

水鳥の沼における微小動物及び その食性について (英文)

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List of Microphagotrophs and Their Food Habits in Mizutori-no-numa Pond

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INTRODUCTION

Mizutori-no-numa pond is shaded by tree crowns and have little macrophytes in water. The leaf litter from surrounding trees plays a considerable role as a nutrient source of a biotic community in water. Microphagotrophs such as protozoans and rotifers appear frequently and abundantly in habitats where microorganisms are actively decomposing organic matter. In Mizutori-no-numa pond, seasonal succession of microphagotrophs showed higher number of both individuals and taxa from late autumn to next early summer, while autumnal leaf litter from deciduous trees was decomposed and turned into sapropel (Hatano & Watanabe 1981).

In this report, microfauna and their food habits were examined, and the energy flow was charted for the biotic community in Mizutori-no-numa pond with a special reference to leaf-litter decomposition.

METHODS

Microphagotrophs were collected from pond water, litter layer and sapropel of the west site in Mizutori-no-numa pond from 1978 to 1983. Observation on each species was made with the two following methods. (1) Living organisms in the pond water were observed on a slide glass to examine their body size, shape and movement under a stereoscopic or a phase contrast microscope ($\times 100$ – 1000). A 10% polyethylene glycol (M. W.=20000) solution in the inorganic nutrient medium ($\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ 0.5g, KNO_3 0.2g, $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ 1.0g, $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ (1% solution) 2 drops and distilled water 1000ml) was used to reduce the speed of their movement. Then, the organisms were squashed with a cover glass to examine food materials contained in food vacuoles or an alimentary canal (Fig. 1). (2) The organisms were fixed and/or stained to examine their fine

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structure under a stereoscopic or a scanning electron microscope ($\times 100-5000$) (Fig. 2). The fixatives and the stains used here are shown in Table 1. Unidentified species were expressed with tentative names of capital letters. Nematoda, Amoebidae, small ciliates (less than $30\mu\text{m}$) and flagellates (less than $20\mu\text{m}$) were not classified into taxonomically subordinate levels.

RESULTS AND DISCUSSION

(1) Taxonomical List and Food Habits

The taxa collected during the five years are listed with the food habits in Table 2. Since species description is different between nomenclators in some cases, determination of species name is conformed to the references designated in the table. Unidentified species are indicated with the possible species in parentheses. In the case of organisms whose genus name could not be determined, they are expressed by tentative names of capitals; the last letters of the name, 1 and X, mean the number of species included in the taxon, i. e. one and multiple, respectively. Total number of the microphagotroph taxa was 140 (11 in Sarcodina, 97 in Ciliata, 25 in Rotifera and 7 in other micrometazoa).

Their food habits are described with those in references. The minute food items of several taxa are different between various habitats probably according to the food conditions, and it suggests euryphagy in their potential food habits. Bacteria, non-colonial small flagellates and small algae were the most common diet of microphagotrophs. Among twelve taxa that feed on other microphagotrophs, *Dileptus* sp. and *Paradileptus* sp. were very rare in this pond. There are two taxa bearing zoochlorella, *Stentor polymorphus* and *Prorodon viridis*.

The relationship between body size and food items of protozoan taxa is illustrated in Fig. 3, arranged from Table 2. Most taxa appeared to be size-selective feeders and generalists for food. It is unknown whether the omnivores that can feed on large-size organisms consumed smaller-size organisms such as bacteria. Some taxa of the small- and middle-size omnivores in Fig. 3 were cultured in filtered pond water enriched with the leaf infusion of *Idesia polycarpa*. The testasids such as *Arcella* and *Centropyxis*, and hypotrichid ciliates, *Tachysoma* and *Onychodromopsis*, could multiply by feeding only on bacteria, but *Spirostomum* and *Uroleptus* could not although they have been reported to take up bacteria as shown in Table 2. The carnivores and algivores, only several taxa in all, were observed to feed on relatively specific organisms. The carnivores, *Litonotus*, *Trachelius* and UNF 31 did not take up algae and flagellates with an adequate size in this pond.

