ZOOBENTHOS ASSOCIATED WITH SUBMERGED MACROPHYTES IN LITTORAL AREAS OF LAKE VICO (ITALY): SOME RELATIONS BETWEEN FAUNA STRUCTURE AND WATER QUALITY

L. Mastrantuono

Department of Animal and Human Biology, University of Rome. Viale dell'Università 32, 00185 Roma. Italia.

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ABSTRACT

The invertebrate fauna associated with submerged macrophytes in some areas of Lake Vico was analysed following the intensification of agricultural practices in the surrounding land in the last decade. The fauna was qualitatively rich and quantitatively abundant. A total of 110 taxa were identified, widely distributed over all stations and quantitatively represented mainly by Crustacea, Nematoda and Chironomidae, and secondarily by several other groups accounting for quite high percentages. The analysis of structural parameters of the community indicated a satisfactory environmental quality in the zones considered. Some significant differences between stations pointed to the interest of qualitative and quantitative aspects of the community in the environmental monitoring of littoral lacustrine zones.

INTRODUCTION

The composition and distribution of the invertebrate fauna associated with submerged macrophytes was analysed in some littoral areas of Lake Vico, located close the cultivated lands surrounding the North part of the lake. The intensification of agricultural activities in the last decade pointed to the advisability of analysing the littoral biocoenosis in order to identify possible negative effects on littoral fauna, also considering the importance of the lake for fishing. Moreover, a study carried out in the same period and sites on the zoobenthos living in sandy shores (MASTRANTUONO & LA ROCCA, 1988) showed concrete evidence of a highly trophic condition in the zones directly exposed to the effects of the cultivations (hazel orchards), periodically subjected to treatments with fertilizers and pesticides.

Previous data refer to multidisciplinary research on chemical and biological aspects of the lake (BARBANTI *et* al., 1971). At that time it was classified as mesotrophic and in natural conditions, supported by the absence of important pollution sources. Littoral and sublittoral zoobenthos have been studied (NOCENTINI, 1973) with reference only to some zoological groups (mainly Oligochaeta, Chironomidae and Gastropoda) and considering as a whole the fauna associated with bottoms and submerged vegetation.

So, this analysis had the purpose both to define, as completely as possible, the composition of the meio- and macrofauna associated with submerged macrophytes, and to verify the role of some qualitative and quantitative aspects of the community in an evaluation of environmental quality of littoral lacustrine zones.

Owing to the high heterogeneity of both the fauna and the substratum and to the remarkable environmental variations of physico-chemical parameters, this community has traditionally been considered less significant than the bottom community in evaluating water quality. So, several authors (PIECZYŃSKI, 1973; SOSZKA, 1975; BIGGS & MALTHUS, 1982; BROWN *et* al., 1988) have adres-

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sed their attention principally to the relations between macrobenthic organisms and substratum. However, some indications referring to both invertebrates and macrophytes (OZIMEK & SIKORSKA, 1976; CLAKKE, 1979; LACHAVANNE, 1985; MASTRANTUONO, 1986, 1987) supplied useful elements to clarify the interest of the community in environmental monitoring.

MATERIAL AND METHODS

Lake Vico, located in a volcanic area at 510 m a.s.l., has a surface area of 12.081 km^2, a perimeter of 16.9 km and a maximum depth of 48.5 m. The water level is regulated by an effluent (Rio Vicano) artificially connected to the lake in the sixteenth century through an underground tunnel (fig. 1). This effluent caused the emersion of a wide part of land in the north of the lake. where the difference between the ancient shoreline and the present one is noteworthy (fig. 1, c). The lake is characterized by a small catchment-basin (40.93 km^2) and by a rain water flow largely dispersed on the lands. A few small affluents, which lie to the N and NE of the lake (fig. 1. r), pass through the cultivated soils (BARBANTI, 1969).

