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A KEY FOR THE IDENTIFICATION OF THE NAUPLII OF COMMON BARNACLES OF THE BRITISH ISLES, WITH EMPHASIS ON *CHTHAMALUS*

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ABSTRACT

Chthamalus stellatus and *C. montagui* are warm-water barnacles common on rocky shores in southwest England, Ireland, and southern Europe. They are partly sympatric, with overlapping vertical and horizontal distributions. It has been suggested that the differing horizontal distribution of the adults may be related to differences in the distribution of the larval stages. To this end, we have examined plankton samples taken during the summer breeding period at Plymouth, from inshore to 15 miles offshore. The samples also contained large numbers of other cirriped nauplii, notably *Elminius modestus*, *Balanus perforatus*, *B. crenatus*, and *Verruca stroemia*, from which the chthamalids had to be distinguished. The chthamalids can be separated from the other nauplii by use of characters that include a unilobed or trilobed labrum, the length of posterior processes and the shape and size of the cephalic shield, but the two species of *Chthamalus* are more difficult to distinguish. Scanning electron microscopy (S.E.M.) has allowed development of a key to the main barnacle nauplii occurring off the British Isles. This key, with accompanying SEM photographs, will enable enumeration of the two chthamalids and help answer the question whether there is a differential distribution of the larvae of these species.

Rocky shores in southwest England are inhabited by several species of barnacles that occupy slightly different niches. Estuaries are now dominated by the immigrant Australasian species *Elminius modestus* Darwin, 1854, which is accompanied at low-tide levels by *Balanus crenatus* Bruguière, 1789, and *B. improvisus* Darwin, 1854; all three can occur sublittorally. In normal salinities, at moderate exposure to wave action, individuals of *E. modestus* still occur at low densities but are outnumbered by *Semibalanus balanoides* L., 1767, in the middle shore and *Balanus perforatus* Bruguière, 1789, on the lower shore, together with *Chthamalus montagui* Southward, 1976, on the upper shore. Under increasing exposure to wave action, the chthamalids outnumber the other species, with *Chthamalus stellatus* Poli, 1791, dominating the lower shore. On wave-beaten headlands and offshore reefs (e.g., the Eddystone), *Chthamalus stellatus* is dominant and may replace *C. montagui* at all levels. *Verruca stroemia* O. F. Müller, 1776, is predominantly a sublittoral species but, like *Balanus crenatus*, can extend up into the lower intertidal in cryptic situations in moderate exposure (Southward, 1976; Crisp *et al.*, 1981).

Since the separation of *Chthamalus montagui* from *C. stellatus* (Southward, 1976), there has been considerable debate about the factors influencing the distribution of the two species, particularly the tendency for the former to be abundant in embayed situations and the latter appearing to be a blue-water species (Southward, 1976; Crisp *et al.*, 1981; Burrows, 1988; Burrows *et al.*, 1992, 1999; O'Riordan *et al.*, 1999; Power *et al.*, 1999a, b). It has been suggested that the larvae of *C. montagui* are retained closer to shore and in embayments, while the larvae of *C. stellatus* are dispersed to exposed headlands and fragmented habitats (Burrows *et al.*, 1992, 1999). The evidence in support of this is based on differences in the size and development of the larval stages. Nauplii of *C. montagui* reared in the laboratory reach stage V in a shorter time period and are smaller than those of *C. stellatus* (Burrows *et al.*, 1999). The smaller *C. montagui* nauplii develop into smaller cyprids, which disperse for shorter distances and settle back on shore, with the larger, more widely dispersed cyprids of *C. stellatus* (O'Riordan *et al.*, 1999; Power *et al.*, 1999a, b).

To investigate whether there is a differential distribution of larval stages in the water column requires sampling of plankton along a transect from inshore to offshore and the identification of nauplii in the samples. The larval stages of the two *Chthamalus* species are in the water column at the same time, with adults releasing larvae into the plankton in summer (June–September, Burrows *et al*., 1992, 1999). There is, however, considerable difficulty in identifying the nauplii in the plankton samples. This is because of the similarities in morphology and also the presence of other nauplii such as *Elminius modestus*, *Verruca stroemia*, and *Balanus perforatus* and the lack of an up-to-date key that can be used to identify them. Although there are separate existing descriptions of the nauplii of each of the common species (Groom, 1894; Bassindale, 1936; Pyefinch, 1948a, b; Knight-Jones and Waugh, 1949; Norris and Crisp, 1953; Burrows *et al*., 1999), the only useful key (Lang, 1980) does not include the chthamalids found in Europe. A key used alongside photographic material provides the best chance of identifying the nauplii accurately. Without such appropriate tools for identification, it will not be possible to determine the distribution of larvae in the plankton. Thus, the aim of this paper was to prepare a key that could be used to identify the main species of nauplii occurring in the plankton and to highlight the major morphological features of nauplii of *Chthamalus* using scanning electron microscopy.

Materials and Methods

Larvae were sampled using a quantitative plankton net. The net consisted of a 4 m long cone with 250 μm mesh suspended from a 0.7 m diameter metal ring. A calibrated flowmeter was positioned in the centre of the opening of the net. The first set of samples was taken on 18 July 1984 and 30 August 1984. At this time, one sample was taken in the top one metre of the water column, along two transects at six stations on a 15 km line starting at Penlee Point (50°19′0″N, 4°10′6″W) to the Eddystone Rocks (50°10′9″N, 4°18′0″W), Plymouth, England. The second set of samples was taken on 4 and 13 September 2000. At this time, two replicate samples were taken at one and ten meter depth of water along two transects at six stations on a 15 km line starting at the mouth of the Tamar (50°21′40″N, 4°09′59″W) and Plym (50°21′59″N, 4°08′10″W) estuaries out to the Eddystone Rocks in Plymouth, England. After a five minute tow at two knots, the nets were brought in and washed down. The cod end of the net was removed, and a small quantity of formaldehyde solution or alcohol was added to each sample. On return to the laboratory, the samples were transferred to 5% Formalin in sea water to preserve the samples. The samples were then examined. The volume of the subsample was chosen according to the abundance of barnacle larvae in the plankton. Small subsamples (0.33–1 mL) were used when the larvae were abundant, and large subsamples (2–3 mL) when they were rare. The subsamples were sorted in a Bogorov tray placed on the stage of a compound microscope. The low power objective was used to search for nauplii and cyprid larvae; the high power objective was used to measure them and the published descriptions used for identification (Figs. 1, 2). Some *C. stellatus*, *C. montagui*, and *E. modestus* nauplii were removed from the plankton samples for scanning electron microscopy. The preparation of the nauplii involved dehydration and critical point drying, followed by mounting onto stubs, and gold sputtering. Photographs were taken to show the main carapace shape and labrum structure.