(2) Food Chains and Energy Flow

Since most microphagotrophs tend to select their food by the size, they feed on both decomposers and autotrophs. Although the whole food web in the microphagotroph community appears to be greatly complicated due to the large overlap of their diets, two food chains are extracted to show the trophic relationships, that is, grazing and detritus food chains (Fig. 4). The former includes autotrophic organisms such as algae and chlorophyll-bearing flagellates in the basic food link, while the latter does decomposer organisms such as bacteria. (a) The

dominant algal species was *Melosira* sp. in winter and *Microcystis* sp. in summer. It seemed that the both species were hardly eaten because of forming long filaments or large colonies, but short fragments of *Melosira* were frequently observed in the food vacuoles of ciliates such as *Frontonia*, *Climacostomum* and *Uroleptus*. The flagellates larger than 20 μ m, such as euglenoids and monads, were mainly eaten by middle-and large-size omnivores (Fig. 3). In colony-forming dominant flagellates, *Synura* sp. and *Dinobryon* sp. were observed in only a few cells of *Frontonia* and *Stentor*, but probably eaten by larger phagotrophs such as Crustacea (Tappa, 1965). (b) The detritus food chain was usually composed of more trophic links than the grazing. It is probably due to the scarcity of small-size autotrophs that do not form colonies or filaments. Free-swimming organisms were more apt to be eaten by other microphagotrophs, while hypotrichids, heterotrichids and other creeping organisms were not so regardless of their sizes.

Microphagotrophs play a role of a middle food link between their food organisms and their predators. Although not examined in detail, the larger phagotrophs were present in this pond as follows. One of carnivorous oligochaets, *Chaetogaster* sp. appeared in the litter layer. This oligochaet is possibly an effective predator on heterotrichid and hypotrichid ciliates (Taylor, 1980). Many cyclopoid species have been known to eat planktonic rotifers and protozoans (Williamson, 1983; Fryer, 1957). The dominant cyclopoid in this pond, *Tropocyclops prasinus* is also predatory. Furthermore, detritus feeders such as shrimps and chironomids may consume microphagotrophs with detritus. In Mizutori-no-numa pond, gammarids with a high density shredded leaf litter actively from late autumn to spring. The gammarids turned a considerable amount of leaf litter into sapropelic feces so that it influenced microfauna perhaps through microspatially environmental conditions. From these trophic relationships, energy flow is charted in Fig. 5 for the biotic community in Mizutori-no-numa pond in a special reference to leaf-litter decomposition.

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摘 要

水鳥の沼に出現する微小動物（体長 1 mm 以下の食餌栄養動物）の種構成及び食性を調べた。観察した微小動物は 140 taxa（原生動物肉質虫類 11, 同繊毛虫類 97, 輪虫動物 25, その他の後生動物 7）であり, 落葉層で最も多かった。これらの多くは食物をその大きさで選択する広食者とみられ, 細菌, 微小鞭毛虫, 微小藻類が一般的な餌であった。比較的狭食性のものとして, 小型繊毛虫又は輪虫ばかりを摂食する肉食者が 12 taxa 認められた。しかし, 専ら藻類を食物とするような微小動物は少なく, これは水鳥の沼に優占する微小藻類がコロニーを形成する *Microcystis* (夏) や糸状の *Melosira* (冬) など, 摂食しにくいタイプであるためと考えられた。

微小動物は, 貧毛類やケンミジンコ, さらに大型の甲殻類や昆虫などによって捕食され, 落葉分解に由来する腐生食物連鎖において分解微生物と大型動物の仲介役を果たしている。大型動物には, 捕食以外の間接的影響を微小動物相に及ぼしているとみられるものもあった。ヨコエビやザリガニ幼生等枯葉食者による落葉の破砕は, 落葉の微生物分解を促進し, 落葉の微視的環境を変化させる。

食性の観察結果から, 微小動物の食物連鎖, 池の生物群集におけるエネルギーの流路を考察した。

Table 1. Fixatives and stains used for species identification.

