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Sublittoral and profundal chironomid (Diptera) communities of Lake Vico (Central Italy) : relationship to the trophic level

M. Seminara[1]
M. Bazzanti[1]
C. Tamorri

Keywords : Chironomidae, community structure, depth distribution, trophic level, lake, Italy.

Sublittoral and profundal chironomid community structure, depth distribution and relationship to the trophic level of the waters were investigated in Lake Vico (Central Italy) during 1985-1986. PCA analysis indicated a depth-dependent group of true profundal stations at 20, 30 and 40 m depths, characterized by *Micropsectra, Procladius, Microtendipes, Tanytarsus* and *Paratendipes,* and a group of 10 m stations, characterized by *Cryptochironomus, Polypedilum bicrenatum* gr., *Cladopelma lateralis* gr. and *C. laccophila* gr., representing the sublittoral features of this depth. In agreement with the chemical data, the chironomid community indicated a mesotrophic condition of Lake Vico, with a tendency towards an increasing trophic level in the deepest zone. A significant role in revealing future trophic changes in the lake may be attributed to the key-indicator *Micropsectra.*

Communautés de Chironomidés (Diptera) des zones sublittorale et profonde du Lac Vico (Italie Centrale) : relation avec le niveau trophique.

Mots clés : Chironomidés, structure des communautés, distribution selon la profondeur, niveau trophique, lac, Italie.

La structure des communautés sublittorale et profonde des Chironomidés, leur distribution selon la profondeur et leur relation avec le niveau de trophie du Lac Vico ont été étudiées au cours des années 1985-1986. L'Analyse en Composantes Principales permet de différencier un groupement des stations profondes à − 20, − 30 et − 40 m d'un groupement des stations de la zone sublittorale à − 10 m. Le premier groupement est caractérisé par les genres *Microspsectra, Procladius, Microtendipes, Tanytarsus* et *Paratendipes* et le deuxième par les genres *Cryptochironomus, Polypedilum bicrenatum* gr., *Cladopelma lateralis* gr. et *C. laccophila* gr. Corrélativement aux données chimiques, la communauté chironomidienne correspond bien à l'état mésotrophique du lac avec une tendance à l'augmentation de la trophie dans la zone profonde. Le rôle significatif du genre *Micropsectra* dans la détection de futurs changements trophiques du lac est souligné.

1. Introduction

The family Chironomidae constitutes a widespread, diverse and abundant group of invertebrates inhabiting all freshwater ecosystems. Their community structure has traditionally been investigated, and many workers underlined their relevant role both in lake metabolism and water quality assessment (Warwick 1975, Gallepp et al. 1978, Granéli 1979, Saether 1979, Wiederholm 1980, Gardner et al. 1983, Wasson 1984, Seminara & Bazzanti 1988).

In European countries some topics involving chironomids, e.g. community structure, composition, phenology and seasonal variations, have been long and extensively studied, while other aspects, e.g. depth distribution, are reported less frequently in literature (Laville 1971, Aagaard 1978, Lindegaard 1980, Kansanen et al. 1984, Gerstmeier 1989 a, Heinis 1989, Heinis et al. in press).

This paper deals with the sublittoral and profundal chironomid communities of Lake Vico (Central Italy) in order to examine their structure, their depth distribution, and their relationships with the trophic status of the lake. The results of this paper also contribute to the knowledge of this dipteran family in

1. Dipartimento di Biologia Animale e dell'Uomo, Università « La Sapienza », v. le dell'Università 32, 00185 Roma, Italia.

Central Italian lakes (Nocentini 1973, Bazzanti 1981, Bazzanti & Loret 1982, Mastrantuono 1986, Bazzanti & Seminara 1987 a & b, Mastrantuono 1987, Mastrantuono & La Rocca 1988, Seminara & Bazzanti 1988). This study forms part of a wider research (P.I.M. ; Piano Integrato Mediterraneo) aimed at assessing the lake water quality and at an adequate strategy to improve local fish management. Data about the whole profundal benthic community of the lake will be published elsewhere.