Results

To start distinguishing between species of nauplii, the shape of the labrum is a useful feature. The labrum is a disproportionately large structure in nauplii and readily observable even in Stage II (Figs. 1, 2). In summer-breeding barnacles, *Elminius modestus* and *Balanus perforatus* can be distinguished from *Chthamalus stellatus*, *C. montagui*, and *Verruca stroemia* by the presence of a trilobed labrum (Appendix 1; Figs. 1, 3). In *E. modestus*, the medial lobe of the trilobed labrum extends beyond the two lateral lobes (Figs. 1, 3, 4). The relative length of the medial to the lateral lobes in the labrum of *E. modestus* is maintained throughout the six naupliar stages. *Balanus perforatus* also has a trilobed labrum throughout the six naupliar stages, but the medial lobe does not extend greatly beyond the length of the other two lateral lobes (Fig. 1). The other three summer-breeding barnacles all have unilobed labra (Appendices 1, 2; Figs. 1, 5–12). After separating the nauplii into two groups based on the shape of the labrum, the next distinguishing feature is the length of the abdominal processes in relation to the caudal spine. *Verruca stroemia* can be easily distinguished from the chthamalids by the abdominal process which is approximately the same length as the caudal spine and almost as long as the cephalic shield (Appendices 1, 2; Fig. 1). Stage II of *V. stroemia* is also 0.1 mm greater in total length than the chthamalids. Distinguishing between the chthamalid species, however, particularly in the early stages is difficult. The shape of the carapace and labrum, the size of the nauplii and the relative length of the abdominal processes are key features in this.

In stage II larvae, the lateral margins of the cephalic shield are more rounded in *Chthamalus montagui* (Fig. 8) than in *C. stellatus* (Fig. 5). The labrum is unilobed in each species. The

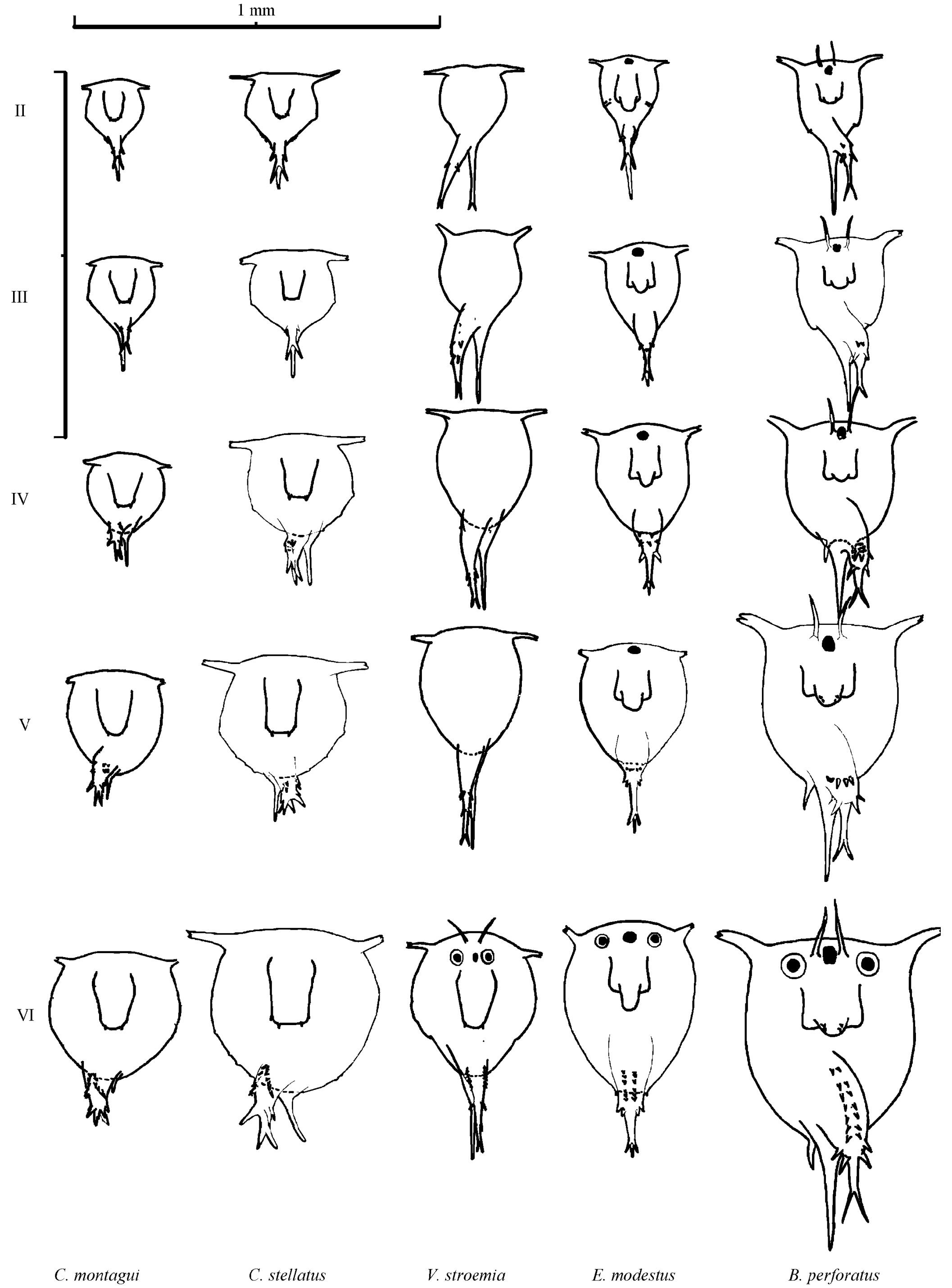

Fig. 1. Naupliar stages of summer-breeding barnacle larvae. The larvae in row 1 are stage II; row 2, stage III; row 3, stage IV; row 4, stage V; and row 5, stage VI. Larvae (from left to right) are those of *Chthamalus montagui*; *C. stellatus* (from Burrows *et al*., 1999); *Verruca stroemia* (from Bassindale, 1936); *Elminius modestus* (from Knight-Jones and Waugh, 1949); and *Balanus perforatus* (from Norris and Crisp, 1953).