reagent	purpose	content
GF mixed solution	fixation	glutaraldehyde (20%) : formalin (37%) : cacodylate buffer (pH 7.0)=7: 4: 30
Glutaraldehyde	fixation	10% solution
Acridin Orange	fixation	10% solution
	vital staining of nuclei	0.01% solution
Methyl-green	staining of nuclei	0.5% in acetic acid (1%)
Coomassie Brilliant Blue	staining of cilia & cirri	CBB 10mg, ethanol (95%) 5ml, H ₃ PO ₄ (85%) 10ml

Table 2. Taxonomical list of microphagotrophs in Mizutori-no-numa pond and their food habits

Body size is expressed by the range of somatic length or diameter under the natural conditions for most species, but for some taxa, other length was measured and expressed as follows; p: width of peristome, h: length from a peristome to a scopula of peritrichids, lo: length of lorica. The length of variational spines of rotifers was indicated in a parenthesis.

The following abbreviations are used in the items of food habits; BA: bacteria, FU: fungi, FL: flagellates, AL: algae, PR: protozoa, CI: ciliates, TE: testacids, RO: rotifers, OL: oligochaetes, PL: planarian, DE: detritus, and LE: leaf litter. The item with an asterisk was ascertained by culturing.

The layer, where each taxon was chiefly observed, is recorded as the preferable layer. The capitals of W, L and S show water, litter and sapropel layers respectively, and TR means the body surface of a cyclopoid, *Tropocyclops prasinus* regardless of the layers.

The references of species identification and food habits are designated by the number in brackets.

taxon	body size (μm)	food habits		preferable layer
		observed in this pond	reported by other authors	
«SARCODINA»				
<i>Actinophrys</i> sp. (sol Ehrb.)	30-50		FL, CI, RO, AL [21]	WL
<i>A.</i> sp.	30-50	AL		L
<i>Actinospherium</i> sp. (<i>eichhorni</i> Ehrb..)	125-150	AL, CI (<i>Coleps</i> , <i>Pleuronema</i> UNSCX), FL, RO	FL, AL, CI, RO, CR [21]	L
<i>Arcella</i> sp. (<i>hemisphaerica</i> Perty [17])	50	BA*		LS
<i>A.</i> sp. (<i>discoides</i> Ehrb. [17])	120-150		AL, FL, CI [21]	LS
<i>Diffugia</i> sp. (<i>limnetica</i> Levander [17])	65-75		AL [21]	LS
<i>D.</i> sp.				L
<i>Centropyxis aculeata</i> Stein	60-65	BA*		L
<i>Cyphoderia</i> sp. (<i>ampulla</i> Ehrb. [14, 17])	100			L
AMPRX	>100		(FL, AL, CI, RO, [21])	L
AMSXX	<50	AL, BA*		L
«CILIATA»				
<i>Coleps hirtus</i> Müller [12, 14]	50-57	AL (<10 μm), UNSCX	CI, RO, AL, FL [1]	WL
<i>Homalozoon vermiculare</i> Stokes [12]	500	CI (<i>Coleps</i>), AL (<10 μm)	CI [21]	L
<i>Spathidium</i> sp.	230		(CI, AL, FL [1])	L
<i>Litonotus</i> sp. (<i>lamella</i> Scheviakoff [12])	150-220	CI	CI [1, 21], FL [1]	L
<i>Hemiophrys</i> sp. (<i>pleurosigma</i> Stokes [12])	100-210		CI, FL [1]	L
<i>H.</i> sp.	500			L
<i>Loxodes striatus</i> Engelmann [12]	150-210	AL (diatom<70 μm etc)	AL [21]	L
<i>L.</i> sp. (<i>vorax</i> Stokes [12])	100		ditto	L
<i>L.</i> sp. (<i>magnus</i> Stokes [12])	300		AL [9, 21]	L
<i>Dileptus</i> sp. (<i>anser</i> Müller [12])	220		CI, RO, OL, PL [1]	L
<i>Loxophyllum</i> sp. (<i>helus</i> Stokes [12])	90			L
<i>Prorodon</i> sp. (<i>griseus</i> Clapareda & Lachmann [12])	180-250	FL (monads), AL (green colony)	AL, FL [21]	L
<i>P.</i> sp. (<i>viridis</i> Ehrb.-Kahl [12])			AL, BA [21]	L

