自然教育園報告（Rept. Inst. Nat. Stu.）
第16号：99—112，1985

水鳥の沼における微小動物及びその食性について（英文）

草 野 晴 美*

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

Harumi Kusano*

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 (×100-1000). A 10% polyethylene glycol (M. W.=20000) solution in the inorganic nutrient medium ($MgSO_4 \cdot 7H_2O$ 0.5g, KNO_3 0.2g, $CaCl_2 \cdot 2H_2O$ 1.0g, $FeCl_3 \cdot 6H_2O$ (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

* 東京都立大学理学部生物学科，Department of Biology, Tokyo Metropolitan University

structure under a stereoscopic or a scanning electron microscope (×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 30μm) and flagellates (less than 20μm) 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 μm, 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 prisinus* is also predatory. Furthermore, detritus feeders such as shrimps and chilonomids 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.

ACKNOWLEDGEMENTS

I wish to thank Mr. N. Hisai, Institute for Nature Study, for his kind assistance in sample collections.

REFERENCES

1. Bick, H. 1972. Ciliated Protozoa. 198 pp. World Health Organization, Geneva.
2. Bogdan, K. G. & Gilbert, J. J. 1982. Seasonal patterns of feeding by natural populations of *Keratella, Polyarthra*, and *Bosmina*: Clearance rates, selectivities, and contributions to community grazing. Limnol. Oceanogr., 27 : 918–934.
3. Curds, C. R. 1969. An illustrated key to the British freshwater ciliated Protozoa commonly found in activated sludge. Water Pollution Research Technical Paper, No. 12. 90 pp. London.
4. ———, Cochburn, A. & Vandyke J. M. 1968. An experimental study of the role of the ciliated protozoa in the activated-sludge process. Wat. Pollut. Control, 67 : 312–329.
5. Dumont, H. J. 1977. Biotic factors in the population dynamics of rotifers. Arch. Hydrobiol.

Beih., 8 : 98–122.

6. Edmondson, W. T. 1965. Reproductive rate of planktonic rotifers as related to food and tempera- ture in nature. Ecol. Monogr., 35 : 61–111.

7. Fryer, G. 1957. The food of some freshwater cyclopoid copepods and its ecological significance. J. Anim. Ecol., 26 : 263–286.

8. Gilbert, J. J. & Starkweather, P. L. 1978. Feeding in the rotifer ***Brachionus calyciflorus***. III. Direct observation on the effects of food type, food density, change in food type, and starvation on the incidence of pseudotrochal screening. Verh. Int. Verein. Limnol., 20 : 2382–2388.

9. Goulder, R. 1972. Grazing by the ciliated protozoon ***Loxodes magnus*** on the alga ***Scenedesmus*** in a eutrophic pond. Oikos, 23 : 109–115.

10. Hamm, A. 1964. Untersuchungen über die Ökologie und Variabilität von ***Aspidisca costata*** (Hypotricha) im Belebtschlamm. Arch. Hydrobiol., 60 : 286–339.

11. Hatano, H. & Watanabe, Y. 1981. Seasonal change of protozoa and micrometazoa in a small pond with leaf litter supply. Hydrobiologia, 85 : 161–174.

12. Kahl, A. 1930–1935. Die Tierwelt Deutschlands und der angrenzenden Meeresteile.18. Urtiere oder Protozoa. I. Winpertiere oder ciliata (Infusoria). 886 pp.

13. Kaul, N. & Sapra, G. R. 1983. Feeding behavior and digestion patern in ***Stylonychia mytilus*** Ehrenberg. Arch. Protistenk., 127 : 167–180.

14. Kudo, R. R. 1966. Protozoology. 5th. 1174 pp. Charles C. Thomas Pub.

15. Miracle, M. R. 1974. Niche structure in freshwater zooplankton : A principal components approach. Ecology, 55 : 1306–1316.

16. Mizuno, T. 1976. Illustrations of the freshwater plankton of Japan. 251 pp. Hoikusha Pub. [in Japanese]

17. Ogden, C. G. & Hedley, R. H. 1980. An atlas of freshwater testate amoebae. 222 pp. British Museum.

18. Okada, K., Uchida, S. & Uchida, R. 1965. New Illustrated Encyclopedia of the Fauna of Japan, the second volume. 803 pp. Hokuryukan Pub., Tokyo. [in Japanese]

19. Pontin, R. M. 1978. A key to the freshwater planktonic and semi-planktonic Rotifera of British isles. Freshwater Biological Assoc. Scientific Pub., No. 38. 178 pp.