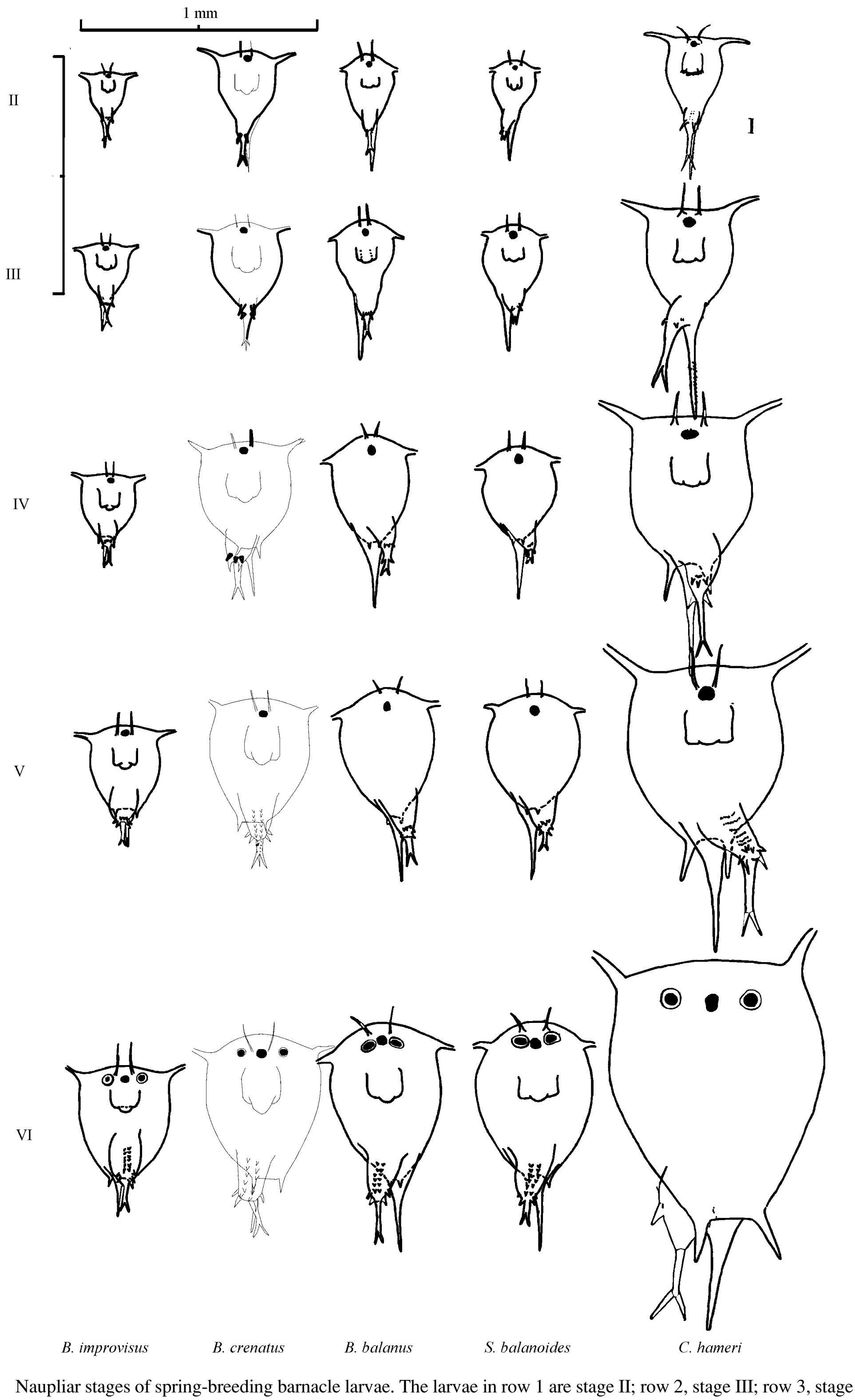

Fig. 2. Naupliar stages of spring-breeding barnacle larvae. The larvae in row 1 are stage II; row 2, stage III; row 3, stage IV; row 4, stage V; and row 5, stage VI. Larvae (from left to right) are those of *Balanus improvisus* (from Jones and Crisp, 1954); *B. crenatus* (from Herz, 1933); *B. balanus* (from Crisp, 1962a); *Semibalanus balanoides* (from Crisp, 1962a); and *Chirona hameri* (from Crisp, 1962b).

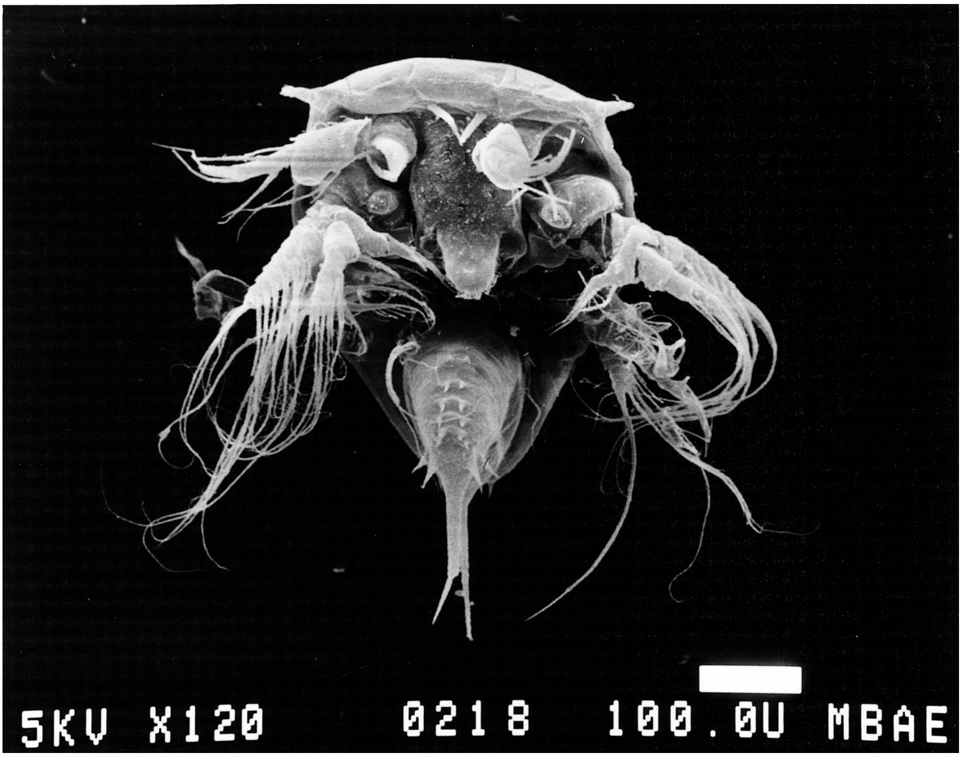

Fig. 3. The ventral surface of Stage VI nauplius larva of *Elminius modestus* showing details of six pairs of abdominal spines and trilobed labrum.

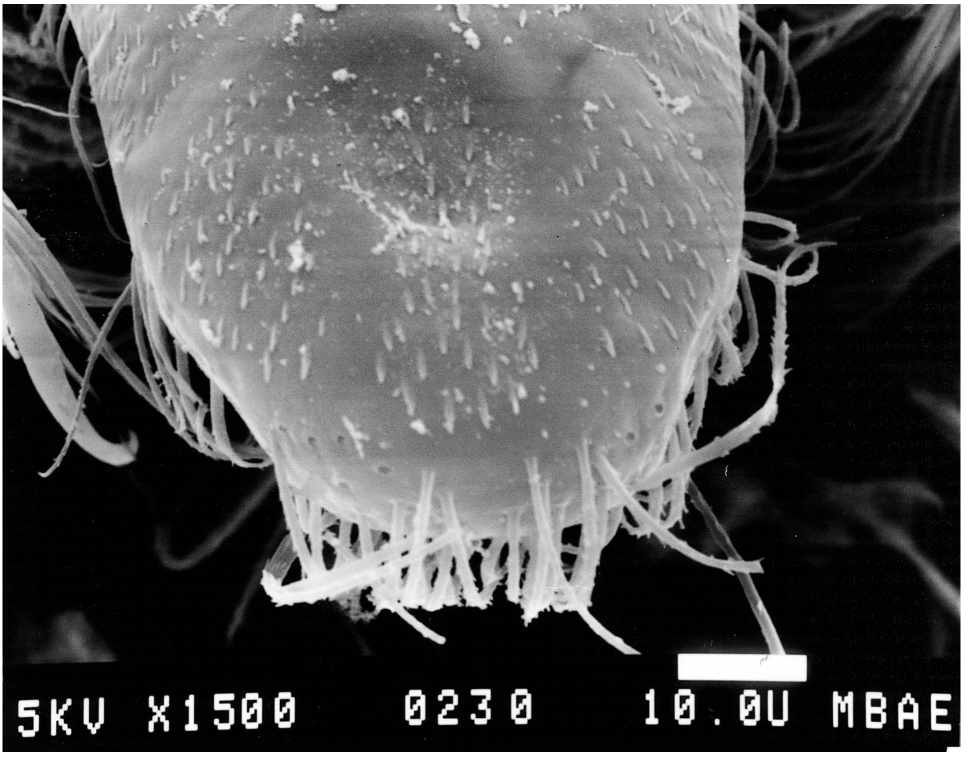

Fig. 4. The ventral surface of the medial lobe of the labrum of a Stage VI nauplius larva of *Elminius modestus*.

