Epibiont bryozoans (Bryozoa, Ctenostomatida) of the crab *Goneplax rhomboides* (Brachyura, Goneplacidae) off the Ebro delta (western Mediterranean)

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Epibiont bryozoans (Bryozoa, Ctenostomatida) of the crab Goneplax rhomboides *(Brachyura, Goneplacidae) off the Ebro delta (western Mediterranean).*– The occurrence of the bryozoan *Triticella flava* Dalyell, 1848 and *Alcyonidium mamillatum* Alder, 1857 was detected on the carapaces of the crab *Goneplax rhomboides* (Linnaeus, 1758) on the continental shelf off the Ebro delta (western Mediterranean). The main characteristics of the morphology of both species are described and illustrated. From the occurrence data of both bryozoans on individuals of the host species, their prevalence is studied as a function of sex, size and maturity stage of the host, as well as their seasonal and bathymetric variability. The host population studied thrives around the river Ebro delta and was sampled using epibenthic trawls. *T. flava* preferentially colonized the coxae of the pereiopods and the posterior dorsal margin of the carapace, whereas *A. mamillatum* basically colonized the smooth dorsal surfaces of the carapace and chelipeds. A morphometrical analysis of the individuals of *T. flava* was performed, showing that those individuals settled on more protected areas of the carapace had longer peduncles than those settled on more exposed areas. The prevalence of *T. flava* (36.3%) was much higher than that of *A. mamillatum* (0.7%). A significant increase in prevalence with size was found in males, but not in females, in agreement with the occurrence of different moulting patterns between the sexes. The prevalence was much higher in individuals parasitised by a sacculinid, which seemed to inhibit moulting. Moreover, the prevalence was also much higher in ovigerous than in non-ovigerous females. No significant variation in prevalence was detected with depth. The occurrence of epibionts was found to be fairly regular throughout the year.

Key words: Epibiosis, Bryozoa, Brachyura, *Goneplax, Triticella, Alcyonidium.*

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Introduction

The carapaces of epibenthic decapod crustaceans constitute one of the few available hard substrata found on bottoms which are considered as soft, such as sand and mud, the most widespread substrates in the sea. Many organisms (protozoans, algae, cirripedes, bryozoans, hydrozoans, bivalves, etc.) use this substratum, which has a relatively short life-span due to moulting (shedding of the crab's exoskeleton), as an alternative to other permanent hard substrata. The study of epibiont species can provide important information on the age, population structure and behavioural characteristics of the host species (Botton & Ropes, 1988; Williams & Moyse, 1988; Abelló et al., 1990; Jeffries et al., 1992; etc.). Furthermore, the close association between the moulting cycle and the possible settlement and growth of epibiont species on the carapace, enables the development of an ecological succession temporally limited by the length of the intermoult period of the host species (Barnes & Bagenal, 1951; Eggleston, 1971; Gili et al., 1993). Moreover, crustacean carapaces have been very little studied and understood and provide scientific surprises such as the recent discovery of a new species which actually constituted a new zoological phylum (Funch & Kristensen, 1995).

The present study set out to analyse the patterns of occurrence of two epibiont bryozoans on the crab *Goneplax rhomboides* (Linnaeus, 1758) in order to acquire complementary information on the biology and ecological behaviour of the host species from the information that can be gathered from the epibionts themselves. *G. rhomboides* is a species which excavates and inhabits burrows on muddy bottoms of the Mediterranean and western Atlantic (Zariquiey-Álvarez, 1968; Rice & Chapman, 1971; Atkinson, 1974a, 1974b). The association between the epibionts and the host appears to be highly specific since the occurrence of the epibiont species has not been detected on any other type of substratum in the study area.

