

Infestation of some Mediterranean Brachyuran crabs by the Polychaete *Iphitime cuenoti*

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Abstract: The branchial chambers of some brachyuran crabs of the species *Liocarcinus depurator*, *Macropipus tuberculatus*, and *Goneplax rhomboides* have been found to be infested by the polychaete *Iphitime cuenoti*. Here we provide an account of the intensity and prevalence of the infestation and their relationship to body size, sex, and depth inhabited by the hosts. The frequency of infested animals were 5,5 % for *L. depurator*, and 12,3 % for *M. tuberculatus*. Infestation prevalence increases in both species with host size, and in *L. depurator* also increases towards deeper habitats. The statistical distribution of infestation intensity fits a contagious distribution for *L. depurator* and *M. tuberculatus*.

Résumé: La présence du Polychète *Iphitime cuenoti* a été détectée dans les chambres branchiales des brachyours *Liocarcinus depurator*, *Macropipus tuberculatus* et *Goneplax rhomboides*. Les caractéristiques de l'infestation sont étudiées : intensité et prévalence de l'infestation en relation avec la taille, le sexe et la profondeur de capture de l'hôte. La fréquence d'individus infestés par *I. cuenoti* est de 5,5 % et 12,3 %, respectivement pour *L. depurator* et *M. tuberculatus*. Chez *L. depurator*, la prévalence augmente avec la profondeur. Chez ces deux hôtes, la prévalence augmente avec leur taille. L'intensité de l'infestation présente des caractéristiques de distribution contagieuse.

INTRODUCTION

In the course of a survey of the decapod crustacean populations of the Catalan coast, NW Mediterranean (Abelló, 1986) we observed the presence of a polychaete in the branchial chambers of some brachyuran species: *Liocarcinus depurator* (Linnaeus, 1758), *Macropipus tuberculatus* (Roux, 1830) and *Goneplax rhomboides* (Linnaeus, 1758). This polychaete was identified as *Iphitime cuenoti* Fauvel, 1914, a species belonging to the family Iphitimidae, whose presence in the Mediterranean had been recently shown (Abelló, 1985).

The family Iphitimidae Fauchald, 1970, comprises two genera (1) *Iphitime* Marenzeller 1902, whose species occur in the branchial chambers or under the abdomens of decapod crustaceans, and (2) *Veneriserva* Rossi, 1984, whose single species described to date has been found inhabiting the coelomic cavity of the polychaete *Aphrodita longipalpa* Essenberg. The identification characters of the genus *Iphitime* are the presence of a pair of frontal antennae, one or two peristomial segments, uniramous parapodia with 1 to 8 aciculae per parapodium, and simple or compound falciger setae, a pair of fused maxillae, a first maxilla, and the presence of mandible.

The genus *Iphitime* comprises up to date six species, all of them living associated to decapod crustaceans. *I. doderleini* Marenzeller, 1902, inhabits the branchial chambers of *Macrocheira kaempferi* (Temminck, 1836) in the Japanese seas; *I. cuenoti* Fauvel, 1914, has been found in the branchial chambers of *Goneplax*

rhomboides (Linnaeus, 1758), *Macropodia tenuirostris* (Leach, 1814), *Maia squinado* (Herbst, 1788), *Liocarcinus depurator* (Linnaeus, 1758) and *Macropipus tuberculatus* (Roux, 1830) in the NE Atlantic and Mediterranean; *I. paguri* Fage and Legendre, 1934, has been found associated to *Pagurus bernhardus* (Linnaeus, 1758) in the NE Atlantic; *I. loxorhynchi* Hartman, 1952 lives associated to *Loxorhynchus grandis* Stimpson, 1857 in the Western coast of North America; *I. hartmanae* Kirkegaard, 1977, lives under the abdomen of *Hyas araneus* (Linnaeus, 1758) and *Hyas coarctatus* Leach, 1815, off the North European coast, and *I. holobranchiata* Pilger, 1971, lives associated to *Cancer antennarius* Stimpson, 1856, off the western coasts of North America.

The species *Iphitime cuenoti* was first described by Fauvel (1914) on the basis of a single specimen collected in Arcachon (French Atlantic coast) in association to *Maja squinado*. The species was more carefully described by Fage and Legendre (1925, 1933), who examined a larger number of specimens removed from the branchial chambers of *Liocarcinus depurator*, *Goneplax rhomboides* and *Macropodia tenuirostris* also captured in the French Atlantic coast. More recently, this species has been found in association to *Macropodia tenuirostris* in the British coast (Hartnoll, 1962), and in the Mediterranean coast (Abelló, 1985; Belloni & Mori, 1985).

The goals of this paper are three fold, (1) to describe the individuals of *Iphitime cuenoti* collected in the Mediterranean, (2) to examine the characteristics of the infestation of the polychaete in the branchial chambers of its brachyuran hosts, and (3) to gather information on the diet of *I. cuenoti*.

