This article was downloaded by: [University of Bath]

On: 13 February 2014, At: 14:46

Publisher: Taylor & Francis

Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK

Journal of Natural History

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/tnah20>

Structure and distribution of carapace setae in British spider crabs

Tommy Szebeni^a & Richard G. Hartnoll^b

^a London, UK

^b Port Erin Marine Laboratory, Isle of Man, British Isles

Published online: 06 May 2009.

To cite this article: Tommy Szebeni & Richard G. Hartnoll (2005) Structure and distribution of carapace setae in British spider crabs, *Journal of Natural History*, 39:44, 3795-3809, DOI: [10.1080/00222930500404744](https://doi.org/10.1080/00222930500404744)

To link to this article: <http://dx.doi.org/10.1080/00222930500404744>

PLEASE SCROLL DOWN FOR ARTICLE

Taylor & Francis makes every effort to ensure the accuracy of all the information (the "Content") contained in the publications on our platform. However, Taylor & Francis, our agents, and our licensors make no representations or warranties whatsoever as to the accuracy, completeness, or suitability for any purpose of the Content. Any opinions and views expressed in this publication are the opinions and views of the authors, and are not the views of or endorsed by Taylor & Francis. The accuracy of the Content should not be relied upon and should be independently verified with primary sources of information. Taylor and Francis shall not be liable for any losses, actions, claims, proceedings, demands, costs, expenses, damages, and other liabilities whatsoever or howsoever caused arising directly or indirectly in connection with, in relation to or arising out of the use of the Content.

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden. Terms & Conditions of access and use can be found at <http://www.tandfonline.com/page/terms-and-conditions>

Structure and distribution of carapace setae in British spider crabs

TOMMY SZEBENI¹ & RICHARD G. HARTNOLL²

¹London, UK, and ²Port Erin Marine Laboratory, Isle of Man, British Isles

(Accepted 6 October 2005)

Abstract

Carapace setae were examined by SEM in species of spider crabs (Family Majidae). These setae are predominantly hamate (i.e. hooked), to which extraneous materials are attached for the purpose of concealment. They are described for eight species collected around the Isle of Man. In each species setae were sorted to types on the basis of consistent differences in size, shape and fine structure. Diversity ranged from two to six types per species, and this was examined in the context of their masking, or camouflage, habits. Certain setae can be assigned to particular species, so a limited taxonomic usage is indicated: however, further work is required for this to become a comprehensive tool. Distribution of setal types on the carapace is also described, and compared to patterns reported in previous studies.

Keywords: *Carapace setae, camouflage, hooked setae, Isle of Man, spider crabs*

Introduction

Most members of the spider crab family Majidae attach foreign materials to setae on the dorsal surfaces of their carapace and appendages, particularly to specialized hooked (or hamate) setae. This habit is termed masking, and is generally assumed to be primarily a means of concealment from predators (Rasmussen 1973; Getty and Hazlett 1978; Wicksten 1979; Dudgeon 1980; Wicksten 1980, 1983, Kilar and Lou 1984; Wilson 1987; Fernandez et al. 1998). Various aspects of masking have been studied by different authors, such as the process of masking (Hartnoll 1961; Wicksten 1977; Woods 1995; Woods and Page 1999), the materials used (Wicksten 1980; Mastro 1981; Hartnoll 1993; Woods and McLay 1994b), and its possible relation to feeding (Kilar and Lou 1984, 1986; Woods and McLay 1994a). Nevertheless, the structure and distribution of these carapace setae have received relatively little attention. Wicksten (1976) described the hamate setae of *Hyas lyratius* Dana, 1851, and subsequently (Wicksten 1977) briefly described the distribution of the “hooked setae” of *Loxorhynchus crispatus* Stimpson, 1857, also giving a detailed description of their SEM structure. Setal distribution has been described and quantified for *Trichoplatus huttoni* A. Milne Edwards, 1876 (see Woods 1995), and mapped for

Correspondence: Richard G. Hartnoll, Port Erin Marine Laboratory, University of Liverpool, Isle of Man, British Isles. Email: rgh@liv.ac.uk

Published 30 January 2006.

