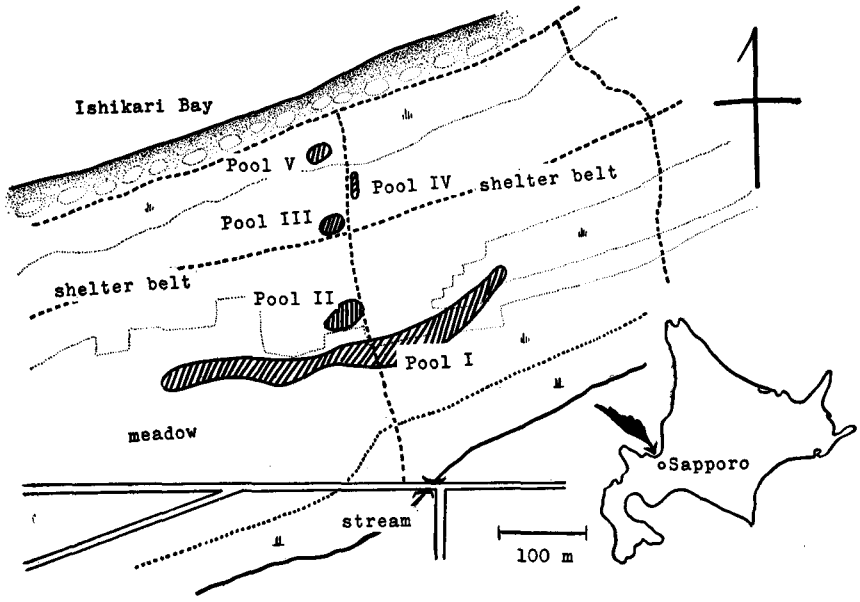

Fig. 1. Distribution of the temporary pools observed.

Fig. 2. Climax aspect of the temporary pool (Pool I), laying behind the shelter woods. (9th April 1957)

Table 1. General features of five pools studied. (9th April 1957)

No.	Site	Max. Length	Max. Width	Mean Depth	Light Intensity
I	outside	1000m	25.0m	30 cm	high
II	inside	30	10.0	80	moderate
III	inside	20	8.5	70	moderate
IV	inside	15	1.0	50	low
V	outside	15	5.5	30	high

ridges after thawing of the snow during mid April, and are dried up by late May or early June. The soil of the woods is characterized as a typical sandy soil, (A horison gray, being 10 to 15 cm in depth). Five pools along a ruined path were chosen for the present survey (Fig. 1). In 1958, some chemical samplings were made on Pools I and II in parallel with the population study of the animals inhabiting them. The area was free from any artificial disturbance during the study.

Physical and chemical conditions

In 1957, the maximum depth of snow cover in the woody area was 130 cm during early February. In 1958, when the first sampling was taken on March 13, the area was covered by snow of 40 cm depth. Under the blanket of snow, however, water pools had been formed already. Consequently, earlier samplings were taken through snow holes. On March 23, the pools exposed their outward features, with floating pieces of ice still on the surface.

Temperature of the water: Water temperature was variable from pool to pool. It may partly depend on the form of the pool and on the intensity of the solar radiation into the waters. In Pool I, the water temperature at 10 cm below the surface was occasionally 2 to 3°C higher than the air temperature. No remarkable vertical gradient in water temperature was detected in any of the pools.

The water temperature was always highest in Pool I and lowest in Pool II. The results of thermal measurement are shown in the upper part of Fig. 3. The measurements were made during the period noon to 2.00 p.m. at the same sites in each pool.

Change of the water depth: In order to measure the loss of water in due time, changes of the water depth was recorded for Pools I and II by reading change of the submerged portion of the scaled rods installed after the first examination. The water level increased rapidly when the water temperature rose to 4°C. On April 8, 1958, each of the pools shown maximum water levels, namely, 80 cm in Pool I, and 30 cm in Pool II. Thereafter, the depth gradually decreased from mid April to early May. During late May the pools were transformed into small puddles, and they vanished during mid or late June, except a few pools.