Material and methods

The study area was located on the continental shelf off the river Ebro delta. A total of 43 samples, evenly distributed throughout the year, was examined. These were obtained using benthic trawls performed at depths of between seven and 75 m on detritic mud bottoms throughout 1991 (April-November: 17 samples) and between November 1992 and October 1993 (26 samples). A total number of 2783 *Goneplax rhomboides* (1980 males and 803 females) was examined in vivo to assess the occurrence of macroepibionts (those visible to the naked eye) on their carapace. Sex (with indication of the occurrence of ovigerous females), size (carapace length, with an accuracy of 0.1 mm), occurrence and specific identification of macroepibionts, and occurrence of rhizocephalan externae were assessed in each host individual examined.

The length of the zooid and peduncle of the individuals of *Triticella flava* present on different areas of the carapace of an adult male of the host species was measured with an ocular micrometer coupled to a binocular microscope.

To study the variability of the epibiosis prevalence as a function of depth, those samples with 10 or more captured individuals of each sex of the host species were analysed. The mean depth of each trawl was used to assign each sample to a depth. Variability in sampling depth was minimal due to the particular geomorphology of the continental shelf of the Ebro river delta. A total of 34 male and 21 female samples was used.

Results

Macroepibionts

The occurrence of the bryozoans *Triticella flava* Dalyell, 1848 and *Alcyonidium mamillatum* Alder, 1857 was detected on the carapaces of the crab *Goneplax rhomboides*. These bryozoans are the most prevalent macroepibionts on the exoskeleton of *G. rhomboides*, since the occurrence of an unidentified serpulid polychaete was detected only occasionally (0.3% of the host individuals examined).

Triticella flava Dalyell, 1848 (fig. 1)

Triticella korenii Prenant & Bobin, 1956: 268; d'Hondt, 1983: 70-71, fig. 38 A.

Triticella flava Hayward, 1985: 117-119, fig. 39.

Table 1. Mean values (in µm) (mean), standard deviation (S.d.), maximum (max) and minimum (min) of zooid length (ZL), width (ZW), peduncle length (PL) and ratio zooid length-total length (ZL/TL=ZL/ZL+PL) of the individuals of *Triticella flava* occurring in different regions of the carapace of an adult male *Goneplax rhomboides:* Isc1. Ischium of the first pereiopod; Pteryg. Pterygostomian region; Coxa4. Coxa of the fourth pereiopod; Mer/carp3. Mero-carpial articulation of the third pereiopod; Stern. Thoracic sternite; Carp/prop3. Carpo-propodial articulation of the third pereiopod; Post marg. Posterior margin of the carapace.

Valores medios (en µm) (mean), desviación típica (S.d.), máximo (max) y mínimo (min) de la longitud del zooide (ZL), anchura (ZW), longitud del pedúnculo (PL) y relación longitud del zooide-longitud total (ZL/TL=ZL/ZL+PL) de los individuos de Triticella flava *presentes en distintas regiones del caparazón de un macho adulto de* Goneplax rhomboides: *Isc1. Isquio del primer pereiopodio; Pteryg. Región pterigostomiana; Coxa4. Coxa del cuarto pereiopodio; Mer/carp3. Articulación mero-carpial del tercer pereiopodio; Stern. Esternito torácico; Carp/prop3. Articulación carpo-propodial del tercer pereiopodio; Post marg. Margen posterior del cefalotórax.*

