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DECORATION PREFERENCES OF *MAJA CRISPATA* RISSO 1827 (BRACHYURA, MAJIDAE)

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Decoration preferences, position, structure and morphology of the hooked setae were questions addressed in this study. Data were collected through the use of a scanning electron microscope. The location of the hooked setae on the exoskeleton was mapped.

Spider crabs (family Majidae) often decorate themselves. They put pieces of marine organisms among the hooked setae of the exoskeleton. The decoration might serve as protection from visual predators. *M. crispata* is an opportunist that uses several algae, based on the abundance of the available algae and the morphological structure. *M. crispata* also is a generalist: it attempts to look less like a crab in order to become invisible to its visual predators.

Key words: camouflage, algae, *Maja crispata*, Majidae, Adriatic Sea

Fürböck, S. & R. A. Patzner: Odabir ukrasa kod male rakovice *Maja crispata* Risso 1827 (Brachyura, Majidae). Nat. Croat., Vol. 14, No. 3., 175–184, 2005, Zagreb.

U ovom radu obrađuju se pitanja odabira dekoracija, položaja, strukture i morfologije kukastih seta. Podaci su prikupljeni pomoću skenirajućeg elektronskog mikroskopa. Ucrtavan je položaj kukastih seta na egzoskeletu.

Rakovice (porodica Majidae) se često ukrašuju. Među kukaste sete na svom egzoskeletu stavljaju dijelove morskih organizama. Ta dekoracija može služiti kao zaštita od vizualnih predatora. *M. crispata* je oportunist koji koristi nekoliko algi, ovisno o brojnosti dostupnih algi i morfološkoj strukturi. *M. crispata* je također generalist: pokušava što manje izgledati kao rak da bi tako postala što manje vidljiva svojim vizualnim predatorima.

Ključne riječi: maskiranje, alge, *Maja crispata*, Majidae, Jadran

INTRODUCTION

Like many other members of the family Majidae, the spider crab *Maja crispata* attaches pieces of algae, sponges, bryozoans, hydrozoans and ascidians to the exoskeleton. This is called »decorating« (AURIVILLIUS, 1889; BÜRGI, 1968; WICKSTEN,

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1980, 1983) and provides a moving garden habitat for a large community of sessile marine organisms like brachiopods, bivalves and polychaetes.

A number of hypotheses regarding the origin and function of decoration behaviour have been presented by AURIVILLIUS (1889) for different species of *Hyas*, and WICKSTEN (1979, 1980, 1993) for the Californian spider crabs *Loxorhynchus grandis* and *L. crispatus*. Decoration might serve as protection from visual predators, if it allows the animal to blend into the environment, by either matching the background or by »looking less like a crab« (WICKSTEN, 1980, 1993). Decoration can also enable crabs to ambush unsuspecting prey, as has been suggested by WICKSTEN (1980, 1993). It also has been hypothesized that some majid crabs attach algae to their bodies in order to store food for later consumption (WICKSTEN, 1980, 1993; MASTRO, 1981; WOODS & MCLAY, 1994a; WOODS, 1995; KENNISH & WILLIAMS, 2000; SATO & WADA, 2000; CRUZ-RIVERA, 2001). If crabs place algae on their carapace to consume it later, it palatable algae could be expected to be favoured for decoration (WOODS & MCLAY, 1994a, b; WOODS, 1995). This would entail some degree of selectivity by the crabs when attaching algae to their bodies.

The majority of the spider crabs, however, do not choose particular species of vegetation. They use species that are common in their habitat. *Acanthonyx petiveri* preferentially camouflages itself with algae of the same colour as its background. It may acquire matching pigments in its exoskeleton from the algae that it eats (WILSON, 1987). *Libinia dubia* also shows a kind of selectivity. STACHOWICZ & HAY (2000) have demonstrated that *L. dubia* camouflages almost exclusively with the chemically noxious algae *Dictyota menstrualis* in order to gain protection from omnivorous consumers.