taxon	body size (μm)	food habits		preferable layer
		observed in this pond	reported by other authors	
<i>Pithothorax simplex</i> Kahl [12]	23		AL, BA [21]	
<i>Trachelius ovam</i> Ehrb [14]	150-220	RO (<i>Trichocerca</i>)	CI (vorticellid), AL, RO [21]	L
<i>Paradileptus</i> sp. (<i>elephantinus</i> Svec. [12])	100-150			
<i>Chilodonella cucullulus</i> Müller [14]	88-125	AL (diatom, <i>Melosira</i> etc)	BA, AL [1, 21]	L
<i>Lacrymaria pupula</i> Müller [12]	93-100	AL	CI [21]	LS
<i>L. vertens</i> Stokes [12]	100-120			L
GYTR 1 (<i>Trachelophyllum</i> sp.)	40-50			L
GYPR 1 (<i>Prorodon discolor</i> Ehrb. [21])	75-80	AL	(AL [12])	LS
<i>Paramecium caudatum</i> Ehrb. [14]	170-220	BA*	BA [1]	L(S)
<i>Colpoda</i> sp.	50		(BA [21])	(L)S
<i>Plagiopyla</i> sp. [1, 12]	70		BA, AL [1]	
<i>Frontonia leucas</i> Ehrb. [12]	200-250	AL (diatom, <i>Melosira</i> < 93 μm , desmids, etc), FL (<i>Synura</i> , euglenoids, etc), RO, CI (<i>Coleps</i> , <i>Aspidisca</i> , etc)	AL, FL, RO, SA [21]	L(S)
<i>F.</i> sp. (<i>acuminata</i> Ehrb.) [12]	90-100	AL (diatom, <i>Melosira</i> , etc)	AL, CL [1, 12]	L(S)
<i>Hemicyclium halitideus</i> Penard [4]	50-60			S
<i>Urocentrum turbo</i> Müller [4, 12]	50-70		BA [1]	(L)S
<i>Glaucoma</i> sp.	27		(BA [1, 21])	L
<i>Uronema</i> sp. (<i>granulatum</i> Lepsi [12])	20-25	BA*	BA [21]	WL
<i>U.</i> sp. (<i>nigricans</i> Florentin [3])	21-25		BA [21]	
<i>Lembadion magnum</i> Stokes [12]	100-105	AL, FL	AL, CI [12]	L
<i>L.</i> sp. (<i>lucens</i> Maskell [12])	50-58	AL (diatom < 20 μm , etc)		L
<i>Pleuronema</i> sp. (<i>coronatum</i> Kent [12, 14])	70-80	AL, FL (monads)	AL, BA [12]	LS
<i>Astylozoon fallax</i> Engelmann [12]	100			W
<i>Vorticalla</i> sp. (<i>campanulla</i> Ehrb. [1, 14])	p80/h88		BA [1, 21]	L
<i>V.</i> sp.	p50/h50			L
<i>V.</i> sp. (<i>monilata</i> Totem [14])	p50/h45-50		BA [21]	L
<i>V.</i> sp.	p30/h38			L