		Isc1	Pteryg	Coxa4	Mer/ carp3	Stern	Carp/ prop3	Post marg	Total
ZL	mean	568.8	933.3	687.5	687.5	775.0	690.6	810.7	697.0
	s.d.	132.1	137.7	153.2	140.1	94.2	128.7	98.8	152.5
	max	800	1075	900	850	875	850	925	1075
	min	400	800	450	450	550	450	625	400
ZW	mean	251.6	300.0	287.5	292.5	302.3	293.8	346.4	290.0
	s.d.	41.3	25.0	36.1	44.2	53.0	42.3	58.5	49.7
	max	350	325	350	375	375	375	400	400
	min	200	275	225	250	200	200	250	200
PL	mean	1923.4	2350.0	1481.3	780.0	1600.0	676.6	728.6	1292.3
	s.d.	701.4	312.2	1049.6	310.0	824.0	346.5	375.7	839.1
	max	3250	2600	3650	1350	3150	1325	1275	3650
	min	950	2000	550	375	500	225	400	225
ZL/TL	mean	0.239	0.284	0.370	0.482	0.366	0.532	0.550	0.404
	s.d.	0.056	0.021	0.120	0.068	0.135	0.105	0.094	0.149
	max	0.356	0.305	0.549	0.605	0.592	0.700	0.646	0.700
	min	0.164	0.262	0.180	0.379	0.204	0.359	0.414	0.164
	N	16	3	12	10	11	16	7	75

Colony formed by a network of thin stolons fixed on the carapace from which the pedunculate zooids arise. The zooids are transparent with a light yellow-brownish coloration and are asymmetric and laterally compressed in shape. A chitinous band (frenaculum) is present on their dorsal margin, at approximately one third above the basal zone and is directed obliquely towards the apex. The orifice is terminal and circular in shape.

Measurements of both the zooids and the peduncle showed a high variability. In

Fig. 1. Zooids of *Triticella flava*: f. Frenaculum. (Scale bar 500 µm).
Zooides de Triticella flava: *f. Frenaculum. (Escala 500 µm).*

the colonies on an adult male *Goneplax rhomboides*, the autozooid length ranged between 0.40 and 1.08 mm (mean 0.70 ± 0.15), whereas the width ranged between 0.20 and 0.40 mm (mean 0.29 ± 0.05) (table 1). Concerning the peduncle length, the measurements ranged between 0.23 and 3.65 mm (mean 1.29 ± 0.84). A high variability was observed in peduncle length as a function of the degree of exposure of the part of the crab where the colony grew. Thus, in protected regions, such as the ischium of the first pair of pereiopods, the pterygostomian region, the coxa of the fourth pair of pereiopods, or the sternal region, the peduncles were longer than in exposed areas, such as the posterior margin of the cephalothorax or the carpopropodial and mero-carpial articulations of the third pair of pereiopods.

Alcyonidium mamillatum Alder, 1857 (fig. 2)
Alcyonidium mamillatum Prenant & Bobin, 1956: 199-200, fig. 82; d'Hondt, 1983: 25-40, figs. 14, 15.

The colony is encrusting and unilaminar, with almost transparent or slightly brownish irregular margins. The zooids are flattened and separated by well-defined walls. The orifice is subterminal and is placed at the

