CENTRO, Vol. 1, No. 4, 1989, pp. 28–40.

Composition and structure of planktonic and benthic communities as a basic information in fishpond culture

MARCELLO BAZZANTI, ORNELLA FERRARA and LUCIANA MASTRANTUONO

(Dipartimento di Biologia Animale e dell'Uomo, Università "La Sapienza", Viale dell'Università 32, 00185 Roma, Italia)

(Received 5th October 1987; accepted with revision 5th April 1988)

ABSTRACT

Zooplankton and zoobenthos of two fishponds were studied in order to define their seasonal patterns and community structures. The ponds P1 and P2, of similar depth and surface, were interconnected, annually fertilized and mostly utilized for grey mullet rearing. P2 was less eutrophic than P1 which received further nutrient inputs from the surrounding cultivated area by means of a drainage canal.

A total of 25 zooplanktonic species and 14 zoobenthic taxa was recorded, most of which were typical of eutrophic waters. The comparison of the invertebrate fauna between the two ponds showed a strong similarity in the qualitative composition and significant differences in density of some taxa and in the community structure.

The results suggest that the analysis of these communities can be a good tool to monitor eutrophication in fishponds in the same way as observed in lakes, and could provide some basic information to improve fishpond management.

Introduction

Aquaculture practices play a determinant role in the productivity of fishponds, where several interventions can be made up. Some of them, such as introduction of artificial food and manuring, can bring about an appreciable productive improvement on the low levels of the food chain. These treatments, frequently used in fishponds management, are the most important factors affecting the structure of the invertebrate fauna, which represents the fundamental source of natural food for fish (Shaw and Mark, 1980; Zaret, 1980; Zur, 1980; Whiteside *et al.*, 1985). Biological studies on zooplankton and zoobenthos may therefore provide basic information to test the functionality of the system in order to enhance fish production.

This investigation was made to analyze the seasonal variations and the structure of the invertebrate communities in two artificial fishponds, with respect to the eutrophication influence. Our study assumes a further interest considering the scarcity in Mediterranean regions, and more particularly in Italy, of data concerning the invertebrate fauna of these freshwater ponds frequently studied in other countries (Hillbricht-Ilkowska, 1966; Lellák, 1969; Wróbel. 1972; Dimitrov, 1977; Grygierek and Wasilewska, 1979; Fry and Osborne, 1980; Šeda 1985).

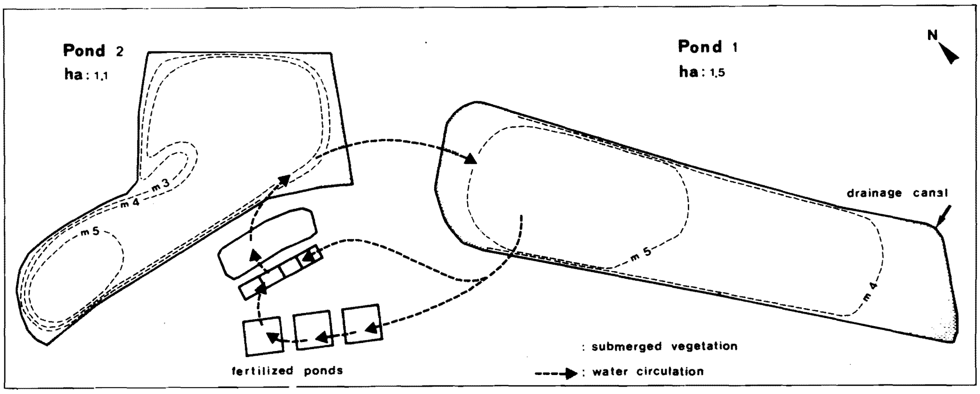


Fig. 1 – Map of the ponds and diagram of water flow.

Study area, material and methods

The ponds, located near Rome, were initially used for game fishing and, from 1977, exclusively for fish culture. The two ponds (P1 and P2, Fig. 1) had similar size and depth, and were interconnected and subject to a similar treatment. A series of small ponds for fry culture was situated near P2. They were annually fertilized with manure and urea, and treated with hydrated lime and Dipterex. The water flow carried the fertilizers from the small ponds to the two ponds (Fig. 1). Furthermore, only P1 was fed by a canal draining the water from the surrounding cultivated soil. This direct input of nutrients increased the eutrophication in P1, where higher B.O.D. and total P values, and lower oxygen contents were observed (Table 1). The temperature measurements (Fig. 2) showed similar profiles in the two ponds.

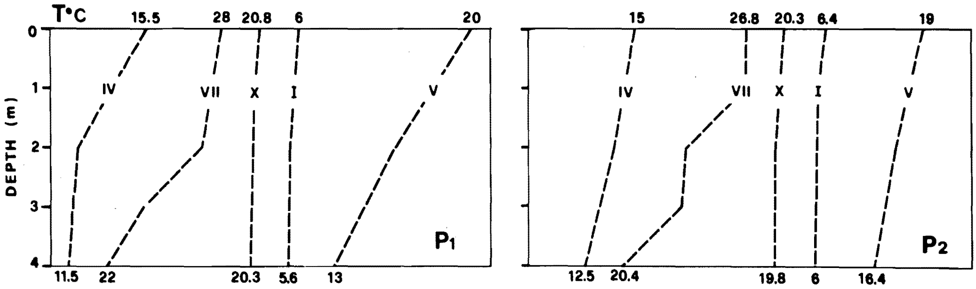


Fig. 2 – Temperature profiles in the two ponds.