taxon	body size (μm)	food habits		preferable layer
		observed in this pond	reported by other authors	
<i>V. sp. (picta</i> Ehrb. [14])	p33/h35			L
<i>Carchecium sp.</i>	p43/h70			L
<i>Opercularia sp. (nutans</i> Ehrb. [1])	h50-55		BA [1]	L
<i>O. sp. (phryganeae</i> Kahl [3])	p50/h130	AL (green, blue-green)		L
<i>Epistylis sp. (lacustris</i> Imhoff [12])	p36/h55-83			TR
PEVS 1	p12/h25	(without a stalk)		TR
<i>Metopus es</i> Müller [1, 12, 14]	80-150		BA [1, 21] AL, FL [1]	S
<i>M. sp. (striatus</i> McMurrich [12])	55-60			S
<i>M. sp.</i>	100			S
<i>Brachonella spiralis</i> (Smith) Jankowski [4]	100	AL (brown, green)	BA, FL, AL [1]	S
<i>Caenomorpha sp.</i>	70-80		BA [1, 21]	S
<i>Blepharisma undulans</i> Stein [14]	120-167	BA*		L
<i>B. sp. (lateritium</i> Ehrb.)	125			L
<i>Spirostomum ambiguum</i> Ehrb. [1, 12, 14]	1000		BA, FL [1, 21] AL [1]	LS
<i>S. inflatum</i> Kahl [12]	200-250			L
<i>S. minus</i> Roux [12, 14]	700-800			L
<i>S. intermedium</i> Kahl [12, 14]	400-600			L
<i>S. filum</i> Ehrb. [12, 14]	300-400			LS
<i>Gruberia uninucleata</i> Kahl [12]	300-500			L
<i>Stentor coeruleus</i> Ehrb. [14]	1000	AL (desmid, diatom, etc), FL (euglenoid, <i>Synura</i> , <i>Dinobryon</i> , monad, etc), CI (<i>Coleps</i>)	CI, RO, AL, BA, FU (hyphae), FL (<i>Phacus</i> , <i>Eug-</i> <i>lena</i>) [1, 21]	L
<i>S. roeseli</i> Ehrb. [12, 20]	500-1090	AL (desmid, diatom, etc), FL (<i>Synura</i> , <i>Dinobryon</i> , monad, etc)	CI, FL, AL, BA [1]	L
<i>S. polymorphus</i> Müller [14]	1000-1300	FL (euglenoid, <i>Phacus</i> , monad), CI (<i>Coleps</i>)	FL, AL [1]	L
<i>S. igneus</i> Ehrb. [12, 14]	150-320	AL		L
<i>S. spp.</i>				L
<i>Climacostomum vireus</i> Ehrb. [12, 14]	100-130	AL (diatom, <i>Melosira</i> , etc)		L
<i>Halteria grandinella</i> Müller	30-50		BA [1]	WL

taxon	body size (μm)	food habits		preferable layer
		observed in this pond	reported by other authors	
<i>Strobilidium</i> sp. (gyrans Stokes [12, 14])	28-30	FL (<20 μm)	AL (diatom) [21]	WL
<i>Codonella cratera</i> Leidy [12, 14]	55			W
<i>Tintinnopsis cylindrata</i> Kofoid & Campbell [12, 14]	40-55			W
<i>Tintinnidium</i> sp. (<i>fluviatile</i> Stein [1, 12, 14])	86		BA, AL (diatom), FL [1]	W
TIsti (<i>Strombidinopsis</i> sp.)	40			WL
<i>Epalxis</i> sp. (<i>mirabilis</i> Roux [12])	23			LS
<i>Hypotrichidium conicum</i> Ilowaiski [12, 14]	100-150	AL (desmid, etc), FL (<i>Dinobryon</i> , monad, etc), CI (<i>Coleps</i>)		W
<i>Tachysoma</i> sp. [12]	50-70	BA*, FL (<5 μm), AL (<i>Chlorella</i>)*	(AL, BA [12])	L
HPS 11	75			L
HPS 21	70-80			L
<i>Onychodromopsis</i> sp. (<i>flexilis</i> Stokes [12])	110-125	BA*, FL (<5 μm), AL (<i>Chlorella</i>)*		L
<i>Holosticha</i> (<i>Amphisiella</i>) sp. [12]	120	AL (green, brown), FL (<5 μm)		L
HPLB 1	125			L
<i>Holosticha</i> sp. [12]	70-110	AL (<15 μm)		L
HPLP 1	70-110			L
<i>Gastrostyla</i> sp. (<i>muscorum</i> Kahl [12])	160-180	AL (<i>Melosira</i> , diatom <65 μm), FL (monad, etc)		L
HPL 31	150-200			L
<i>Stylonychia</i> sp. (<i>mytilus</i> Müller [1, 14])	90-130	AL (diatom <15 μm , <i>Melosira</i> , etc), BA*, FL*	AL, FL, CI [1, 13], BA [13]	L
<i>Uroleptus</i> sp.	150-250	AL (diatom <25 μm , <i>Melosira</i> , etc)	BA, AL, FL [21]	L(S)
<i>Strongylidium</i> sp. (<i>lanceolatum</i> Kowalevski [12])	140			L(S)
<i>Aspidisca costata</i> Dujardin [1, 12]	30-40	BA*	BA [1, 10]	L(S)
<i>A. sulcata</i> Kahl [12]	35-45		BA [1]	L(S)
<i>A. lynceus</i> Ehrb. [1, 12]	40-50		ditto	L(S)
<i>Euplotes</i> sp.	120-150	AL		L
<i>E.</i> sp.	45			L
<i>Acineta</i> sp.	23-35			TR