MATERIAL AND METHODS

In 1984 we performed several trawls over the muddy substrates within a depth of 50 to 400 m off Barcelona (NW Mediterranean) to collect specimens of brachyuran crabs. The carapace of the individuals collected was separated from the body as to allow examination of their branchial chambers (895 males and 1 069 females of *Liocarcinus depurator*; 551 males and 501 females of *Macropipus tuberculatus*, and a few individuals of *Goneplax rhomboides*), to assess the presence of the polychaete, and the degree of infestation. The specimens of *I. cuenoti* found were preserved for later examination in 10 % formalin.

The alimentary regime of the polychaete was studied by examination of the gut contents of 53 individuals mounted on glycerine. Prior to examination, the preserved specimens were carefully washed with distilled water, to remove formalin and debris from their surfaces. The washed specimens were immersed in a glycerine solution (20 ml 96° ethanol, 1 ml bidistilled glycerine, and 79 ml distilled water) until the complete evaporation of the distilled water and ethanol. This treatment prevents the disruption of the internal structure of the specimens and results in a

greater transparency of the tissues, allowing a better examination of the gut contents. The specimens mounted in glycerine were then examined under the binocular to assess the degree of fullness of the gut. We attempted to characterize the gut contents through examination under the optical microscope.

Statistical analyses followed Sokal and Rohlf (1979) and Elliot (1979). The terms used throughout the paper follow the recommendations of Margolis *et al.* (1982) and Overstreet (1983). Thus, prevalence is defined as the ratio between the number of individuals of a host species infested with *I. cuenoti* and the number of hosts examined; intensity, as the number of individuals of *I. cuenoti* in each infested host; mean intensity, as the mean number of individuals of *I. cuenoti* per infested host in a sample, and abundance or relative density, as the mean number of individuals of *I. cuenoti* per host examined.

DESCRIPTION of *Iphitime cuenoti*

Iphitime cuenoti Fauvel, 1914

Fauvel, 1914; p. 34

Fage and Legendre, 1925; p. 219

One of the most striking characteristics of this species is its strong sexual dimorphism. This dimorphism is evident in the considerable size difference between the bigger adult females (20-40 mm total length) and the smaller (10-25 mm total length) males. The number of setigers also differs between the 80-120 of females and the 60-80 characteristic of males. In addition, female branchiae are much more developed than male branchiae.

The prostomium (Fig. 1-C, 2-C) has a round, half-moon shaped, aspect in both males and females (Fage & Legendre, 1925). There are two antennae in the dorsal part that may protrude above the prostomium. The ventral surface presents two round excretions that may have a sensorial function. This species has no eyes or ocular spots. The prostomium is followed by two achaetous segments.

The third segment of the animal corresponds to the first setiger, and contains all the characteristic parapodial formations. Branchiae are first present from this first setigerous segment. These are expansions over the parapodia, and differ considerably between sexes. The branchiae extend to the distal parts of the body in both sexes (Fig. 1-A, 2-A), but a progressive disappearance of the branchial lobes can be observed. Male branchiae are an expansion with at most one branchial lobe (Fig. 2-B), whereas females have 3 to 4 branchial lobes on the tenth setiger, 4 to 7 lobes on the intermediate setigers, and only 2 to 3 branchial lobes on the terminal setigers (Fig. 1). These branchiae are bigger than the parapodial lobes, and may even cover the dorsal part of the body (Fig. 1-B). Some authors suggest that they originate from simple expansions of the general cavity of the body (Marenzeller, 1902), and that they are used to store genital products by sexually mature females (Fage & Legendre, 1925).