20. Pourriot, R. 1977. Food and feeding habits of Rotifera. Arch. Hydrobiol. Beih., 8 : 243–260.

21. Sandon, H. 1932. The food of Protozoa. 187 pp. The Egyptian Univ.

22. Starkweather, P. L. 1980. Aspects of the feeding behavior and trophic ecology of suspension-feeding rotifers. Hydrobiologia, 73 : 63–72.

23. Tappa, D. W. 1965. The dynamics of the association of six limnetic species of ***Daphnia*** in Aziscoos Lake, Maine. Ecol. Monogr., 35 : 395–423.

24. Taylor, W. D. 1980. Observation on the feeding and growth of the predacious oligochaete ***Chaetogaster langi*** on ciliated Protozoa. Trans. Amer. Micros. Soc., 99 : 360–368.

25. Ueno, M. (ed) 1980. Freshwater biology of Japan. 760 pp. Hokuryukan Pub. [in Japanese]

26. Williamson, C. E. 1983. Invertebrate predation of planktonic rotifers. Hydrobiologia, 104 : 385–396.

摘　　要

水鳥の沼に出現する微小動物（体長 1 ㎜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_3PO_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 prisinus*** 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: observed in this pond	food habits: reported by other authors	preferable layer
≪SARCODINA≫				
Actinophrys sp. (sol Ehrb.)	30–50		FL, CI, RO, AL [21]	WL
A. sp.	30–50	AL		L
Actinospherium sp. (*eichhorni* Ehrb..)	125–150	AL, CI (*Coleps*, *Pleuronema* UNSCX), FL, RO	FL, AL, CI, RO, CR [21]	L
Arcella sp. (*hemisphaerica* Perty [17])	50	BA*		LS
A. sp. (*discoides* Ehrb. [17])	120–150		AL, FL, CI [21]	LS
Difflugia sp. (*limnetica* Levander [17])	65–75		AL [21]	LS
D. sp.				L
Centropyxis aculeata Stein	60–65	BA*		L
Cyphoderia sp. (*ampulla* Ehrb. [14, 17])	100			L
AMPRX	>100		(FL, AL, CI, RO, [21])	L
AMSXX	<50	AL, BA*		L
≪CILIATA≫				
Coleps hirtus Müller [12, 14]	50–57	AL (<10μm), UNSCX	CI, RO, AL, FL [1]	WL
Homalozoon vermiculare Stokes [12]	500	CI (*Coleps*), AL (<10μm)	CI [21]	L
Spathidium sp.	230		(CI, AL, FL [1])	L
Litonotus sp. (*lamella* Scheviakoff [12])	150–220	CI	CI [1, 21], FL [1]	L
Hemiophrys sp. (*pleurosigma* Stokes [12])	100–210		CI, FL [1]	L
H. sp.	500			L
Loxodes striatus Engelmann [12]	150–210	AL (diatom<70μm etc)	AL [21]	L
L. sp. (*vorax* Stokes [12])	100		ditto	L
L. sp. (*magnus* Stokes [12])	300		AL [9, 21]	L
Dileptus sp. (*anser* Müller [12])	220		CI, RO, OL, PL [1]	L
Loxophyllum sp. (*helus* Stokes [12])	90			L
Prorodon sp. (*griseus* Clapareda & Lachmann [12])	180–250	FL (monads), AL (green colony)	AL, FL [21]	L
P. sp. (*viridis* Ehrb.-Kahl [12])			AL, BA [21]	L

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

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

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

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

taxon	body size (μm)	food habits: observed in this pond	food habits: reported by other authors	preferable layer
[6, 19]				
Filinia terminalis Plate [16]	160–170		(DE, BA, AL [5, 20])	W
ROMO 1 (*Monommata* sp.)	100(+115)			
≪OTHER MICROMETAZOA≫				
Chaetonotus hystrix Metschnikoff [18, 25]	110–120		AL, CI, DE [25]	LS
C. nodicaudus Voigt [18, 25]	260–330			LS
C. truncatus Saito [18, 25]	150–170			LS
Heterolepidoderma sp. (*gracile* Remane [25])	I60			LS
Nematoda (Species identification was not made.)				LS
Herpetocypris intermedia Kaufmann [18]	1300–1400			L
Hypsibus augsti Murray [18]	300	DE		L
≪UNCOUNTED MICROMETAZOA≫				
Bosminopsis sp. (*deiters* Richard [16])	325			W
*Tropocyclops prasinus** Fisher [18]	—			WL
Cyclops vicinus Uljanin [16, 18]	1000–2000			WL
MICP 1 (*Eucyclops serrulatus* Fischer [18])	700–1270			W
MICP 1' (*Macrocyclops* sp.)	2000–3000			W
≪LARGER BENTHIC ANIMALS≫				
Jesogammarus sp.**	—	LE, (BA)		L
Procambarus clarkii Girard [25]	—	LE, DE,		L(S)
Palaemon paucidens 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.