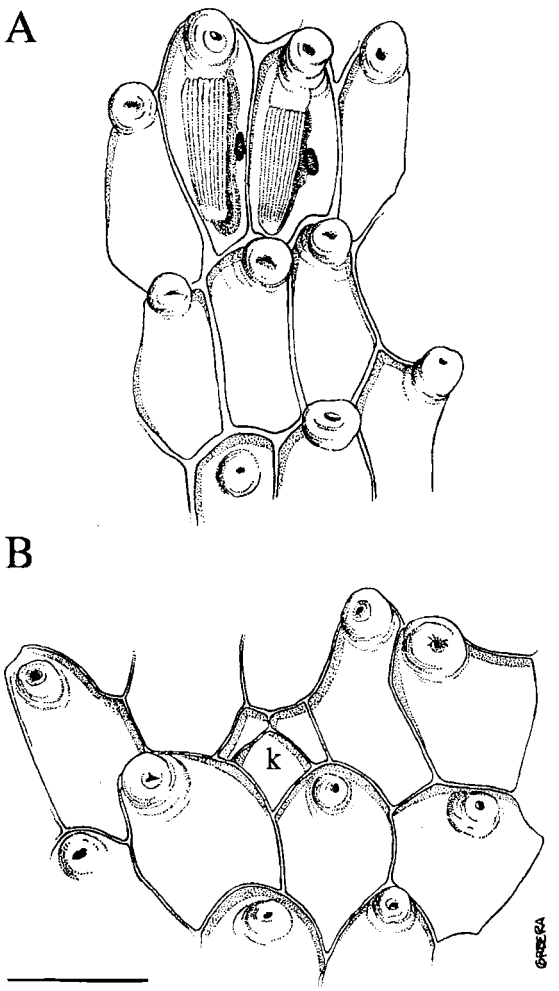

Fig. 2. Zooids of *Alcyonidium mamillatum*: A. Central region of the colony; B. Margins of the colony, with kenozooids (k). (Scale bar 500 μm).
Zooides de Alcyonidium mamillatum*: A. Región central de la colonia; B. Márgenes de la colonia, con kenozooides (k). (Escala 500 μm).*

end of a cylindrical peristome in the most contracted zooids or is slightly conical in those less affected by the contraction. In the central zone of the colony, the zooids have a rectangular or slightly hexagonal shape (fig. 2a), whereas in the margins they are less regularly placed and more irregular in shape. A few kenozooids of a polygonal shape have also been observed (fig. 2b). However, the zooids are always contiguous.

Characteristics of the epibiosis

A total of 2783 individuals of *Goneplax rhomboides* (1980 males and 803 females) was examined. The occurrence of epibionts was detected in a total of 650 males (32.8%) and 366 females (45.6%). These proportions are significantly different (G-test (2x2), $p < 0.001$). Female crabs, therefore, presented a significantly higher epibiont prevalence than males.

Table 2 presents the prevalence of each macroepibiont identified in males and females of the host species. The prevalence of *Triticella flava* (36.3%) was much higher than that of *Alcyonidium mamillatum,* which was only present in 0.7% of the host individuals examined.

The analysis of *Triticella flava* prevalence as a function of size in males and females of the host species indicated that there was a significant positive correlation ($p < 0.001$) between size and prevalence in males, but not in females ($p > 0.1$) (figs. 3, 4).

The prevalence of *Triticella flava* was much higher (G-test; $p < 0.001$) in both male and female individuals parasitised by a sacculinid rhizocephalan (table 3). Prevalence was also much higher (G-test; $p < 0.001$) in ovigerous than in non-ovigerous females (table 3).

Triticella flava occurred throughout the sampled depth range (7-75 m) and no significant correlation in epibiosis prevalence as a function of depth was detected in either male or female crabs ($p > 0.1$). Additionally, the occurrence of epibionts was approximately constant throughout the year (fig. 5). The depth range of occurrence of *Alcyonidium mamillatum* varied between seven and 47 m.

Discussion

The occurrence of epibiotic bryozoans on the carapaces of *Goneplax rhomboides* appears to be a common phenomenon given the high prevalence found in the population studied. Although no previous records of the two