2. Study area and methods

Lake Vico (*Fig.* 1) is a volcanic water body surrounded by both agricultural and non-anthropized lands. It is situated about 50 km North of Rome in the volcanic area of the Cimini Mountains, where a Regional Nature Reserve including the lake and the neighbouring area was instituted in 1982. The lake has a catchment area of 28.05 km^2 and a theoretical water renewal time of about 17 years (Barbanti 1969). Specific morphometric data are reported in figure 1. Commercial fish stock (mainly coregonids) is managed by means of artificial reproduction of the autochthonous breeding individuals. Moreover, the lake waters are utilized for sportfishing and recreational purposes. In the surrounding grounds a massive use of fertilizers and pesticides for agricultural practices was recorded over the last two decades. Lake Vico was first studied by the Hydrobiological Institute of Pallanza during 1969-1970 (Barbanti et al. 1971). The results, based on both physico-chemical and biological data, indicated a mesotrophic condition of the waters. In 1985-1986, a similar content of nutrients but a higher orthophosphate concentration and a more pronounced summer-autumn deoxygenation in the deepest layers of the hypolimnion were observed (Table I). During the study, pH ranged from 7.1 to 8.7, temperature from 6.2 to 25° C and transparency from 3.5 to 12.6 m.

Table I. Selected chemical parameters monthly registered from May 1985 to March 1986 in the waters of Lake Vico (Nicotra, 1987).

Depth (m)		0	10	20	30	40
	min.	8.2	9.0	4.2	1.0	0.2
Oxygen (mg/l)	mean	9.4	10.3	8.4	6.2	5.3
	max.	11.0	12.2	11.2	11.1	11.0
	min.	9	10	11	12	11
Total P (μg/l)	mean	13.7	15.8	19.1	18.9	35.2
	max.	20	22	28	25	125
	min.	3.0	2.0	4.0	4.1	4.0
P-PO4 (μg/l)	mean	6.7	5.6	6.4	7.1	19.4
	max.	10.0	9.0	11.0	13.1	66.0
	min.	2.0	2.0	4.0	4.0	6.0
N-NO3 (μg/l)	mean	6.9	7.6	8.6	13.7	28.4
	max.	14.0	12.0	17.0	38.0	77.0
	min.	0.1	0.1	0.0	0.1	0.0
N-NO2 (μg/l)	mean	0.4	0.3	0.4	0.7	2.1
	max.	0.8	0.8	1.0	1.8	14.0
	min.	1.0	2.0	2.0	3.0	1.0
N-NH3 (μg/l)	mean	3.4	3.5	4.8	13.5	61.6
	max.	6.0	6.0	14.0	36.0	243.0

Benthic samples were collected bimonthly from May 1985 to March 1986 in three sites of the lake (*Fig.* 1). Sampling depths were established at 10, 20, 30 and 40 m at site A, and at 10 and 20 m at sites B and C. At each depth and date triplicate samples were obtained by an Ekman grab (area : 225 cm^2), for a total of 144 samples during the study. Material was filtered through a 0.28 mm mesh screen and preserved in 10 % formalin. Chironomid larvae and pupae were hand-sorted, counted, weighed and then identified at the genus or species group level. Additional samples were collected for laboratory larval rearing in order to obtain specific adult identification of the most diffused taxa. The oligochaete/chironomid ratio (O/O + C%, Wiederholm 1980) was adopted to point out the trophic status of Lake Vico. The Shannon diversity index (Pielou 1969) was calculated as a synthetic expression of chironomid community structure. Principal Component Analysis (PCA), largely utilized in benthic studies on freshwater ecosystems to evidence environmental gradients (Rae 1985, Bradt & Berg 1987, Glazier & Gooch 1987, Allison & Harvey 1988, Diaz 1989, Reynoldson 1990), was carried out on the log (x + 1) transformed densities to detect relationships between depths and chironomid assemblages. Linear correlations were made on log (x + 1) (Elliott 1977) or arcsin $\sqrt{P}$ (Sokal & Rohlf 1973) transformed absolute and relative data, respectively. Statistical treatments were performed using SPSS/PC software.