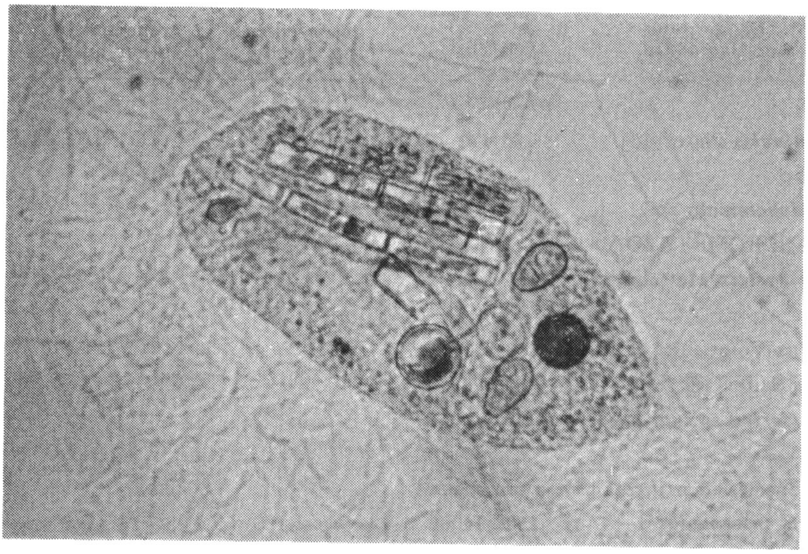


Fig. 1 Examination of food items. A squashed ciliate, ***Frontonia*** sp. (***acuminata*** like), ingesting various algae.

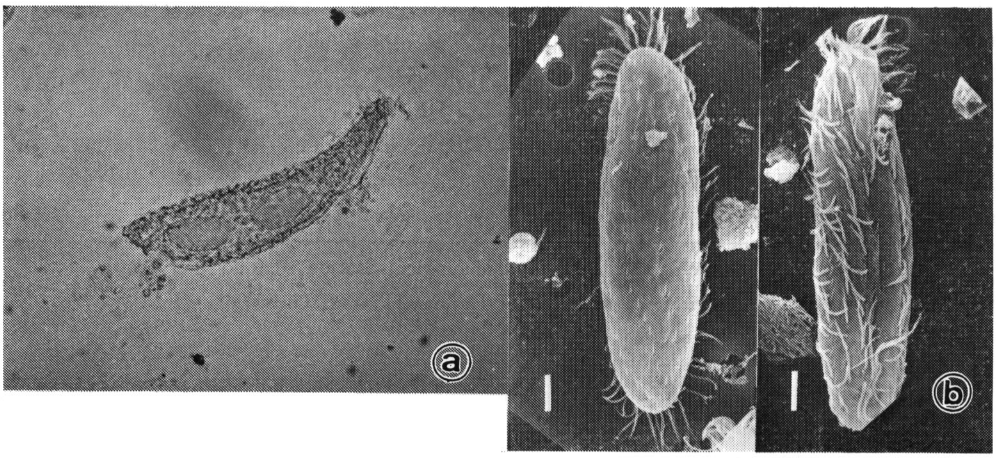
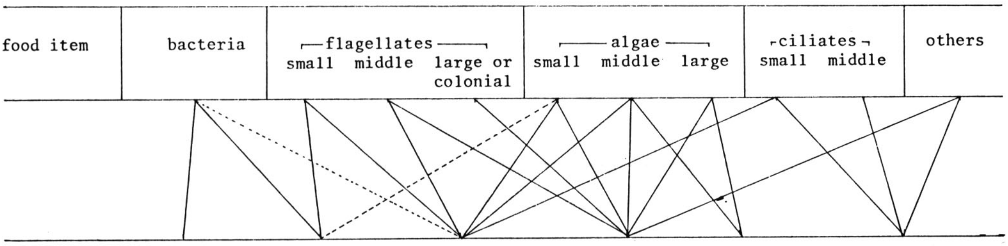