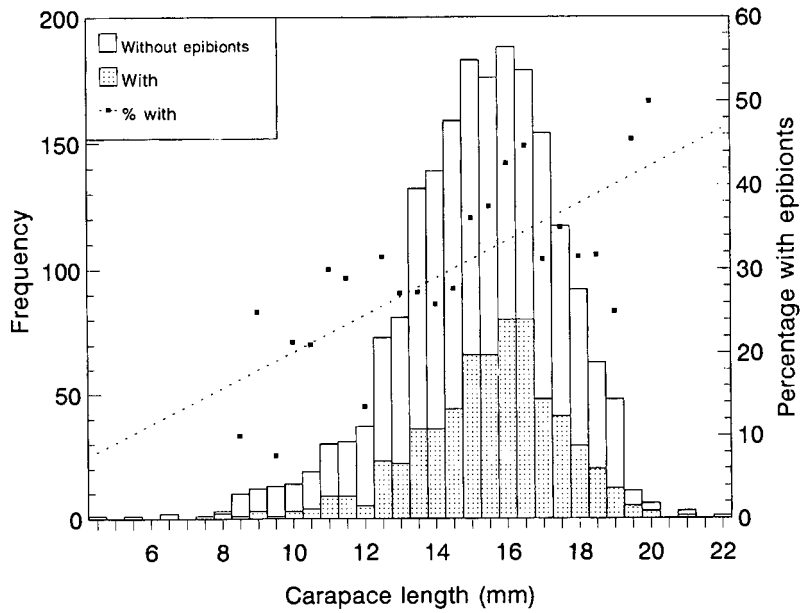

Fig. 3. Size frequency distribution of the *Goneplax rhomboides* individuals (males) examined, with indication of those carrying epibionts (*Triticella flava*) on their carapaces, as well as the percentage crabs with epibionts as a function of size.

Distribución de frecuencias de tallas de los individuos (machos) de Goneplax rhomboides *examinados, con indicación de aquellos que transportan epibiontes (*Triticella flava*) sobre su caparazón, así como el porcentaje de cangrejos con epibiontes en función de la talla.*

Table 2. Prevalence, as a function of the host sex, of the different macroepibiont species identified on the exoskeleton of the crab *Goneplax rhomboides*.

Prevalencia, en función del sexo del hospedador, de las distintas especies de macroepibiontes identificadas sobre el exoesqueleto del cangrejo Goneplax rhomboides.

	Males (n=1980)	Females (n=803)
Triticella flava	32.5%	45.6%
Alcyonidium mamillatum	1.0%	0.0%
Serpulidae	0.4%	0.0 %

Table 3. Prevalence of the epibiosis (%) by *Triticella flava*. RC. Rhizocephalan crustacean.

Prevalencia de la epibiosis (%) por Triticella flava. RC. Crustáceo rizocéfalo.

	Epibionts		
	Without	With	n
Males			
With RC	18.0	82.0	61
Without RC	68.7	31.3	1919
Females			
With RC	4.7	95.3	43
Without RC	57.2	42.8	760
Non-ovig.	62.1	37.9	662
Ovigerous	24.5	75.5	98

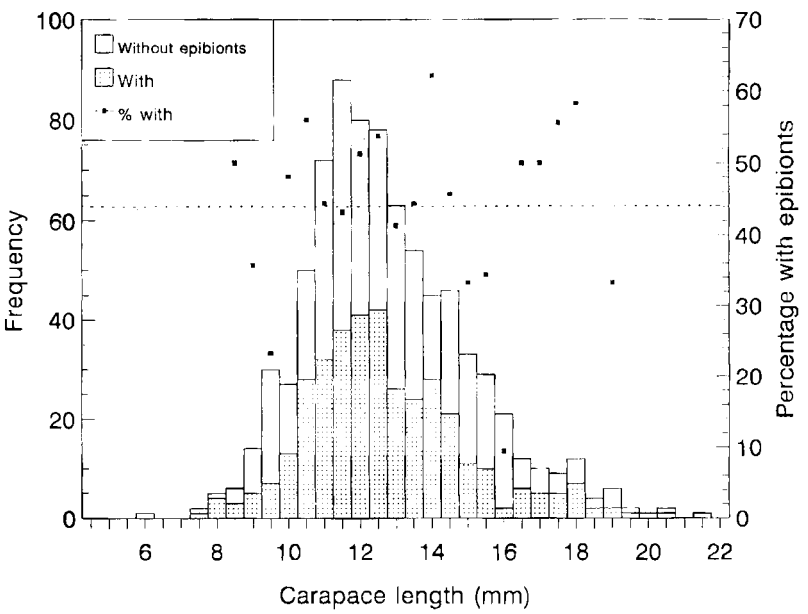

Fig. 4. Size frequency distribution of the *Goneplax rhomboides* individuals (females) examined, with indication of those carrying epibionts (*Triticella flava*) on their carapaces, as well as the percentage crabs with epibionts as a function of size.