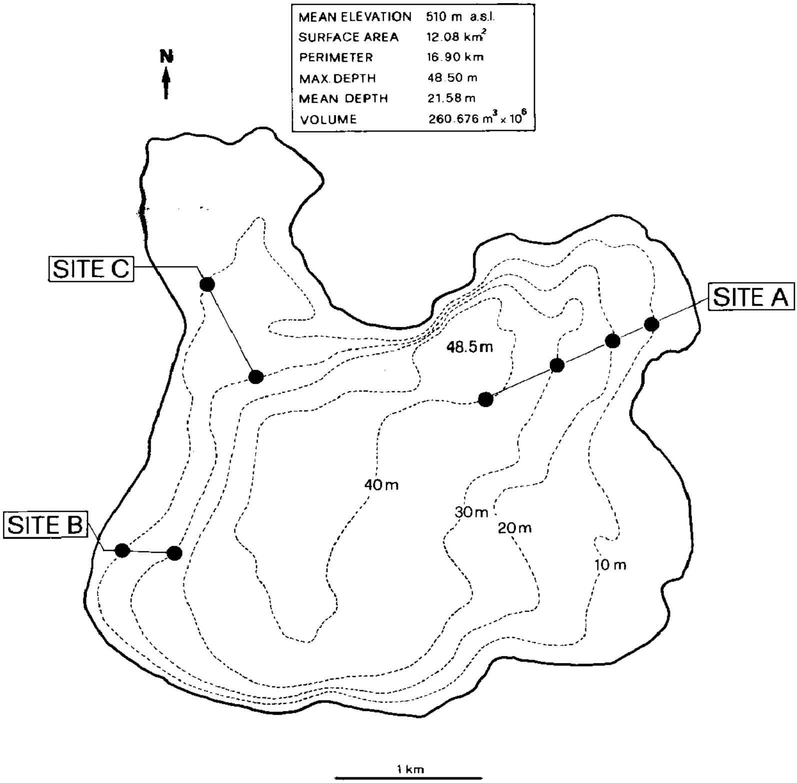

Fig. 1 : Morphometric data and sketch map of Lake Vico with sampling sites (A, B and C) and depths (from Barbanti, 1969).

3. Results

About 7000 chironomid larvae and pupae belonging to 15 taxa were collected and identified during the study (Table II). Sublittoral and profundal chironomids of Lake Vico accounted, on average, for 36.04 % of density of the total benthic fauna, with a minimum of 0.3 % and a maximum of 76.0 %. The minimum, mean and maximum percentage values on total fauna biomass were 0.2 %, 36.25 % and 80.6 %, respectively. Seasonal values of chironomid densities and biomasses at sampling sites and depths are reported in figure 2. The extreme values registered were 15 and 12 976 ind/m^2 for densities, 0.01 and 11.63 g/m^2 for biomasses. In all three sites, the highest densities and biomasses generally occurred at 20 m depth and the lowest ones at 40 m depth, whereas intermediate values were recorded at 10 and 30 m depths. Both density and biomass decreased with increasing depth ($r = -0.53$, $p < 0.001$ and $r = -0.43$, $p < 0.01$, respectively). The number of taxa showed the highest values at 10 m and the lowest at 40 m, significantly decreasing with depth ($r = -0.74$, $p < 0.001$). Diversity ranged from 0, sometimes recorded at 30 and 40 m, to 2.54 occurring at 10 m (Table II), and was inversely correlated to the depth ($r = -0.70$, $p < 0.001$). The most frequent and abundant genera (Table II and *Fig.* 3) were *Procladius, Tanytarsus* and *Micropsectra*, followed by *Paratendipes* and *Microtendipes*. The remaining taxa were less frequent and/or present in low numbers and percentages. *Polypedilum nubeculosum* gr., *P. bicrenatum* gr., *Parachironomus, Chironomus* sp. and Pentaneurini were present only in 10 m samples (Table II).

The oligochaete/chironomid ratio (Table II) generally showed annual mean values from 44.3 % to 82.4 % at 10 and 20 m depths, and increased at 30 and 40 m, where the theoretical maximum was reached at the end of the thermal stratification. The values of this index significantly increased with increasing depth ($r = 0.46$, $p < 0.001$). An inverse correlation ($r = -0.57$, $p < 0.001$) was found between chironomid diversity and oligochaete/chironomid ratio.