Fish fauna comprised 13 species in both ponds, except for the planktivorous *Aristichthys nobilis,* present in low density only in P1. The dominant species were *Mugil cephalus* and *Liza ramada,* annually restocked. Selective fishing was carried out in order to enhance the population of grey mullet.

Zooplankton was collected every month (two times in July) and zoobenthos every two months from April 1979 to May 1980. Zooplankton was sampled with a net (width of mesh 50 μ) at the depths of 0.50m and 3m in two transects in each pond. Horizontal hauls were taken for 200m in P1 and 100m in P2. The material was fixed in 5%

formalin and later made up to 200 ml. Individuals were identified and counted, and data expressed per m^3 as mean density of the two subsamples.

Benthic organisms were collected with an Ekman grab (surface area: 225 cm^2) in six points of each pond at the depth of 5 ± 1m. The sediment was washed through a 0.28 mm sieve and the residue fixed in 10% formalin. Organisms were counted, identified and their wet weight determined. The mean values of the six samples per pond were expressed as ind/m^2 and g/m^2. Shannon diversity (H) and evenness (e) indices (Pielou, 1969) were applied in order to analyze the community structure. $\bar{T}$-test on paired comparisons (Eason *et al.,* 1980) was used to evaluate the significance in differences of densities, biomasses and diversities of the invertebrate fauna between the ponds. PSc index (Whittaker and Fairbanks, 1958) was adopted to detect community similarities between the ponds.

Table 1. Values of total P, dissolved oxygen and B.O.D. in May 1980.

	P1		P2	
sample depth (m)	3	4.5	3	4.5
Total P (µg/l)	300	300	220	200
Dissolved oxygen (mg/l)	6.2	0	8.6	1.8
B.O.D. (mg/l)	4.0	9.0	2.0	4.0

Results and discussion

1. Zooplankton

a) Composition

Zooplankton included 25 species (Tab. 2): 19 rotifers, 5 cladocerans and 1 copepod. Their seasonal changes of the planktonic species are reported in a previous paper (Ferrara and Mastrantuono, 1982), so we only report here the main trend of the groups (Fig. 3) and of the most important species.

Rotifers were the dominant group in number of species (18 in P1 and 19 in P2) and in density values (81% in P1 and 45% in P2 of the total zooplankton). The higher abundances in the ponds occurred in winter and spring, when also the species richness increased. Both qualitative and quantitative reduction was observed in summer. *Keratella cochlearis* and *Polyarthra dolicoptera-vulgaris* were the most abundant species in each pond (Tab. 2). Other species, such as *Synchaeta stylata, Pompholix sulcata, Anureopsis fissa* and *Brachionus angularis* occurred in higher number only in P1, while *Keratella quadrata* and *Filinia terminalis* were more abundant in P2. The remaining taxa had generally low densities. On the whole, the rotifer population was characterized by typical species of highly eutrophic waters, such as *K. cochlearis. K. quadrata* and *B. angularis* (Pejler, 1957; De Beauchamp, 1965). Although total densities of this group did not differ significantly in the two ponds, P1 can be defined a typical rotifer pond, due the high percentage of these organisms in the zooplankton.

Cladocerans constituted 17% of the total community in P1 and 24% in P2, with low numbers in superficial waters and high densities at 3m. The small cladoceran *Bosmina longirostris* was the dominant component in P1, followed by *Ceriodaphnia pulchella.* In P2, *Daphnia longispina, Bosmina longirostris* and *Diaphanosoma brachyurum* showed higher abundances. In this pond *D. longispina* was very abundant in spring and early summer, replaced by *D. brachyurum* in late summer. This seasonal succession can be attributed to phenomena of feeding competition, caused by the almost identical size of these larger cladocerans (Hrbácek, 1977). Although the densities of cladocerans were similar in the two ponds, *B. longirostris,* a good indicator of eutrophy (Brooks, 1969), was dominant in P1, A greater specific diversification was observed in P2.

Copepods, represented only by the calanoid *Eudiaptomus padanus etruscus,* constituted 2% of the total zooplankton in P1 and 31% in P2. As the differences in