Chemical conditions: As the pools were located near the tidal zone, Cl^-

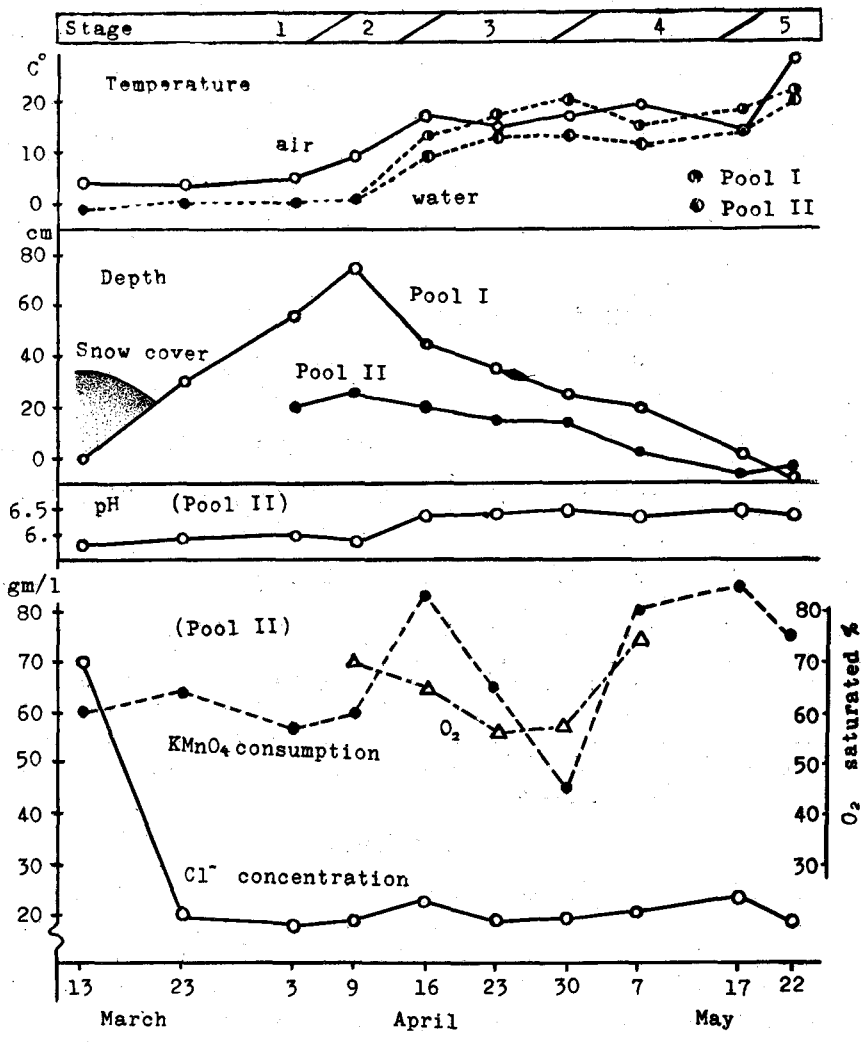

Fig. 3. Change of temperature, depth, pH and some chemical conditions in the temporary pools (Pool I & II) during observation in 1958. All data are plotted as averages of five samples.

concentration of the water in each pool was examined. Judging from the measurements, these pools can be considered as a fresh water. It is interesting, however, that Cl^- concentration changed in proportion to the evaporation of the water (Fig. 3).

The measurement of pH was undertaken by colorimetry. The variation

between the pools ranged from 5.9 to 6.8, hence, it may be said, with no remarkable difference. The pH rose gradually as time advanced, perhaps associated with rise of the water temperature and increase of the decomposed organic matters. The $KMnO_4$ consumption value showed a significant variation, namely, from 70 to 80 mg/ litre in early measurements, and 30 to 50 mg/ litre in later ones, without any considerable difference between Pools I and II. The O_2 concentration was measured only occasionally ; it was about 55 to 75 % of saturation.

The water of the pools was usually characterized by dilute coffee colour, as is characteristic to bog pools.

Stages of the temporary pools

From the physical and chemical conditions mentioned above, the pools can on the basis of time periods be divided into the following five stages :

1) *Thawing stage* : Snow begins to melt and the water appears under the snow blanket. Water temperature is 0°C at maximum.
2) *Developmental stage* : Thawing finishes and the water body reaches its maximum in depth and size. Water temperature ranges from 0° to 4°C. Sometimes floating ice is observed on the surface.
3) *Pre-decreasing stage* : Water level decreases rapidly. Water temperature keeps in balance with the air temperature.
4) *Post-decreasing stage* : The water still decreases but slowly compared with the preceding stage. Sometimes, the pools receive spring rain water in this stage.
5) *Puddle or swampy stage* : The pools are separated into many small puddles and show swampy appearance. Some of them maintain such condition to late summer.

