HYPERBENTHIC MYSIDAE HAWORTH, 1825 (PERACARIDA, MYSIDA) FROM THE CONTINENTAL SHELF OF THE NORTHERN ADRIATIC SEA

BY

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ABSTRACT

Species composition, distribution, and spatio-temporal dynamics of hyperbenthic Mysidae Haworth, 1825 (Peracarida, Mysida) were studied on the continental shelf of the northern Adriatic Sea. A total of seven species was collected: *Anchialina agilis*, *Erythrops elegans*, *Haplostylus lobatus*, *Leptomysis gracilis*, *Mysidopsis angusta*, *Mysidopsis gibbosa*, and *Paraleptomysis banyulensis*. The hyperbenthic mysid assemblage was dominated by *A. agilis*, *E. elegans*, and *L. gracilis*, in terms of frequency of occurrence, abundance, and biomass. Notable seasonal fluctuations in the abundance of the catches were observed, with a minimum reached in the period July-September, probably due to the species' life cycles as well as to environmental factors, such as the presence of mucilaginous aggregates close to the bottom.

RESUMEN

Se estudiaron la composición en especies, la distribución y la dinámica espacio-temporal de los crustaceos suprabentonicos de la familia Mysidae Haworth, 1825 (Peracarida, Mysida), en un area de la plataforma continental del Mar Adriatico del Norte. Siete especies fueron capturadas: *Anchialina agilis*, *Erythrops elegans*, *Haplostylus lobatus*, *Leptomysis gracilis*, *Mysidopsis angusta*, *Mysidopsis gibbosa*, *Paraleptomysis banyulensis*. *A. agilis*, *E. elegans* y *L. gracilis* dominaron las capturas, por lo que concierne la frecuencia de captura, los valores de abundancia y biomasa. Las capturas mostraron amplias fluctuaciones temporales, con un mínimo en Julio-Septiembre, probablemente debido tanto a las caracteristicas del ciclo biológico de las especies como a factores ambientales, en este caso a la presencia de agregados mucilaginosos cerca del fondo.

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INTRODUCTION

The macrofaunal assemblages of the Benthic Boundary Layer (BBL), also defined as hyperbenthos or suprabenthos, are composed of small-sized animals (particularly peracarid crustaceans) with swimming capacity, that occupy the sediment-water interface layer immediately above the sea bottom during different periods of their life or at different times of day, while retaining some contact with the substratum (Brunel et al., 1978; Mees & Jones, 1997). Information on the taxonomic composition and the role of hyperbenthic species in the trophic webs and energy flow of the benthic ecosystem is still scarce and scattered, even though most hyperbenthic groups (e.g. mysids, amphipods) represent basic components in the diet of adults and juveniles of several demersal commercial species (Cartes & Sorbe, 1999; Cartes et al., 2002; Pallaoro et al., 2004). Mysids are considered the most important component of the hyperbenthic assemblages of the continental shelf, while their importance decreases in slope-shelf break habitats, increasing again on muddy bathyal bottoms (Cartes & Sorbe, 1999; Cartes et al., 2001; Madurell & Cartes, 2003).

Consistent catches of mysids belonging to the family Mysidae Haworth, 1825 (Peracarida, Mysida) were obtained by experimental sampling in the northern Adriatic Sea, in the framework of the EU Project "Response of benthic communities and sediment to different regimes of fishing disturbance in European coastal waters" (Acronym: RESPONSE, Contract n° Q5RS-2001-00787).

The present paper is focused to describe the species composition and the temporal trend of the mysid assemblage collected in the investigated area and to provide some biological data for the most abundant species.

MATERIALS AND METHODS

The study was carried out in an area of about 10 km^2, located 15 nautical miles (approx. 27 km) off the harbour of Fano (Italy) in the northern Adriatic Sea (fig. 1). The local sea bottom is flat, and gently slopes from 50 to 55 m depth. Sediments are composed of fine and very fine sand; the median grain size is around 75 μm and remained practically constant during the sampling period, as did the organic matter content (OM, around 1.5%). The near-bottom turbidity and near-bottom temperature were characterized by variations (fig. 2) during the sampling period. Near-bottom turbidity was high in summer; the highest values of near-bottom temperature were observed in autumn.