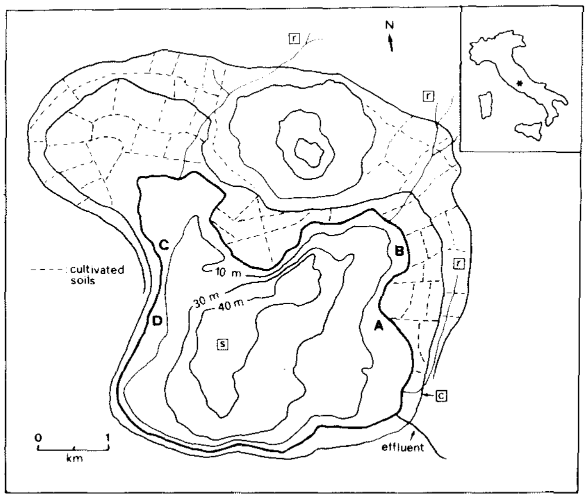

Figure 1.- Map of Lake Vico and location of the sampling stations (A. B, C, D).
Mapa del lago Vico y localización de los puntos de muestreo (A, B, C. D).

The lake is monomictic with summer stratification, the temperature varied from 6.5 °C (February) to 25 "C (August) in surface waters and from 6.2 "C to 9 "C in deep waters. Oxygen, high in winter at all depths (about 10 mg/l), showed a considerable depletion in summer below a depth of 30 m (0.2 mg/l). pH was alkaline (from 7.2 to 8.8 throughout the year) and the transparency was high (maximum value: 13 m; annual mean: 6.5 m). Small quantities of nutrients were observed in the water column 0-40 m (P total: 21 µg/l, N-NO_3: 13 µg/l, N-NH_3: 18 µg/l, N-NO_2: 0.8 µg/l, annual averages, station s, fig. 1), indicating an oligo-mesotrophic condition in the waters (O.E.C.D. report, 1982).

The samples of benthos were collected bimonthly from March 1985 to March 1986 in four sampling zones (A, B, C, D, fig. 1), chosen in areas differently influenced by the surrounding cultivations. Stations A and B were located close to the cultivated land, station C was farther away and station D was at a considerable distance from the cultivations. The sampling was carried out for each station and date at three depth intervals (0-3 m, 3-6 m, 6-10 m) using a sledge dredge (opening: 35 cm in width, 20 cm in height, mesh size: 180 µm). It was dragged for about 50 m, parallel to the shore, following a sinusoidal path at the selected depth interval. The material was preserved in 10 % formalin. In the laboratory the plants were washed and separated from all invertebrates. The macrobenthic organisms were sorted from the whole sample and the meiobenthic ones were counted in four subsamples that, together, represented 1116 of the entire sample.

The similarity between stations was evaluated using the qualitative QS coefficient (SØRENSEN, 1948) and the quantitative PSc index (RENKONEN, 1938). Community structure was analysed by means of the Shannon index (MARGALEF, 1957) and evenness index (PIELOU, 1966).

RESULTS

Submerged macrophytes

A total of 13 taxa were identified (table 1), whose distribution reached a maximum depth of about

Table I.- Submerged macrophyte composition in Lake Vico: seasonal variations and bathymetric distribution. + = present; o = rare; • absent: +++ abundant.
Composición de los macrófitos sumergidos del lago Vico: variaciones estacionales y distribución batimétrica. + = presente; o = rara; • ausente; +++ abundante.

	1985					1986		Depth interval (m)		
	III	*V*	*VII*	*IX*	*XI*	*I*	*III*	*0-3*	*3-6*	*6-10*
Halorrhaginaceae										
Myriophyllum spicatum	a	a	+++	+++	+++	+++	•	+	+	a
Polygonaceae										
Polygonum **amphyhrum**	•	•	o	o	•	•	•	+	•	•
Najadaceae										
Najm marina	•	o	o	o	•	•	•	+	+	+
Najm minor	•	•	o	o	•	•	•	+	+	+
Ranunculaceae										
Ranunculus sp	•	•	•	o	•	•	•	+	•	•
Potamogetonaceae										
Potarnogeton *pectinatus*	•	•	+++	+++	+++	+++	•	•	+	+
Potamogeton *pusillus*	•	•	o	o	•	•	•	+	•	•
Potarnogeton *lucens*	•	•	o	o	•	•	•	+	•	•
Potamogefon *crispus*	•	•	o	o	o	•	•	+	•	•
Characeae										
Chara sp. a	•	•	+++	+++	+++	•	•	+	+	+
Chara sp. b	•	•	o	•	•	•	•	+	•	•
Nitella sp.	•	•	o	•	•	•	•	+	•	•
. Ceratophyllaceae										
Ceratophyllum **demersum**	+++	+++	+++	+++	+++	+++	+++	•	+	+