The statistical comparisons performed on several parameters of the community structure (i.e. density of taxa, percentages, diversity, total density and biomass, etc.) by means of the non-parametric Wilcoxon test (Eason et al. 1980) did not suggest any clear pattern in the chironomid spatial distribution and seasonal variation among the three sites, so that such aspects are not considered.

The PCA analysis (*Fig.* 4, Table III) was performed on a set of 48 data (8 depth stations per 6 sampling visits). Taxa occurring with percentages lower than 1 % of the total chironomid fauna were not considered (taxa 1, 2, 12, 15 in Table II). The first two principal components accounted for 53.5 % of the total variance. The second factor separates most of the 10 m stations from those situated in the deepest area of the lake. The latter stations are ordered along factor 1 according to a gradient of depth. In fact, excluding 10 m stations from the previous pool of data, there is a highly significant correlation ($r = 0.89$, $p < 0.001$) between depth and distances of the remaining sampling stations from factor 2.

Table III : Factor loadings of chironomid taxa from Lake Vico. Values lower than | 0.50 | were arbitrarily neglected.

Factors	Principal 1	Components 2
Eigenvalue	3.98	1.90
Variance accounted for (%)	36.2	17.3
Variables		
Micropsectra	0.85	
Procladius	0.81	
Microtendipes	0.73	
Tanytarsus	0.72	
Paratendipes	0.51	
Cryptochironomus		0.85
Polypedilum bicrenatum gr.		0.76
Cladopelma lateralis gr.		0.57
C. laccophila gr.		0.55

4. Discussion

Chironomids of Lake Vico were essentially characterized by densities and biomasses strongly infuenced by increasing depth. Diversity values indicated a more diversified community at 10 and 20 m, whereas a more simplified and monotonous structure was generally present at 30 and 40 m, especially during the stratification period when the oxygen deficit comes into effect.

A clear picture of the depth distribution of chironomids is provided by the plot of the sampling stations derived from the PCA analysis. It describes

Table II : Mean and range of density, number of taxa, diversity and oligochaete/chironomid ratio of sublittoral and profundal chironomids at the sampling sites and depths in Lake Vico. *Procladius choreus* (Meigen), *Cladopelma virescens* (Meigen), *Microtendipes* cf. *pedellus* (DeGeer) and *Paratendipes albimanus* (Meigen) resulted from the adult identification.

Sites		A				B		C	
Depth (m)		10	20	30	40	10	20	10	20
1. *Psectrocladius*	min.	0	0	0	0	0	0	0	0
	mean	3	3	0	0	0	0	10	0
	max.	15	15	0	0	0	0	44	0
2. Pentaneurini	min.	0	0	0	0	0	0	0	0
	mean	0	0	0	0	5	0	0	0
	max.	0	0	0	0	15	0	0	0
3. *Procladius*	min.	119	474	59	0	30	400	192	222
	mean	763	1017	447	45	790	938	675	1439
	max.	2222	1600	1230	119	2074	1807	1200	4385
4. *Tanytarsus*	min.	0	267	0	0	15	74	15	548
	mean	264	1538	67	30	296	360	635	913
	max.	548	3481	252	89	1363	844	1615	1422
5. *Micropsectra*	min.	0	207	0	0	0	30	0	44
	mean	27	906	240	32	25	281	30	1743
	max.	89	2074	963	119	103	607	103	7599
6. *Cladopelma laccophila* gr.	min.	0	0	0	0	0	0	0	0
	mean	64	25	3	0	67	5	35	12
	max.	119	119	15	0	341	15	89	44
7. *C. lateralis* gr.	min.	0	0	0	0	0	0	0	0
	mean	106	30	3	0	101	36	47	5
	max.	533	74	15	0	489	124	133	15
8. *Polypedilum bicrenatum* gr.	min.	0	0	0	0	0	0	0	0
	mean	20	0	0	0	17	0	5	0
	max.	74	0	0	0	74	0	30	0
9. *P. nubeculosum* gr.	min.	0	0	0	0	0	0	0	0
	mean	34	0	0	0	5	0	0	0
	max.	133	0	0	0	30	0	0	0
10. *Microtendipes*	min.	0	59	0	0	0	0	0	0
	mean	121	400	52	3	5	49	57	52
	max.	281	1249	148	15	30	89	222	148
11. *Paratendipes*	min.	15	0	0	0	0	15	15	15
	mean	193	64	10	0	72	274	354	37
	max.	519	133	59	0	296	785	1407	74
12. *Parachironomus*	min.	0	0	0	0	0	0	0	0
	mean	3	0	0	0	0	0	3	0
	max.	15	0	0	0	0	0	15	0
13. *Cryptochironomus*	min.	0	0	0	0	0	0	0	0
	mean	30	15	0	0	8	3	70	0
	max.	103	44	0	0	30	15	207	0
14. *Chironomus plumosus* gr.	min.	0	0	0	0	0	0	0	0
	mean	358	22	10	0	25	72	30	17
	max.	771	59	30	0	74	163	59	44
15. *Chironomus* sp.	min.	0	0	0	0	0	0	0	0
	mean	7	0	0	0	0	0	0	0
	max.	44	0	0	0	0	0	0	0
Number of taxa	min.	4	6	1	1	3	6	6	4
	mean	9	8	4	2	7	7	8	6
	max.	11	9	5	3	9	8	10	8
Diversity	min.	1.32	1.29	0.00	0.00	1.30	1.31	1.33	1.19
	mean	2.17	1.79	1.16	0.58	1.82	1.68	1.89	1.55
	max.	2.54	2.22	1.93	1.35	2.48	2.17	2.48	1.96
O/O+C%	min.	55.2	13.9	50.0	81.1	41.7	71.3	37.0	40.4
	mean	61.8	44.3	82.6	93.8	82.4	79.2	57.1	65.6
	max.	82.5	60.2	100.0	100.0	97.5	87.2	92.8	95.7