Seven experimental cruises were carried out: March, July, August, September, October, and November 2003, and March 2004, using a sledge (mouth 80 × 40 cm), provided with a plankton net of 500 μm mesh size. Four diurnal

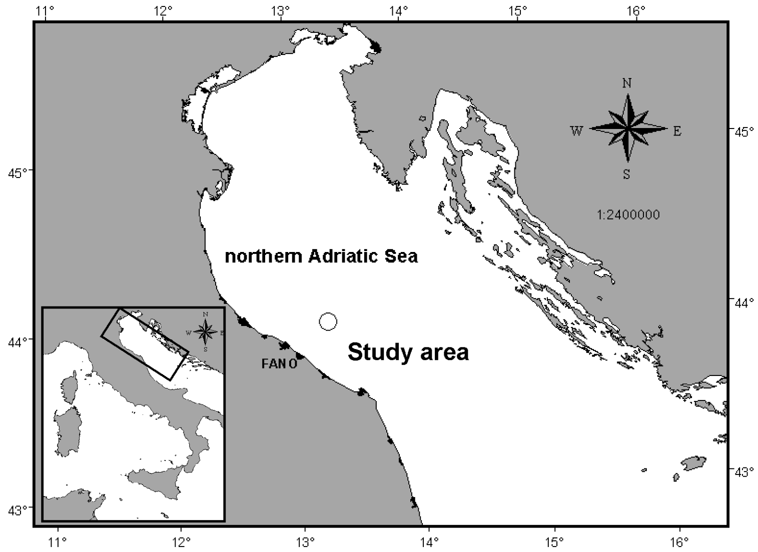

Fig. 1. The study area in the northern Adriatic Sea.

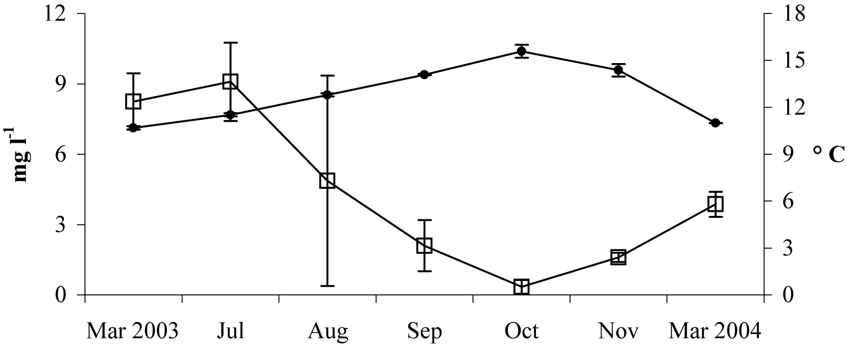

Fig. 2. Abiotic factors in the study area; near-bottom turbidity (□, mg l^{-1}) and near-bottom temperature (●, °C); vertical bars indicate standard deviation.

hauls (towing duration 10 minutes, speed 2.5 km h^{-1}) were performed on each cruise. All material collected was preserved in 4% buffered formaldehyde. In the laboratory, mysids were sorted and identified to the lowest taxonomic level possible. Determination was carried out with the keys provided by Tattersall & Tattersall (1951), Hatzakis (1977), Mauchline (1980), Wittmann (1986), and Hanamura (1998). Several specimens belonging to the species identified were preserved in the collection of the Centro Interuniversitario di Biologia Marina ed Ecologia Applicata of Livorno (Italy). For each taxon, the total number of specimens was determined; total wet weight (WW) was recorded using an electronic balance (accuracy 10^{-4} g), after eliminating surface water by blotting specimens on tissue paper. Standardized abundance and biomass indices were estimated (ind·100 m^{-2}, g 10^{-4} WW·100 m^{-2}) (Cartes et al., 2001).