taxon	body size (μm)	food habits		preferable layer
		observed in this pond	reported by other authors	
UNF 31	150	RO (<i>Notholca</i>)		L(S)
UNPS 1	100–110			LS
UNPL 1	170–200			LS
UNNM 1	75			L
UNBA 1	100			L
UNSCX	<30			WLS
《ROTIFERA》				
<i>Rotaria rotatoria</i> Pallas [16]	>300			LS
<i>Polyarthra</i> sp. (<i>remata</i> Skorikov [19])	100–120	AL, FL (monad)	FL [5, 15], AL [5]	WL
<i>P. trigla</i> Ehrb. [16]	168			
<i>Synchaeta</i> sp. (<i>stylata</i> Wierzejski [16, 19])	>210	AL		
<i>S.</i> sp. (<i>pectinata</i> Ehrb. [16, 19])	200		PR, RO [15], AL, FL [20]	
<i>Brachionus angularis</i> Gosse [16, 19]	lo 123			L
<i>B. quadridentatus</i> Horman [16, 19]	lo 180			L
<i>B. calyciflorus</i> Pallas [16, 19]	—		BA, AL, FL [8, 20, 22], DE [20]	L
<i>Squatinella</i> sp. (<i>tridentata</i> Fresenius [19])	lo 80			L
<i>S.</i> sp.	200			L
<i>Keratella cochlearis</i> Gosse [16, 19]	130–150	AL (green)	BA, AL, FL [2, 6, 20], DE [20]	WL
<i>K. valga</i> Ehrb. [16, 19]	170		DE, BA, AL, FL [20]	WL
<i>K. quadrata</i> Müller [16, 19]	125 (+40)		ditto	WL
<i>Anuraeopsis</i> sp. (<i>fissa</i> Lauterborn [16, 19])	75–85		DE, BA [20]	L
<i>Trichocerca</i> sp. (<i>tenuior</i> Gosse [16])	150(+60)		(AL [20])	L
<i>T.</i> sp.	100(+60)		(ditto)	L
<i>Colurella colurus</i> Ehrb. [16]	92			L
<i>C. biscopidata</i> Ehrb. [16]	100			L
<i>C. tessellata</i> Glasscoff	88–100			L
<i>Asplanchna</i> sp. (<i>sieboldi</i> Leydig [16])	100		AL, FL, PR, RO [5]	WL
<i>Lepadella acuminata</i> Ehrb.	lo 100			L
<i>L. oblonga</i> Ehrb. [16]	lo 100			L
<i>Notholca</i> sp. (<i>squamula</i> Müller)	lo 130–150			L

taxon	body size (μm)	food habits		preferable layer
		observed in this pond	reported by other authors	
[6, 19]				
<i>Filinia terminalis</i> Plate [16]	160-170		(DE, BA, AL [5, 20])	W
ROMO 1 (<i>Monommata</i> sp.)	100(+115)			
《OTHER MICROMETAZOA》				
<i>Chaetonotus hystrix</i> Metschnikoff	110-120		AL, CI, DE [25]	LS
[18, 25]				
<i>C. nodicaudus</i> Voigt [18, 25]	260-330			LS
<i>C. truncatus</i> Saito [18, 25]	150-170			LS
<i>Heterolepidoderma</i> sp. (<i>gracile</i> Remane [25])	160			LS
Nematoda (Species identification was not made.)				LS
<i>Herpetocypris intermedia</i> Kaufmann [18]	1300-1400			L
<i>Hypsibius augsti</i> Murray [18]	300	DE		L
《UNCOUNTED MICROMETAZOA》				
<i>Bosminopsis</i> sp. (<i>deitersi</i> Richard [16])	325			W
<i>Tropocyclops prasinus</i> * Fisher [18]	—			WL
<i>Cyclops vicinus</i> Uljanin [16, 18]	1000-2000			WL
MICP 1 (<i>Eucyclops serrulatus</i> Fischer [18])	700-1270			W
MICP 1' (<i>Macrocyclops</i> sp.)	2000-3000			W
《LARGER BENTHIC ANIMALS》				
<i>Jesogammarus</i> sp.**	—	LE, (BA)		L
<i>Procambarus clarkii</i> Girard [25]	—	LE, DE,		L(S)
<i>Palaemon paucidens</i> De Haan [25]	<5000	(DE)		WL
Oligochaeta (Species identification was not made.)				LS
Insecta (Species identification was not made.)				LS