After drying up of the water bodies, the sites were mainly covered with the sedge (*Carex* sp.) and the reed (*Phragmites communis* Trin.) in sunny parts, but were almost free from vegetation in shady parts.

Faunal make-up

The material was sampled quantitatively on March 13, 23, April 9, 16, 23, 30, May 7, 17, 22, 1958, using a plankton net (No. 6 bolting silk). Usually, two kinds of sampling methods were employed; 1) The benthic animals were dredged by a U-shape net from 1/4 m^2 area. 2) The plankton and nekton were obtained by a 500 ml water sampler and condensed to 200 ml through the net. In each pool each sampling was repeated five times. All samples were preserved in Ulmer's solution.

Faunal make-up of these pools is relatively simple. It consisted of about 30 species of macroscopic animals belonging to six phyla as follows :

Protozoa

1) *Volvox globator* Ehenberg. Plankton, abundant at sunny sites, late April to the last stage.

Plathelminthes

2) *Mesotoma* sp. Benthos, relatively common, late April to early May.

3) *Dendrocoelopsis lacteus* Ichikawa et Okugawa. Benthos, relatively common, early May to mid May.

Rotatoria

4) *Hydantina* sp. Plankton, rare, observed only in the first week of April, 1958.

Annelida

5) *Lumbriculus* sp. Benthos, relatively rare, all stages.

Mollusca

6) *Pisidium japonicum* Pisbry et Hirase. Benthos, more abundant than the following two species combined, mid April to the last stage.
7) *Gyruaulus* sp. Benthos, relatively common, early April to the last stage.
8) *Lymnea truncatuta* (Müller). Benthos, rare, during stages 3 and 4.

Crustacea

Copepoda

9) *Cyclops* (*Acanthocyclops*) *vernalis* Fischer. Plankton.
10) *C.* (*Megacyclops*) *gigas* Lowndes. Plankton.
11) *C.* (*Megacyclops*) *viridis* (Jurine). Plankton. These three copepods were very common during the investigation.
12) *Canthocamptus staphlnoides* Pearse. Plankton, relatively common, early April to the late April.

Cladocera

13) *Ceriodaphnia reticulata* (Jurine). Plankton, very rare, observed only on 22 May, 1958.

Ostracoda

14) *Candona* sp. Plankton, very common, observed during all stages.
15) *Cypridopsis* sp. Plankton, abundant, early April to the last stage.

Isopoda

16) *Asellus nipponensis* Nicols. Benthos, common among the organic matters on the bottom mud, mid April to the last stage.

Hydracarina

17) *Hydryphantes* (*Hydryphantes*) *ruber ruber* (De Geer). Nekton rather than plankton, relatively common, mid April to the last stage.

Insecta

Odonata

18) *Coenahridae* Gen. sp. Nekton, relatively common, mid April to the last stage.

Trichoptera

19) *Dinarthrodes japonica* Tsuda. Benthos, rare, mid April to the last stage.

Hemiptera

20) *Notonecta triguttata* Motschulsky. Nekton, rare, during stages 3 and 4.

Coleoptera

21) *Halipulus minutus* Takizawa. Nekton.
22) *Hydrophilidae* Gen. sp. Nekton.
23) *Rantus punctatus* Fourcory. Nekton.
These beetles were rare and observed only during stages 3 and 4. Further, another species of larva of beetle was found but it was not identified.

Diptera

24) *Chironomus* spp. Benthos, common, late April to the last stage, including several species.
25) *Moclonyx* sp. Nekton, common, early April to mid May.

26) *Aedes* (*Ochlerotatus*) *hexodontus* Dyar.
27) *A.* (*Ochlerotatus*) *intrudens* Dyar.
28) *A.* (*Ochlerotatus*) *excrucians* (Walker).

The three species of *Aedes* were very abundant during April to mid May. It is interesting that two circumpolar species *A.* (*O.*) *hexodontus* and *A.* (*O.*) *intrudens* were also discovered from Hokkaido, but exclusively from earlier thawing season.

Classification of inhabitants

Inhabitants in these pools can be divided into the following two groups on the basis of the manner in which they spend the drought time:

1) Animals which spend their whole lifetime in these pools prossessing high resistance to drought. During dry season they exist as eggs or small bodies; e.g., *Ostracoda*, *Cyclops*, *etc.*[1]

2) Animals which spend only their larval time in these pools. During drought time, they migrate to other communities; e.g., Insects.

Population shift in certain species

Among various species mentioned above, *Copepoda*, *Ostracoda* and *Volvox* necessarily aquatic animals and the larvae of three mosquito species occupied the majority of the total population of animals. With respect to these dominant species, the following trends were obtained from the results of the successive samplings (cf. Fig. 4).