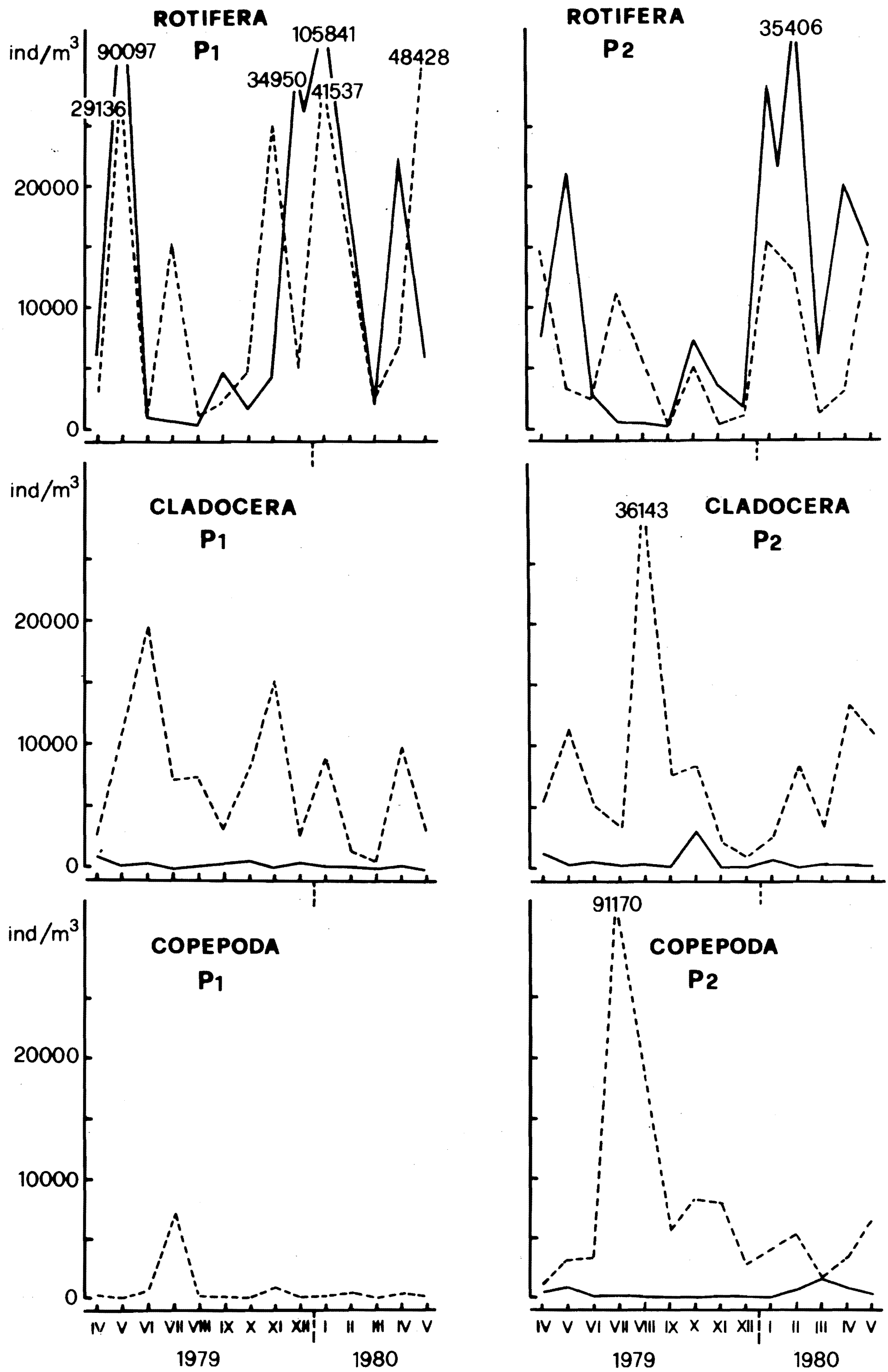


Fig. 3 – Seasonal variations in density of rotifers, cladocerans and copepods at 0.50m (————) and 3m (- - - - - -) in P1 and P2. Numerical values of copepods at 0.50m in P1, as unremarkable, are not graphed.

Table 2. List and annual average densities (ind/m^3) of the zooplanktonic species in the two ponds.

	P1		P2	
sample depth (m)	0.5	3	0.5	3
Rotatoria				
Brachionus angularis Gosse	515	1095	90	40
Keratella quadrata (O.F. Müller)	22	61	738	2281
Keratella cochlearis (Gosse)	9332	5654	3738	1314
Anureopsis fissa (Gosse)	1011	430	390	36
Trichotria pocillum (O.F. Müller)	0	0	2	2
Colurella colurus (Erhemberg)	2	1	3	6
Lecane luna (O.F. Müller)	4	1	3	0
Cephalodella sp.	4	0	15	0
Ascomorpha agilis Zacharias	82	11	131	219
Gastropus minor (Rousselet)	16	10	2	0
Asplanchna priodonta Gosse	118	2321	322	708
Synchaeta stylata Wierzejski	4942	1144	951	103
Poliarthra dolicoptera-vulgaris gr.	2886	2681	2687	271
Testudinella patina (Hermann)	2	0	2	0
Pompholix sulcata Hudson	1992	475	994	133
Filinia terminalis (Plate)	223	287	611	914
Conochilus unicornis Rousselet	11	9	17	84
Collotheca balantonica Varga	139	56	9	7
Rotaria trisecata (Weber)	4	34	0	32
Cladocera				
Diaphanosoma brachyurum Liévin	2	304	6	1894
Daphnia longispina (O.F. Müller)	37	833	20	2844
Ceriodaphnia pulchella Sars	58	1078	49	653
Moina micrura Kurz	1	58	13	584
Bosmina longirostris (O.F. Müller)	202	4980	443	2475
Copepoda				
Eudiaptomus padanus etruscus (Losito)	42	627	340	11205

abundances of this species between the ponds were significant ($p<0.01$), *E. padanus etruscus* was the component clearly diversifying the two zooplanktonic communities. The higher eutrophication in P1 can be the main factor negatively affecting the density of this species. According to some authors (Patalas, 1972; Janicki *et al.*, 1979), calanoids show decreasing densities when eutrophication increases, probably because of their superior filtering capacity on low densities of algal cells, occurring in less eutrophicated waters (Mc Naught, 1975).