ISSN 0022-2933 print/ISSN 1464-5262 online © 2005 Taylor & Francis

DOI: 10.1080/00222930500404744

Notomithrax ursus (Herbst, 1788) (see Woods and McLay 1994a) and *Thacanophrys filholi* (A. Milne Edwards, 1876) (see Woods and Page 1999).

The aim of this study is to describe the structure and distribution of setae on the carapaces of eight British spider crabs. Wicksten (1976) suggested that these “setae might be useful as a taxonomic character in the family Majidae”: this concept is also investigated.

Methods

Terminology

A seta may be defined as “an articulated cuticular extension of virtually any shape or size” (Watling 1989). According to Jacques’ (1989) classification, most carapace setae described here belong to the macrosetal system ($>50\mu\text{m}$, forming groups visible to the naked eye). They are largely hook-shaped or bent, resulting in internal and external perimeters to the curve (Figure 1). Whilst most setal types observed tapered from base (or proximal end) to tip (distal end), others possessed flange-like extensions around the inner perimeter of the curve: this is presumed to provide strengthening to maintain the hook-shape. Setae strengthened in such a way are usually thickest just below the apex of the curve, before narrowing again towards the tip.

Non-articulated cuticular outgrowths of the setal shaft, which do not move relative to the shaft, have been variously named. Wicksten (1976, 1977) termed those found on the inside of the curved region of hamate setae “spinules”. These are, unless otherwise stated, normally like a canine tooth in appearance, and help to secure material held by the seta. Watling (1989) uses the term “denticles”, and Jacques (1989) “teeth”, for similar outgrowths on other setal types. “Denticles” is the most general term used in crustacean setal literature, and will be used here. In general, denticles are either arranged randomly or in rows, and point outwards and proximally. They occasionally form a single or double straight row along the shaft, but generally vary in position across and along the shaft. Where their arrangement is otherwise random, they may become aligned into rows towards the tip

Figure 1. Diagram of a hamate seta and its various regions.

of the seta. Although they sometimes appear relatively blunt, this is presumed to be due to wear, since some pointed denticles can be found in examples of every setal type (see Figure 3B for a comparison). On some setae denticles were also observed on the external perimeter of the curve, in single or double rows, or arranged randomly (Figure 3G). These also normally point outwards and proximally, and are often flattened in cross-section. Whilst the denticles on the inside of the curve are thought to aid in securing actively attached materials (Wicksten 1976, 1977), those on the outside perhaps play a more passive role in trapping materials. In addition, some setae bear “setules” (Jacques 1989; Watling 1989): these are longer, articulated outgrowths of a relatively uniform width (Figure 5E). Seta length was measured along the external periphery of the shaft from base to tip, and seta width was measured at the base.

Main setal types

There are three basic forms of carapace setae: curved—the typical hamate form (Figure 3A), bent (Figure 3C) and “straight” (Figure 4G). The first generally has a relatively long straight shaft, with an obvious gradually curved distal region (see Figure 1). Unless otherwise stated, these bear strengthening features and denticles on the interior of the curve. Bent setae are typically shorter, either with a more acute bend, or with a short straight section to the shaft, producing a near upside-down “U” shape. Unlike curved setae they usually taper distally, though they occasionally bear strengthening flanges. “Straight” setae have at most a slight curve to the shaft, and taper distally.

At least two types of “masking” setae were found in each species examined. Setal types were differentiated by shape, size and fine structures: these included shape and distribution of denticles, presence of these on the exterior of the curved region, and presence of strengthening structures. Within each species setal types were termed A, B, C, etc. The largest curved setal type was designated A, the next largest B, and so on. The sequence was continued with bent, and then straight types. These letters are preceded by an abbreviation of a species’ generic and species names: thus type A setae of *Inachus dorsettensis* (Pennant, 1777) are labelled Id-A.