12 m, in relation to the high transparency values. The vegetation was quantitatively quite abundant and reached its maximum species richness and quantitative presence in summer. The dominant taxa were *Myriophillum spicatum, Potamogeton pectinatus, Chara* sp. and *Ceratophyllum demersum*. This latter, always present during the year mainly at depths from 6 to 10 m, covered a good proportion of the littoral bottoms.

The macrophyte composition, according to categories proposed by LACHAVANNE (1985), can be considered indicative of a mesotrophic condition. This evaluation is based on the following observations: a) medium-high level of species richness; b) colonization to a depth of 10-12 m; c) association of taxa typical of better environmental conditions *(Ranunculus* sp., *Chara* sp.) with others tolerant the organic increase (P. *pectinatus,* P. *pusillus).*

Invertebrate fauna

The fauna included a total of 110 taxa belonging principally to Chironomidae (larvae), Oligochaeta and Cladocera, secondarily to Nematoda, Hydracarina, Gastropoda and Copepoda.

Crustacea, mainly Copepoda, were quantitatively predominant in all stations, followed by Nematoda and Chironomidae with lower percentages. Several other groups such as Oligochaeta, Gastropoda, Hydracarina, Turbellaria and Hydroida were present in comparatively high percentages at least in some stations (table 2).

Copepoda reached very high abundance mainly at stations A, B and C (range: 60.4-67.1 %). The dominant species were *Macrocyclops albidus, Eucyclops serrulatus* and *Eucyclops macruroides* (table 3), typical cyclopids of littoral zones, having a large geographical diffusion and a wide ecological range. The remarkable occurrence of pelagic cyclopids *(Cyclops abyssorum* and *Mesocyclops leuckarti)* represents a phenomenon already observed in Lake Nemi and in Lake Campotosto (MASTRANTUONO, 1986, 1987), and probably related to high mobility and particular biological cycles of these species.

Cladocera were composed of a high number of species (12) most of which attained a considerable percentage at all stations. *Acroperus harpae, Chydorus sphaericus, Alona affinis, Simocephalus vetulus* and *Eurycercus lamellatus* represented the dominant cladocerans. Other crustaceans (Ostracoda, Isopoda and Amphipoda) displayed a sporadic presence, while an uncommon abundance of the decapod *Palaemonetes antennarius*, disappeared from some lakes in Central Italy, was observed everywhere.

Among insects, Chironomidae constituted the most diversified and abundant group, although with moderate percentages. *Psectrocladius psilopterus, Tanytarsus, Labrundinia* and *Larsia* reached the highest percentages, while Chironominae had generally low presence. All chironomid taxa previously recorded (Nocentini, 1973) were found, and also some others belonging to Pentaneurini, Orthocladiinae and Chironominae. Other insects showed usual percentages for Central Italy (Lake Nemi, Lake Campotosto, Lake Albano), with the exception of Ephemeroptera, present in Lake Vico with higher number of taxa (6) and percentage values (range: 0.2-1.0 %).

Nematoda, comprising 8 taxa, were mostly represented at all stations by *Ethmolaimus pratensis*, a common nematode in Italy. High abundances of nematodes have been observed at station D (12.5 %) where also D. *asymphydorus* reached considerable percentages *(5* %).

Oligochaeta were present with a higher number of taxa (19) and lower percentage values than in other studied lakes in Central Italy. Only at station A were relatively high percentages of oligochaetes (9.4 %) were found, due to a conspicuous abundance of *Nais variabilis* (4.6 %), *Nais simplex* (3.4 %) and *Nais communis* (1.2 %).