Decorating is an activity for which the crab is morphologically well adapted. All species of the family Majidae have rows of hooked setae on the surface of the carapace, as documented by AURIVILLIUS (1889) and WICKSTEN (1976). The setae are cuticular growths with a central canal, filled with a fine-grained mass. The walls are thick up to the top, made out of horn and therefore flexible. The structure of the walls is homogeneous. The surface of the sides show a raised structure. The setae are found in a depression of the cuticula. At the base of the depression, the cuticula forms a ring-shaped thickening. The setae are hooked. On the strong, large and concave side of the hook, smaller spinules are found. The curve of the hook points down to the base. The setae on the crab are arranged in clusters, in which the curves of the setae on one side point toward each other. This opposed position allows them to grasp objects better. Crabs use various behavioural strategies for concealment, but decorating by attaching pieces to the hooked setae of the exoskeleton has been found only in the family Majidae (AURIVILLIUS, 1889; WICKSTEN, 1976).

The purpose of this study is to determine if *M. crispata* shows selection preferences in algal decorations in the field. The structure, morphology and position of the hooked setae of the exoskeleton are studied. Observations of the crabs in life are provided. The decorating strategies of *M. crispata* are compared to those of other spider crabs.

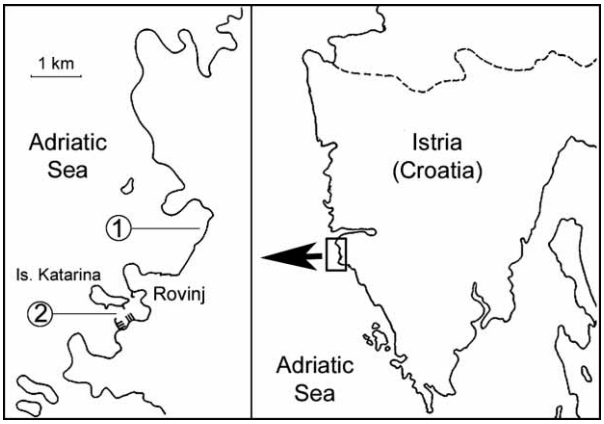

Fig. 1. Coast outline of the study site in Istria at Rovinj with the two selected areas. 1) boulder field and 2) sandy area with rocks.

MATERIAL AND METHODS

The study was carried out along the coast of Rovinj, Croatia (45°04,06´N and 13°38,04´E). Data on decoration preferences were collected in two selected areas (Fig. 1): a boulder field region near Camping Biondi and a shallow sandy area with some rocks near the island of Katarina.

All of the spider crabs found in the field were collected for measurement and sexing, and for description of the species and placement of decorating material on the carapace. All the algae were taken off with a forceps. After assessment, crabs were released back to the place where they had been originally caught. The algae were sorted under a microscope and identified according to MUNDA *et al.* (2004) and GUIRY & NIC DHONNCHA (2005). The distribution of the algae available to the crabs in the field was quantified by random encounter methods.

Examinations of the setae were done with a Cambridge Stereoscan 250 electron microscope. Parts of the carapace were secured with soft silver on sample holders. Afterwards, these parts were sputtered for conducting gold layers onto the sample to prevent charging effects in the scanning electron microscope.

RESULTS

The boulder field is characterized by a well-developed phytal composed mainly of *Cladophora* sp., *Dictyota dichotoma, Halimeda tuna, Padina pavonica, Codium vermilara, Asparagopsis armata, Stypocaulon scoparium, Plocamium cartilagineum*, while *Dictyota dichotoma* was the most abundant alga in the habitat. All *Maja crispata* examined in this area of study were predominantly masked with four species of algae: *Dictyota dichotoma, Halopteris scoparia, Corallina rubens* and *Asparagopsis armata* (Fig. 2).