To describe setal distribution the carapace was divided into 17 areas (Figure 2), based on those used by Ingle (1980). Most areas could be delimited by natural contours of the carapace, but this was not always the case. There were the following exceptions. The mesogastric and metagastric regions could not be separated in *Inachus phalangium*, *I. leptochirus*, *Achaeus cranchi*, *Macropodia rostrata*, and *M. tenuirostris*. In *Eurynome aspera* the urogastric and cardiac regions could not be separated, nor the branchial, meta-branchial, and intestinal regions.

Preparation of specimens and collection of images

Specimens were collected with a 2.5 m width beam trawl (8 cm net mesh size), or with Newhaven (queen scallop) dredges (55 mm belly ring diameter). Specimens were transported to holding tanks with running sea water. Whenever possible, freshly moulted specimens were isolated while still soft and clean of any epibionts and masking materials. They were allowed 1–2 days to harden their new carapaces before being killed (to minimize preparation artefacts), and generally required no subsequent cleaning before coating for the SEM. Carapaces were otherwise obtained either from individuals that died during captivity, or were killed by placing them in freshwater for 30–45 min, then 60–70% ethanol.

Figure 2. Designated carapace divisions used. Diagram of *Inachus dorsettensis* carapace modified from Ingle, 1980.

Aerial Essential washing powder (4 g) was dissolved in 40–50 ml of tepid water and one or two carapaces (depending on their lengths) were immersed. This powder contains enzymes which, after incubation at 40–50°C for 5–10 h, removed most masking materials without damaging the setae or the integument. Samples were then placed in a Ney 300 Ultra Sonic bath on full power for 5 min to shake off remaining loosely attached mask components. Although not all of the mask was removed by the enzymes, it was subsequently less consolidated, and remaining materials came away relatively easily. Carapaces which could not be cleaned properly were discarded.

Cleaned carapaces were mounted on SEM stubs with Bostic clear glue and coated with 60% gold–palladium using a Polaron E5100 coater, and examined with a Philips 501B

SEM. Some features described on the setae, particularly longitudinal furrows, may be preparation artefacts resulting from shrinkage. However, these could not be discriminated.

Results

Specimens examined are listed following each species name, with the following abbreviations: M, mature; J, juvenile; CL, carapace length. For each seta type ranges of length (L) and width (W) are listed. For denticles ranges of length are given where appropriate. At the end of each setal type description, areas of the carapace where that setal type was predominantly observed are listed.

Hyas coarctatus Leach, 1815

J♂, 14.5 mm CL, 14.7 mm CL; M♂, 21.0 mm CL, 27.5 mm CL; M♀, 17.5 mm CL, 20.0 mm CL.

Hc-A (Figure 3A, B). L 870–1250 µm, W 35–80 µm. Shaft curved, with proximal half bearing annular structures which become distorted and reduced as strengthening develops in the curved region. Grooves are present along the lateral midlines, forming the borders of the area bearing denticles in distal half. Denticles (L 4–8 µm) random, thought to be initially tooth-like, but often blunted by wear (Figure 3B). Occurring singly, in pairs, or groups of several individual and paired setae. A double row, facing each other, extends posteriorly on each half of the rostrum, over frontal and mesogastric regions. These rows become single, directed posteriorly, and diverging around the metagastric area, terminating on dorsal branchial regions. Also found on protogastric, metagastric, hepatic and lateral branchial regions.

Hc-B (Figure 3C). L 160–200 µm, W 20–25 µm. Shaft bent, ridges on exterior of bend, directed longitudinal proximally but variable distally. Denticles (L 4–6 µm) generally random, terminating in a group at the apex. Along outer edges of rostrum, occasional in most other regions.

Hc-C (Figure 3D). L 220–260 µm, W 48–50 µm. Shaft slightly bent. Denticles replaced by setules (L ~9–11 µm) over entire seta surface. In distribution co-occur with *Hc-B*.

Hc-D (Figure 3E). L 130–280 µm, W 12–28 µm. Shaft tapering, predominantly straight but with slight distal curve. Denticles on inside appear single, but no suitable images obtained for measurement and detailed observations. Random setules (L ~28 µm) emerging from entire circumference of shaft proximal to denticles. Some also distally on opposing side to denticles. On posterior carapace margin.