Hydracarina and Gastropoda, which qualitatively constituted a representative part of the community (14 taxa as a whole), attained comparatively high percentages only at station D (1.1 % and 3.7 % respectively). The species of gastropods previously identified by Nocentini (1973) were found again, except all Planorbidae *(Hippeutis*

Table 2.- Total number of specimens collected at each station and at the three depth intervals (expressed as annual averages) and respective percentage values of the zoological groups at the sampling stations. **As** the samples are semi-quantitative. the numbers of specimens have reported as comparative data.
Número total de individuos recolectados en cada estación y en los tres niveles de profundidad (expresado en medias anuales) y porcentajes respectivos de los grupos zoológicos cn los puntos dc muestreo. Puesto que las muestras son semicuantitativas, el numero de individuos tienen valor comparativo.

	***Number of** specimens*				%			
Stations	***A***	*B*	*C'*	*D*	***A***	***B***	C	*D*
Hydroida	143	24	682	979	0.2	0.05	1.3	3.2
Turbellaria	168	157	230	289	0.3	0.3	0.5	0.9
Ncmatoda	1196	443	1798	3810	1.8	0.9	3.5	12.5
Oligochaeta	6076	119	274	153	9.4	0.2	0.5	0.5
Cladocera	16215	14946	12117	9040	25.0	29.0	23.3	29.6
Copepoda	39178	33574	34879	13969	60.4	65.2	67.1	45.7
Ostracoda	26	—	16	3	0.04	—	0.03	0.009
Isopoda	1	1	10	1	0.0008	0.001	0.02	0.004
Amphipoda	—	2	—	—	—	0.003	—	—
Decapoda	85	118	74	34	0.1	0.2	0.1	0.1
Ephemeroptera	143	78	297	307	0.2	0.2	0.6	1.0
Odonata	2	7	5	3	0.002	0.01	0.009	0.01
Heteroptera	—	1	8	—	—	0.001	0.01	—
D. Chironomidac	1213	1517	1256	522	1.9	2.9	2.4	1.7
D. Ceratopogonidae	—	3	1	2	—	0.006	0.0005	0.004
Diptera alia	1	5	5	—	0.0008	0.009	0.009	—
Trichoptera	18	13	73	6	0.02	0.02	0.1	0.02
Lcpidoptera	6	3	1	1	0.009	0.005	0.002	0.002
Hydracarina	201	175	128	328	0.3	0.3	0.2	1.1
Gastropoda	237	298	140	1125	0.4	0.6	0.3	3.7
Total	64908	51484	51994	30567				

Table 3.- List of the identified taxa and percentage values (calculated on the annual mcan abundances) at the sampling stations. * Genera and species not identified due to an accidental loss of material; imm. Tub. = immature Tubificids).
Lista de los taxones identificados y porcentajes (calculados sobre las abundancias medias anuales) en los puntos de muestreo. * Géneros y especies no identificados por perdida accidental de material; imm. Tub. = l'ubificidos immaduros.