*; identified by Dr. Y. Kikuchi, the Itako Hydrobiological Station, Ibaraki University.

**; identified by Dr. H. Morino, Department of Biology, Ibaraki University.

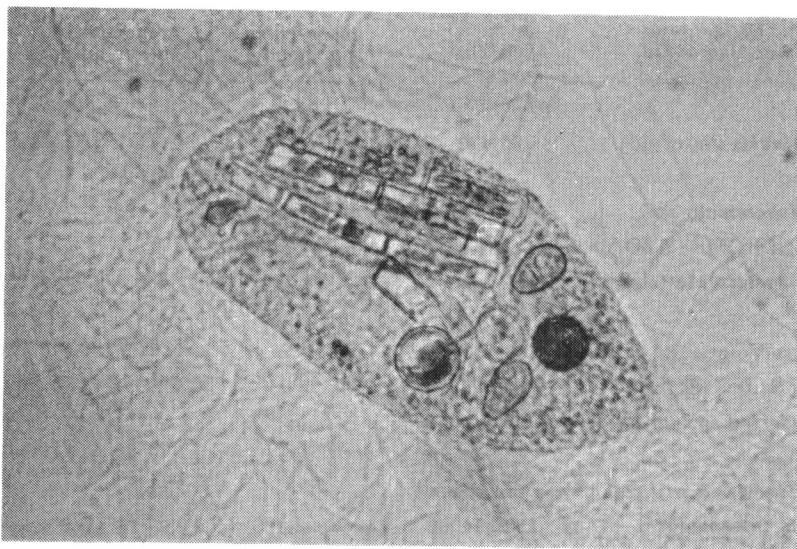


Fig. 1 Examination of food items. A squashed ciliate, *Frontonia* sp. (*acuminata* like), ingesting various algae.

