Abstract Mandibles and stomachs of three Antarctic shrimp species (Nematocarcinus lanceopes, Notocrangon antarcticus, and Chorismus antarcticus) were investigated by means of scanning electron microscopy. Transmission electron microscopy of the midgut glands was applied to find out the nutritional status of the animals, which contained a broad variety of food items in their stomachs. In contrast to the Antarctic krill, the three carideans possess a dual filter system; primary filters in the cardia and secondary filters in the pyloric chamber. Morphologically, the mandibles and stomachs of the three species vary considerably; however, their food items are similar. We conclude that stomach contents do not really reflect the different modes of life or habitat preferences of the investigated species.

Introduction

The scarcity of decapod species in the Southern Ocean has attracted attention since the beginning of modern Antarctic research (e.g. Yaldwyn 1965; Maxwell 1977; Kirkwood 1984). Only 11 benthic and 13 pelagic species have been found hitherto on the Antarctic continental shelves and 1 in the adjacent deep sea. In addition, 13 decapod species, all caridean and penaeid shrimps, have been recorded in the pelagial within the Antarctic Convergence (Gorny 2000). Scarcity of species does not necessarily mean low abundance. Research during the past decade has shown that some species of benthic caridean shrimps occur regularly, or are even dominant, in many areas of the Southern Ocean. In the southeastern Weddell Sea and the Lazarev Sea, which have been extensively sampled by RV “Polarstern”, the three most abundant benthic shrimp species are distributed along an overlapping depth gradient: Chorismus antarcticus is most common in shallow waters (200–500 m), Notocrangon antarcticus in intermediate depths (300–700 m), and Nematocarcinus lanceopes occurs from 600 to >2,000 m (Arntz and Gorny 1991; Sirenko et al. 1997). A substantial amount of information has been collected on abundance, distribution, reproductive ecology and growth of these species (e.g. Maxwell 1977; Clarke and Lakhani 1979; Gutt et al. 1991; Gorny et al. 1992, 1993). However, knowledge is still lacking on their role in the Antarctic food web, their feeding habits, as well as mechanical and biochemical degradation of their food in the course of its passage through the alimentary canal.

One of the most obvious characters of the alimentary canal of Decapoda is the complicated stomach or proventriculus, which is composed of an anterior cardiac shelves and 1 in the adjacent deep sea. In addition, 13 decapod species, all caridean and penaeid shrimps, have been recorded in the pelagial within the Antarctic Convergence (Gorny 2000).
mandibles play a crucial rôle because they can crush the food items. They are located close to and in front of the mouth opening between the upper lip (labrum). The paired lower lips (labia) or their distal portions may be situated in the mouth cavity. Mouth parts, especially mandibles, and stomach morphology give an indication of feeding habits. R-cells of the midgut glands may give hints as to the quality of the absorbed food.

In this paper, we analyse mandibles and stomach filters of the three dominant Antarctic shrimps, *Nematocarcinus lanceopes* Bate (Nematocarcinidae), *Notocrangon antarcticus* Pfeffer (Crangonidae) and *Chorismus antarcticus* (Pfeffer 1887) (Hippolytididae), to estimate their efficiency in food degradation. The findings are discussed in an ecological context.