As observed in other water bodies (Hillbricht-Ilkowska and Wegleńska, 1970; Gliwicz, 1977), such quantitative differences in the total zooplankton can be in agreement with a higher eutrophication in P1, which favoured both a numerical increase of microfilterers (rotifers and small cladocerans) and a reduction of macrofilterers (larger cladocerans and calanoids).

b) Diversity and similarity

Zooplankton diversity (Table 3) showed annual average and range values relatively low and very similar in the ponds. Evenness values (Table 3) generally appeared very low, displaying a community structure with dominance of a few species.

The values of PSc showed an intermediate similarity at 0.50m (annual average: 57.5%), mainly due to the dominance of rotifers in both ponds, and a lower similarity at 3m (annual average: 37.2%), due to the differences in density of some cladocerans and of *Eudiaptomus* between the ponds.

Table 3. Mean and range values of zooplankton diversity (H) and evenness (e) in the two ponds.

	depth		P1	P2
H	0.50m	min.	0.77	0.76
		mean	1.84	2.00
		max.	2.66	2.75
	3m	min.	1.39	0.82
		mean	2.16	2.20
		max.	2.99	2.82
e	0.50m	min.	0.06	0.06
		mean	0.18	0.16
		max.	0.69	0.22
	3m	min.	0.08	0.05
		mean	0.20	0.15
		max.	0.75	0.18

2. Zoobenthos

a) Composition

A total of 14 taxa, 12 of which common to both ponds, was found in the bottom (Table 4). Density and biomass values of the total fauna and of each group are reported in Figures 4, 5 and Table 5. Chironomids and chaoborids accounted for 47% in P1 and 69% in P2 for densities, 96.5% in P1 and 96.2% in P2 for biomasses of all organisms collected. Oligochaetes, benthic cladocerans, ceratopogonids and nematodes were mainly present in relatively low densities and in very low biomasses. No significant differences were found in density and biomass of the total fauna between the ponds, but t-test applied on densities excluding April data, where cladocerans reached an exceptionally high abundance in P1 (12000 ind/m^2), indicated a significantly higher density ($p<0.05$) in P2 than in P1.

Chironomids constituted the most abundant group both in density and in biomass, reaching 32% and 72% of the total fauna in P1 and 45% and 59% in P2, respectively. T-test showed a significant difference ($p<0.05$) between densities of chironomids in the ponds, but not between their biomasses. Densities and biomasses showed similar trends in the ponds, with a great variation during the year (see CV% values). Figure 5 shows the highest chironomid values in winter, their period of emergence more concentrated in spring and a remarkable reduction of larvae in summer. This reduction, typical of eutrophic waters, was more accentuated in P1, where the larval recolonization of the bottom was slower than in P2. The most common genera were: ***Procladius, Chironomus plumosus*** gr, and ***Cladopelma,*** frequently found in eutrophic waters (Bryce and Hobart, 1972; Saether, 1979; Bazzanti and Seminara. 1987). The different proportion of *C. plumosus* on the total chironomids (37.1% in P1 and 15.5% in P2) clearly indicated the greater eutrophication of P1.

Chaoborids reached the highest abundances in summer and the lowest ones in autumn and spring. Their fluctuations were opposite to those of chironomids. Numerical and weight values of *Chaoborus flavicans* were different in the two ponds, with a significant predominance in P2 ($p<0.05$). Recent observations (Stenson, 1978) detected a great ability of this species to escape predation, thanks to the extremely trasparent body and to the possibility of finding shelter in the bottom, where anaerobic conditions reduce the predation pressure. The summer maximum density of larvae in

Table 4. List of benthic taxa collected in the two ponds.

Nematoda (only in P1)

Oligochaeta
- *Dero digitata* (Müller)
- *Limnodrilus hoffmeisteri* Claparède
- *Limnodrilus claparedeianus* Ratzel (only in P2)
- Immature tubificids without hair chaetae

Cladocera
- *Iliocryptus* sp.