Cyclops spp. showed no remarkable change in the population size compared with other groups up to the finale of the pools in the late spring. *Candona* sp. appeared in early spring with the peak on April 23, 1958, then decreased gradually in parallel with the diminishing of the pools. *Cyclocypris* sp. reached the first small peak in stage 3, then the maximum in stage 4, with subsequent gradual decrease. *Camthocampus* showed no remarkable change in total number, in each pool, but increased in stage 2 and disappeared during stage 4.

Colonial flagellate, *Volvox*, appeared relatively later in the pool. The population increased during the week from 23 to 30 April, 1958, reached to the maximum in number within this week, and afterward kept rather constant. No sufficient data were obtained upon which to base any consideration of the population shifts of the other inhabitants.

Local and annual difference of fauna

To examine the difference between the pools located in and outside of the shelter woods, the relative abundance of dominant species in 1958 in Pools I and II

1) Although not discovered in the present survey, one species of fairy shrimp, *Chirocephalopsis uchidai*, was discovered and described by Kikuchi (1957), which is characteristic by its strong resistance to drought.

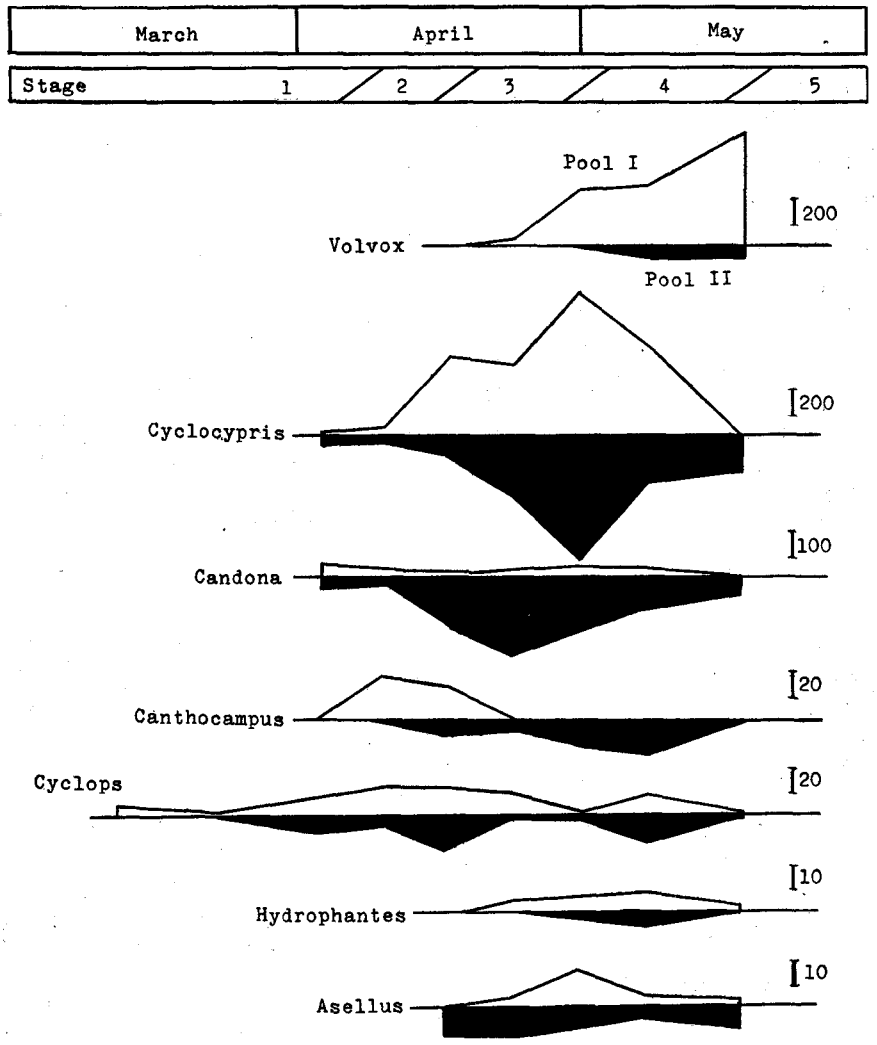

Fig. 4. The seasonal sequence of individual numbers of certain dominant species in the temporary pools (Pool I & II) in 1958.

were separately illustrated in Fig. 5. Although no qualitative differences were obtained, certain species behaved differently in the two habitats. *Candona* sp. was relatively abundant in the sheltered pools, while *Volvox* preferred exclusively those outside the woods, surely caused by the stronger solar radiation. The most interesting relation was found among three species of *Aedes*. As seen in Fig. 5.