**Materials and methods**

The specimens investigated were caught with various types of bottom trawls in depths of 220 m to 2,100 m in the eastern Weddell Sea between 71°S 10°W and 76°S 30°W during ANT XV/3 of RV “Polarstern” in January to March 1998 (Arntz and Gutt 1998). Dissection was undertaken on board using a Wild stereomicroscope. The specimens were identified according to Kirkwood (1984) and Tiefenbacher (1990). The investigated specimens measured 24–30 mm carapace length (CL) in *Nematocarcinus lanceopes*, 20–23 mm CL in *Notocrangon antarcticus* and 17–19 mm CL in *Chorismus antarcticus*. These sizes lie well within the known adult size ranges of the respective species (Arntz and Gorny 1991; Gorny et al. 1992). Tissue samples of ten individuals of each species were fixed in a solution containing 1.5% glutaraldehyde and 1.5% potassium hexacyanoferrate, tissue samples were rinsed in 100 mM cacodylate buffer (pH 7.4), incubated (5 min) in a 1% solution of OS04 containing 1.5% paraformaldehyde in phosphate buffer (pH 7.4), adjusted to an osmolarity of 900 mOsm by the addition of sucrose and sodium chloride. After postfixation in a 1% solution of OS04 containing 1.5% potassium hexacyanoferrate, tissue samples were rinsed in 100 mM cacodylate buffer (pH 7.4), incubated (5 min) in a 1% solution of uranyl acetate (in 50 mM maleate buffer at pH 5.2), dehydrated in ethanol and embedded in Araldite. Thin sections were stained for 5 min with uranyl acetate (saturated solution in 70% methanol) and for another 5 min in lead citrate. The sections were examined under a Zeiss EM 10C (TEM) electron microscope. For scanning electron microscopy, specimens were critical-point dried, coated with gold, and examined with a Cambridge SEM S4-10 microscope. For light microscopic analysis of the stomach contents and filters, we used a Zeiss Axioskop equipped with an MC 100 camera. Stomach contents were analysed from 15 specimens per species.

**Results**

**Mandibles**

The mandibles of the three species investigated differ considerably in their position, size and architecture. Those of *Nematocarcinus lanceopes* (Figs. 1a, b, 2) consist of a base carrying two processes and a palp. The molar process is located orally (or may be accommodated in the mouth cavity); the incisor process is in an aboral position (or may lie immediately anterior to the mouth opening). The mandibles reach nearly the length of the stomach, are highly asymmetrical in their molar processes, and are deep red. Their incisor processes are flanked by an upper lip and paired lower lips and are equipped with acute teeth. The molar processes are massive and fitted with a complicated profile composed of protruberances and several rows of bristles (Figs. 1a, b, 2). The following structures can be distinguished: molar-like protruberances (Fig. 2a), conical-shaped teeth (Fig. 2b) and bristles (Fig. 2c). The differences between left and right molar process are documented in Figs. 1a, b. Each mandible bears a three-jointed palp with long setae on the two distal joints. The mandibles of *Chorismus antarcticus* also almost reach the length of the stomach (Figs. 1e, f, 3). Their incisor processes are located behind the lips, have the shape of an acute blade with a cutting edge, and are fitted with several pointed subterminal teeth on their medial face. The yellow molar process stands at an angle of > 90° towards the incisor process and is partly fringed by a row of brown bristles. Its shape is similar to a cylinder with the surface of the right being smaller than the left (Fig. 1e, f) and fitting into each other so as to grind material. The complicated microstructure of the molar process (Fig. 1e, f) is characterised by rows of stout and blunt teeth, irregular and pointed teeth, and bristles (Fig. 3a–d). The dissimilarity between right and left pars molaris is documented in Fig. 1e, f. As in *Nematocarcinus lanceopes*, the palp is three-jointed and bears setae on all joints.

Regarding the mandibles, *Notocrangon antarcticus* stands apart; its mandibles bear neither incisor processes nor palps. They are long, curved, slightly asymmetrical structures, the distal ends of which, meeting in the oral cavity, are equipped with acute yellow teeth that mesh together (Fig. 1c, d). They reach barely half the length of the stomach. There are neither setae nor scales on their surfaces. Fig. 4 summarises the findings in a diagrammatic way.

**Stomach**

In *Nematocarcinus lanceopes*, the stomach reaches almost half of the carapace length; in *Notocrangon antarcticus* it is slightly longer than half the carapace length, and in *Chorismus antarcticus* it measures one-third of the carapace length. The stomach wall of *Nematocarcinus lanceopes* is very thin and transparent, whereas the other two species have muscular, thick stomach walls, especially *Notocrangon antarcticus*.

The primary filters are nearly rectangular, roof-shaped structures in *Nematocarcinus lanceopes* and wedge-shaped in the other two species (Fig. 5a, c, e) with the tip anteriorly directed. In adult specimens, they are 1.4–2.8 mm long and are composed of two rows of parallel feather-like setae covering one ventro-lateral channel each, which conveys the filtrate to the secondary filters. The distance between the two rows of filter setae varies considerably in the three species investigated. Each row of filter setae is composed of 400–500 setae, which have different lengths in the three species (Fig. 5b,