Stations	*A*	*B*	*C*	*D*
Hydroida				
Hydra sp	0.2	0.05	1.3	3.2
Turbellaria				
Turbellaria undet.	0.07	0.002	—	0.03
Dugesia tigrina (Girard)	0.2	0.3	0.4	0.9
Polycelis sp.	—	0.001	—	—
Ncmatoda				
Plectus parvus Bastian	—	0.02	—	0.005
Ethmolaimus pratensis De Man	1.7	0.7	2.9	7.4
Tobrilus helveticus (Hofmanner)	0.007	0.07	0.2	0.04
Tobrilus gracilis (Bastian)	—		0.006	—
Dorylaimus asymphydorus Andrassy	—	—	—	5.0
Mesodorylaimus sp.	0.006	0.07	0.4	0.004
Laymidorus sp.	0.01	—		
Paractinolaimus macrolaimus (De Man)	0.2			
Oligochaeta				
Chaetogaster diaphanus (Gruithuiscn)	—	0.006	—	—
Chaetogaster diastrophus (Gruithuisen)	0.02	0.03	0.009	0.008
Chaetogaster limnaei Von Bacr	—	0.005	—	
Amphichaeta leydigii Tabucr	0.0006	0.002	—	
Nais communis Piguet	1.2	0.007	0.01	0.008
Nais christinae Kasparzak	—	0.01	—	0.1
Nais variabilis Piguet	4.6	0.04	0.1	0.03
Nais simplex Piguet	3.4	0.008	0.1	0.04
Nais barbata (Müller)	0.006	—	—	0.007
Pristina aequiseta Bourne	0.02	0.02	0.03	0.004
Pristinu longiseta Ehrenberg		0.002	—	0.008
Pristina foreli Piguet		0.01		
Pristina sp.	—	0.005		—
Stylaria lacustris (L.)	0.008	—	0.04	0.2
Dero digitata (Miiller)	0.02	0.04	0.1	0.008
Aulodrilus pluriseta (Piguet)	0.003			—
Psammoryctes albicola (Michaelscn)	0.0002	—	—	0.008
Imm. Tub. with hair chaetac	0.03	0.01	0.08	0.02
Imm. Tub. without hair chaetae	0.01	0.02	—	
Cladocera				
Daphnia sp.	0.3	0.5	0.09	0.3
Ceriodaphnia pulchella Sars	1.7	1.8	—	0.5
Simocephalus vetulus (O.F. Miiller)	0.9	4.7	4.9	6.6
Simocephalus serrulatus (Koch)	0.2	1.1	—	—
Bosmina longirostris (O.F. Müller)	—	0.001	—	0.2
Ilyocryptus sordidus Lièvin	0.002	0.008	—	—
Eurycercus lamellatus (O.F. Müller)	1.8	1.8	4.9	6.8
Acroperus harpae (Baird)	5.6	4.3	2.2	10.3
Alona affinis (Leydig)	9.9	0.8	5.5	0.6
Leydigia acanthocercoides (Fischcr)	—	0.003	—	
Chydorus sphaericus (O.F. Müller)	4.6	13.6	5.5	2.8
Alonella exigua (Lilljeborg)	—	0.4	0.2	1.5

Table 3.- Continuation

Stations	*A*	*B*	*C*	*D*
Copepoda				
Macrocyclops albidus (Jurine)	19.3	29.0	16.8	19.7
Eucyclops serrulatus (Fischer)	11.0	15.1	14.3	10.5
Eucyclops macruroides (Lilljeborg)	5.8	16.3	10.2	5.9
Paracyclops affinis (G.O. Sars)	0.2	0.3	—	—
Cyclops abyssorum Sars	23.0	3.7	24.1	0.8
Mesocyclops leuckarti (Claus)	0.6	0.8	1.1	8.8
Harpacticoida	0.6	0.02	0.6	0.04
Ostracoda				
Ostracoda undet.	0.04			—
Cypridopsis vidua (O.F. Müller)	—	—	—	0.008
Limnocythere inopinata (Baird)	—	—	0.004	—
Candona sp.	—	—	0.03	—
Isopoda				
Proasellus coxalis (Dollfus)	0.0008	0.001	0.02	0.003
Amphipoda				
Echinogammarus sp.		0.003	—	
Decapoda				
Palaemonetes antennarius (Milne Edwards)	0.1	0.2	0.1	0.1
Ephemeroptera				
Ephemeroptera undet.	0.07	0.05	0.06	0.2
Baetidae	0.03	0.02	0.03	0.09
Centroptilum	0.05	0.04	0.1	0.3
Cloeon	0.02	0.04	0.05	0.08
Procloeon	0.01	0.004	0.04	0.04
Caenis	0.02	0.0008	0.3	0.2
Odonata				
Pyrrhosoma nimphula (Sulzer)	0.002	0.01	0.009	0.01
Heteroptera				
Corixinae	—	0.001	0.01	—
Micronecta	—	—	0.002	—
Diptera Chironomidae				
Psectrocladius psilopterus gr	0.9	0.3	0.8	0.4
Cricotopus	0.01	0.1	0.05	
Hydrobaenus	0.001	0.003	0.009	—
Tanytarsus	0.3	1.2	0.6	0.2
Paratanytarsus	—	—	0.001	—
Procladius	0.03	0.07	0.1	0.05
Larsia	0.2	0.06	0.2	0.2
Labrutrdinia	0.2	0.2	0.08	0.7
Nilothauma		0.003	—	
Cryptochironomus	—	0.006	—	—
Pseudochironomus	0.003	0.02	0.03	0.06
Parachironomus	0.001	0.001	0.03	0.1
Chironomus	0.03	0.07	—	0.01
Polypedilum laetum gr.	0.008	0.006	—	
Polypedilum nubeculosum gr.	0.0004	—	—	
Polypedilum bicrenatum gr.	0.0004	0.006	0.03	—
Cryptocladopelma laccophila gr.	0.004	0.3	0.03	0.007
Cryptocladopelma lateralis gr.	0.001	—	0.003	—
Glyptotendipes	0.03	0.02	—	
Microtendipes	0.01	0.1	0.04	—
Paratendipes	0.03	0.1	0.07	0.03
Dicrotendipes	0.06	0.1	0.3	0.008
Phaenopsectra	0.006	0.03	—	—