Fig. 2 Fine structure of ciliates. (a) Two macronuclei and a micronucleus between them in *Hemiophrys* sp., stained with methyl-green. (b) A scanning electron micrograph of cirri location on dorsal (left) and ventral (right) sites of ***Onychodromopsis*** sp.



food size	<1 µm	<5 µm	<20 µm	<Ca 100 µm	spec* (<15 um)	spec*
food habit	bacterivore	small omnivore	middle omnivore	large omnivore	algivore	carnivore
Sarcodina	small amoeba	Arcella Diffulugia Centropyxis	Actinophrys	Actinosphe-rium large amoeba		
Ciliata	Vorticella Tintinnopsis Codonella Halteria Uronema Metopus Aspidisca	Oxytricha Spirostomum Strobilidium Onychodromo-psis 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.

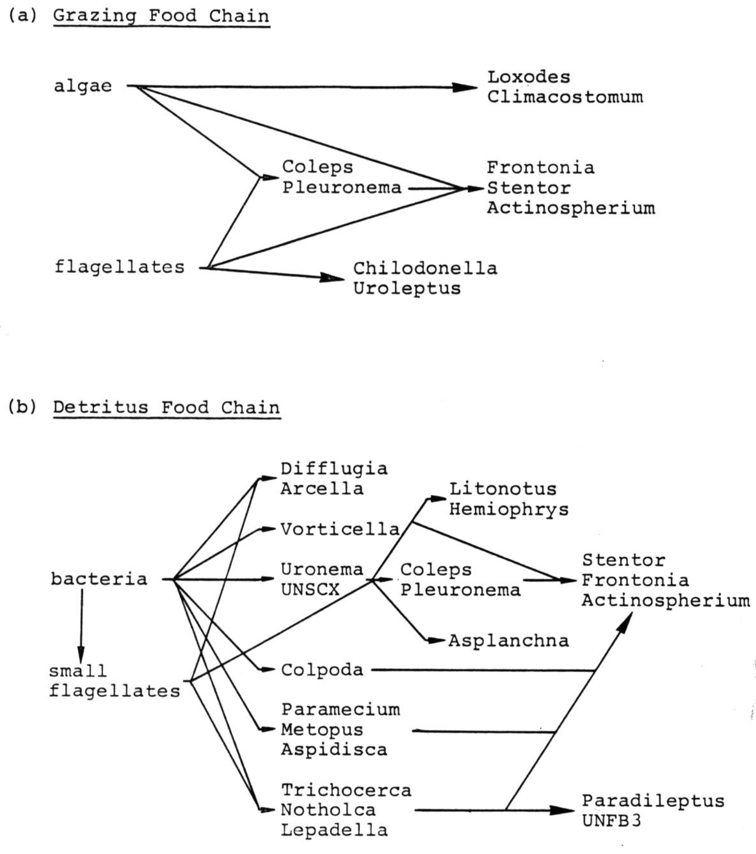


Fig. 4 Scheme of grazing and detritus food chains in Mizutori-no-numa pond.

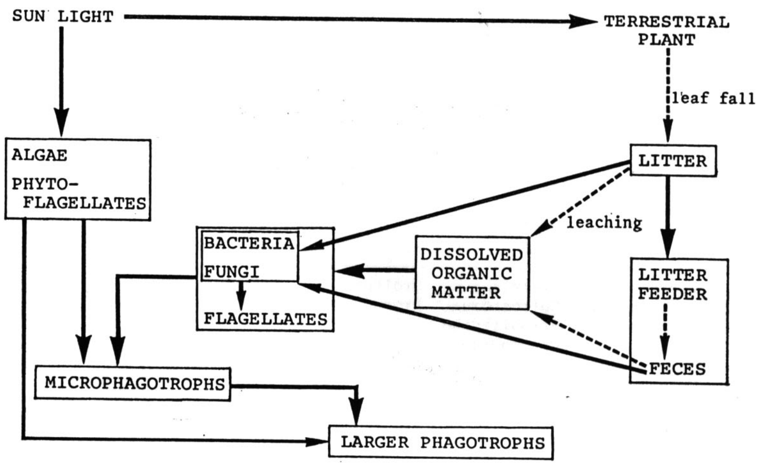


Fig. 5 Scheme of the energy flow in a biotic community in Mizutori-no-numa pond. Solid lines indicate utilization of energy by photosysthesis or food intake.