Calcul et mesure de la diversité chez quelques groupes planctoniques des Eaux Côtières Libanaises (Méditerranée Orientale)

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Pour étudier la structure et l'organisation d'une communauté planctonique, il est indispensable de connaître la diversité spécifique. Plusieurs critères et modèles ont été proposés pour le calcul de la diversité spécifique (Whittaker, 1972; Pielou, 1975; Grassle et al., 1979). Plusieurs méthodes de calcul ont été réalisées sur la diversité spécifique (Giller, 1984). Margalef (1957), considère que dans un échantillon à composition donnée, l'attribution d'un individu à une espèce comme étant un signal élémentaire d'information. Ainsi l'information moyenne par individu donnée par Margalef: $I=1/Q\log_2 Q/q_1!q_2!...q_N!$ tend vers l'information donnée par la formule de Shannon: $I=-p_i \log_2 p_i$. Toutes les analyses de la diversité qui sont basées sur la théorie de l'information, prennent en considération la fonction de Reyni (1961) qui généralise l'entropie de Shannon et celle de Patil et Taillie (1976) qui généralise l'indice de dominance de Simpson. D'autres indices sont encore utilisés: l'indice d'uniformité ou entropie relative "eveness" et l'indice "richness" de Margalef. Ces indices ont servi de base à l'élaboration de quelques programmes d'analyse de la diversité élaborés par Scimone et al. (1987) que nous avons utilisés pour les calculs de la diversité chez trois groupes planctoniques importants des eaux Libanaises: les Copépodes, les Tintinnides et les Dinoflagellés. Les matrices des densités ont été élaborées à partir d'analyses d'échantillons planctoniques effectués tous les mois en plusieurs stations de la côte libanaise (Méditerranée orientale) entre 1985 et 1988 (Lakkis et Zeidane, 1987).

1-Les COPEPODES. Le programme DIV utilisé, élabore une matrice m x n contenant huit indices différents de diversité. Les variations mensuelles de la diversité chez les copépodes ont le même aspect pour les huit indices (Tab.1). En mai la diversité est la plus élevée (H'=2,87 bits/ind.) alors qu'elle est la plus faible en mars (H'=0,653). Un autre programme BETADIV, consiste à calculer 10 mesures de diversité pour chacun des vecteurs mois et donner les tracés correspondants (Fig.1a, 1b). Ces calculs sont basés sur la fonction de Patil et Taillie: $H(beta) = (1-Sp(i)^{(beta+1)/beta}$ $i=1,...,m$ où beta varie de -1 à 1 en augmentant chaque fois de 0,2.

2-Les TINTINNIDES. Les Tintinnides sont très abondants dans les eaux portuaires et semi-fermées (Lakkis et Lakkis, 1985). Le programme PRODIV permet de tracer les profils de la diversité de Whittaker suivant les mois en se basant sur l'entropie de Shannon ou de l'indice de Gini-Simpson: $D=Sp(i)^2$ $i=1,...,m$. La figure 2 montre la courbe de la diversité totale des Tintinnides (44 espèces) trouvés dans le port de Jounieh entre 1985 et 1986. La diversité est maximale en décembre (H'=2,311 bits/ind.) alors qu'elle est minimale en août et septembre (H'=0,005).

3-Les DINOFLAGELLES. Sur les 110 espèces identifiées sur les côtes du Liban (Lakkis et Lakkis, 1981), 50 dont la fréquence de présence est supérieure à 10% ont été retenues pour cette analyse. Le programme INFORMA nous permet de calculer les indices de similitude ou les distances entre les mois de la matrice. Les résultats sont donnés sous forme de matrice triangulaire (Tab.2) de 12 éléments (mois) comprenant les indices de similitudes de Rajski. Par ailleurs les différentes composantes de l'entropie générale sont aussi calculées: information entre les lignes (espèces), entre colonnes (mois), information conjointe, information mutuelle, équivocation, indice de Rajski et indice de cohérence. La diversité la plus élevée tombe en février (H'=2,59), la plus faible en octobre (H'=1,20).

Malgré une pauvreté marquée en biomasse, le plancton des eaux libanaises est caractérisé par une diversité spécifique assez élevée.