Cephalothorax lentgth (CL) was measured to the nearest 0.1 mm, from the tip of the rostrum to the mediodorsal margin of the carapace, using a dissection microscope provided with a micrometer eyepiece. Specimens were weighed with an accuracy of 10^{-4} g. For the smallest size species and specimens, a variable number of individuals was grouped to estimate mean weight by size class (Cartes & Sorbe, 1999).

For the most abundant species, size-frequency distributions and abundance of oostegal females (with well developed marsupium) were computed; the weight-length relationship was described by means of the power equation $w = \mathrm{a} \cdot l^{\mathrm{b}}$, where w is weight (10^{-4} g WW) and l is size (CL, mm). Parameters a and b were estimated using ordinary least-square regression on log-transformed data. Student's t-test was applied to test the isometry of the relationship.

RESULTS

A total of 13 268 mysids was collected, corresponding to 14.8 g WW; *Anchialina agilis* (G. O. Sars, 1877), *Erythrops elegans* (G. O. Sars, 1863), and *Leptomysis gracilis* (G. O. Sars, 1864) were the most important species in terms of abundance and frequency of occurrence (table Ia). *A. agilis* was rare from March 2003 to September; catches showed a sharp increase from October onward (table Ib). The specimens caught showed wide size and weight ranges. Female maximum size was 2.9 mm CL, while males reached 3.1 mm CL. The weight-length relationship was negatively allometric (table II). Consistent catch rates were obtained in October and November 2003, and March 2004. Thus, size-frequency distributions were computed from those cruises only. In that period, the structure of the population was substantially the same, dominated by small-sized specimens, with a modal size of 0.9 mm CL (fig. 3a). Oostegal females ranged from 1.7 to 2.9 mm CL. Similar densities of oostegal females were observed in October 2003 and March 2004; a lower value was obtained in November 2003 (fig. 5).

E. elegans showed a pattern similar to that observed for *A. agilis*: consistent catches were obtained in October and November 2003, and in March 2004 (table Ib). Males ranged from 1.1 to 2.0 mm CL, females from 1.1 to 1.7 mm CL. The weight-length relationship was negatively allometric (table II). Size-frequency distributions (fig. 3b) of October and November were similar, characterized by two modal classes at about 1.0 mm CL and at 1.2 mm CL. The presence of larger specimens was consistent in March 2004. Females with marsupium were observed from 1.1 to 1.6 mm CL.

TABLE I

a, Species list including frequency of occurrence (%), total number of specimens (N), size (CL, mm), and weight (10^{-4} g WW) range; b, mean abundance and biomass indices (± standard deviation) of the species of Mysidae collected

a

			CL (mm)		WW (10^{-4} g)	
Family Mysidae Haworth, 1825	%	N	min.	max.	min.	max.
Subfamily Gastrosaccinae Norman, 1892						
Anchialina agilis (G.O. Sars, 1877)	96	5318	0.5	3.1	0.8	94.0
Haplostylus lobatus (Nouvel, 1951)	50	187	0.6	3.5	1.0	112.0
Subfamily: Mysinae Haworth, 1825						
Erythrops elegans (G.O. Sars, 1863)	86	3318	0.5	2.0	0.8	11.0
Leptomysis gracilis (G.O. Sars, 1864)	86	3560	0.6	3.9	2.0	129.0
Paraleptomysis banyulensis (Băcescu, 1966)	18	31	0.9	3.3	1.0	89.0
Mysidopsis angusta G.O. Sars, 1864	64	294	0.6	2.1	0.8	22.0
Mysidopsis gibbosa G.O. Sars, 1864	82	560	0.7	2.3	1.0	26.0