Inachus dorsettensis (Pennant, 1777)

J♂, 15.0 mm CL, 17.0 mm CL; M♂, 26.5 mm CL; J♀, 14.2 mm CL; M♀, 15.4 mm CL, 20.0 mm CL.

Id-A (Figure 3F). L 580–950 µm, W 20–40 µm. Shaft curved. Denticles (L 4–8 µm) forming a single row basally, becoming double distally. On all areas, except rostrum, orbital and urogastric regions.

Figure 3. Hamate setae of *Hyas coarctatus* (A–E) and *Inachus dorsettensis* (F–H). (A) Hc-A setae arranged in double row facing each other; (B) Hc-A setae showing teeth-like (right seta) and worn denticles (left seta); (C) Hc-B setae; (D) Hc-C setae with setules; (E) Hc-D setae; (F) Id-A setae; (G) Id-B setae; (H) Id-C seta.

Id-B (Figure 3G). L 140–440 µm, W 10–20 µm. Shaft curved. Denticles (L 2–7 µm) forming a single row on inside of curve, on outside mostly in pairs basal to curved region. On frontal, mesogastric, metagastric, branchial, and metabranchial regions, and along posterior carapace margin.

Id-C (Figures 3H, 4A). L 80–180 µm, W 10–15 µm. Shaft bent at 30–40°, with longitudinal ridges producing a wrinkled appearance. On inside denticles (L 2–7 µm) in single row distal to bend, though staggered to either side in places. Sometimes normal basally directed denticles preceded by one or two directed apically. On outside random, proximal to those inside. Denticles diminish in size approaching apex to form a cluster of barbs (L 0.7–2.6 µm) on one side (Figure 4A). Extend anteriorly from orbital regions along outer edges of rostrum, also covering its tip and dorsal face. On urogastric area, extending to dorsal aspect of branchial area. On cardiac and intestinal regions, extending on to the slopes of their spines. However, apices of these spines are covered by the smaller *Id-D* setae.

Id-D (Figure 4B). L 85–140 µm, W 12–20 µm. Shaft bent, wrinkled due to longitudinal grooves. Denticles (L 2–4 µm) on inside forming a single row. Denticles on outside (L 3–6 µm) random. On rostrum, frontal and branchial regions, and tips of spines in these areas.

Inachus phalangium (Fabricius, 1775)

J♂, 10.4 mm CL, 12.0 mm CL; M♂, 16.5 mm CL.

Ip-A (Figure 4C). L 270–390 µm, W 20–27 µm. Shaft curved. Denticles (L 7–8 µm) on inside single, relatively few. Denticles on exterior of curve (L 6–7 µm) paired and single, proximal to denticles on inside. At base of rostrum, and on frontal, hepatic, mesogastric, metagastric, and branchial regions.

Ip-B (Figure 4D). L 100–120 µm, W 15–25 µm. Shaft bent, with longitudinal ridges. Denticles absent. On rostrum, orbital, protogastric, urogastric, cardiac, metabranchial, and intestinal regions. Tubercle spines in all areas are covered by these setae.

Ip-A/B (Figure 4E). In areas where the two above types meet, setae show features of both. These setae bear denticles, and sometimes a degree of strengthening, and vary in length and width between the two types. Locations include the bases of tubercle spines, and parts of the protogastric and cardiac regions.

Inachus leptochirus Leach, 1817

M♂, 20.1 mm CL; M♀, 18.1 mm CL.

Il-A (Figure 4F). L 460–690 µm, W 30–35 µm. Shaft curved, with relatively long straight basal section. Denticles (L 9–11 µm) on inside single and staggered basally, becoming paired, then single again towards apex. Denticles on exterior of curve (L 5–6 µm) random, extending further proximally than those on interior. At base of rostrum, and on frontal, hepatic, mesogastric, metagastric, urogastric, frontal slope of cardiac, branchial, and metabranchial regions.

Figure 4. Hamate setae of *Inachus dorsettensis* (A, B), *Inachus phalangium* (C–E), and *Inachus leptochirus* (F–H). (A) Id-C seta tip showing mass of barbs; (B) Id-D seta; (C) Ip-A setae; (D) Ip-B setae; (E) Ip-A/B setae, where areas of Ip-A and Ip-B meet; (F) Il-A setae; (G) Il-B setae; (H) Il-B seta with denticles on two sides of shaft.