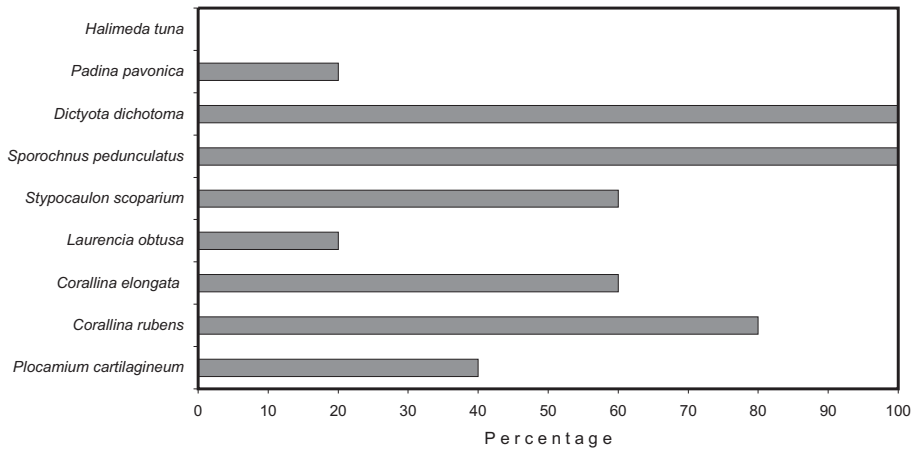

Fig. 2. Algae of the boulder field and the percentage of use for decoration by *Maja crispata*.

In the sandy area the most abundant algae were *Halimeda tuna, Padina pavonica, Sporochnus pedunculatus, Stypocaulon scoparium, Laurencia obtusa, Corallina elongata, Plocamium cartilagineum* and *Corallina rubens*. The decorated crabs were found to use mainly *Dictyota dichotoma, Sporochnus pedunculatus* and *Corallina rubens* (Fig. 3).

The number and the length of algal pieces applied did not vary with size of the crab. The chelipeds of none of the crabs were decorated. The material placed on the carapace was larger than that on the walking legs. Algal fragments ranged in length from 3 to 40 mm. The species of algae used in decoration did not depend on the size or sex of the individual.

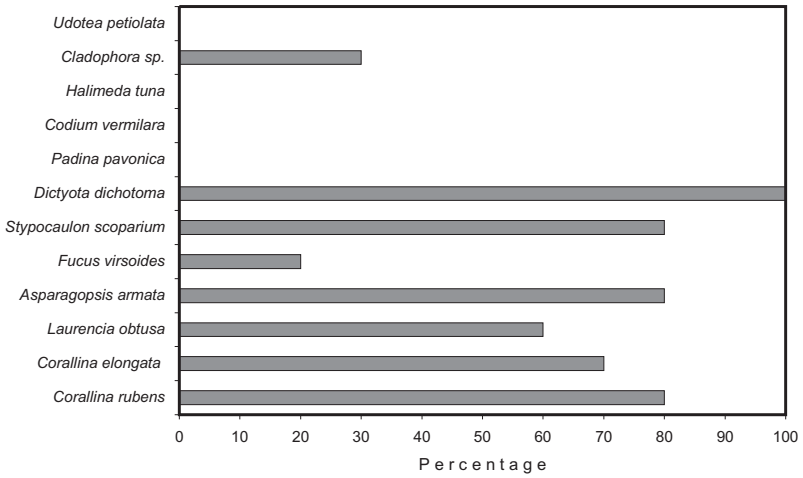

Fig. 3. Algae of the sandy area with rocks and the percentage of use for decoration by *Maja crispata*.

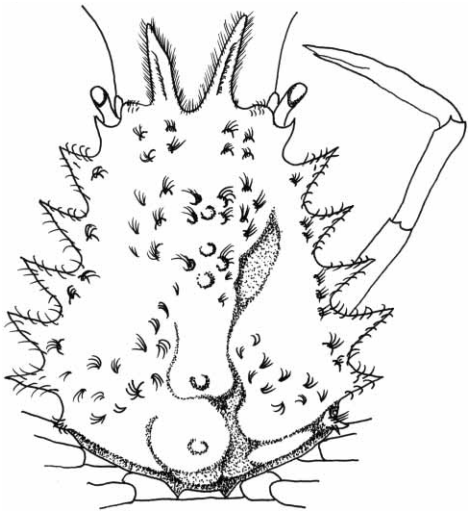

Fig. 4. Surface of the carapace with the location of the setae.