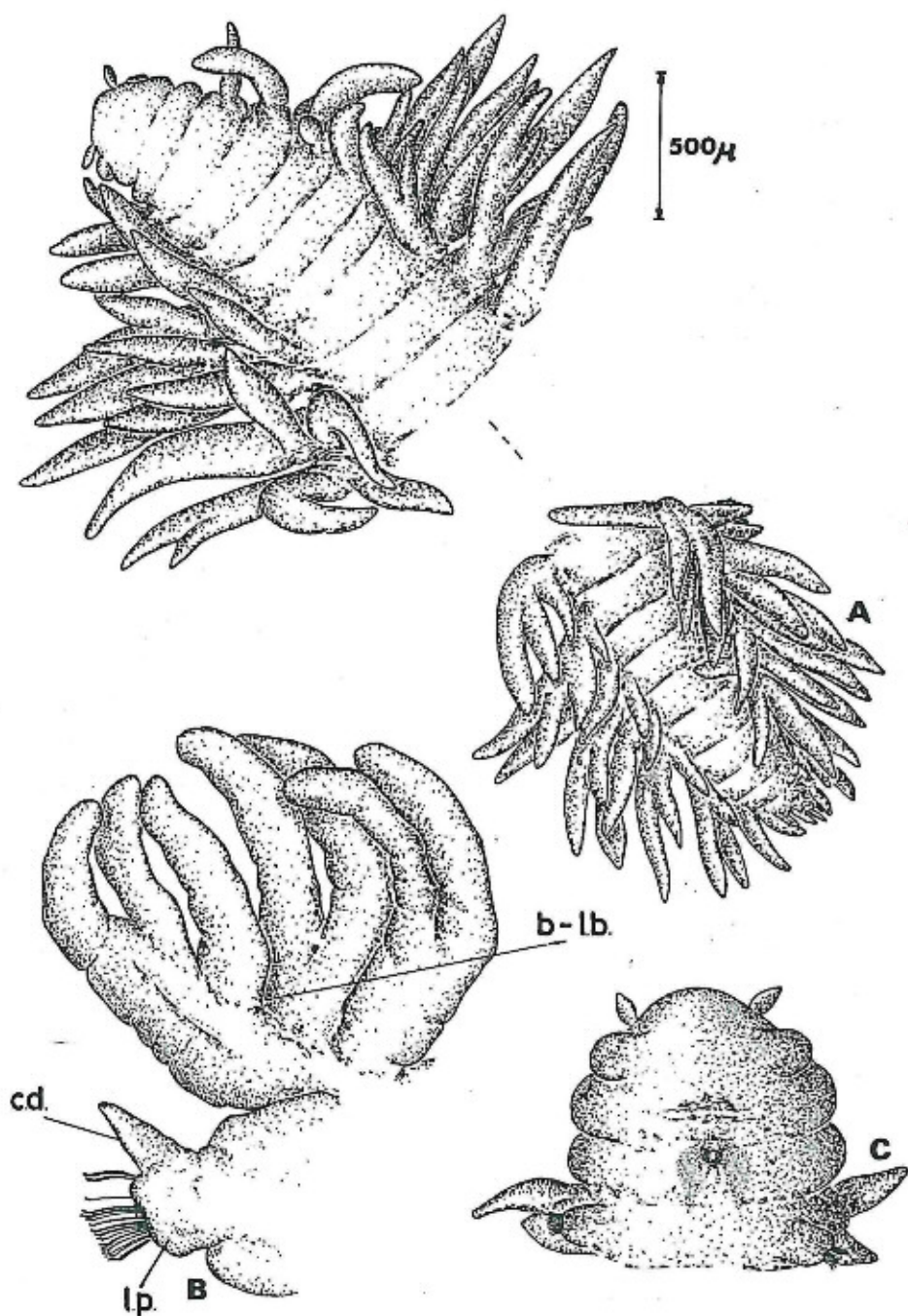


Fig. 1 - Female *Iphitime cuenoti*: A - Anterior and posterior regions; B - Parapod of the middle region of the body; C - Ventral view of the prostomium; Scale: (A - 55 μ m). c. d. = dorsal cirrum; b.-l. b. = branchia and branchial lobes; l. p. = parapodial lobes.