Il-B (Figure 4G, H). L 450–490 μm , W 21–27 μm . Shaft almost straight, tapering distally. Denticles on interior of curve (L 9–10 μm) as for *Il-A*. Denticles on exterior of curve (L $\sim$ 5 μm) mostly in pairs, mainly over same region as interior denticles, but sometimes shifted basally: they are directed distally (Figure 4H). On rostrum, orbital, protogastric, posterior slope of metagastric, cardiac, and intestinal regions. Tubercle spines in all areas are covered by these setae.

Achaeus cranchii Leach, 1817

M♂, 8.8 mm CL; M♀, 9.1 mm CL, 9.6 mm CL.

Ac-A (Figure 5A). L 510–950 μm , W 25–50 μm . Shaft curved, often with a slight proximal bend in opposite direction to distal curved region. Denticles (L 2–6 μm) random, except near apex, sometimes appearing flattened in cross-section. Extending posteriorly from rostrum as a row on each side of frontal region, and over both sides of mesogastric, terminating after crossing the border with metagastric area. A group on each hepatic area, arranged in a circular pattern, and on lateral aspect of each branchial region.

Ac-B (Figure 5B). L 1000 μm , W 35 μm . Shaft curved, apparently strengthened from base (however, only one clear image was obtained of this setal type). Denticles (L $\sim$ 6.5 μm) arranged randomly. On orbital, mesogastric (between two rows of *Ac-A* setae) and intestinal regions, dorsal surface of branchial region, posterior carapace margin, and apices of metagastric and cardiac tubercles.

Ac-C (Figure 5C). L 290–305 μm , W 8–10 μm . Shaft curved, with slight proximal bend in opposing direction to main curve. Denticles (L 2–7 μm) predominantly staggered and single, but some pairs occur nearing the tip. On rostrum, frontal and mesogastric areas, and slopes of cardiac spine.

Ac-D (Figure 5D, E). L 710 μm , W 30 μm . Shaft curved but unstrengthened, with a median groove developing about 300 μm from base, dividing shaft into two halves. Denticles absent, replaced by setules flattened in cross-section, up to 10–12 μm length (Figure 5E). On orbital and mesogastric regions, and cardiac and metagastric tubercles.

Ac-E (Figure 5F). L 100–130 μm , W 3–6 μm . Shaft bent (thought to be about 90°, but most are prostrate in preparations). Spinule (L 1.5–3.5 μm) arrangement not clear from images obtained. However, as on *Id-C*, a mass of barbs (L 1–2 μm) is present on one side of apex. On frontal, hepatic, branchial, and cardiac regions.

Ac-F (Figure 5F). L 90–100 μm , W 8–9 μm . Shaft bent, similar to *Ac-E*, but without denticles or barbs, and with longitudinal ridges producing a wrinkled surface. On same regions as *Ac-E*.

Macropodia rostrata (Linnaeus, 1761)

M♂, 11.1 mm CL.

Mr-A (Figure 5G). L 550 μm , W 40 μm . Shaft strongly curved to produce a near circular form. The short proximal straight section bears ridges running in several directions.

Figure 5. Hamate setae of *Achaeus cranchii* (A–F) and *Macropodia rostrata* (G, H). (A) Ac-A setae; (B) Ac-B seta; (C) Ac-C seta; (D) Ac-D seta; (E) Ac-D seta close-up, showing setules; (F) Ac-E and Ac-F setae; (G) Mr-A setae; (H) Mr-B setae.

Denticles (L 4–5 μm) random, flattened in cross-section. On outer margins of rostrum, frontal, mesogastric, metagastric, protogastric, and hepatic regions. Branchial with a double row, facing each other, extending along centre of that area.

Mr-B (Figure 5H). L 350 μm , W 20 μm . Shaft curved. Denticles (L $\sim$ 3 μm) single, staggered across area bearing them. On rostrum, but many were thought to be missing from other areas.