Distribución de frecuencias de tallas de los individuos (hembras) de Goneplax rhomboides *examinados, con indicación de aquellos que transportan epibiontes (*Triticella flava*) sobre su caparazón, así como el porcentaje de cangrejos con epibiontes en función de la talla.*

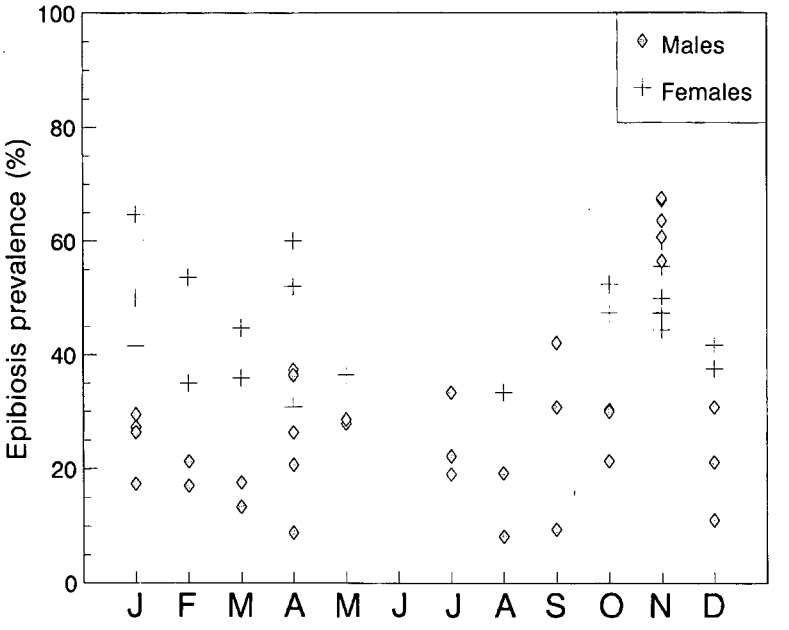

Fig. 5. Seasonal variability in *Triticella flava* epibiosis prevalence in male and female *Goneplax rhomboides*.

Variabilidad estacional en la prevalencia de la epibiosis por Triticella flava *en machos y hembras de* Goneplax rhomboides.

bryozoan species studied herein were found concerning their occurrence in the seas around the Iberian peninsula, ZABALA (1986) suggested that this might be due, as the present paper demonstrates, to the lack of appropriate sampling on the right substrata, in the present case, the carapaces of decapod crustaceans.

The distribution area of *Triticella flava* encompasses the continental shelf of the north-eastern Atlantic and Mediterranean (HAYWARD, 1985). *Triticella flava* has been previously reported on burrowing macruran decapods, such as *Calocaris macandreae, Upogebia* or *Nephrops norvegicus* (HAYWARD, 1985; PRENANT & BOBIN, 1956), and on several crabs, such as *Goneplax rhomboides* itself, which is also a burrowing species (RICE & CHAPMAN, 1971; ATKINSON, 1974a, 1974b), and on *Liocarcinus arcuatus, L. depurator, Geryon trispinosus, Xantho pilipes* and *Carcinus maenas* in the north Atlantic (INGLE, 1983).

Alcyonidium mamillatum is known to colonize hydroids, *Laminaria* fronds, decapods and mollusc shells (PRENANT & BOBIN, 1956). Although its occurrence is rare, it presents a wide distribution, which comprises the shallow shore, typically sublittoral (HAYWARD, 1985) of the Arctic Ocean, North Sea, Atlantic Ocean, Mediterranean Sea and Pacific Ocean (D'HONDT, 1983). No kenozooids have been observed previously in the colonies of European seas, but they are present in colonies from Brazil (HAYWARD, 1985).