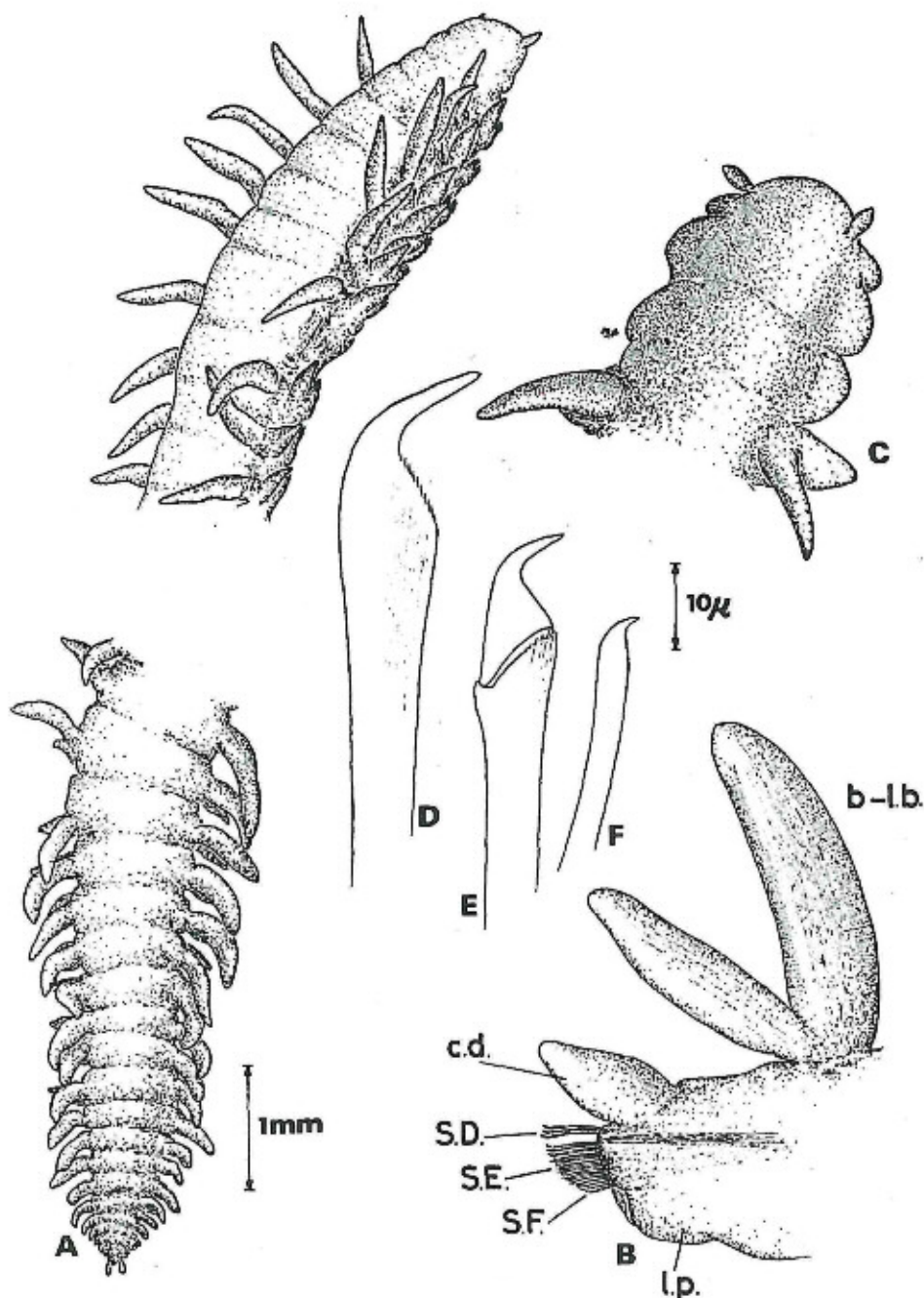


Fig. 2 - Male *Iphitime cuenoti*: A - Anterior and posterior regions; B - Parapod of the middle region of the body; C - dorsal view of the prostomium; D - Upper simple seta from a parapod; E - Compound seta; F - Lower simple seta. Scale: (A - 1 mm; D, E, F - 100 μ m). c. d. = dorsal cirrum; b. - l.b. = branchia and branchial lobes; l. p. = parapodial lobes; S.D. = type D setae; S.E. = type E setae; S.F. = type F setae.

The parapodia have a large dorsal cirrus that exceeds them in length (Fig. 1-B, 2-B) and have no ventral cirri. Parapodia consist of a bilobed presetal lobe, and a straight postsetal lobe. Between them emerge the setae. The upper setae fasciculum comprises some six simple setae. These have an enlarged distal part finished in a long and sharp protuberance, whose tip has a hook shape (Fig. 2-D). A large number of compound setae are located below the upper fasciculum (Fig. 2-E). The inferior side of the parapodia has 3 or 4 simple setae, similar in structure, albeit much thinner, to the dorsal ones (Fig. 2-E).

The branchial diverticuli disappear on the final segments of the body. The pigidium has a similar shape as the prostomium, and ends in two short anal cirri.

Figure 3 shows a scaled representation of the maxillae and mandibles of an adult male and female, with 65 and 90 setigers respectively. The mandibular apparatus is rather complex, smaller in the females than in the males (Fig. 3, A-D), and presents a characteristic asymmetry. The mandibles are two rigid oblique rods, joined by a central sheet, that leaves a central opening separating the rods. The maxillae consist of two hooks somewhat longer than the mandibles. They are joined in their central part by a single piece, and another pair of smaller pieces above them.

RESULTS

TABLE 1

Prevalence of the infestation by the polychaete *Iphitime cuenoti* in the crabs *Liocarcinus depurator* and *Macropipus tuberculatus* for males and females captured at different depths.

Liocarcinus depurator

Depth	Males			Females			Total		
	n° inds with <i>Iphitime</i>	n° total	%	n° inds with <i>Iphitime</i>	n° total	%	n° inds with <i>Iphitime</i>	n° total	%
< 100 m	5	758	0,7	17	838	2,0	22	1596	1,4
100-200 m	1	14	7,1	6	28	21,4	7	42	16,7
200-300 m	6	67	9,0	35	107	32,7	41	174	23,6
300-400 m	9	56	16,1	28	96	29,2	37	152	24,3
Total	21	895	2,4	86	1069	8,0	107	1964	5,5

Macropipus tuberculatus

Depth	Males			Females			Total		
	n° inds with <i>Iphitime</i>	n° total	%	n° inds with <i>Iphitime</i>	n° total	%	n° inds with <i>Iphitime</i>	n° total	%
< 100 m	--	--	--	--	--	--	--	--	--
100-200 m	14	130	10,8	12	75	16,0	26	205	12,7
200-300 m	27	232	11,6	30	217	13,8	57	449	12,7
300-400 m	20	189	10,6	26	209	12,4	46	398	11,6
Total	61	551	11,1	68	501	13,6	129	1052	12,3

TABLE 2

Prevalence of the infestation by the polychaete *Iphitime cuenoti* in the crabs *Liocarcinus depurator* and *Macropipus tuberculatus* as a function of body size.