Chironomidae
- *Procladius*
- *Tanypus*
- *Chironomus plumosus* gr.
- *Chironomus*
- *Polypedilum nubeculosum* gr.
- *Cladopelma*
- *Microchironomus*

Ceratopogonidae
- *Palpomyia*

Chaoboridae
- *Chaoborus flavicans* (Meigen)

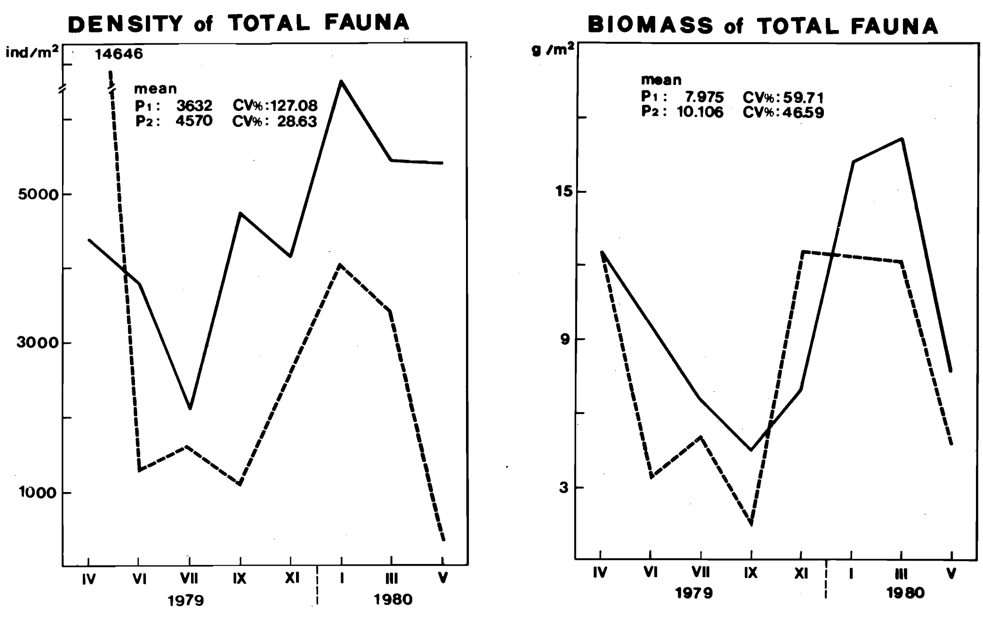


Fig. 4 – Seasonal variations in density and biomass of the total fauna in P1 (– – – –) and P2 (———). CV% = coefficient of variation.

P1 and P2 could be ascribing to a reduced feeding activity of fish on the bottom (Cataudella, pers.comm.).

Oligochaete densities, due almost exclusively to *Dero digitata,* showed significant numerical ($p < 0.01$) and weight ($p<0.05$) dominances in P2. As already observed by some authors (Lellàk, 1969; Ali *et al.,* 1977), numerical scarcity of oligochaetes in both ponds was probably related to competition with detritivorous chironomids.