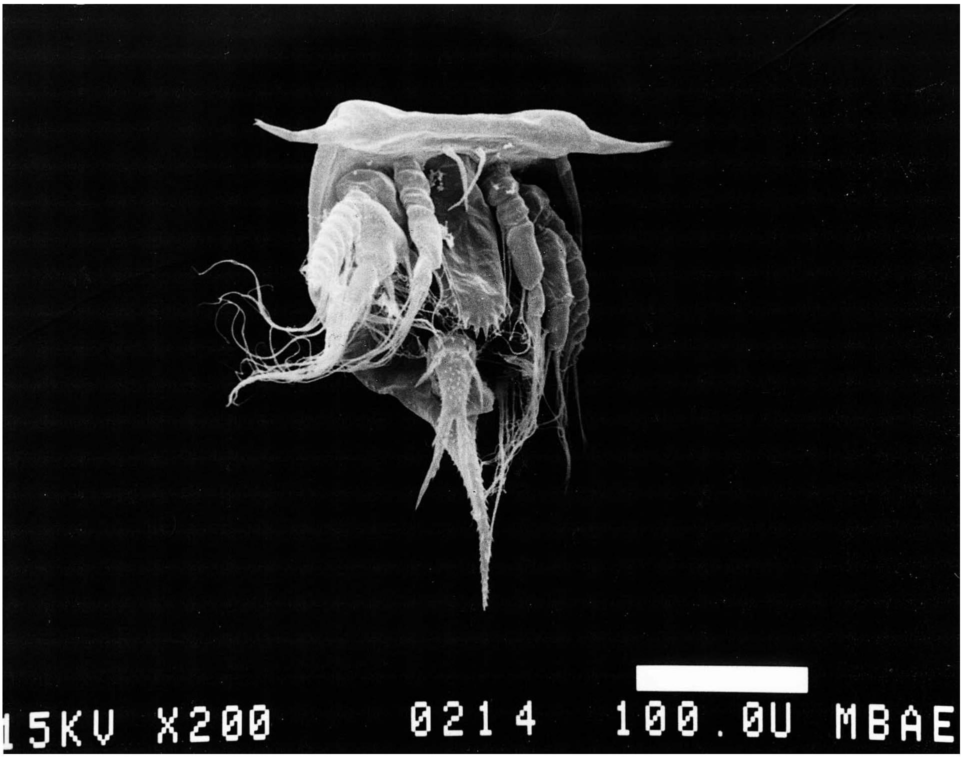

Fig. 5. The ventral surface of Stage II nauplius larva of *Chthamalus stellatus* showing details of unilobed labrum and apex with stout teeth.

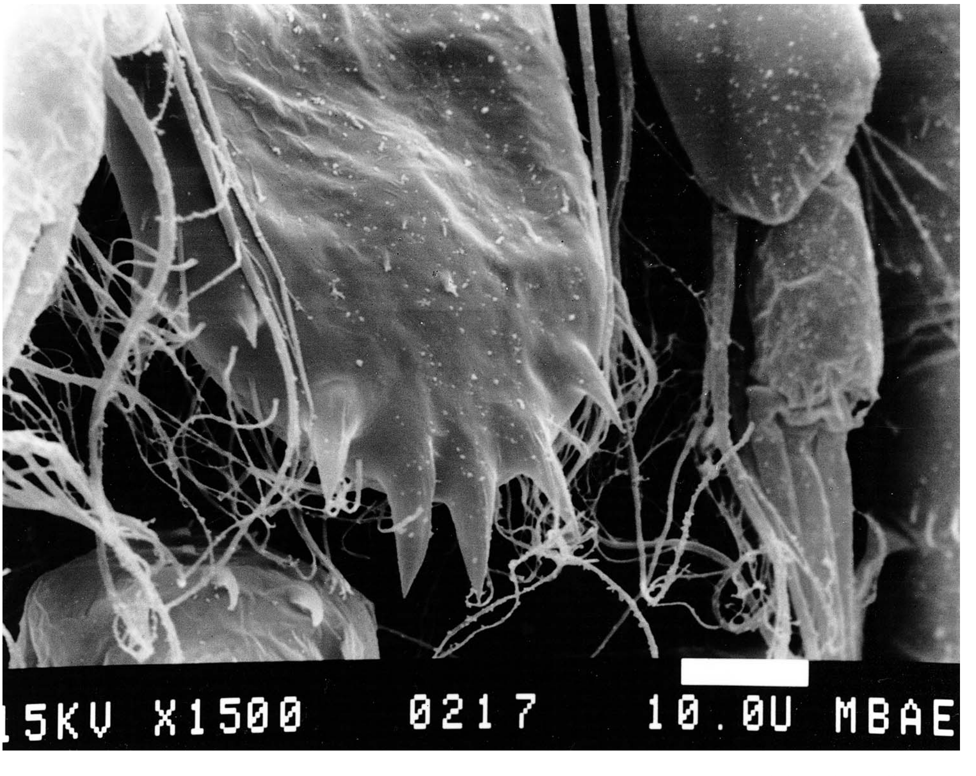

Fig. 6. The ventral surface of the apex of the unimodal labrum in Stage II nauplius larva of *Chthamalus stellatus* showing detail of stout teeth on the apex.

Fig. 7. The ventral surface of Stage III nauplius larva of *Chthamalus stellatus* showing details of long frontolateral horns.