The peduncles of the zooids of *Triticella flava* are longer in those zooids occurring on protected regions of the exoskeleton than in those present on areas more overtly exposed to friction with the burrow walls. These differences in morphology of the zooids may be related to two facts: one

would be a trophic reason, according to which the zooids occurring on protected regions would have longer peduncles which would allow them to reach wider access to food; the other would be a purely mechanical constraint, according to which those zooids occurring in more exposed areas would have shorter peduncles and then result in less friction with the walls of the burrows where *Goneplax rhomboides* inhabits. These burrows are very tightly fitted to the body of the crab (ATKINSON, 1974a), and there appears to be a high level of friction between the burrow wall and the crab carapace. This evidently affects the morphological characteristics of the epibionts.

The significant increase in epibiosis prevalence in relation to size in males of the host species *Goneplax rhomboides*, as well as the overall prevalence in both sexes, is an indicator of the existence of differing moulting patterns in the two sexes of this crab, a phenomenon which has also been reported for other crustacean species (ABELLÓ et al., 1990). The moulting cycle in female crabs is very closely related to the development of the reproductive cycle, in such a way that moulting can not take place during the period of egg carrying, as happens in decapod crustaceans of the suborder Pleocyemata. This strongly limits the periodicity and the time of moulting in female crabs. The prevalence of epibionts has been found to be much higher in ovigerous than in non-ovigerous females, since egg carrying dominates over moulting processes in females. This is not so in males, in whom moulting is not usually as markedly seasonal as in female crabs and tends to be more widely spread throughout the year.

Epibiosis prevalence was also much higher in those host crabs parasitised by a sacculinid rhizocephalan. This parasitation, besides inducing parasitic castration, also appears therefore to inhibit or drastically diminish moulting in those crabs affected.

The two bryozoan species studied were not observed in any other species of decapod crustacean of the study area, such as *Liocarcinus depurator,* the most common crab of the region, or even in other sympatric burrowing species, such as the stomatopod *Squilla mantis*. This would therefore indicate that a high degree of specificity takes place in the relationship between host and epibionts in the study area.

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Resumen

Briozoos (Bryozoa, Ctenostomatida) epibiontes del cangrejo Goneplax rhomboides *(Brachyura, Goneplacidae) en el delta del Ebro (Mediterráneo occidental)*

Se ha detectado la presencia de los briozoos *Triticella flava* y *Alcyonidium mamillatum* viviendo sobre los caparazones del cangrejo *Goneplax rhomboides* en la plataforma continental del delta del rio Ebro (Mediterráneo occidental). Se realiza una descripción e ilustración de la morfología de cada especie (figs. 1, 2). A partir de los datos de presencia-ausencia de los citados briozoos sobre individuos de la especie hospedadora se estudia la prevalencia en función del sexo, talla, y estado de madurez de los individuos de la especie hospedadora (figs. 3, 4), así como las variaciones temporales y espaciales en función de la batimetría (fig. 5). La población estudiada procede de la plataforma continental alrededor del delta del rio Ebro y se muestreó con artes de arrastre epibentónicos. Los individuos de *T. flava* colonizan preferentemente las coxas y articulaciones de los pereiópodos y margen posterior dorsal del cefalotórax, mientras que *A. mamillatum* coloniza básicamente las superficies lisas dorsales del caparazón y quelípedos. Se ha realizado un análisis morfométrico de los individuos de *T. flava*, indicando que aquellos individuos asentados en zonas más protegidas del caparazón presentan longitudes de pedúnculo superiores a los asentados en zonas más expuestas (tabla 1). La prevalencia de *T. flava* (36,3%) es muy superior a la de *A. mamillatum* (0,7%). Se ha detectado un aumento significativo de la prevalencia en función de la talla en machos, pero no en

hembras, el cual está de acuerdo con la diferencia existente entre los ciclos de muda de machos y hembras. La prevalencia es muy superior en individuos parasitados por un saculínido. Igualmente, la prevalencia es muy superior en hembras ovígeras que en hembras no ovígeras (tablas 2, 3). No se han detectado variaciones significativas en la prevalencia de la infestación en función de la batimetría. La presencia de epibiontes es aproximadamente constante a lo largo del año sin que se hayan observado épocas con una mayor prevalencia (fig. 5).