Figure 5 shows the comprehensive low densities of cladocerans, ceratopogonids

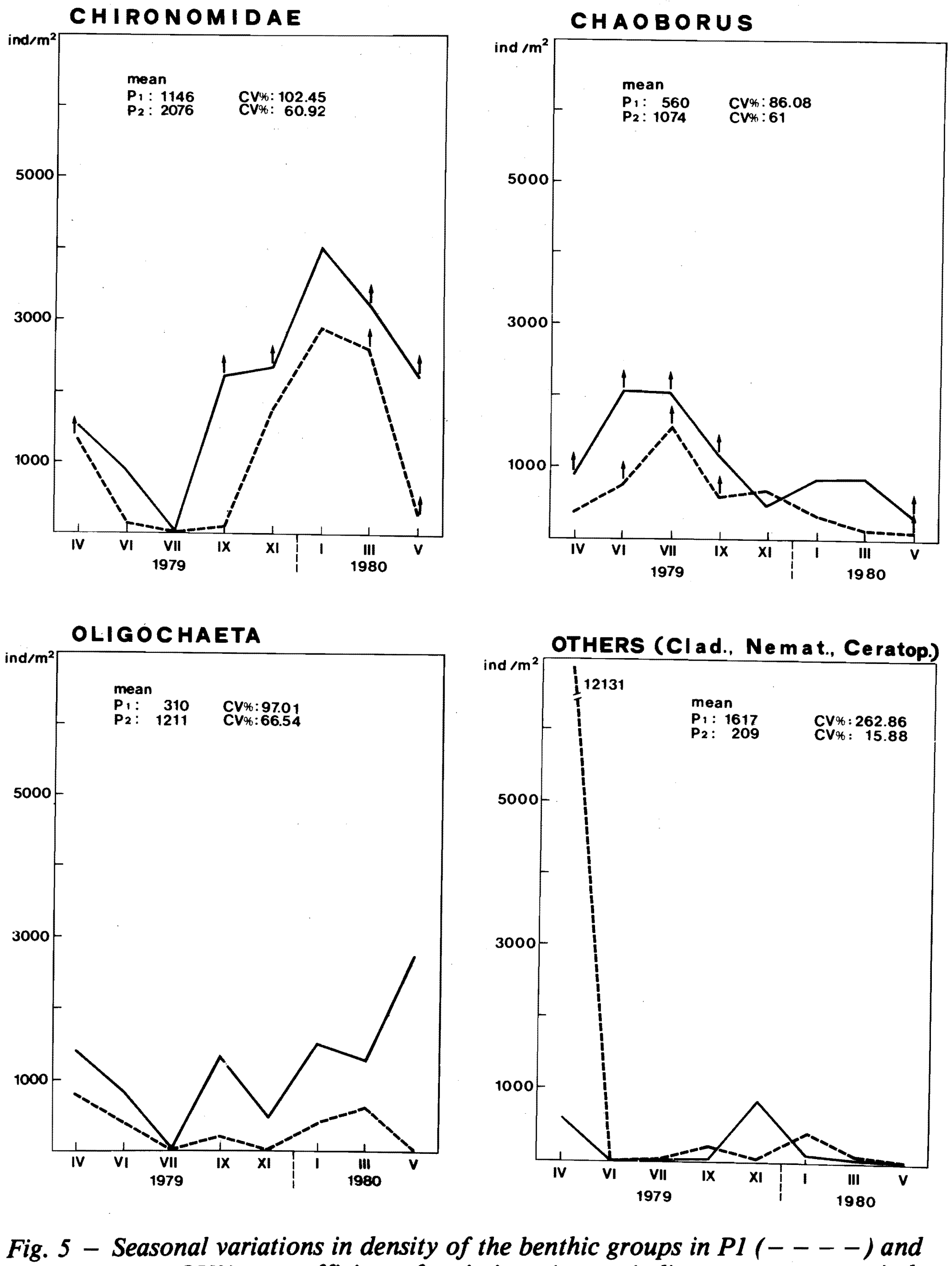


Fig. 5 – Seasonal variations in density of the benthic groups in P1 (– – – –) and P2 (————). CV% = coefficient of variation. Arrows indicate emergence period.

and nematodes, occurring in very low biomasses (Table 5). No significant differences were observed in density and biomass of the three groups between the ponds.

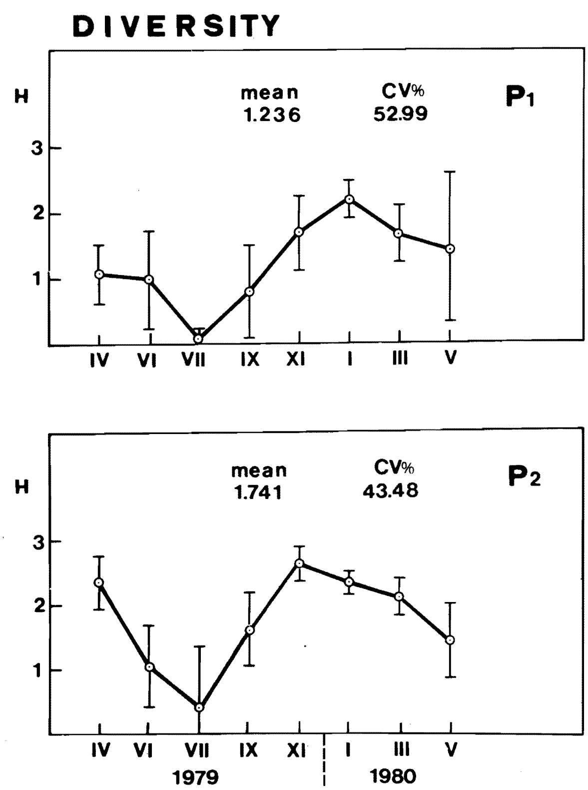
In both ponds, chironomids and chaoborids constituted the bulk of the total benthos. Similar conditions have been recorded in fishponds containing a high presence of temporary fauna (mainly chironomids) (Lellàk, 1969, 1978; Wròbel, 1972; Dimitrov, 1977). It is interesting to observe that the dominance of chironomids both determines a numerical instability of the benthic community and seems to increase fish production. Indeed, chironomid larvae are more easily accessible for fish compared to other organisms such as tubificids (Lellák, 1969, 1978) and have a particularly high protein content (Czeczuga and Gierasimov, 1978).

Moreover, seasonal variations of density and biomass (compare CV% values) of the total benthic fauna and of each group indicated a lower stability (persistence over time) of the community in P1 than in P2.

b) Diversity and similarity

The highest diversity (Fig. 6) was observed in November (in P2) and in January (in P1), mostly due to an increase in the number of chironomid taxa, and the lowest one in July, due to a strong simplification of the total communities. Evenness (Fig. 6) followed a trend similar to the diversity. T-test detected a significant difference ($p<0.05$) in diversity and evenness values between the ponds. The lower community diversification and the less stable diversity and evenness (compare CV% values) in P1 can be in agreement with the higher eutrophication in this pond.

The values of PSc showed an intermediate similarity between the benthic fauna of the two ponds (annual average value: 60.9%). The highest similarity was reached in summer (95.5%) due to the great simplicity of the benthic structure in both ponds.