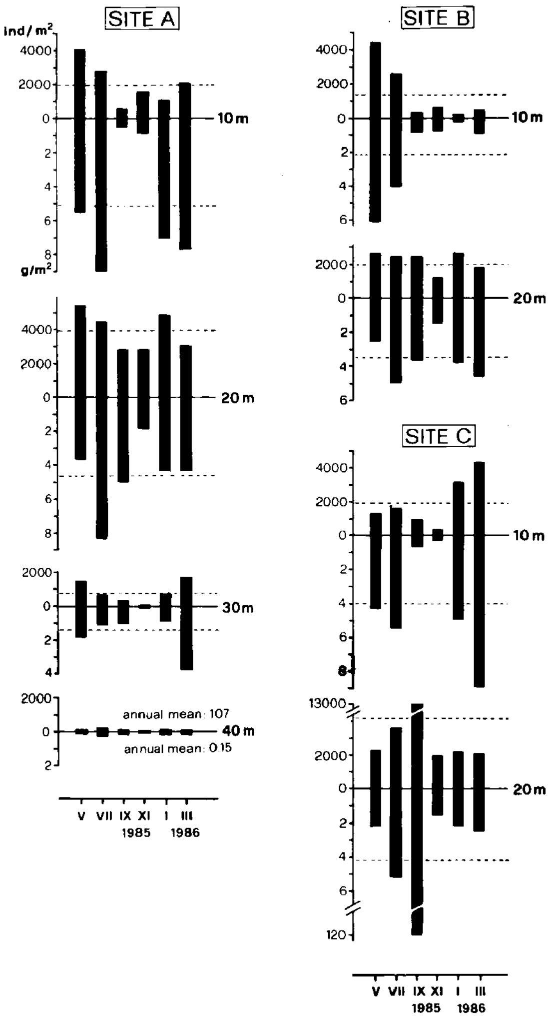

Fig. 2 : Densities (ind/m²) and biomasses (g/m²) of the total chironomids at sites A, B and C and depths. Interrupted lines indicate annual mean values.