Mr-C (Figure 6A). L 110–130 μm , W 17–20 μm . Shaft bent, strongly wrinkled. Denticles absent, setules (L $\sim$ 20 μm) on some setae. On rostrum, orbital region, and metagastric spine.

Macropodia tenuirostris (Leach, 1814)

M♀, 19.0 mm CL.

Mt-A (Figure 6B). L 300–550 μm , W 25–45 μm . Details as for Mr-A.

Mt-C (Figure 6C). L 140–220 μm , W 17–25 μm . Details as for Mr-C.

Eurynome aspera (Pennant, 1777)

M♂, 15.7 mm CL; M♀, 14.0 mm CL.

Ea-A (Figure 6D, E). L 700–860 μm , W 30–35 μm . Shaft curved distally and with slight bend in same direction 150–200 μm from base. Denticles (L 5–7 μm) in rows across shaft, varying in numbers 1 to 4. Along inner edges of rostrum, continue emerging in groups posteriorly from tubercles along sides of frontal and mesogastric areas. The parallel lines diverge around the scutellate tubercle of metagastric and terminate reaching branchial region. Also on protogastric.

Ea-B (Figure 6F). L 200–300 μm , W 8–10 μm . Shaft curved, tapering with longitudinal wrinkles. Denticles (L 3–4 μm) on the interior of curved region arranged transversely in rows of up to four, directed distally. Elsewhere random, generally worn, from about 50–75 μm from base to apex. On all regions, including rostrum, mostly emerging from edges of boletate, scutellate, and spine-like tubercles.

Ea-C (Figure 6G). L 55–80 μm , W 10–17 μm . Shaft bent, forming an inverted “U”. Denticles (L 7–16 μm) as paddle-shaped growths, starting 6–7 μm from base, around entire circumference. Directed distally, flattened cross-section becomes more rounded apically. Generally shorter on the outside of curve, probably due to wear. On rostrum and all major tubercles.

Discussion

Twenty-five types of carapace setae were observed by SEM on eight species of spider crab, ranging from two (*Inachus phalangium* and *I. leptochirus*) to six (*Achaeus cranchii*) varieties per species. Setal types have been distinguished by size, overall shape, and the presence/

Figure 6. Hamate setae of *Macropodia rostrata* (A), *Macropodia tenuirostris* (B, C), and *Eurynome aspera* (D–G). (A) Mr-C setae; (B) Mt-A setae; (C) Mt-C seta with setules; (D) Ea-A setae; (E) Ea-A seta close-up, with cuticle around base of denticles; (F) Ea-B seta; (G) Ea-C setae.

absence and distribution of fine structures. With the exception of Hc-C and Ea-C, outgrowths of setae were of limited distribution, i.e. localized on specific parts of the shaft (Jacques 1989). Setae themselves were observed to emerge in four types of groupings, previously described by Jacques (1989):

- “Linear series”: arranged in a single row, such as Ac-A and Ea-A, although this latter might more appropriately be described by “Fringes” (Jacques 1989).
- “Localized setiferous fields”: collections of setae over a cuticular surface without preferential alignment. Homogeneous examples observed were Ip-A, Ip-B, Il-A, and Il-B. Examples of heterogeneous fields: areas of *Inachus dorsettensis* with Id-A and Id-C, *A. cranchii* with Ac-E and Ac-F occurring with Ac-A.
- “Bundles”: isolated groups, often emerging in linear series. Hc-A were observed in such an arrangement, usually of a heterogeneous variety.
- “Setae related to surface relief features”: repeated carapace relief features, with setal arrangement being closely related to these. Ea-A and Ea-B were associated with tubercles of *E. aspera*. Ip-B and Il-B setae were also associated with tubercle spines, even in areas otherwise covered by Ip-A and Il-A. Also, the tips of *I. dorsettensis* spines were covered by Id-D setae.

Certain setae appeared to be “hybrids” and posed difficulties for classification. Such was the case where areas of the two setal types of *I. phalangium* meet (Figure 4E), seeming to merge into each other, rather than being separated by a sharp border. Such areas have been termed “compound setiferous fields” by Jacques (1989), where a distinct gradation from one type of seta to another occurs. This is understandable, since the function of different carapace areas will similarly change gradually.