Liocarcinus depurator

Size (mm)	Males			Females			Total		
	N° infested	N° total	%	N° infested	N° total	%	N° infested	n° total	%
< 20	0	17	0,0	0	14	0,0	0	31	0,0
20-24	2	218	0,9	18	386	4,7	20	604	3,3
25-29	8	493	1,6	52	636	8,2	60	1129	5,3
> 30	10	205	4,9	16	117	13,7	26	322	8,1

Macropipus tuberculatus

Size (mm)	Males			Females			Total		
	N° infested	N° total	%	N° infested	N° total	%	N° infested	n° total	%
< 20	1	73	1,4	0	85	0,0	1	158	0,6
20-24	11	340	3,2	26	433	6,0	37	773	4,8
25-29	51	445	11,5	45	202	22,3	96	647	14,8
> 30	11	82	13,4	2	29	6,9	13	111	11,7

Prevalence

A total of 107 of 1 964 *Liocarcinus depurator* and 129 of 1 052 *Macropipus tuberculatus* contained polychaetes in the branchial chambers (Table 1). Thus, prevalence in *L. depurator* is 5,5 % and in *M. tuberculatus*, it is 12,3 %. Females show a greater prevalence (8,0 %) than males (2,4 %) in *L. depurator* whereas in *M. tuberculatus* prevalence shows similar values (11,1 % in males; 13,6 % in females). Since only 9 specimens of *Goneplax rhomboides* were captured, the calculated prevalence (22,2 %) is only indicative.

The increase in infestation prevalence in *L. depurator* towards deeper habitats (Table 1, Fig. 4) is in agreement with the results published by different authors (Fage & Legendre, 1933; Abelló, 1985; Belloni & Mori, 1985). The smallest prevalence values (c. 1 %) coincide with the depth range where *L. depurator* has its maximum abundance (<100 m in the Catalan coast) (Castellón & Abelló, 1983), whereas up to 25 % of the individuals of this species captured below 200 m, where sparser populations occur, were infested by *I. cuenoti*. Infestation prevalence in *M. tuberculatus* was found to be relatively constant throughout the depth range of this species (>100 m deep).

The comparison of infestation prevalence between males and females (Table 2) by means of a chi squared test using a 2 by 2 contingency table (Elliot, 1979) revealed significantly higher values for the females than for the males of *L. depurator*

(chi squared = 29,6, $P < 0.001$). On the other hand, no such sex differences were observed for *M. tuberculatus* (chi squared = 1.30, $P > 0.20$)

Infested branchial chambers have been found in *L. depurator* males ranging between 21-37 mm of carapace length, and *M. tuberculatus* males between 19-33 mm. The size range of infested females is very similar both for *L. depurator* (22-33 mm carapace length) and *M. tuberculatus* (20-31 mm). The examination of infestation prevalence for different ranges of host body size (Table 2) clearly shows a positive relationship between infestation prevalence and body size (Fig. 5).

The comparison of infestation prevalence for different moulting stages of *L. depurator* and *M. tuberculatus* hosts (Table 3) shows that postmoulting individuals may also have infested branchial chambers.

Infestation intensity

The infestation intensity (number of *I. cuenoti* individuals per infested host) is rather variable (Fig. 6). Most infested individuals present a single specimen of *I. cuenoti* in their branchial cavities, although as much as four polychaetes per host have been found both for *L. depurator* and *M. tuberculatus*. This maximum infestation intensity is lower than the value of six *I. cuenoti* individuals per host reported by Fage and Legendre (1933).

In both species, *L. depurator* and *M. tuberculatus*, the index of dispersion (variance/mean) is significantly different from one ($P < 0.01$) (Elliot, 1979). This is characteristic of an overdispersed population (Bliss & Fisher, 1953), which indicates that the distribution of the infestation follows a contagious distribution. To measure the contagiousness, a negative binomial distribution has been fitted to the observed values (Table 4). The good fit of this distribution to the data for both *L. depurator* and *M. tuberculatus* (chi squared, $P > 0.05$) (Elliot, 1979) implies that the infestation is not an independent and random process. The negative binomial parameter, k , is low, indicating a high degree of aggregation of individuals across the collective host population.