b

ind·100 m^{-2}	Mar 2003	Jul 2003	Aug 2003	Sep 2003	Oct 2003	Nov 2003	Mar 2004
A. agilis	4.7 ± 3.9	4.9 ± 2.4	5.7 ± 2.3	3.5 ± 4.1	139.6 ± 109.6	100.7 ± 68.7	278.7 ± 236.5
H. lobatus	0.2 ± 0.4	0.2 ± 0.4	0.1 ± 0.2	–	1.7 ± 1.2	1.3 ± 0.9	15.4 ± 10.8
E. elegans	1.9 ± 2.9	2.0 ± 2.7	3.6 ± 2.2	9.4 ± 12.6	153.3 ± 89.9	114.7 ± 76.2	50.6 ± 13.3
L. gracilis	92.3 ± 76.5	0.2 ± 0.4	3.1 ± 1.7	0.9 ± 1.1	32.9 ± 15.9	47.6 ± 31.2	182.9 ± 132.7
P. banyulensis	0.3 ± 0.4	–	–	–	–	–	2.8 ± 2.4
M. angusta	–	0.6 ± 1.2	2.5 ± 0.9	1.1 ± 1.5	14.4 ± 11.1	6.3 ± 4.3	4.9 ± 1.3
M. gibbosa	–	8.1 ± 6.5	7.8 ± 2.7	3.7 ± 3.4	18.8 ± 12.6	6.9 ± 9.1	11.3 ± 1.3
g 10^{-4} WW·100 m^{-2}							
A. agilis	65 ± 72	67 ± 33	98 ± 40	67 ± 93	1607 ± 1047	916 ± 715	1686 ± 914
H. lobatus	1 ± 1	1 ± 2	1 ± 1	–	40 ± 32	39 ± 17	236 ± 170
E. elegans	9 ± 14	13 ± 21	21 ± 14	56 ± 87	852 ± 624	596 ± 395	199 ± 14
L. gracilis	1833 ± 1666	10 ± 20	69 ± 49	11 ± 16	718 ± 458	671 ± 480	2893 ± 1499
P. banyulensis	3 ± 5	–	–	–	–	–	57 ± 50
M. angusta	–	7 ± 15	29 ± 12	10 ± 14	149 ± 159	65 ± 44	36 ± 12
M. gibbosa	–	81 ± 71	74 ± 29	35 ± 46	169 ± 111	56 ± 83	58 ± 25

L. gracilis showed high catch rates in March, October, and November 2003, and in March 2004, while the species practically disappeared during the summer period. Therefore, fig. 4 shows the size-frequency distributions of March 2003 and those from October 2003 to March 2004. In October and November, the maximum size was 2.7 mm CL, while larger size classes were observed in March, both in 2003 and 2004. Both males and females reached the maximum size of 3.9 mm CL. The weight-length relationship was positively allometric (table II). Females with

TABLE II

Weight-length relationship in three species of northern Adriatic Mysidae: n = number of specimens measured; a and b = parameters of the power curve; SE = standard error; R^2 = determination coefficient; s_1 = significance level of F test (null hypothesis: b = 0); s_2 = significance level of Student's t-test (null hypothesis: b = 3); * = $p < 0.05$; ** = $p < 0.01$

Species	n	a	b	SE (b)	R^2	s_1	s_2
Anchialina agilis (G. O. Sars, 1877)	451	5.01	2.73	1.10	0.86	**	**
Erythrops elegans (G. O. Sars, 1863)	358	2.12	2.19	0.95	0.84	**	**
Leptomysis gracilis (G. O. Sars, 1864)	490	1.46	3.21	0.84	0.94	**	*