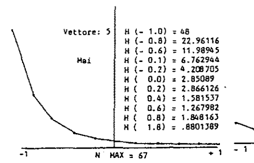

Fig. 1a. Tracé de la courbe de diversité chez les Copépodes des eaux Libanaises (Station J), Mai 1987. Prog. BETADIV

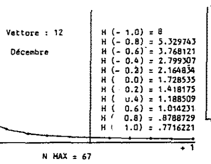

Fig. 1b. Tracé de la courbe de diversité chez les Copépodes du Liban (Station J) en Décembre 1987. Programme BETADIV

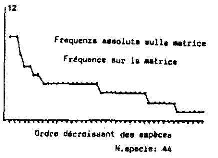

Fig.2. Tracé du profil de la diversité totale chez les Tintinnides des côtes Libanaises (Station P, 1987). Programme PRC

Componenti dell'entropia generale	
Informazione di riga	5593.985
Informazione di colonna...	4786.606
Informazione congionia....	3946.312
Mutua informazione........	1434.379
Equivocazione.............	7511.833
Indice de Rajski	.8396664
Coerenza	.5431026

Tableau 2. Matrice des indices de similitude et de distance entre les mois chez les Dinoflagellés du Liban, basée sur la théorie de l'Information (Station J, 1987), calculés en utilisant Progr. INFORMA.

Matrice di simmetrica fra i vetteri colonna per: indice di somiglianza di Rajski

1.000	0.879	0.873	0.868	0.857	0.868	0.847	0.881	0.844	0.826	0.874	0.856
1.000	0.959	0.956	0.895	0.896	0.863	0.880	0.823	0.882	0.878	0.911	
1.000	0.955	0.939	0.947	0.927	0.915	0.833	0.789	0.849	0.927		
1.000	0.925	0.918	0.893	0.876	0.845	0.856	0.852	0.920			
1.000	0.961	0.961	0.933	0.813	0.903	0.913	0.894				
1.000	0.942	0.956	0.835	0.925	0.925	0.912					
1.000	0.920	0.795	0.904	0.916	0.879						
1.000	0.838	0.892	0.914	0.894							
1.000	0.956	0.901	0.903								
1.000	0.901	0.934									
1.000	0.932										
1.000											

Rilievo	S/R	R/T	H MAX	H MAXT	SP	H'	EVEN	RICH
1	24	0.358	3.178	0.756	0.481	1.221	0.394	3.474
2	24	0.358	3.178	0.756	0.120	2.477	0.780	4.865
3	33	0.567	3.638	0.865	0.775	0.654	0.180	4.791
4	35	0.522	3.555	0.846	0.464	1.442	0.406	5.563
5	49	0.731	3.892	0.926	0.112	2.847	0.732	8.961
6	23	0.343	3.135	0.746	0.C82	2.823	0.900	5.814
7	46	0.687	3.829	0.911	0.243	1.967	0.514	7.026
8	42	0.627	3.738	0.889	0.247	1.831	0.490	6.123
9	34	0.507	3.526	0.839	0.137	2.350	0.666	5.622
10	23	0.343	3.135	0.746	0.397	1.414	0.451	3.030
11	24	0.358	3.178	0.756	0.342	1.576	0.496	3.656
12	9	0.134	2.197	0.523	0.228	1.729	0.787	1.689

S/R= N. specie /Rilievo — N.Totale specie = 67
R/T = N.specie per Rilievo/N.Totale specie — N. Rilievi = 12
H MAX = Diversita' massima per Rilievo (log N.Specie) — H MAX totale = 4.204693
H MAXT = H MAX per Rilievo/H MAX totale
SP = Indice di Dominanza Simpson
H' = Indice di Diversita' di Shannon
Even = Indice di Uniformita' (entropia relativa)
Rich = Indice di Ricchezza di Margalef

Tableau 1. Matrice des 8 mesures d'indice de diversité mensuelle chez les Copépodes du Liban (Station J, 1987), calculée à l'aide du programme DIV (Scimone et al., 1987).

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Distribution of Macroplankton and marine circulation in the Ligurian Sea

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During two cruises conducted respectively in April and August 1986, by the GRO-G (Oceanological Research Group-Genoa) and the Institute of Marine Environmental Science of the University of Genoa, macroplankton samples were collected in the northeastern sector of the Ligurian Sea, over a grid of offshore stations; three stations (45, 46, 47), however, were located at the eastermost end of the basin, parallel to the coastline, near the edge of the continental shelf.

The sampling was carried out from April 24th to 27th and from August 25th to 27th, using a 1 mt ORI net of 1 mm mesh, equipped with a flowmeter and towed on the surface at 1,5 knot speed during day time. The average volume of filtered water was 1,444 cubic meters. In the laboratory the organisms were counted and sorted into the main taxa and the biomass of each taxon was evaluated (dry weight, 60°C).

Temperature and salinity recordings from 0 to 100 db were made at the same time using a Neil Brown CTD onboard the O/V "Minerva", the purpose being to acquire information on the physical and dynamic conditions of the water masses at the sampling time. In order to obtain a general view of the marine circulation pattern, the mean temperature and salinity of the layer comprised between 0 and 100 db were calculated, and the average isotherms and isohalines were plotted.