As might be expected, the two *Macropodia* spp. exhibited a great degree of similarity in their carapace setae. Although no equivalent of Mr-B setae was observed on the specimen of *M. tenuirostris* examined, the same types are thought to be present on both species. This was not the case for the *Inachus* species—*I. dorsettensis* supporting twice as many (four) setal types as either of the other two species. Also, whilst all setae on *I. dorsettensis* are curved or bent for the securing of extraneous materials, only Il-A setae of *I. leptochirus* are shaped for this purpose. A large number of Ip-B setae of *I. phalangium* were also straightened to a degree. It is possible that the diversity of setal types serve to enable *I. dorsettensis* to attach a wider range and size of materials. *Inachus leptochirus*, in particular, is normally only covered by sponges, as is *I. phalangium* in most cases (Hartnoll 1993), and the setae of these species are probably appropriate for this purpose. *Inachus dorsettensis*, however, masks itself with a wider range of materials, in inshore areas at least, mainly in the form of various algae (Hartnoll 1993).

The largest number of setal types was observed on *Achaeus cranchii*, which is also the species found to be the most cryptic, due to its small size and extensive masking behaviour. It was noted during collection trips, and while live specimens were kept in tanks, that this species covers itself extensively, and has a strong affinity to do so, making it the most difficult species to locate visually. *A. cranchii*, however, is specific in its choice of materials, being exclusively found on and covered by the red algae it lives among. Setal diversity for this species, therefore, does not appear to allow a diversity of materials to be attached, but perhaps a wider size range of pieces.

If the number of types of setae on a species were to be a reflection of masking activities, *Eurynome aspera* poses a problem. This species was found to bear three types of carapace setae, yet it is normally covered only with detritus (personal observation) or a thin layer of

sponge at the most (Hartnoll 1993), which presumably settle on these crabs on their own accord. It is not known if this species masks itself at all. Apart from Ea-A setae of *E. aspera*, however, which only has denticles on the inside of the curve, all the setae bear numerous protrusions over most of their surfaces, and this is perhaps an adaptation for retaining materials in a passive way. This was also seen on both setal types of *I. leptochirus*, although it is not known for this latter species whether or not sponges are originally planted there by the crab.

Setal morphology can contribute to identification when only a portion of an individual is available, though it does not yet seem capable of providing a comprehensive key. The localized distribution of setal types poses a particular problem. Hc-A setae of *H. coarctatus* appear very similar to images provided by Wicksten (1976) of those of *Hyas lyratus*. Although Ac-A setae of *A. cranchii* have a similar appearance, the ringed structures observed on the two *Hyas* spp. were not seen on any other species. According to Jacques (1989), proximal transverse constrictions on hamate setae serve to provide flexibility while also resisting the pull of attached materials, and presumably of the crab itself, during attachment. The observed rings could be useful during identification of carapace fragments, if not to a species level, at least to a generic one, where more than one species of *Hyas* occur. Other types of setae are exclusive to certain species, such as those of *E. aspera* and Il-B setae of *I. leptochirus*, this latter being the only straight type with denticles. The former species is distinct in all of its setal types: Ea-A with the collar around the base of the denticles, and Ea-B and Ea-C with their unique protrusions. Setae similar to Ac-D of *A. cranchii* were again not seen on other species, and Id-C of *I. dorsettensis* was also distinctive in its shape and protrusions. Mt-A and Mr-A were also typical for *Macropodia* spp. due to their near circular shape. However, setal morphology is unlikely to be more than one component of specific identification.

Acknowledgements

We wish to thank C. J. Veltkamp, School of Biological Sciences, University of Liverpool, for all his help in producing the SEM images. Much gratitude to the late A. Deutsch who funded T.S. during this project.