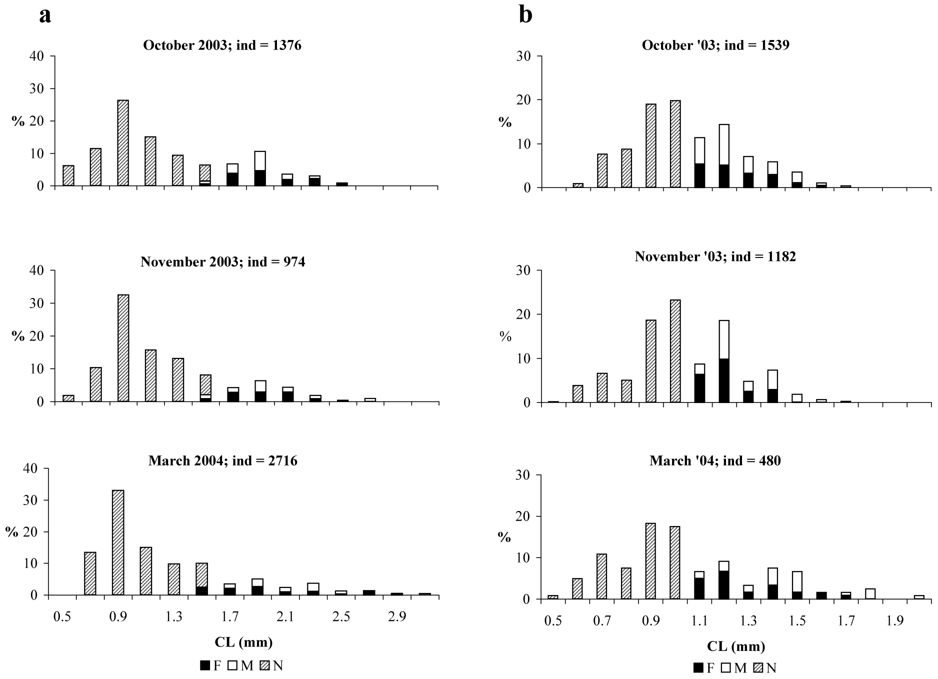

Fig. 3. Size-frequency distributions of: a, *Anchialina agilis* (G. O. Sars, 1877); b, *Erythrops elegans* (G. O. Sars, 1863); F, females; M, males; N, unsexed.

marsupium ranged from 1.5 to 3.9 mm CL. Similar densities of oostegal females were observed in March 2003 and 2004; lower densities were obtained in October and November 2003 (fig. 5).

DISCUSSION

Since the "Hvar" expedition (Hoenigman, 1963, 1968), the present study represents one of the first sources of information on BBL mysid assemblages in

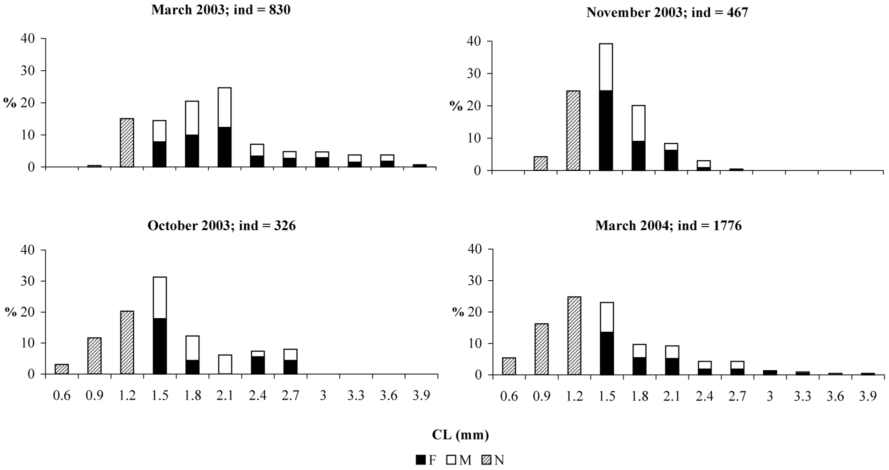

Fig. 4. *Leptomysis gracilis* (G. O. Sars, 1864): size-frequency distributions.