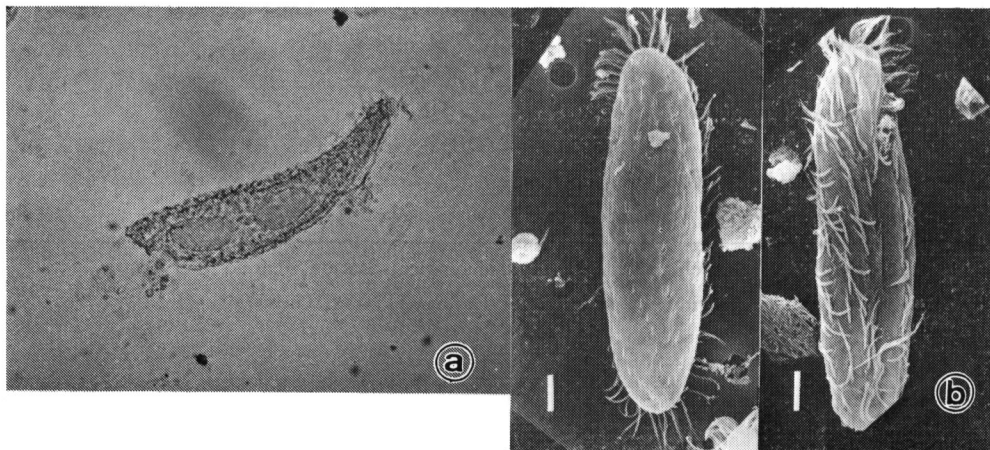


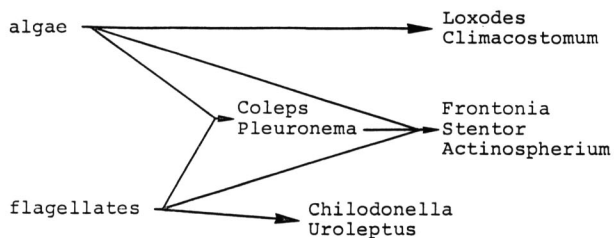
Fig. 2 Fine structure of ciliates. (a) Two macronuclei and a micronucleus between them in *Hemiophrys* sp., stained with methyl-green. (b) A scanning electron micrograph of cirri location on dorsal (left) and ventral (right) sites of *Onychodromopsis* sp.

food item	bacteria	—flagellates—			—algae—			—ciliates—		others
		small	middle	large or colonial	small	middle	large	small	middle	
food size	<1 μ m	<5 μ m	<20 μ m	<Ca 100 μ m	spec*($\leq$ 15 μ m)	spec*				
food habit	bacterivore	small omnivore	middle omnivore	large omnivore	algivore	carnivore				
Sarcodina	small amoeba	Arcella Diffulgia Centropyxis	Actinophrys	Actinospherium large amoeba						
Ciliata	Vorticella Tintinnopsis Codonella Halteria Uronema Metopus Aspidisca	Oxytricha Spirostomum Strobilidium Onychodromopsis Holosticha	Uroleptus Prorodon Coleps Lacrymaria Pleuronema Hypotrichidium Stylonychia	Frontonia Stentor	Loxodes Climacostomum	Litonotus Hemiophrys Trachelius Paradileptus Homalozoon				

spec* ; relatively specific items

Fig. 3 Food habits of protozoan taxa.

(a) Grazing Food Chain



(b) Detritus Food Chain

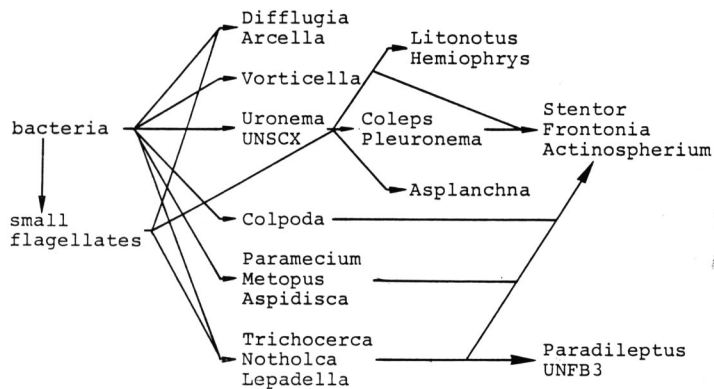


Fig. 4 Scheme of grazing and detritus food chains in Mizutori-no-numa pond.

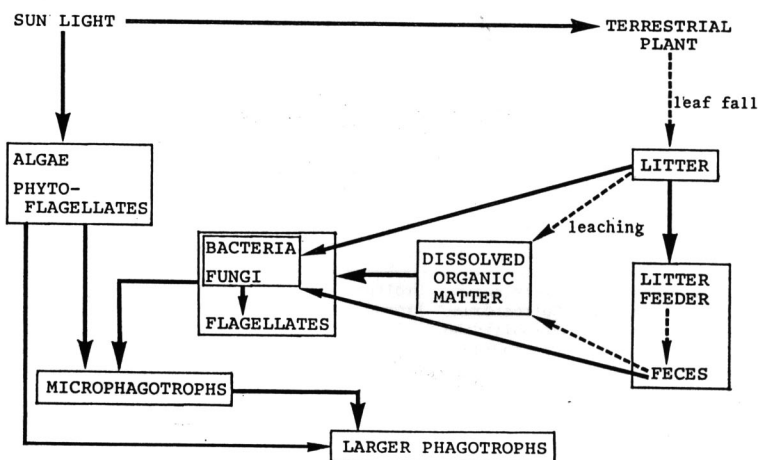


Fig. 5 Scheme of the energy flow in a biotic community in Mizutori-no-numa pond. Solid lines indicate utilization of energy by photosynthesis or food intake.