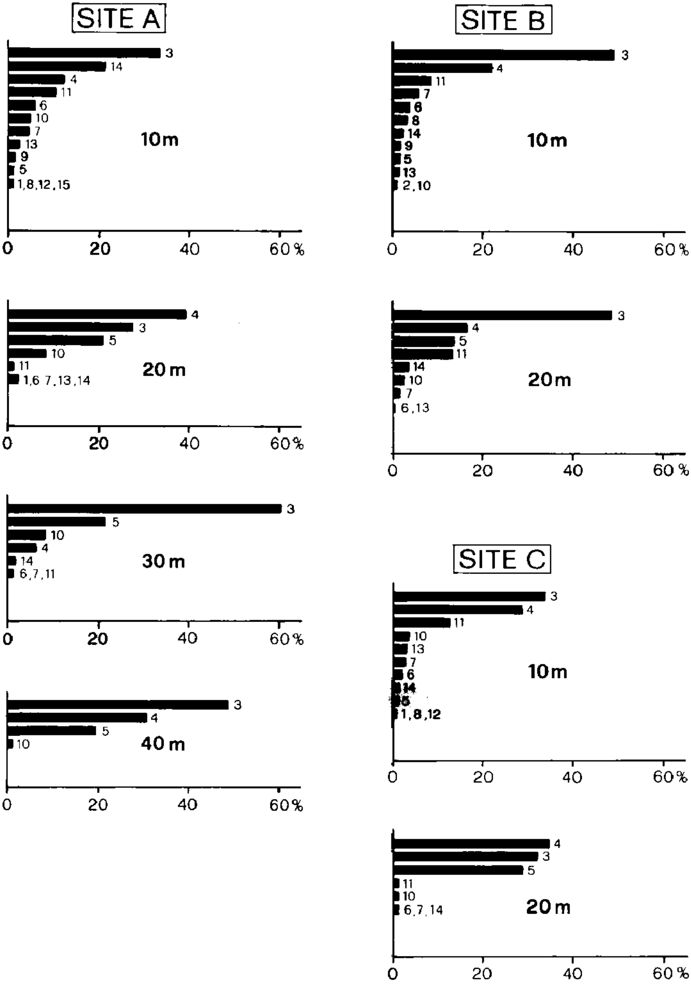

Fig. 3 : Annual mean percentages of taxa on the total chironomids at the sampling sites and depths. Taxa numbered as in Table II.

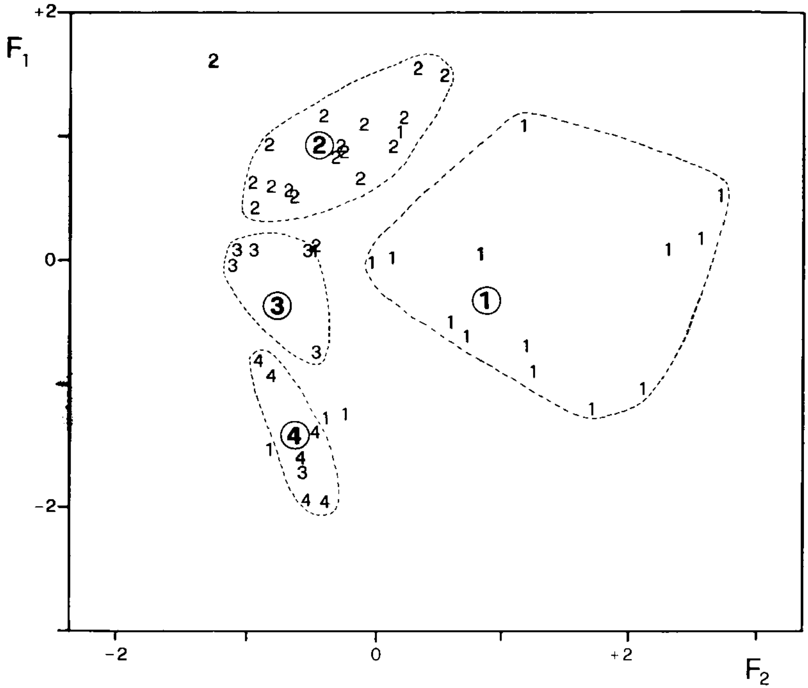

Fig. 4 : Plot of factors 1 and 2 of the PCA analysis. Numbers 1, 2, 3 and 4 indicate the 10, 20, 30 and 40 m depth stations, respectively. Circled numbers represent centroids.