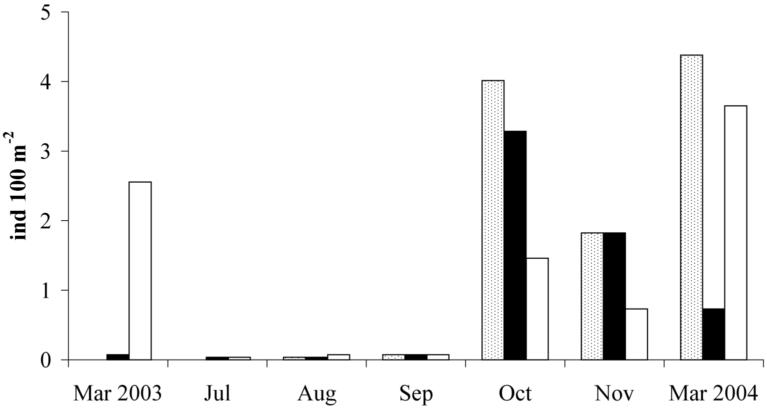

Fig. 5. Abundance (ind·100 m^{-2}) of oostegal females of the three dominant species: dotted bars, *Anchialina agilis* (G. O. Sars, 1877); black bars, *Erythrops elegans* (G. O. Sars, 1863); white bars, *Leptomysis gracilis* (G. O. Sars, 1864).

the northern Adriatic Sea. The observed species assemblage considerably agrees with that reported by Hoenigman (1968). *Mysidopsis angusta* (G. O. Sars, 1864) was also reported by Tattersall & Tattersall (1951) from the northern part of the Adriatic basin. Furthermore, most of the species mentioned in the present study are distributed over the Atlantic-Mediterranean area (Bacesco, 1941; Lagardére & Nouvel, 1980; Barberá Cebrián et al., 2001).

Anchialina agilis, *Erythrops elegans*, and *Leptomysis gracilis* could be considered the dominant and typifying species of the continental shelf BBL mysid assemblage in the area investigated. However, notable abundance and biomass fluctuations, opposite to those shown by the near-bottom turbidity, were observed.

Environmental factors, such as mucilaginous aggregations, mainly produced by diatoms, that were observed in the study area during the investigated period, could play a role in determining the decrease in the mysid assemblage. As a matter of fact, sedimentation and subsequent degradation of high amounts of mucous material can contribute to the accentuation of benthic turbidity and hypoxia, even to the point of reaching an anoxic state. Therefore, populations of those benthic organisms unable to move rapidly from the affected areas are often affected (Rinaldi et al., 1995; Manini et al., 2001; Cornello et al., 2005).

Similar seasonal trends were described for hyperbenthic peracarids and eucarids from bathyal bottoms of the Catalan Sea and of the Bay of Biscay, usually not affected by phytoplankton aggregations (Cartes & Sorbe, 1999; Cartes et al., 2001). Therefore, seasonal patterns and fluctuations of hyperbenthic crustaceans should be mainly related to biological and ecological characteristics, such as life cycles, population dynamics, migrations, etc. (Tattersall & Tattersall, 1951; Mauchline, 1980; Johnson et al., 2001).

In spite of the gaps in the present sampling design, this is one of the first attempts to define the temporal evolution of the population structure of suprabenthic species and its relationships with environmental variables. However, further studies are required, to enhance our knowledge on biology and population dynamics of these organisms and to define their role in the marine trophic webs and energy flows.

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REFERENCES

BACESCO, M., 1941. Les Mysidacés des eaux méditerranéennes de la France (spécialement de Banyuls) et des eaux de Monaco. Bull. Inst. Oceanogr., **795**: 1-46.

BARBERÁ CEBRIÁN, C., M. RIBEIRO DA CUNHA, P. SÁNCHEZ JEREZ & A. A. RAMOS ESPLÁ, 2001. Misidáceos asociados a fanerógamas marinas en el sudeste ibérico. Bol. Inst. Español Oceanogr., **17** (1): 97-106.

BRUNEL, P., M. BESNER, D. MESSIER, L. POIRIER, D. GRANGER & M. WEINSTEIN, 1978. Le traîneau suprabenthique Macer-GIROQ: appareil amélioré pour l'échantillonage quantitatif étagé de la petite faune nageuse au voisinage du fond. Int. Rev. ges. Hydrobiol., **63**: 815-829.