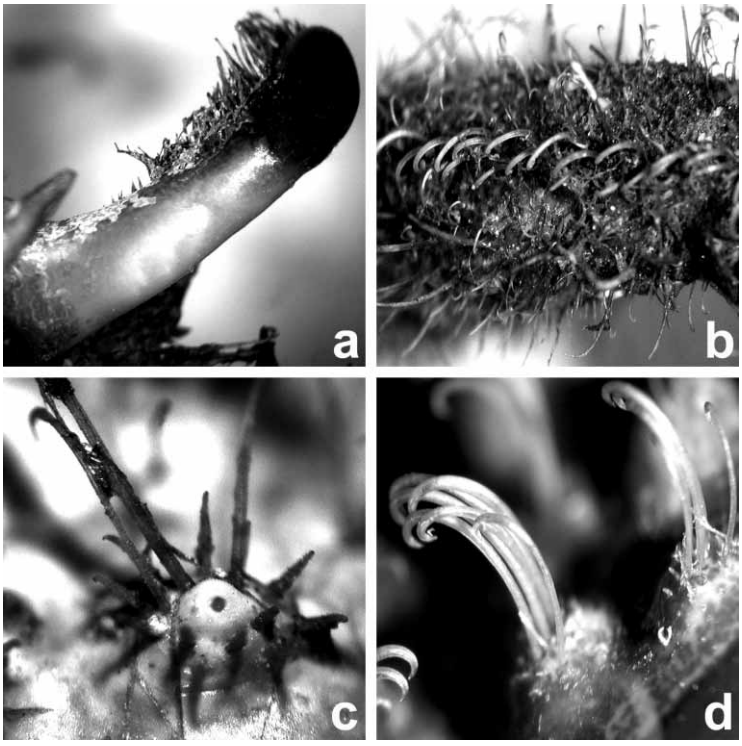

Fig. 5. Hooked setae of *Maja crispata*. a) left eye b) surface of walking leg c) ring of setae with one longer seta in the middle d) longer setae arranged in a bunch.