A cyclonic circulation is a permanent feature of the Ligurian Sea, flowing along the coast at variable speed in relation to the stresses brought about by atmospheric circulation. Deep masses show an upwelling tendency at the centre of the circuit (central divergence), as against the downwelling tendency of surface masses at its periphery (convergence). The divergence axis, therefore, is identified by minimal mean temperatures, as well as by highest mean salinities (HELA 1963, ASTRALDI & GASPARINI 1986, HECQ et al. 1987).

a) Dynamic conditions of water masses. APRIL 24-27, 1986. The isothermal pattern showed an absolute temperature minimum (13.13°C) in the central and deepest area of the basin (St. 27): the central divergence appeared to follow two directions, corresponding to stations 25, 31 and 27, 34, 40. The main displacement of surface masses was at the periphery of this area.

AUGUST 25-27, 1986. The pattern of mean isotherms and isohalines pointed to the presence of a divergence area at stations 34 and 41; stations 32, 33, 34, 40 and 41 were all within an area characterized by prevailing vertical motions. The cyclonic motion at the periphery of this area was almost parallel to the coastline.

b) Composition and distribution of macroplankton. APRIL 24-27, 1986. Gelatinous specimens were prevailing in most of the samples. On the average 74% of the plankton biomass (dry weight) were Siphonophora, the other taxa in the examined area being : Tunicata (9%), Pteropoda (7%), Crustacea (6%), Polychaeta (2%) and Medusae (1%). The average proportion of Chaetognatha and Pisces larvae in the whole biomass was less than 1% dry weight.

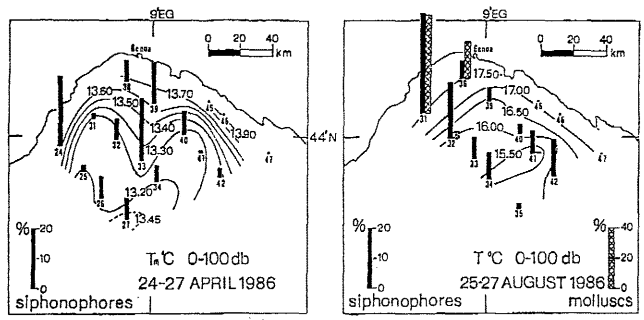
Zooplankton density was highest into inshore stations (46, 47). In offshore waters Siphonophora showed a very heterogeneous distribution, concentrating at three stations (24, 33, 39) located outside the central divergence zone, mainly in station 24 which was characterized by particularly intense temperature and salinity gradients. In the said three stations, moreover, there were specimens of all the taxa inhabiting the surface waters at the time of sampling. On the other hand, stations 25, 26, 27, 31 and 34, located in the area of greatest divergence, were characterized by a less diversified population and a general impoverishment of the whole biomass. However, in some of these stations, the concentration of Copepoda (*E.rostrata*, *A.patersoni*) and Euphausids larvae appeared to be rather high.

AUGUST 25-27, 1986. Mollusca or Siphonophora were dominant by weight in individual samples. On the average Mollusca were prevailing contributing to 54% of dry biomass, followed by Siphonophora (25%), Chaetognatha (11%), Crustacea (5%) and Medusae (4%). The Tunicata and Pisces larvae were less than 1%.

The divergence area at the center of the basin (33, 34, 35, 39, 40) was very poorly populated, Siphonophora being almost the exclusive presence. In offshore waters the biomass was mainly concentrated in two stations (31, 38) along the cyclonic circuit, where Mollusca, Chaetognatha (31, 38), Siphonophora, Medusae (31), *Doliolum*, Stomatopods larvae, Pisces larvae (38) were present in highest density.

Concluding remarks. The large-scale macroplankton sampling carried out in a large area of the Ligurian Sea in the shortest possible time, and the contemporary observation of the physical and dynamic conditions of the waters, enabled us to evidence the influence exerted by the basin dynamic conditions on the macroplankton distribution.

The data show that in the basin area characterized by vertically moving components of water masses, the macroplankton biomass is subject to an overall decrease and the macroplanktonic population is poorly diversified. Altogether, the macroplankton appears to be richer along the cyclonic circuit flowing by the Ligurian coast, and to concentrate mostly in the peripheral areas where temperature and salinity gradients are highest. Major biomass densities are due mainly to Siphonophora and Mollusca, i.e. to the largest populations encountered in the diurnal surface macroplankton at the time of the surveys. Taxa other than Copepods contribute in a lesser amount to the highest biomass concentrations in these areas. Hydrodynamical conditions coupled with behavioral patterns (vertical migration, reproduction) may aggregate zooplankton. The predominant role of biological factors in the small-scale spatial distribution of Copepods was shown by Boucher (1984) in the Ligurian front facing the French coast.



Position of sampling stations, mean isothermal for 0-100 db layer and percentage distribution of biomass (mgDW/100cm) for offshore stations.

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