The mean infestation intensity (mean number of *I. cuenoti* individuals per infested host) was 1.19 for *L. depurator*, and 1,3 for *M. tuberculatus*. The abundance or relative density of the polychaete (mean number of *I. cuenoti* individuals per host examined) was 0.18 for *L. depurator* and 0.064 for *M. tuberculatus*.

Alimentary regime

The examination of the guts of *I. cuenoti* specimens revealed the presence of some contents in only 8 of the 53 individuals examined (15% of the specimens). These contents were largely composed of a brown-reddish amorphous organic substance, and in some cases sand grains.

The high degree of disaggregation and digestion of the gut contents prevented the identification of their origins for most specimens, although we were able to identify

echinoderm spicules together with organic aggregates in the guts of one of the specimens, a male.

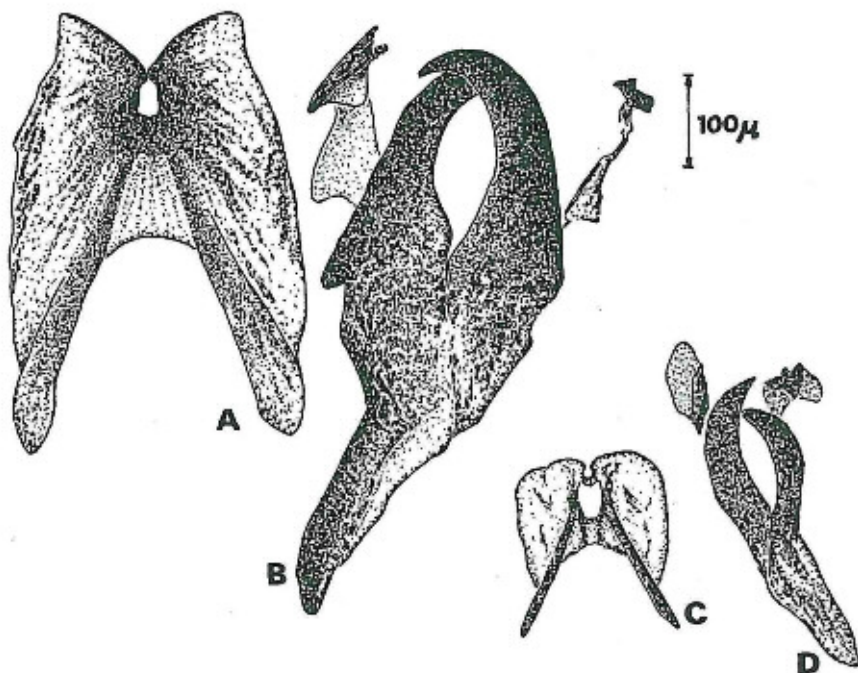


Fig. 3 - Mandibular apparatus: A - Male mandibles. B - Male maxillae; C - Female mandibles; D - Female maxillae. Scale: A, B, C, D - 100 μm).

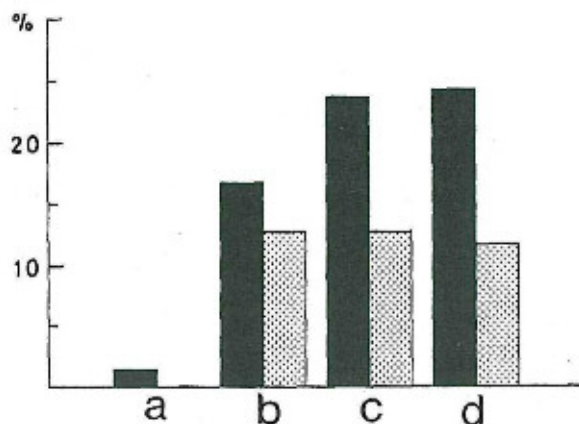


Fig. 4 - *Iphitime cuenoti* infestation prevalence for *Liocarcinus depurator* and *Macropipus tuberculatus* in relationship to the depth of host capture (a = < 100 m; b = 100-200 m; c = 200-300 m; d = 300-400 m) (closed bars: *L. depurator*; dotted bars: *M. tuberculatus*).

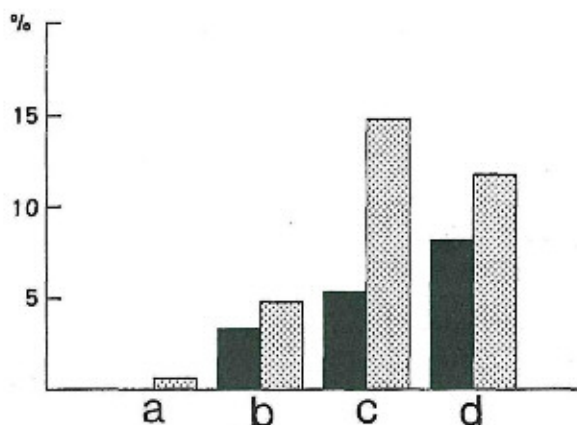


Fig. 5 - Relationship between *Iphitime cuenoti* infestation prevalence for *Liocarcinus depurator* and *Macropipus tuberculatus*, and host size (a = < 20 mm of carapace length; b = 20-24 mm c.l.; c = 25-29 mm c.l.; d = > 30 mm c.l.) (closed bars: *L. depurator*; dotted bars: *M. tuberculatus*).