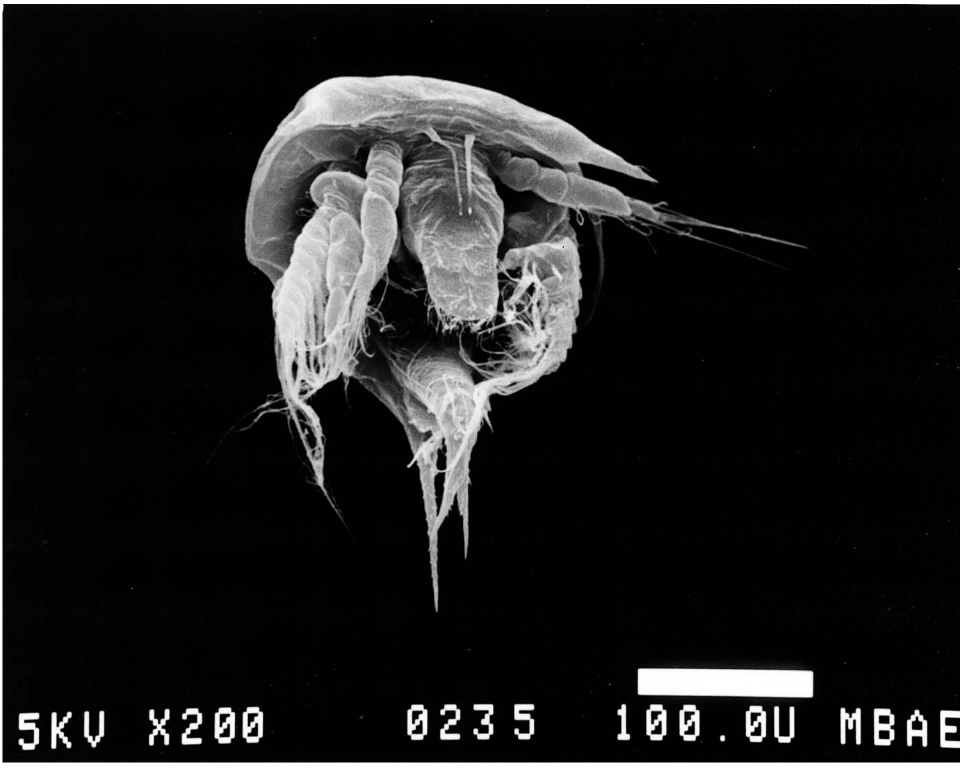

Fig. 8. The ventral surface of Stage II nauplius larva of *Chthamalus montagui* showing details of unilobed labrum.

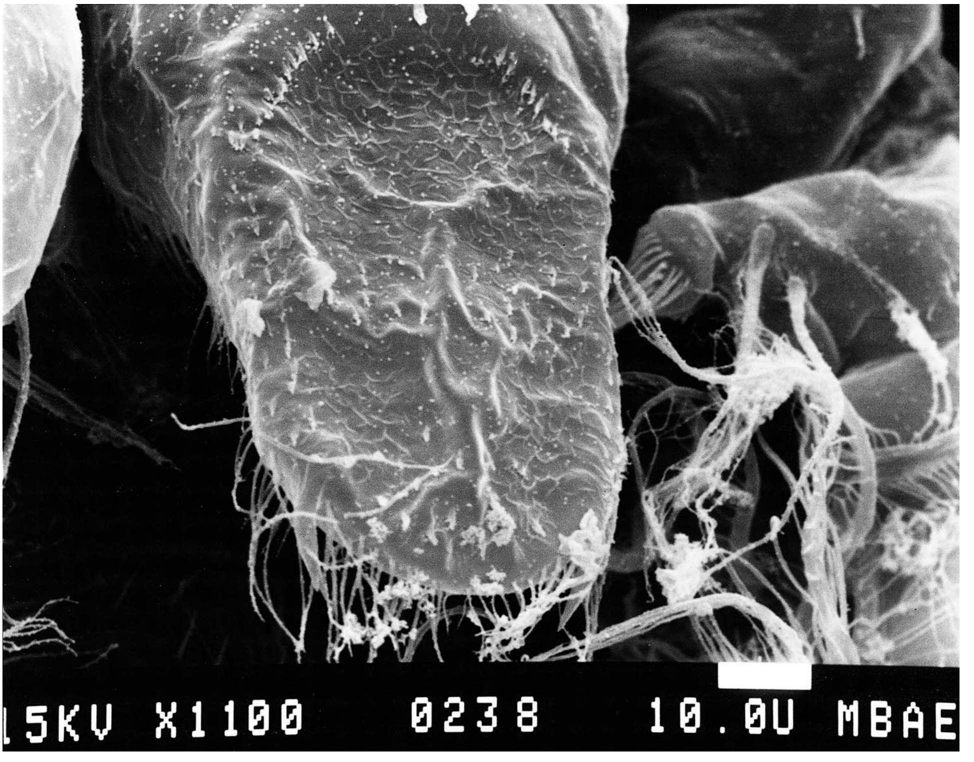

Fig. 9. The ventral surface of the apex of the unimodal labrum in Stage II nauplius larva of *Chthamalus montagui* showing detail of apex with one pair of stout teeth.

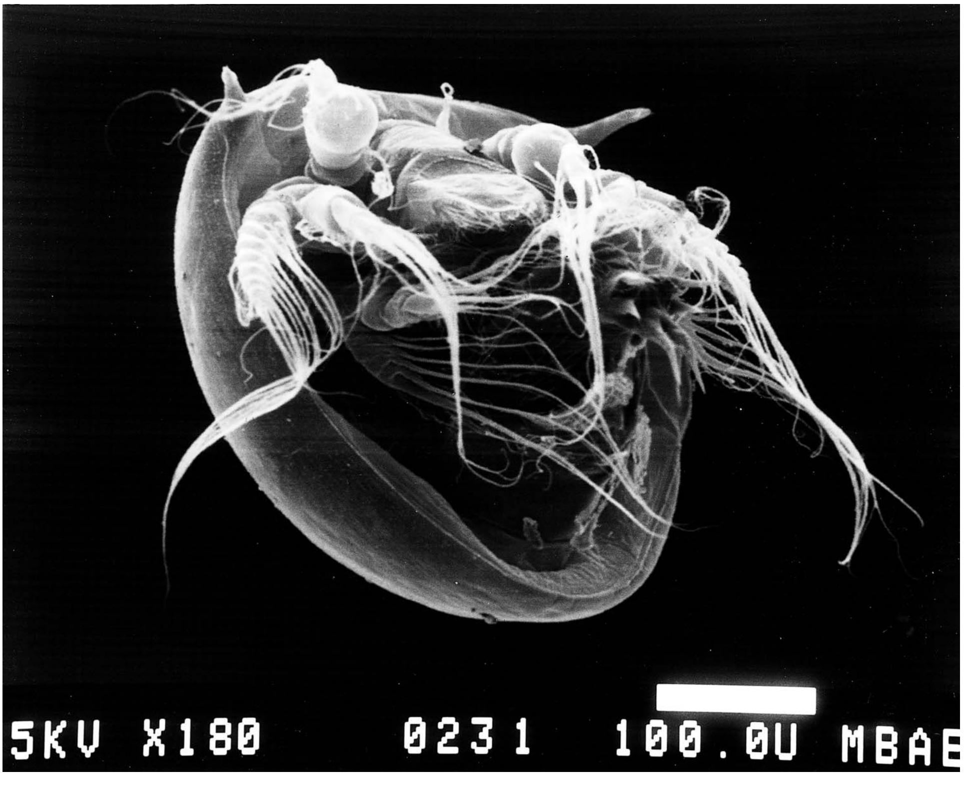

Fig. 10. The ventral surface of Stage VI nauplius larva of *Chthamalus montagui* showing details of rounded carapace and reduced abdominal process.