References

- Dudgeon D. 1980. Some inter- and intraspecific differences in the decorating patterns of majid crabs (Crustacea: Decapoda) from the coastal waters of Hong Kong. In: Morton BS, Tseng CK, editors. Proceedings of the First International Marine Biological Workshop. Hong Kong: Hong Kong University Press. p 825–834.
- Fernandez L, Parapar J, Gonzalez Gurriaran E, Muino R. 1998. Epibiosis and ornamental cover patterns of the spider crab *Maja squinado* on the Galician coast, northwestern Spain: influence of behavioral and ecological characteristics of the host. *Journal of Crustacean Biology* 18:728–737.
- Getty T, Hazlett BA. 1978. Decoration behaviour in *Microphrys bicornutus* (Latreille, 1825) (Decapoda, Brachyura). *Crustaceana* 34:105–108.
- Hartnoll RG. 1961. Studies on the biology of Manx spider crabs [PhD thesis]. Liverpool: University of Liverpool.
- Hartnoll RG. 1993. The epibiota of spider crabs. *Bios* 1:163–176.
- Ingle RW. 1980. *British Crabs*. London: British Museum (Natural History) and Oxford University Press. 222 p.
- Jacques F. 1989. The setal system of crustaceans: types of setae, groupings, and functional morphology. In: Felgenhauer BE, Watling L, Thistle AB, editors. *Functional morphology of feeding and grooming in Crustacea*. Rotterdam: A.A. Balkema. p 1–13.
- Kilar JA, Lou RM. 1984. Ecological and behavioral studies of the decorator crab, *Microphrys bicornutus* Latreille (Decapoda: Brachyura): a test of optimum foraging theory. *Journal of Experimental Marine Biology and Ecology* 74:157–167.

- Kilar JA, Lou RM. 1986. The subtleties of camouflage and dietary preference of the decorator crab, *Microphrys bicornutus* Latreille (Decapoda: Brachyura). *Journal of Experimental Marine Biology and Ecology* 101:143–160.
- Mastro E. 1981. Algal preferences for decoration by the Californian kelp crab, *Pugettia producta* (Randall) (Decapoda, Majidae). *Crustaceana* 41:64–70.
- Rasmussen E. 1973. Systematics and ecology of the Isefjord marine fauna (Denmark). *Ophelia* 11:1–495.
- Watling L. 1989. A classification system for crustacean setae based on the homology concept. In: Felgenhauer BE, Watling L, Thistle AB, editors. *Functional morphology of feeding and grooming in Crustacea*. Rotterdam: A.A. Balkema. p 15–26.
- Wicksten MK. 1976. Studies on the hooked setae of *Hyas lyratus* (Brachyura: Majidae). *Syesis* 9:367–368.
- Wicksten MK. 1977. Decorating in the crab *Loxorhynchus crispatus* Stimpson (Brachyura: Majidae) [PhD thesis]. University of Southern California.
- Wicksten MK. 1979. Decorating behavior in *Loxorhynchus crispatus* Stimpson and *Loxorhynchus grandis* Stimpson (Brachyura, Majidae). *Crustaceana Suppl* 5:37–46.
- Wicksten MK. 1980. Decorator crabs. *Scientific American* 242:146–154.
- Wicksten MK. 1983. Camouflage in marine invertebrates. *Oceanography and Marine Biology* 21:177–193.
- Wilson R. 1987. Substrate selection and decorating behavior in *Acanthonyx petiveri* related to exoskeleton color (Brachyura, Majidae). *Crustaceana* 52:135–140.
- Woods CMC. 1995. Masking in the spider crab *Trichoplatus huttoni* (Brachyura: Majidae). *New Zealand Natural Science* 22:75–80.
- Woods CMC, McLay CL. 1994a. Use of camouflage materials as a food store by the spider crab *Notomithrax ursus* (Brachyura, Majidae). *New Zealand Journal of Marine and Freshwater Research* 28:97–104.
- Woods CMC, McLay CL. 1994b. Masking and ingestion preferences of the spider crab *Notomithrax ursus* (Brachyura, Majidae). *New Zealand Journal of Marine and Freshwater Research* 28:105–111.
- Woods CMC, Page MJ. 1999. Sponge masking and related preferences in the spider crab *Thacanophrys filholi* (Brachyura: Majidae). *Marine and Freshwater Research* 50:135–143.