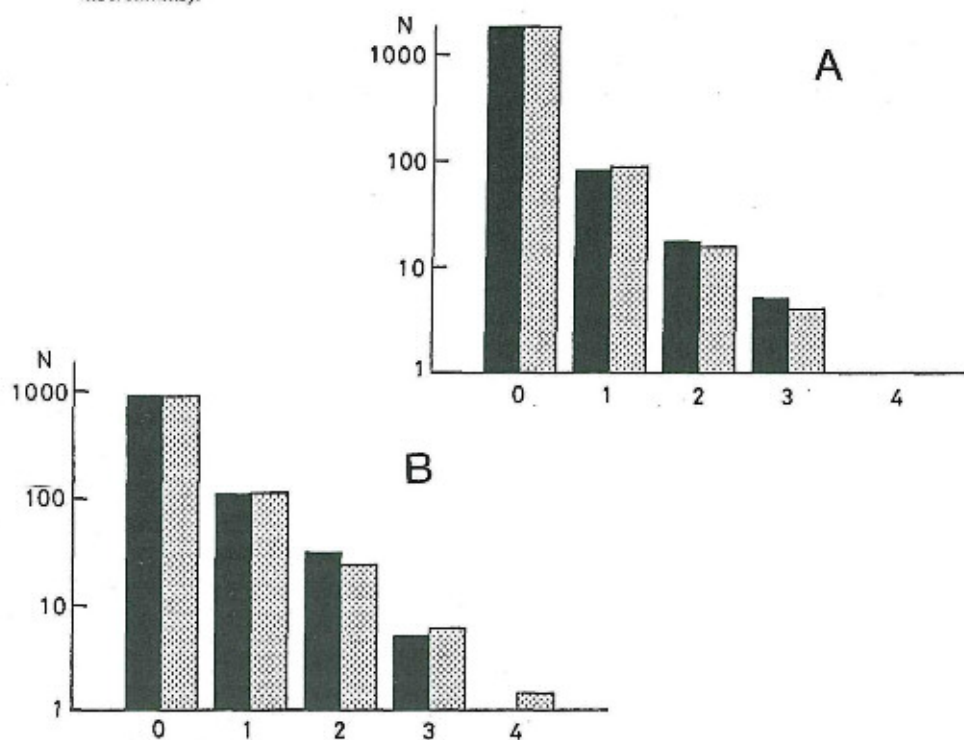


Fig. 6 - Infestation intensity by the polychaete *Iphitime cuenoti* in its brachyuran hosts *Liocarcinus depurator* (A) and *Macropipus tuberculatus* (B). Closed bars: observed frequencies; dotted bars: expected frequencies from a fitted negative binomial distribution. X axis: number of polychaetes found in the branchial chambers of the host; Y axis: number of hosts belonging to each class.

TABLE 3

Number of host individuals infested by *Iphitime cuenoti* in the crabs *Liocarcinus depurator* and *Macropipus tuberculatus*, as a function of moulting state.

Moult stage	Number of crabs with <i>Iphitime</i>	
	<i>L. depurator</i>	<i>M. tuberculatus</i>
Immediate postmoult	1	0
Postmoult	4	1
Advanced postmoult	7	4
Intermoult	94	140
Premoult	1	1

TABLE 4

Observed infestation intensity by the polychaete *Iphitime cuenoti* in the crabs *Liocarcinus depurator* and *Macropipus tuberculatus*, and values expected from a negative binomial distribution fitted to the data. Also included are the mean, variance, and the index of dispersion of the infestation intensity, the k parameter of the fitted distribution, and the results of the Chi-square goodness of fit test.

N° polychaetes/host	<i>L. depurator</i>		<i>M. tuberculatus</i>	
	observed	Frequency expected	observed	Frequency expected
0	1859	1854,8	907	905,9
1	82	89,2	108	113,9
2	17	15,5	31	24,2
3	5	3,9	5	5,9
4	1	1,0	1	1,5
	1964		1052	

Mean number of polychaetes per host :	0,0687	0,1797
Variance :	0,1027	0,2462
Index of dispersion :	1,4942	1,3706
k :	0,1600	0,4196
X ² :	1,0202	2,5101

DISCUSSION

The morphological examination of the polychaetes obtained from the branchial cavities of the brachyuran crabs *Liocarcinus depurator*, *Macropipus tuberculatus*, and *Goneplax rhomboides*, clearly identifies them as individuals of the polychaete species *Iphitime cuenoti*.