Table 3.- Continuation

Stations	*A*	*B*	*C*	*D*
Diptera Ceratopogonidae	—	0.006	0.0005	0.004
Diptera alia	0.0008	0.009	0.009	—
Trichoptera				
Ecnomus tenellus (Rambur)	0.03	0.02	0.1	0.01
Agrypnra varia (Fabricius)	0.0002	—	—	—
Tinodes sp.	—	—	0.006	0.0005
Lepidoptera				
Petrophila sp.	0.009	0.005	0.001	0.002
Hydracarina				
Limnesia maculata (O.F. Müller)	0.1	0.2	0.2	0.5
Neumania spinipes (O.F. Müller)	0.1	0.07	*	0.5
Mideopsis orbicularis (O.F. Müller)	0.0008	0.0004	*	0.02
Forelia sp.	—	0.03	*	0.009
Lebertia sp.	0.02	—	*	—
Arrhenurus sp.	0.006	0.03	*	0.05
Hydrochoreutes sp.	0.05	0.02	*	0.04
Unionicola sp.	—	0.007	*	—
Gastropoda				
Physa acuta (Draparnaud)	0.04	0.05	0.01	0.003
Lymnaea auricularia (L.)	0.0004		0.01	—
Acroloxus lacustris (L.)	0.0002		0.002	0.001
Theodoxus fluviatilis (L.)	0.0004	0.003	0.002	0.001
Valvata piscinalis (Müller)	0.02	0.1	0.02	0.9
Bithynia tentaculata (L.)	0.2	0.4	0.2	2.3
Hydrobioidea	0.03	0.04	0.04	0.5

complanatus, Armiger crista and ***Anisus spirorbis),*** whilst Hydrobioidea represent a new record in the lake.

Distribution

A high number of taxa were observed mainly at stations A and B (841110 and 891110 respectively). Relatively high values of qualitative similarity (QS, table 4) revealed a fairly homogeneous distribution of taxa at the stations. A clear reduction of taxa belonging to insects was observed only at station D (table 5). The values of quantitative similarity (PSc, table 4) were rather high between stations A-C (77.6) and secondly B-C (64.9), whilst station D showed lower values of PSc. This situation reflects some qualitative and quantitative differences observed in the fauna composition at station D. As mentioned above, this zone of the lake was characterized qualitatively by a lower number of insect taxa, and quantitatively by considerable presence of Nematoda, lower predominance of Crustacea (principally Copepoda and Cladocera) and higher abundances of Hydroida, Hydracarina and Gastropoda.

Table 4.- Matrices of qualitative (QS) and quantitative (PSc) similarity between stations. PSc have been calculated on the annual mean abundances.
Matriz de similaridad cualitativa (QS) y cuantitativa (PSc) entre las estaciones de muestreo. El PSc se ha calculado a partir de las abundancias medias anuales.

(QS)	*A*	*B*	*C*	*D*	*(PSc)*	*A*	*B*	C	*D*
A	—	75.1	77.1	74.3		—	58.4	77.6	53.7
B		—	74.6	70.8			—	64.9	56.3
C			—	79.4				—	57.8
D				—					—

The bathymetric distribution of taxa (table 5) showed a higher species richness in the marginal area (0-3 m) due, for the most part, to the number of insect taxa, which decreased from 34 to 23 taxa at greater depths. Diversity and evenness va-

Table 5.- Distribution of the number of taxa at the depth intervals and at the four stations. * Hydracarina not identified.
Distribución del número de taxones en los distintos intervalos de profundidad en cuatro estaciones de muestreo. * Hidrácaros no identificados.