the separation of the sublittoral stations at 10 m from those at depths of 20, 30 and 40 m, which represent the true profundal zone with homogeneous environmental features. The arrangement of 20, 30 and 40 m depths along F1 indicates that the chironomid structure in Lake Vico (i.e. proportion of the most relevant taxa) substantially remained the same along the depth gradient, changing mainly as a result of a gradual loss of taxa and lowering of absolute densities. Typically profundal chironomids resulted to be *Micropsectra, Procladius, Microtendipes, Tanytarsus* and *Paratendipes*. Among them, *Micropsectra* appeared more closely linked to the deeper part of the lake (*Fig.* 3 and Table III). The other genera were well represented at all depths, but they were almost the only taxa present in the profundal of the lake. On the contrary, the higher variability in both occurrence and densities of chironomid taxa among sites and seasons at 10 m makes these stations more highly dispersed and not comparable with a real profundal biocoenosis. Thus, on this basis the group of 10 m stations should be ascribed to a distinct sublittoral zone with characterizing elements such as *Cryptochironomus, Polypedilum bicre-*

natum gr., *Cladopelma lateralis* gr. and *C. laccophila* gr., well represented also in the littoral of the same lake (Mastrantuono & La Rocca 1988). The distinction between the sublittoral and the profundal zone is also supported by the occurrence of taxa exclusively present at 10 m stations, and of vegetation debris (mainly Characeae) only in the samples from these depths. Other authors (i.e. Laville 1971, Lindegaard 1980, Heinis 1989) already found that chironomid community structure shifts from a littoral to a profundal pattern showing that the intermediate environmental character of the sublittoral zone is often related to changes in substrate type, food availability, oxygen content, water quality, etc. A similar picture has been observed also for lacustrine malacocoenoses (Mouthon 1989), making it apparent that many benthic animals are distributed along a depth-dependent environmental gradient.

Chironomids can also provide useful trophic indications for Lake Vico. Unfortunately, the absence of the required indicator taxa and the lack of specific identifications made it impossible to evaluate the lake trophy level by means of Saether's trophic key (Saether 1979), but the occurrence of good quantities of Tanytarsini should traditionally lead to the assessment of a mesotrophic condition of the profundal sediments (cf. Thienemann 1925 & 1954, Brundin 1949 & 1956). Indeed, especially in recent decades, the specific identification of taxa belonging to this group has been strongly recommended for a better comprehension of the relationship among these taxa and the trophic level of lakes. In fact, i.e. the genus *Tanytarsus* holds species with very different ecological sensitivity, varying from oligotrophy to slight eutrophy (Reiss & Fittkau 1971, Saether 1979, Kansanen et al. 1984, Gerstmeier, 1989b). Conversely, a reliable mesotrophy indication is provided by the presence in large abundances of *Micropsectra*, considered as an oligo-mesotrophic taxon with a narrow trophic range even at the level of genus (Wiederholm 1973 & 1976, Saether 1979, Wiederholm & Eriksson 1979, Gerstmeier 1989b). Thus, this taxon can be considered as a key indicator in detecting future trophic changes in Lake Vico. The other common genera were all eurytopic forms living in a wide trophic range, with the exception of the traditionally eutrophic *Chironomus plumosus* gr.

The oligochaete/chironomid ratio seems to confirm the diagnosis of mesotrophy indicated by the previous considerations. In fact, the values registered in Lake Vico are lower than those recorded at the same depths in slightly to strongly eutrophic waters of Central Italy (Bazzanti & Seminara 1987a & 1987b, Bazzanti & Seminara 1988, Seminara & Bazzanti 1988). Moreover, the inverse trend of this environmental index and of the chironomid diversity with respect to depth is indicative of the suitability of this latter in monitoring ecological changes along a depth gradient, as already observed for entire benthic communities (Bazzanti & Seminara 1987c, Bazzanti & Seminara 1988).

In synthesis, according to chemical data, the sublittoral and profundal chironomids of Lake Vico indicated a mesotrophic condition of the waters. However, emphasis should be laid on the tendency towards increasing trophy in the deepest layers of the hypolimnion, as revealed by high values of total P, the occurrence of summer-autumn oxygen depletion, reduction of diversity and abundances of chironomid communities, and constantly high values of oligochaete/chironomid ratio.

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