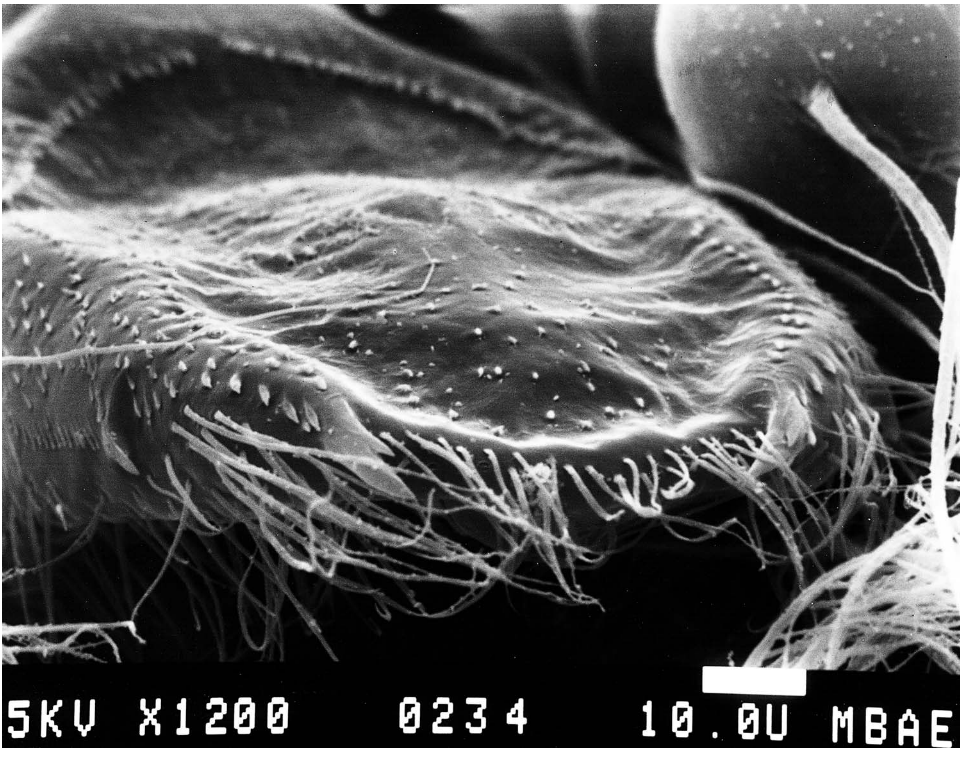

Fig. 11. The ventral surface of the medial lobe of the labrum of a Stage VI nauplius larva of *Chthamalus montagui* showing the detail of the apex with one pair of stout teeth.

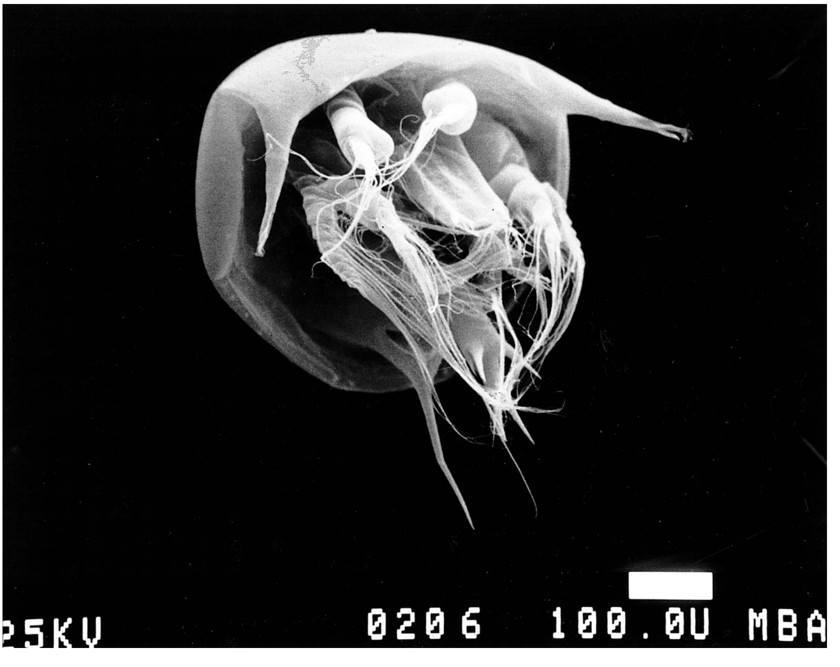

Fig. 12. The ventral surface of Stage VI nauplius larva of *Chthamalus stellatus* showing details of elongate frontolateral horns and parallel-sided labrum.

labrum in *C. stellatus* has parallel sides with a broad, straight distal end and several stout teeth (Figs. 5, 6). The labrum of *C. montagui* is tapered, with a rounded distal end that carries one pair of teeth and a number of setae (Figs. 8, 9). There are also differences in the shape of the anterior shield margin and the frontolateral horns. In *C. stellatus*, the anterior shield margin is straight or slightly concave, while in *C. montagui* it appears to be more rounded. Because of this, the frontolateral horns in *C. stellatus* appear relatively long and slender while those of *C. montagui* appear shorter and stouter (Figs. 5, 8). The sizes of larvae collected from the plankton also differed, with nauplii of *C. montagui* being smaller (Stage II 0.27–0.32 mm; Stage III 0.31–0.36 mm) and nauplii of *C. stellatus* larger (Stage II 0.30–0.34 mm; Stage III 0.37–0.42).

As the nauplii grow, some of the features used to distinguish Stages II and III from the other species can also be used for Stages IV–VI. The most obvious features are the more rounded carapace and short, stout frontolateral horns of *C. montagui* compared to the slender and elongate frontolateral horns of *C. stellatus* (Figs. 10, 12). The dorsal thoracic spine also becomes subequal to the abdominal process in *C. montagui* (Fig. 1). In *C. stellatus*, the length of the dorsal thoracic spine is either similar in length or longer than the abdominal processes (Figs. 1, 12). The shape of the labra in the latter stage is similar to Stages II and III. In *C. montagui*, the labrum is tapered and carries one pair of stout teeth (Figs. 10, 11), while in *C. stellatus* the labrum is parallel sided with a broad, straight distal end (Fig. 12). The several stout teeth present in Stage II (Figs. 5, 6) appear to give way to one pair of stout teeth based more laterally from stage III (Figs. 7, 12).

Discussion

The size, shape of cephalic shield, relative lengths of dorsal thoracic spines and abdominal process, and the shape of the labrum (unilobed or trilobed) have been used by other workers to develop keys to identify to species level the larval stages of barnacles (Lang, 1980). In summer, the main species of barnacles in the plankton off Plymouth are *Verruca stroemia*, *Elminius modestus*, *Balanus perforatus*, *B. crenatus*, *Chthamalus stellatus* and *C. montagui*. *Elminius modestus* and *B. perforatus* are easily separated from *C. stellatus*, *C. montagui*, and *V. stroemia* because of their trilobed labra (Knight-Jones and Waugh, 1949; Norris and Crisp, 1953). In general, the nauplii of *E. modestus* are smaller than *B. perforatus*, they are more pyriform in shape, and the frontolateral horns are stubby in the latter stages (IV–VI) and do not extend from the shield (Norris and Crisp, 1953). The most distinctive feature of *E. modestus*, however, is the relative length of the median lobe of the trilobed labrum. In *E. modestus*, the long median lobe extends out much farther than the lateral lobes (Knight-Jones and Waugh, 1949), while in *B. perforatus* the median lobe of the labrum only extends slightly beyond the lateral lobes (Groom, 1894; Bassindale, 1936; Norris and Crisp, 1953) and has a square shape even though it is trilobed (Knight-Jones and Waugh, 1949).