	Number of taxa				Number of taxa			
	Total	0-3 m	3-6 m	6-10 m	A	B	C	D
Hydroida	1	1	1	1	1	1	1	1
Turbellaria	3	2	2	3	2	3	1	2
Nematoda	8	5	7	4	5	4	4	5
Oligochaeta	19	15	11	11	13	15	8	12
Cladocera	12	9	8	11	9	12	7	9
Copepoda	7	7	7	6	7	7	6	6
Ostracoda	4	2	3	2	1	—	2	1
Isopoda	1	1	1	—	1	1	1	1
Amphipoda	1	—	1	—	—	1	—	—
Decapoda	1	1	1	1	1	1	1	1
Ephemeroptera	6	6	6	5	6	6	6	6
Odonata	1	1	1	1	1	1	1	1
Heteroptera	2	2	—	—	—	1	2	—
D. Chironomidae	23	19	18	16	20	20	16	11
D. Ceratopogonidae	1	1	1	—	—	1	1	1
Diptera alia	1	1	1	—	1	1	1	—
Trichoptera	3	3	2	1	2	1	2	2
Lepidoptera	1	1	1	—	1	1	1	1
Hydracarina	8	6	8	7	6	7	1*	6
Gastropoda	7	7	7	5	7	5	7	6
	110	90	87	74	84	89	69	72

lues also showed a clear tendency to a progressive decrease with depth, particularly between the depth intervals 0-3 and 3-6 m (table 6).

Therefore, these differences showed a more complex and rich community in marginal areas. This phenomenon can be considered typical of wide littoral areas, weak bottom slope and stable water level. In fact, a narrow, steep littoral belt seems to cause higher similarity (in species richness and diversity) between different depth intervals (MASTRANTUONO, in prep.), whilst water level fluctuations induce the opposite trend, characterized by an increase in species richness, diversity and abundances at greater depths (GRIMÅS, 1965; MASTRANTUONO, 1987).

DISCUSSION

The analysis of the biocoenosis associated with submerged macrophytes in the examined zones of

Table 6.- Number of taxa, Shannon index (H) and evenness index (e) (calculated on the annual mean abundances) at the depth intervals of the sampling stations.
Numero de taxones, índice de Shannon (H) e índice de uniformidad (calculado a partir de las abundancias medias anuales) en los distintos intervalos de profundidad de las estaciones de muestreo.

	A			B			C			D		
	taxa	H	e	taxa	H	e	taxa	H	e	taxa	H	e
0-3 m	67	3.6	0.59	58	3.6	0.61	56	3.3	0.57	48	3.9	0.69
3-6 m	56	3.2	0.55	51	3.0	0.52	53	2.9	0.50	50	3.6	0.62
6-10 m	55	3.2	0.55	56	2.9	0.50	41	2.6	0.49	50	3.5	0.62

the lake revealed a community which was qualitatively rich and quantitatively rather abundant. A total of 110 taxa were identified, well distributed within numerous zoological groups and largely represented in all stations.

The fauna was mainly composed of widely diffused and euryoecious taxa. This aspect, which generally characterizes the community associated with submerged macrophytes in lakes, has always raised difficulties in the identification of bioindicator species and of structural parameters of the community which would be useful to water quality evaluation. Nevertheless, in this regard particular attention has been addressed principally to Cladocera and Gastropoda, so far representing the main organisms to which a certain role can be assigned as bioindicators in littoral lacustrine zones (GLIWICZ, 1969; CLARKE, 1979; MOUTHON, 1981; ØKLAND, 1983).