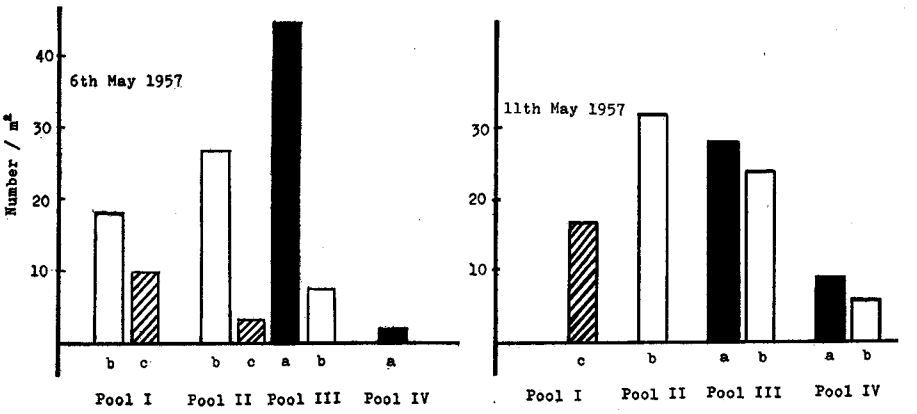

Fig. 5. The relative abundance of some mosquito larvae, *Aedes* (*Ochlerotatus*) *hexodontus*, *A.* (*O.*) *intrudens* and *A.* (*O.*) *excrucians* in each pool. a....*A.* (*O.*) *hexodontus*, b....*A.* (*O.*) *intrudens*, c....*A.* (*O.*) *excrucians*.

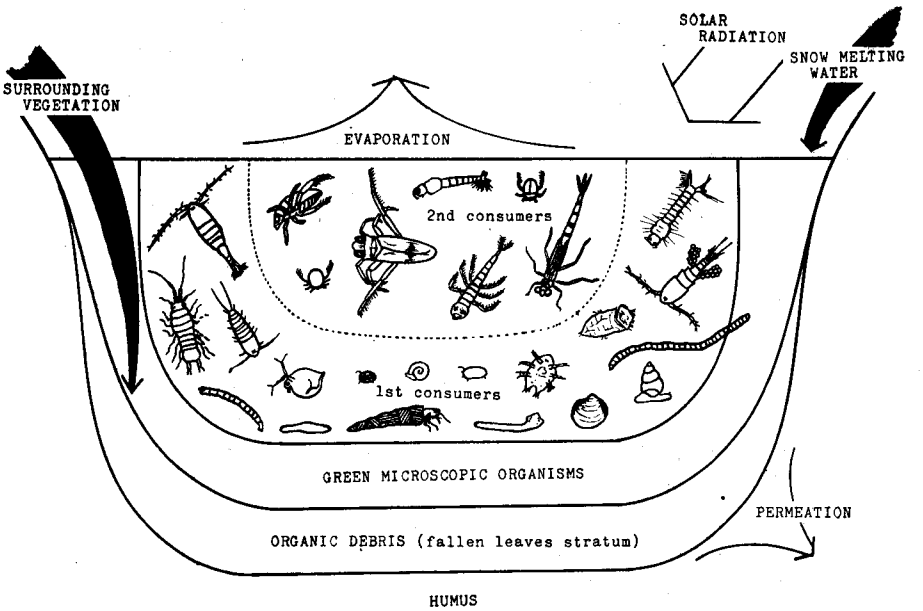

Fig. 6. Diagram showing the food chain in temporary pools at Zenibako.

Aedes (*Ochlerotatus*) *intrudens* was collected from all pools except Pool V. On the other hand, a clear habitat segregation was discovered between other two species *A.* (*O.*) *hexodontus* and *A.* (*O.*) *excrucians*. The most clear difference between inner and outer pools in the environmental conditions is the water temperature (Fig. 2), which is related to the intensity of solar radiation into the water.