Verruca stroemia is then easily separated from the *Chthamalus* larvae by the size, general shape of the carapace, and relative lengths of the posterior processes. *Verruca stroemia* is at least 0.1 mm greater in total length than the chthamalids at each larval stage. The shape of the carapace is triangular in outline (although Pyefinch, 1948a states this is circular), and the labrum is rounded at the distal end (Bassindale, 1936). The shape of the labrum is readily observable using light microscopy, and it appears to have a small protuberance at the apex of the distal end, which is just noticeable in the drawings of Bassindale (1936) but was not mentioned. The most distinctive feature of *V. stroemia*, even using low power magnification of the microscope, is the posterior processes. The dorsal thoracic spine (referred to in Pyefinch, 1948a as the caudal spine) is either sightly longer than or equal in length to the abdominal process; in lateral view, they appear parallel to each other (Pyefinch, 1948a). The dorsal thoracic spine and abdominal processes are almost the same length as the shield (Pyefinch, 1948a).

Although *Balanus crenatus* has a trilobed labrum and *V. stroemia* has a unilobed labrum, they can be easily confused when examining a plankton sample (Pyefinch, 1948a). This is particularly easy to do with Stage II larvae, which are approximately the same size and have a caudal spine that is longer than the abdominal process. The most distinctive feature at this stage is the shape of the anterior margin of the shield. In *Verruca stroemia*, the anterior margin of the shield is straight, while in *B. crenatus* the anterior margin of the shield is curved (Pyefinch, 1948a). In lateral view, the abdominal processes diverge from the caudal spine in *B. crenatus* but are parallel in *V. stroemia*.

In the key of Lang (1980), the presence of the unilobed labrum was used to separate *C. fragilis* from the other barnacles. This feature alone, however, cannot be used to separate the chthamalids because of the presence of the unilobed labrum in *Verruca stroemia*. The sizes and relatively short lengths of the dorsal thoracic spine and the abdominal processes in relation to the length of the cephalic shield, however, are what separate the *Chthamalus* larvae from other nauplii in the plankton.

Distinguishing between the two species of *Chthamalus* is difficult. It has been stated previously that the morphological differences between the larvae of *C. stellatus* and *C. montagui* are "considerable" (Burrows *et al.*, 1999). It takes, however, a great deal of practice to separate the larvae of *C. montagui* from *C. stellatus*. Although the nauplii of *C. montagui* were consistently smaller than *C. stellatus*, in stages II and III there is overlap. The size of the nauplii needs to be used in combination with the shape of the shield, lengths of frontolateral horns and posterior processes, and shape of the labrum.

The shape of the anterior margin of the shield and the shape of the cephalic shield provide a useful starting point to separate the two species of chthamalids. It can be difficult, however, to ascertain the shape of the shield because transmission light microscopy provides a two-dimensional silhouette of the nauplius and can prevent an assessment of the concavity or convexity of the shield. Scanning electron microscopy (S.E.M.) provided a three-dimensional image and highlighted the differences between shield shapes. It would be impractical to use S.E.M. to identify large collections of nauplii or cyprids (O'Riordan *et al.*, 1999), but the use of S.E.M. in this study made it easier to form a search image that then made it easier to identify the nauplii by light microscopy. The shield of *Chthamalus montagui* is more slender in stage II and III larvae, while the shield of *C. stellatus* is more circular (Burrows *et al.*, 1999). In the Bogorov tray, the nauplii tend to fall on their ventral surface and the anterior margin of the shield is convex in *C. montagui*, while it is straight or concave in *C. stellatus* (Burrows, 1988). The shape of the shield and anterior margin coupled with the shorter frontolateral horns in *C. montagui* can be used to distinguish it from *C. stellatus*. In the later stages V and VI, the shield becomes increasingly convex in *C. montagui* and the frontolateral horns stubby, while in *C. stellatus* the frontolateral horns are elongate and the carapace shield remains rounded. In the later stages, the relative length of the dorsal thoracic spine to the abdominal processes change. In *C. montagui*, the dorsal thoracic spine becomes subequal to the squat abdominal processes, while in *C. stellatus* it is maintained (Bassindale, 1936; Burrows *et al.*, 1999).

Burrows *et al.* (1999) noted that the shape of the labrum was a good character for distinguishing between the two species. From Stage II, the labrum of *Chthamalus stellatus* is parallel sided with a broad, straight distal end, while the labrum of *C. montagui* is tapered (Burrows, 1988; Burrows *et al.*, 1999). There are clearly several large, stout teeth in stage II larvae of *C. stellatus*, while in *C. montagui* there is only one pair of large teeth at the lateral edges and some setae. Once this has been identified using light microscopy, it is a useful feature to distinguish between stage II larvae. By stage III, the several teeth of *C. stellatus* have been replaced by one pair of lateral teeth with setae, and although stouter in appearance, the teeth look similar to those of *C. montagui*. Only the shape of the labrum then separates the two species. Overall, although there are considerable differences between the nauplii of *Chthamalus* species, great care needs to be taken in identification.

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APPENDIX 1

A key for the identification of stages II and III of nauplii of spring- and summer-breeding barnacles of the British Isles (TL = total length, measured from the midpoint of the cephalic shield to the tip of the thoracic spine).

1. Labrum unilobed 2
– Labrum trilobed 3
2. Dorsal thoracic spine either slightly longer than or equal in length to abdominal process, almost as long as cephalic shield. Common in spring and summer (II, TL 0.40–0.44 mm; III, TL 0.47–0.50 mm; Bassindale, 1936; Pyefinch, 1948a, Fig. 1) . . . . *Verruca stroemia* O. F. Müller, 1776
– Dorsal thoracic spine longer than abdominal process, short in relation to cephalic shield. Common May to October; nauplius small (II, TL < 0.33 mm; III, TL < 0.38 mm) 9
3. Nauplius very large (II, TL 0.80 mm; III, TL 0.9 mm; Crisp, 1962b). Frontolateral horns proportionately large. Common February to May (Fig. 2) . . . . *Chirona hameri* Ascanius, 1767
– Nauplius small (II, TL < 0.70 mm; III, TL < 0.80 mm) 4
4. Nauplius large (II, TL 0.52–0.59 mm; III, TL 0.60–0.73 mm). Anterior shield margin markedly convex 5
– Nauplius smaller (II, TL < 0.51 mm; III, TL < 0.57 mm) 6
5. Stubby abdominal process with small spines. Common March to June (II, TL 0.51–0.58 mm; III, TL 0.61–0.71 mm; Bassindale, 1936; Pyefinch, 1948a; Crisp, 1962a; Lang, 1980, Fig. 2) . . . . *Semibalanus balanoides* L., 1767
– Distinct abdominal process with large spines (II, TL 0.51–0.56 mm; III, TL 0.60–0.71 mm; Barnes and Costlow, 1961; Crisp, 1962a; Lang, 1980, Fig. 2) . . . . *Balanus balanus* L., 1767
6. Nauplius II, TL 0.44–0.48 mm; III, TL 0.54–0.57 mm (Herz, 1933; Pyefinch, 1948a, c; Lang, 1980, Fig. 2). Common February to May . . . . *Balanus crenatus* Bruguière, 1789
– Nauplius II, TL < 0.45 mm; III, TL < 0.51 mm . . . 7
7. Posterolateral margins of shield with notches tipped with tiny spines (1 in II, 2 in III). Lateral margins of shield parallel. Common in summer (II, TL 0.41–0.44 mm; III, TL 0.49–0.51 mm; Bassindale, 1936; Norris and Crisp, 1953, Fig. 1) . . . . *Balanus perforatus* Bruguière, 1789
– Posterolateral margins of shield without notches . . . 8
8. Median lobe of labrum very prominent. Abdominal process much shorter than dorsal thoracic spine. Furcal spines proportionately long. Common May to October, but may be found at any time (II, TL 0.36–0.43 mm; III, TL 0.35–0.43 mm; Knight-