The importance of microfilterer cladocerans in a trophic evaluation may be related to their ability to use minute particles (tripton and seston) as food source. An increase in organic matter in the water generally induces both a diminution of cladoceran species (due to the disappearance of macrofilterers) and an increase in density of microfilterers (GLIWICZ, 1969). This phenomenon clearly emerged in the polluted Lake Nemi (MASTRANTUONO, 1986), where only three littoral cladocerans were found and *Chydorus sphaericus* alone accounted for most of the total fauna. On the contrary, Lake Vico was characterized, like the oligo-mesotrophic Lake Campotosto, by a high number of cladoceran species (12), for the most part macrofilterers (primarily S. *vetulus*, *S. serrulatus*, *E. lamellatus*, *Daphnia* sp. and secondarily *A. affinis* and *A. harpae)* which showed notable abundance at all stations. Moreover, relatively low percentages of the microfilterer *Chydorus sphaericus* (range: 2.8-13.6) were observed in the lake, particularly at station D. The relative abundance of this species seems to constitute a indicative parameter of trophic level, considering the satisfactory agreement with indications founded on the analysis of other parameters such as macrophyte composition, chemical data and diversity values (MASTRANTUONO, 1986, 1987).

According to a classification of sensitivity to pollution proposed by MOUTHON (1981) for gastropods, all taxa found in Lake Vico, excluding

Table 7.- Values of some parameters of the community at the sampling stations. H and e have been calculated on cumulative data of the three depth intervals.
Valores de algunos de los parametros de la comunidad en los puntos de muestreo. H y e se han calculado en base a datos acumulativos de los tres intervalos de profundidad.

	Stations			
	A	*B*	*C*	*D*
Colonized belt (m)	0-8	0-8	0-8	0-10
Species richness	84	89	69	72
Chydorus sphaericus (%)	4.6	***13.6***	5.5	2.8
Hydrobioidea (%)	0.03	0.04	0.04	0.5
Total fauna	64908	51484	51994	30567
Diversity ([I)	3.6	3.3	3.5	3.9
Evenness (c)	0.57	0.52	0.57	0.65

Hydrobioidea, belong to pollutant-resistant levels. Hydrobioidea, considered sensitive to environmental modifications, have so far been found in Central Italy only in the largest lakes (Lake Bracciano and Bolsena; NOCENTINI, 1973). In Lake Vico very low percentages occurred at stations A, B and C, close to the cultivated lands, and only at station D was a more conspicuous presence of these organisms (0.5 %) evidenced.

On the ground of the results obtained in this study the community structure in the examined areas of Lake Vico is characterized by: a) high species richness (110 taxa), b) high number of cladoceran species (12), c) relatively low percentages of the microfilterer *Chydorus sphaericus,* d) medium-high values of relative abundance of total fauna, e) coexistence of tolerant molluscan species with others sensitive to environmental modifications, f) relatively high values of diversity (range: 2.6-3.9) and evenness (range: 0.49-0.69). These parameters taken together can be considered indicative of a satisfactory environmental quality in the littoral zones examined. Such an evaluation is in good accordance with the indications of oligo-mesotrophy founded on macrophyte composition and chemical data.

So, the influence of the cultivations still appears to be reduced in littoral waters, also at the stations located close the cultivated lands (A, B, *C)*, where the sandy sediments appeared clearly affected by an organic enrichment (MASTRANTUONO & LA ROCCA, 1988). This different result can be easily explained considering that the zoobenthos associated with submerged macrophytes generally shows a much higher degree of resistance (homeostasis) to environmental modifications than communities associated to littoral sediments, following the high dispersion of physico-chemical factors in the waters.

Nevertheless, the comparison of the values of the more significant parameters at the stations (table 7) showed the different situation of station D, characterized by lower percentages of *Chydorus sphaericus*, low values of total fauna, high values of diversity and evenness and higher abundances of Hydrobioidea. All these characteristics are indicative of a low trophic level in this zone of the lake, according to the results obtained in the study of the zoobenthos living in sandy shores.

The differences observed in the lake between the station unaffected by the surrounding cultivations and the remaining ones confirm the importance of the above mentioned parameters of the community in water quality evaluation, in agreement with analogous results obtained in previous studies. These elements encourage further analyses specifically addressed to those particular aspects of this biocoenosis which can be used for a more accurate evaluation of the environmental quality in littoral lacustrine zones.

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