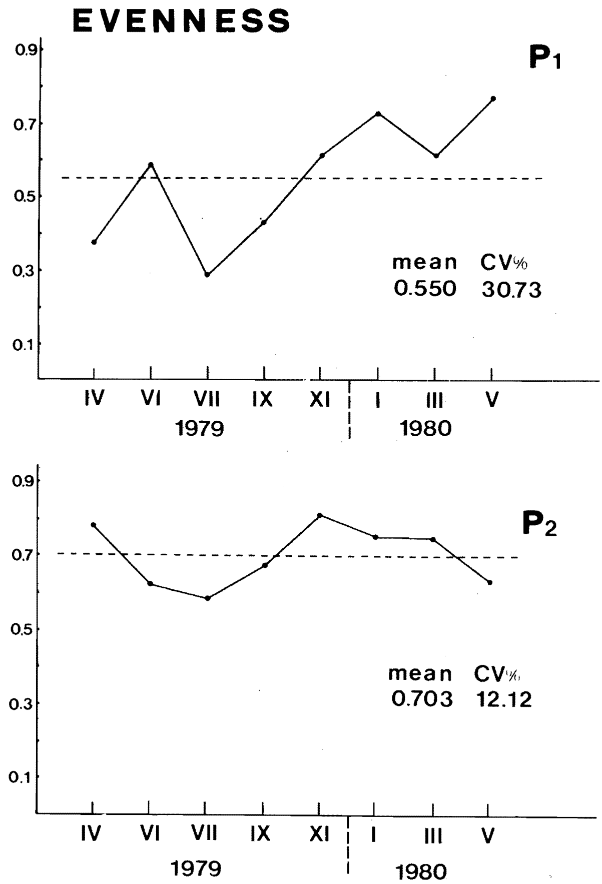


Fig. 6 – Seasonal variations of benthic diversity and evenness in the two ponds. CV% = coefficient of variation. 95% confidence limits are shown by vertical bars.

Concluding remarks

The analysis of the invertebrate fauna in the two fishponds allow us to define some ecological aspects. In both ponds we observed: a) planktonic and benthic communities composed of species typical of eutrophic waters and of a few others with wide ecological valence; b) low planktonic and benthic diversities and evenness, reflecting communities characterized by a few numerically prevailing species; c) benthic communities showing a small number of taxa with a great numerical fluctuation during the year and a strong reduction in summer; d) very high proportions of temporary fauna (Chironomidae and Chaoboridae) with respect to permanent benthos (Oligochaeta).

Although the similar morphological features and the same fertilization treatment of the two ponds, the more eutrophic pond showed: a) a planktonic community composed of lower densities of copepod calanoids (macrofilterers) and numerical dominances of rotifers and small cladocerans (microfilterers); b) a benthic community characterized by lower density and biomass of some groups, by lower diversity, evenness and stability, and by a slower chironomid recolonization of the bottom after summer anoxia.

Table 5. Seasonal variations of benthic biomass (g/m²) in the two ponds. Others: cladocerans, nematodes and ceratopogonids.

	1979					1980			
	IV	VI	VII	IX	XI	I	III	V	mean
P1									
Oligochaeta	0.427	0.222	0.000	0.011	0.006	0.051	0.124	0.004	0.106
Chironomidae	8.676	1.295	0.000	0.048	9.561	10.745	11.345	4.268	5.742
Chaoboridae	2.155	1.829	5.049	1.398	2.937	1.357	0.549	0.374	1.956
Others	1.175	0.000	0.010	0.012	0.016	0.144	0.019	0.024	0.175
P2									
Oligochaeta	0.808	0.211	0.066	0.144	0.099	0.221	0.318	0.680	0.318
Chironomidae	8.020	2.887	0.007	1.219	4.831	12.477	12.695	5.645	5.974
Chaoboridae	3.386	6.406	6.365	3.041	1.852	3.381	4.130	1.405	3.746
Others	0.306	0.000	0.000	0.010	0.079	0.097	0.049	0.018	0.070

Planktonic and benthic communities have long been traditionally used to monitor eutrophication in lakes and play an important role in fish food chain. Our results assume that the analyses of these communities can be a good tool to test the degree of eutrophication also in fishponds. Moreover, the knowledge of the seasonal composition, abundance and structure of these communities can indicate for each pond the best period for fry restocking and the possibility of introducing new fish species according to their food preferences.

ACKNOWLEDGEMENTS

This research was partially supported by a grant from the "Provincia di Roma". We are grateful to Dr. S. Cataudella for information regarding fish fauna and fertilization of the ponds, Dr. M. Seminara for technical collaboration in the study of benthos, Dr. L. Ferrero for providing chemical data, and the "Coop. A B C" for allowing us access to the ponds.

REFERENCES

Ali, S.; Motaharul Haque, A.S.M.; Openheimer, J.R. and Aziz, K.M. S. (1977) Oligochaete fauna of a fish pond and the role of physicochemical factors on their population. *J. Bangladesh Acad.Sci.* 1 : 89-95.

Bazzanti, M. and Seminara, M. (1987) Profundal macrobenthos structure as a measure of long-term environmental stress in a polluted lake. *Water, Air Soil Pollut.* 33 : 435-442.

Brooks, J.L. (1969) Eutrophication changes in the composition of zooplankton. In: G.A. Rohlich (Editor) *Eutrophication: Causes, consquences, correctives.* Nat.Acad.Sci. Washington D.C., pp. 236-255.