References

ABELLÓ, P., VILLANUEVA, R. & GILI, J. M., 1990. Epibiosis in deep-sea crab populations as indicator of biological and behavioural characteristics of the host. *J. mar. biol. Ass. U. K.*, 70: 687-695.

ATKINSON, R. J. A., 1974a. The activity rhythm of *Goneplax rhomboides* (L.). *Mar. Behav. Physiol*, 2: 325-335.

- 1974b. Behavioural ecology of the mud-burrowing crab *Goneplax rhomboides*. *Mar. Biol.*, 25: 239-252.

BARNES, H. & BAGENAL, T. B., 1951. Observations on *Nephrops norvegicus* (L.) and on an epizoic population of *Balanus crenatus* Brug. *J. mar. biol. Ass. U. K.*, 30: 369-380.

BOTTON, M. L. & ROPES, J. W., 1988. An indirect method for estimating longevity of the horseshoe crab (*Limulus polyphemus*) based on epifaunal slipper shells (*Crepidula fornicata*). *J. Shellfish Res.*, 3: 407-412.

EGGLESTON, D., 1971. Synchronization between moulting in *Calocaris macandreae* (Decapoda) and reproduction in its epibiont *Triticella korenii* (Polyzoa Ectoprocta). *J. mar. biol. Ass. U. K.*, 51: 404-410.

FUNCH, P. & KRISTENSEN, R. M., 1995. Cycliophora is a new phylum with affinities to Entoprocta and Ectoprocta. *Nature*, 378: 711-714.

GILI, J. M., ABELLÓ, P. & VILLANUEVA, R., 1993. Epibionts and intermoult duration in the crab *Bathynectes piperitus*. *Mar. Ecol. Prog. Ser.*, 98: 107-113.

HAYWARD, P. J., 1985. *Ctenostome Bryozoans. Synopses British Fauna (New Series). 33.* Cambridge University Press, Cambridge.

HONDT, J.-L. D', 1983. Tabular keys for identification of the recent Ctenostomatous Bryozoa. *Mém. Inst. océanog. Monaco*, 14: 1-134.

INGLE, R. W., 1983. *Shallow-water Crabs. Synopses British Fauna (New Series). 25.* Cambridge University Press, Cambridge.

JEFFRIES, W. B., VORIS, H. K. & POOVACHIRANON, S., 1992. Age of the Mangrove Crab *Scylla serrata* at colonization by stalked barnacles of the genus *Octolasmis*. *Biol. Bull.*, 182: 188-194.

PRENANT, M. & BOBIN, G., 1956. Bryozoaires. 1. Entoproctes, Phylactolèmes, Cténostomes. *Faune de France*, 60: 1-398.

RICE, A. L. & CHAPMAN, C. J., 1971. Observations on the burrows and burrowing behaviour of two mud-dwelling decapod crustaceans, *Nephrops norvegicus* and *Goneplax rhomboides*. *Mar. Biol.*, 10: 330-342.

WILLIAMS, R. & MOYSE, J., 1988. Occurrence, distribution, and orientation of *Poecilasma kaempferi* Darwin (Cirripedia: Pedunculata) epizoic on *Neolithodes grimaldi* Milne-Edwards and Bouvier (Decapoda: Anomura) in the northeast Atlantic. *J. Crust. Biol.*, 8: 177-186.

ZABALA, M., 1986. *Fauna dels Briozous dels Països Catalans. Arxius Secció Ciències, 84.* Institut d'Estudis Catalans, Barcelona.

ZARIQUIEY-ÁLVAREZ, R., 1968. Crustáceos decápodos ibéricos. *Inv. Pesq.*, 32: 1-510.