CARTES, J. E., T. BREY, J. C. SORBE & F. MAYNOU, 2002. Comparing production-biomass ratios of benthos and suprabenthos in macrofaunal marine crustaceans. Canadian Journ. aquat. Fish. Sci., **59**: 1616-1625.

Cartes, J. E., M. Elizalde & J. C. Sorbe, 2001. Contrasting life histories, secondary production, and trophic structure of peracarid assemblages of the bathyal suprabenthos from the Bay of Biscay (NE Atlantic) and the Catalan Sea (NW Mediterranean). Deep-Sea Res., (1) **48**: 2209-2232.

Cartes, J. E. & J. C. Sorbe, 1999. Estimating secondary production in bathyal suprabenthic peracarid crustaceans from the Catalan Sea slope (western Mediterranean; 391-1255 m). Journ. exp. mar. Biol. Ecol., **239**: 195-210.

Cornello, M., R. Boscolo & O. Giovanardi, 2005. Do mucous aggregates affect macrozoobenthic community and mussel culture? A study in a coastal area of the northwestern Adriatic Sea. Sci. total Environm., **353** (1-3): 329-339.

Hanamura, Y., 1998. Gastrosaccini mysids from Australia, with a description of a new species of *Haplostylus* and a key to species of the genus (Crustacea: Mysidacea). Rec. Western Australian Mus., **19** (2): 153-168.

Hatzakis, A., 1977. Contribution á l'étude des Gastrosaccinae (Crustacea, Mysidacea) de la Méditerranée. Description de *Haplostylus bacescui* n. sp. et révision de la nomenclature des *Haplostylus* et *Gastrosaccus* méditerranéens. Biol. Gallo-Hell., **6** (2): 271-287.

Hoenigman, J., 1963. Mysidacea de l'expedition "Hvar" (1948-1949) dans l'Adriatique. Rapp. Comm. int. Mer Méditerranée, **17** (2): 603-616.

— —, 1968. Sur les Mysidacés des eaux ouvertes de l'Adriatique septentrionale. Rapp. Comm. int. Mer Méditerranée, **19** (3): 449.

Johnson, W. S., M. Stevens & L. Watling, 2001. Reproduction and development of marine peracaridans. Adv. mar. Biol., **39**: 105-260.

Lagardère, J. P. & H. Nouvel, 1980. Les Mysidacés du talus continental du golfe de Gascogne. II. Familles des Lophogastridae, Eucopiidae et Mysidae (tribu des Erythropini exceptée). Bull. Mus. natl. Hist. nat., (4A) **2**: 845-887.

Madurell, T. & J. E. Cartes, 2003. The suprabenthic peracarid fauna collected at bathyal depths in the Ionian Sea (eastern Mediterranean). Crustaceana, **76** (5): 611-624.

Manini, E., M. Fabiano & R. Danovaro, 2001. Benthic response to mucilaginous aggregates in the northern Adriatic Sea: biochemical indicators of eutrophication. Chem. Ecol., **17**: 171-179.

Mauchline, J., 1980. The biology of mysids and euphausiids: 1-681. (Academic Press, London).

Mees, J. & M. B. Jones, 1997. The hyperbenthos. Oceanogr. mar. Biol., ann. Rev., **35**: 221-255.

Pallaoro, A., M. Săntíc & I. Jardas, 2004. Diet composition of young-of-the-year saddled bream, *Oblada melanura* (Linnaeus, 1758) from the eastern central Adriatic Sea. Journ. appl. Ichthyol., **20**: 228-230.

Rinaldi, A., R. A. Vollenweider, G. Montanari, C. R. Ferrari & A. Ghetti, 1995. Mucilages in Italian seas: the Adriatic and Tyrrhenian Seas, 1988-1991. Sci. total Environm., **165**: 165-183.

Tattersall, W. M. & O. S. Tattersall, 1951. The British Mysidacea: 1-460. (Ray Society, London).

Wittmann, K. J., 1986. A revision of the genus *Paraleptomysis* Liu & Wang (Crustacea: Mysidacea). Sarsia, **71**: 147-160.

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