Jones and Waugh, 1949, Fig. 1) . . . . *Elminius modestus* Darwin, 1854

– Median lobe of labrum indistinct. Abdominal process subequal to dorsal thoracic spine. Common May to October (II, TL 0.30–0.38 mm; III, TL 0.36–0.42 mm; Jones and Crisp, 1954; Lang, 1980, Fig. 2) . . . . *Balanus improvisus* Darwin, 1854

9. Anterior shield margin straight or slightly concave. Prominent comb-like spines on posterolateral margins of shield. Frontolateral horns proportionately long. Shape of labrum parallel sided, with straight distal end and several stout teeth (Stage II) or only 1 pair (Stage III). Common May to September (II, TL 0.30–0.34 mm; III, TL 0.37–0.42 mm; Burrows *et al*., 1999, Fig. 1) . . . . *Chthamalus stellatus* Poli, 1791

– Anterior shield margin slightly convex but never concave. Indistinct comb-like spines on posterolateral margins of shield. Shape of labrum tapered, with rounded distal end and 1 pair of stout teeth and setae. The smallest nauplius of any British species. Common May to September (II, TL 0.27–0.32 mm; III, TL 0.31–0.36 mm; Burrows *et al*., 1999, Fig. 1) . . . . *Chthamalus montagui* Southward, 1976

APPENDIX 2

A key for the identification of stages IV, V, and VI of nauplii of spring- and summer-breeding barnacles of the British Isles (TL = total length, measured from the midpoint of the cephalic shield to the tip of the thoracic spine; SL = anterior to posterior of shield margin).

1. Posterior margin of shield without spines. Labrum unilobed 2

– Posterior margin of shield with spines. Labrum trilobed 3

2. Dorsal thoracic spine very long, almost as long as shield; abdominal process long, slender. Common in spring and summer (IV, TL 0.54–0.58 mm, V, TL 0.62–0.63 mm; VI, TL 0.69–0.73 mm; Bassindale, 1936; Pyefinch 1948a, Fig. 1) . . . . *Verruca stroemia* O. F. Müller, 1776

– Dorsal thoracic spine short; abdominal process squat. Shield outlines appear rounded. Common June to October 9

3. Nauplius very large (IV, TL 1.1 mm; V, TL 1.2 mm; VI, TL 1.6 mm; Crisp, 1962b). Frontolateral horns large, anteriorly directed. Common February to May (Fig. 2) . . . . *Chirona hameri* Ascanius, 1767

– Nauplius smaller 4

4. Nauplius large (IV, TL 0.70–0.90 mm; V, TL 0.8–1.0 mm; VI, 0.92–1.15 mm). Anterior margin of shield distinctly convex. Frontolateral horns laterally directed. Common February to March 5

– Nauplius smaller (IV, TL 0.39–0.70 mm; V, TL 0.45–0.80 mm; VI, TL 0.48–0.91 mm). Frontolateral horns anteriorly directed 6

5. Stubby abdominal process much shorter than dorsal thoracic spine. Common March to June (IV, TL 0.69–0.87 mm; V, TL 0.81–1.02 mm; VI, TL 1.05–1.25 mm; Bassindale, 1936; Pyefinch, 1948a; Crisp, 1962a; Lang, 1980, Fig. 2) . . . . *Semibalanus balanoides* L., 1767

– Well-formed abdominal process subequal to dorsal thoracic spine. Common March to June (IV, TL 0.66–0.80 mm; V, TL 0.76–1.00 mm; VI, TL 0.92–1.10 mm; Barnes and Costlow, 1961; Crisp, 1962a, Fig. 2) . . . . *Balanus balanus* L., 1767

6. Nauplius small (IV, TL < 0.53 mm; V, TL < 0.65 mm; VI, TL < 0.71 mm) 8

– Nauplius larger (IV, TL 0.55–0.75 mm; V, TL 0.68–0.85 mm; VI, TL 0.83–0.91 mm) 7

7. Anterior shield margin slightly convex. Frontolateral horns proportionately large. Sides of shield straight, almost parallel (IV, SL 0.35–0.41 mm; V, SL 0.43–0.47 mm; VI, SL 0.55–0.61 mm; Bassindale, 1936; Norris and Crisp, 1953). Common in summer (IV, TL 0.54–0.60 mm; V, TL 0.68–0.76 mm; VI, TL 0.83–0.89 mm; Bassindale, 1936; Norris and Crisp, 1953, Fig. 1) . . . . *Balanus perforatus* Bruguière, 1789

– Anterior margin distinctly convex (IV, SL 0.48 mm; V, SL 0.59 mm; VI, SL 0.63 mm; Pyefinch, 1948a). Common February to May (IV, TL 0.58–0.73 mm; V, TL 0.70–0.84 mm; VI, TL 0.91–0.92 mm; Pyefinch, 1948a; Lang, 1980, Fig. 2) . . . . *Balanus crenatus* Bruguière, 1789

8. Spines on posterior of shield small and close set. Medium lobe of labrum obviously extending past lateral lobes. Common May to October though may be found all year round. (IV, TL 0.39–0.50 mm; V, TL 0.45–0.57 mm; VI, TL 0.48–0.71 mm; Knight-Jones and Waugh, 1949, Fig. 1) . . . . *Elminius modestus* Darwin, 1854

– Spines on posterior margin of shield relatively large. Medium lobe of labrum slightly extending past lateral lobes. Common May to October (IV, TL 0.38–0.52 mm; V, TL 0.48–0.60 mm; VI, TL 0.57–0.65 mm; Jones and Crisp, 1954; Lang, 1980, Fig. 2) . . . . . *Balanus improvisus* Darwin, 1854

9. Shield outline still relatively elongate; frontolateral horns elongate. Dorsal thoracic spine equal in length to abdominal process. Shape of labrum parallel, with straight distal end and 2 pairs of teeth. Nauplius larger (up to 0.1 mm TL) than *C. montagui* (IV, TL 0.44–0.48 mm; V, TL 0.48–0.56 mm; VI, TL 0.55–0.65 mm; Burrows, 1988; Burrows *et al*., 1999, Fig. 1) . . . . *Chthamalus stellatus* Poli, 1791

– Shield outline very rounded; frontolateral horns short, stout. Dorsal thoracic spine much shorter than stubby abdominal process. Shape of labrum tapered, with rounded distal end and 2 pairs of stout teeth with setae (IV, TL 0.36–0.39 mm; V, TL 0.36–0.42 mm; VI, TL 0.43–0.49 mm; Burrows, 1988; Burrows *et al*., 1999, Fig. 1) . . . . *Chthamalus montagui* Southward, 1976