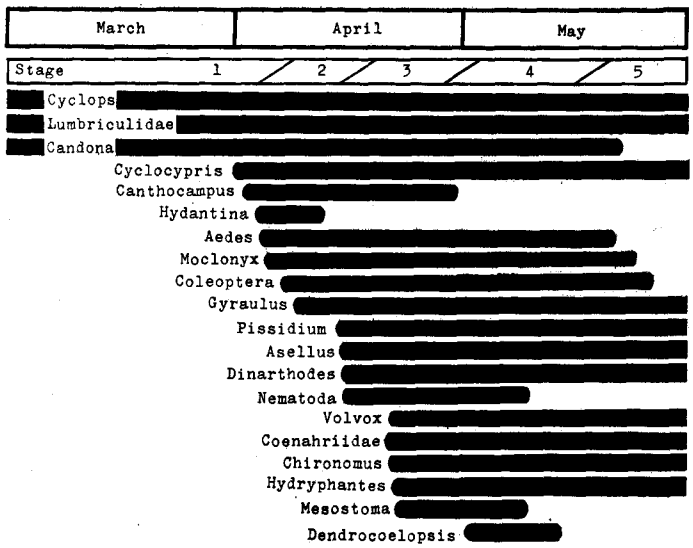

Fig. 7. Seasonal succession of inhabitants in the temporary pool.

In 1957, the survey was begun in late April and continued to the middle of June. The water bodies were observed for two weeks later than in 1958; they dried up in the middle of June in 1957. On the other hand, water mass was less in 1958 than in 1957 and had vanished already in late May. When the last sampling was made on 22 May, 1958, many pupae of *Aedes* were found to be dead on accounts of the dry up. It is obvious that the population dynamics of these animals is principally regulated by the climatic factors, especially snowfall in the preceding winter and rainfall in spring.

Food-chain

The structure of the food chain in the temporary pools studied seems to be relatively simple. The community is not autotrophic. The principal energy source is the fallen leaves and other vegetable matters mainly from oaks, rather than generic producers such as green and blue algae and diatoms. The water beetles, water mites, *Moclonyx* and nymphs of *Odonata* may be regarded as secondary

consumers, although they are partly phytophagous, and the majority of other inhabitants as primary consumers. Most of the latter group show, however, a tendency to behave as scavengers. In Fig. 6, a diagram of the food chain in the community is shown.

Remarks

The most significant feature of the community studied lies in its dependence upon other neighbouring communities, both in structure and function. Consequently, both faunal make-up and ecological succession are strongly affected by the other communities. It may be considered that the succession in the pools studied consists of almost entirely allogenic, but not autogenic processes and not only that each inhabitant but also that the community as a whole, can be regarded as a scavenger of other major communities.

Furthermore, in the community studied, the assemblage of ecological succession can not distinctly be expressed in the clear replacement of inhabitants as shown by many investigators mentioned in the introduction ; for instance Welch (modified from Shelford 1919) 1935, Mohr 1943, *etc.*

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Summary

1) The spring animal community of the temporary pools found after thawing in the shelter woods at Zenibako, near Sapporo, was studied in 1957 and 1958.

2) About 30 species of macroscopic animals belonging to six phyla were collected. The population trend of some dominant species was traced in parallel to the diminishing of the pools.

3) It was recognized that these communities are largely dependent on the major communities near by. Their succession is mainly allogenic without any distinct successive replacement of inhabitants.

Literature cited

Allee *et al.* 1959. Principles of animal ecology, 873 pp. W. B. Saunders Co., Philadelphia and London.

Bornemissza, G. F. 1957. An analysis of arthropod succession in carrion and the effect of its decomposition on the soil fauna. Australian Jour. Zool. 5 :

Hoff, C.C. 1943. Seasonal changes in the ostracod fauna of temporary pond. Ecology, 24 : 116–118.

Kenk, R. 1949. The animal life of temporary and permanent ponds in Southern Michigan. Misc. Publ. Mus. Zool. Univ. Mich., 71 : 1–66.

Kikuchi, H. 1957. Occurrence of a new fairy shrimp, *Chirocephalopsis uchidai* sp. nov., from Hokkaido, Japan (Chirocephalidae, Anostraca). Jour. Fac. Sci. Hokkaido Univ., Ser. VI, Zool. 13, Nos. 1–4 : 59–62.

Mozley, A. 1932. A biological study of a temporary pond in Western Canada. Amer. Nat., 66 : 235–249.

Suzuki, K. 1959. Notes on two species of the subgenus *Ochlerotatus* (gen. *Aedes*) from Hokkaido, Japan (Culicidae, Diptera). (in Japanese with English résumé.) Zool. Mag., 68 : 291–296.

Welch, P. S. 1935. Limnology, 471 pp. McGraw-Hill, New York and London.