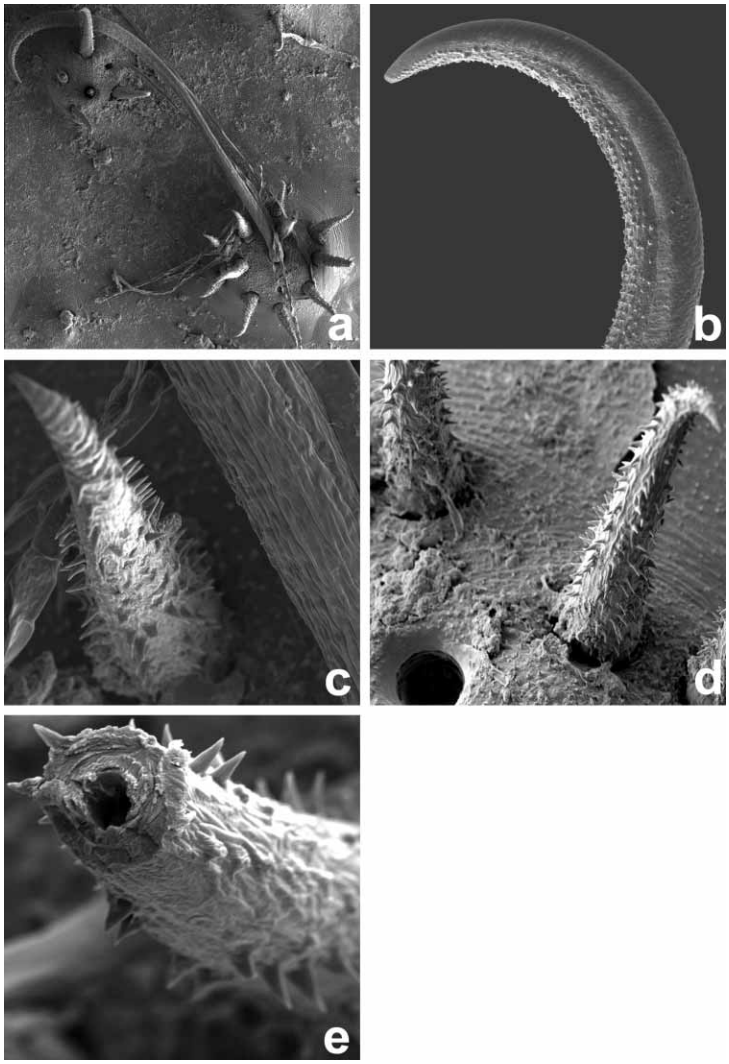

Fig. 6. Hooked setae of *Maja crispata* by scanning electron microscopy. a) ring of setae with one longer seta in the middle, enlarged 43 x; b) curve of a long seta showing spines 200 x; c) surface of a long (right) and short (left) seta, 350 x; d) short setae with long spines, 200 x; e) cross-section of a short seta with a canal in the middle, 8400 x.

Structure and morphology of the setae

The crab has rows of hooked setae on the entire dorsal surface of the carapace and legs, as shown in Fig. 4. The carapace has four rows of longer, bunched setae that lie within reach of the chelae. Two of them lie in the middle of the carapace

and the others are located along the five strong spines on each side. The majority, however, consist of smaller hooked setae arranged in rings over the entire surface of the carapace (Fig. 4). The five spines on each side of the carapace and the two slender outward curving spines protruding from the head are made up of a large number of long hooked setae that are densely compacted side by side. Only the upper side of the legs shows a row of hooked setae. The others are straight and longer.

Figures 5a and 5b show images of the left ocular peduncle and a walking leg with hooked setae. Two different types of arrangements of setae can be recognized. The first type, shown in Fig. 5c, has from 6 to 13 setae arranged in a ring, with one or two longer setae in the middle. The second type has 5 to 9 setae arranged in bunches, located on ridges (Fig. 5d).

The images of the scanning electron microscope show that there are long hooked setae and short bent setae (Fig 6a). The longer hooked setae are 1.5 to 1.7 mm long and 0.05 to 0.1 mm wide. Their entire surface shows an irregularly grooved structure from the base to the top (Fig. 6a). Towards the curve, the grooves are gradually replaced by irregularly placed small spines that may serve to secure the bits of algae with which the crab marks itself (Fig. 6b). The ratio of height and radius of the curve is approximately 9 to 2. The smaller setae (Fig. 6c, 6d), arranged in rings are 0.15 to 0.25 mm high with a diameter at the base of 70 μm. Their entire surface is covered by larger spines. Fig. 6e shows a cross-section through a short seta with a canal filled with a fine-grained mass.

DISCUSSION

The main function of decorating in spider crabs has been considered to be camouflage (AURIVILLIUS, 1889; WICKSTEN, 1980, 1993). Observations of *Maja crispata* in the wild support this hypothesis. During the daylight hours, the crabs remain motionless, resting among rocks, certain types of algae and seaweed. They are difficult to detect visually when they rest on the substrate. If detected, they pinch with the chelae, attempt to run away, hide in a crack or even »parachute« off the side of a cliff by releasing their hold and then spreading the legs.

Different means of camouflage characterize generalists versus specialists. The tactic for a generalist is »to look less like a crab« (WICKSTEN, 1980, 1993). By contrast, the tactic for a specialist is to match the decoration of the crab perfectly to the background. In this case, crabs are more likely to match their decoration to the background environment. They decorate themselveds with a particular algal species, and inhabit the place where those algae are abundant (SATO & WADA, 2000; STACHOWICZ & HAY, 2000). In SATO & WADA (2000), the spider crab *Pugettia quadridens quadridens*, was described as a specialist with a limited microhabitat, whereas the spider crabs *Tiarinia corniger* and *Micippa platipes* may be regarded as generalists. The results of the study show that *M. crispata* is a generalist. It tries to look less like a crab in order to become invisible for its visual predator.