The increase in infestation prevalence with increasing depth observed for *L. depurator* may be a consequence of the thermal conditions required to complete the

life cycle of the polychaete. Although host abundance increases above 100 m depth, the polychaete appears to avoid this depth range. This depth zone experiences broad hydrographic fluctuations (largely thermal ones) during the year, which may explain the very small presence of the polychaete in this zone. The influence of the depth range on the degree of infestation prevalence is further confirmed by the relative independence of infestation prevalence from depth for *M. tuberculatus*, which occurs deeper (> 100 m depth) than the zone subject to broad temperature fluctuations. The influence of depth on the presence of the polychaete in the branchial cavities of *L. depurator* and *M. tuberculatus* has also been observed by Belloni and Mori (1985), although they report a lower relative density in the deepest levels examined than ours. Temperature preferences could be considered one of the main factors affecting distribution of *I. cuenoti*. It is a common fact that species occurring both in the Atlantic and in the Mediterranean inhabit deeper cooler waters in the latter sea (e.g. Laubier, 1973; Abelló & Valladares, 1985).

The higher infestation prevalence in females of *L. depurator* agrees with the results of Fage and Legendre (1933). This sex difference may be attributable to the differences between the moulting cycle of males and females of this species (Abelló, 1986). Belloni and Mori (1985), however, only detected the presence of the polychaete in a small number of females.

The distribution of infestation intensity agrees with the theoretical distribution resulting from a contagious dispersion, although the statistical fit of the distribution alone cannot be used to derive the biological mechanisms which generate the observed distribution. This can only be achieved through the knowledge of the biological characteristics of the species involved. The increase in the degree of infestation prevalence with increasing body size is characteristic of a typical infestation behaviour. The life cycle of the polychaete is yet unknown, but the infestation probably occurs during the larval or postlarval stages. If the infestation occurs through the attachment of a larva or postlarva of the polychaete to the branchial cavity of the host, the probability of infestation of any individual by the polychaete should be directly proportional to the host age.

The presence of the polychaete in crabs in postmoulting stage implies that the polychaete is able to overcome the stress induced by the host moulting. The presence of a single polychaete appears to favour later infestation by a larger number of individuals. This may derive from the production of substances that could attract the larvae or postlarvae of the polychaete, and probably from the reproductive behaviour of this species. No account of free life of the polychaetes in sediments has been reported to date.

The results obtained from the examination of the guts of the polychaetes suggest a commensal relationship between the crab and the polychaete. Even though the observation of some evident branchial damage associated to the presence of *I. cuenoti* has not been detected (see also Pilger, 1971), the relationship may also involve some degree of parasitism. The complex structure of the mandibular ap-

paratus of the polychaete, particularly so in males, appears to be an adaptation to capture and break down small portions of food teared down from the prey of the brachyuran host. Hartnoll (1962) points out however that only a few particles are not filtered and reach the branchial cavity advected by the water flow created by the branchial movements. The differences in mandibular size between males and females cannot be attributed, with the evidence at hand, to dietary differences between the two sexes. The gut contents examined by Gaston and Benner (1981) in a related species, *Eteonopsis geryonicola*, proved probably to be digested mucus from the host crab. No mandibular structure or gut contents point to a blood-sucking way of feeding (Kierkegaard, 1977).

Overstreet (1983) states that commensalism implies that one partner benefits by being able to feed on material captured, attracted or ingested by the second, usually larger, partner, the large partner being ideally neither harmed nor benefited. According to this concept, *I. cuenoti* can be considered as a commensal in association with the studied crabs (*L. depurator*, *M. tuberculatus* and *G. rhomboides*), since no apparent damage has been detected in the host and its way of feeding seems to be related to material captured or attracted by the host. Possible competition regarding oxygen uptake and possible minor damages to the branchiae have not been studied and should be further investigated to obtain more accurate conclusions on the relationships between the commensal and its hosts.

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Resumen : Ha sido observada la presencia del poliqueto *Iphitime cuenoti* en las cámaras branquiales de los braquiuros *Liocarcinus depurator*, *Macropipus tuberculatus* y *Goneplax rhomboides*. Se describen y analizan las características de la infestación: intensidad y prevalencia de la infestación en función de la talla, sexo y profundidad de captura del huésped. Un 5,5 % y un 12,3 %, respectivamente para *L. depurator* y *M. tuberculatus*, de los individuos examinados han resultado estar infestados por *I. cuenoti*. En *L. depurator* la prevalencia aumenta con la profundidad. En ambas especies la prevalencia aumenta con la talla del huésped. La intensidad de la infestación presenta características de distribución de contagio.

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