Bryce, D. and Hobart, A. (1972) The biology and identification of the larvae of the Chrionomidae (Diptera). *Entomologist's Gazette* 23 : 175-217.

Czeczuga, B. and Gierasimov, H. (1978) Aminoacids content in protein from larvae of some Chironomidae species. *Bull.Acad.Pol.Sci., Ser.Sci.Biol.* 26 : 527-530.

De Beauchamp, P.(1965) Classe de Rotifère. In: P.P. Grassè *Traitè de Zoologie, IV (III),* Masson et C[ie], Paris, pp. 1225-1379.

Dimitrov, M. (1977) Development of benthos in ponds under conditions of intensive polycultural rearing fish. *Proceedings Freshwater Fishery Research Station.* Plovdiv, 12 : 91-113.

Eason, G.; Cole, C.W. and Gettinby, G. (1980) *Mathematics and Statistics for Bio-Science.* Chichester: Ellis Horwood Limited, 578 pp.

Ferrara, O. and Mastrantuono, L. (1982) Composizione ed evoluzione dello zooplancton di due stagni artificiali da pescicoltura (Monterotondo, Lazio). *Riv. Idrobiol.* 21 : 113-123.

Fry, D.L. and Osborne, J.A. (1980) Zooplankton abundance and diversity in Central Florida grass carp ponds. *Hydrobiologia* 68 : 145-155.

Gliwicz, Z.M. (1977) Food size selection and seasonal succession of filter feeding zooplankton in a eutrophic lake. *Ecol. pol.* 25 : 179-225.

Grygierek, E. and Wasilewska, B.E. (1979) Possibilités de régulation des biocénoses des étangs à l'élevage des poissons. *Bull.Cent.Etud.Rech.sci., Biarritz* 12: 441-452.

Hillbricht-Ilkowska, A. (1966) The effect of different periods of utilization of fish ponds on the occurrence and abundance of plankton Rotatoria. *Ecol.pol.* 14 : 111-124.

Hillbricht-Ilkowska, A. and Wegleńska, T. (1970) Some relations between production and zooplankton structure of two lakes of a varying trophy. *Pol.Arch.Hydrobiol.* 17 : 233-240.

Hrbácek, J. (1977) Competition and predation, relation to species composition in freshwater zooplankton, mainly in Cladocera. In: J. Cairns (Editor) *Aquatic microbial communities.* Garland Publ. 353 pp.

Janicki, A.J.; Decosta, J. and Davis, J. (1979) The midsummer crustacean plankton communities of seven small impoundments. *Hydrobiologia* 64 : 123-129.

Lellák, J. (1969) The regeneration rate of bottom fauna population of the fish pond after wintering or summering. *Verh.Internat.Verein.Limnol.* 17 : 560-569.

Lellák, J. (1978) Population dynamics of the bottom fauna and its respects to the fish stock in the carp pond. *Verh.Internat.Verein.Limnol.* 20 : 2194.

Mc Naught, D.C. (1975) A hypothesis to explain the succession from calanoids to cladocerans during eutrophication. *Verh.Internat.Verein.Limnol.* 19 : 724-731.

Patalas, K. (1972) Crustacean plankton and the eutrophication of St. Lawrence Great Lakes. *J.Fish.Res.Bd. Canada* 29 : 1451-1462.

Pejler, B. (1957) Taxonomical and ecological studies on planktonic Rotatoria from Central Sweden. *Kungl.Svenska Vetenskapsakad. Handlingar* 7 : 5-52.

Pielou, E.C. (1969) *An introduction to mathematical ecology.* New York: Wiley-Intersciences, 286 pp.

Saether, O.A. (1979) Chironomid communities as water quality indicators. *Holarct. Ecol.* 2 : 65-74.
Seda, J. (1985) Biomass and species diversity of the macrobenthos of two carp ponds in Southern Moravia. *Vest.cs.Spolec.,zool.* 49 : 285-296.
Shaw, P.C. and Mark, K.K. (1980) Chironomid farming – a means of recycling farm manure and potentially reducing water pollution in Hong Kong. *Aquaculture* 21: 155-163.
Stenson, J.A.E. (1978) Relations between vertebrate and invertebrate zooplankton predators in some arctic lakes, *Astarte* 11 : 212-26.
Whiteside, M.C.; Doolittle, W.L. and Swindall, C.M. (1985) Zooplankton as food resources for larval fish. *Verh.Internat.Verein.Limnol.* 22 : 2523-2526.
Whittaker, R.H. and Fairbanks, C.W. (1958) A study of plankton and copepod communities in the Columbia Basin, southeastern Washington. *Ecology* 39 : 46-65.
Wróbel, S. (1972) Some remarks to the production of basic communities in ponds with inorganic fertilization. *Verh.Internat.Verein.Limnol.* 18 : 221-227.
Zaret, T.M. (1980) *Predation and freshwater communities.* New Haven and London: Yale University Press, 187 pp.
Zur, O. (1980) The importance of chironomid larvae as natural feed and as a biological indicator of soil condition in ponds containing common carp *(Cyprinus carpio)* and tilapia *(Sarotherodon aureus)*. *Bamidgeh* 32: 66-77.