The use of attached algae as food (WICKSTEN, 1980; MASTRO, 1981; WOODS & MCLAY, 1994a) was not observed among *M. crispata*. MASTRO (1981) postulated that

if the juvenile *Pugettia producta* are isolated from food, they eat the algae from their own rostrum.

A number of studies suggest that decorator crabs in general are opportunistic decorators. Decoration is an unselective process in which crabs choose materials based on availability (AURIVILLIUS, 1889; WICKSTEN, 1980, 1993; but see STACHOWICZ & HAY, 2000; SATO & WADA, 2000; CRUZ-RIVERA, 2001). The results from the present study generally confirm this hypothesis for *M. crispata*. Decoration can be influenced by a number of factors like habitat, depth and available materials (WICKSTEN, 1993). In *M. crispata*, the preference for *Dictyota dichotoma, Stypocaulon scoparium, Corallina rubens, Asparagopsis armata* and *Sporochnus pedunculatus* may be related to the habitat, abundance of available algae, and morphology of the algae.

There are only a few studies that investigate preference for decoration in relation to the abundance of available algae (WOODS & PAGE, 1999; STACHOWICZ & HAY, 2000). In terms of morphology, the crabs appear to decorate more readily with thinner, branched algae that are presumably easier to cut and attach to the setae (WOODS & MCLAY, 1994b; STACHOWICZ & HAY, 2000; KENNISH & WILLIAMS, 2000; CRUZ-RIVERA, 2001). In the study of CRUZ-RIVERA (2001) three Mediterranean crabs (*Pisa tetraodon, Macropodia rostrata, Acanthonyx lunulatus*) showed a high degree of specificity in decorating preferences based on algal morphology. KENNISH & WILLIAMS (2000) also stated that algal morphology appears to be of prime importance. The nutrient content and digestibility of algae is, however, of secondary importance when it comes to determine the feeding preferences of *G. albolineatus*. The high consumption rate of filamentous algae outweighs their relative nutrient deficiencies. This indicates that they are better suited to meet the physiological needs of the crab than foliose algae.

Usually, *M. crispata* decorates its carapace, rostrum and legs. Similar decorating patterns have been observed by AURIVILLIUS (1889) and WICKSTEN (1980, 1993). Different decoration patterns are seen in *Macropodia rostrata*, which decorated mostly by attaching algal pieces to its legs. *Pisa tetraodon* mostly covered its carapace, but also its legs (CRUZ-RIVERA, 2001). *Acanthonyx lunulatus* attached only small algal pieces to its legs (CRUZ-RIVERA, 2001). In no crabs the chelipeds were decorated. There are only few species that attach materials to their chelipeds, such as *Trichoplatus huttoni* (WOODS, 1995).

The pattern of decorating and the materials used for this process usually do not differ between the sexes (BÜRGI, 1968), as in the case of *M. crispata*. However, in *Loxorhynchus crispatus*, adult females decorate while males do not (WICKSTEN, 1979).

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Summary

Decoration preferences of *Maja crispata* Risso 1827 (Brachyura, Majidae)

S. Fürböck & R. A. Patzner

Investigations regarding decoration preferences showed that *Maja crispata* can be described as a generalist as far as function is concerned and as an opportunist concerning preference of algae. The tactic for a generalist is »to look less like a crab« in order to become invisible for its visual predators. Opportunism in this context means that decoration is an unselective process in which crabs choose materials based on availability. The preference of *M. crispata* for some algae may be related to the habitat, abundance of available algae, and morphology of the algae. In terms of morphology, they appear to decorate more readily with thinner, branched algae, which are presumably easier to cut and attach to the setae. Algal fragments ranged in length from 3 to 40 mm. The species of algae used in decoration did not depend on the size or sex of the individual.

Decorating is an activity for which the crab is morphologically well-adapted. *M. crispata* shows rows of hooked setae over the entire surface of the carapace, rostrum and legs. Investigations made by a scanning electron microscope showed two kinds of setae, which differ in diameter, size and surface.