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SHORT NOTE

Michael Klages · Kay Vopel · Hartmut Bluhm
Thomas Brey · Thomas Soltwedel · Wolf E. Arntz

Deep-sea food falls: first observation of a natural event in the Arctic Ocean

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Abstract Concentrations of scavengers attracted by bait in the deep sea are documented by time-lapse photography and results of baited traps. During a remotely operated vehicle deployment in the Molloy Deep, the deepest depression of the Fram Strait, the carcass of a natant decapod, *Pasiphaea tarda* Krøyer, 1845, was discovered at 79°08.4′N and 002°49.85′E in a depth of 5,551 m. The carcass was covered by hundreds of individuals of *Uristes* sp., a scavenging lysianassoid amphipod. After documentation of this event, both the carcass and the majority of amphipods were collected. This is the first reported observation and sampling of an ongoing feeding process of scavengers on a natural food fall in the deep sea.

Introduction

It is a well-known and documented feature of the deep-sea benthic ecosystem that scavenging amphipods appear rapidly and in large numbers after deposition of bait at the seafloor (see, for example, Smith and Baldwin 1982; Hargrave et al. 1995; Thurston et al. 1995; Collins et al. 1999; Witte 1999). Time-lapse photography has allowed an estimate of the number of amphipods and other scavengers attracted and the time required to utilize such food sources (Hessler et al. 1978; Hargrave 1985; Collins et al. 1999). We report and discuss the first observation of the processing of a natural food fall of smaller size in the deep sea.

M. Klages (✉) · H. Bluhm · T. Brey
T. Soltwedel · W. E. Arntz
Alfred Wegener Institute for Polar and Marine Research,
Columbusstrasse, 27568 Bremerhaven,
Germany
E-mail: mklages@awi-bremerhaven.de
Tel.: +49-471-48311302; Fax: +49-471-48311149

K. Vopel
Institute of Ecology, Department of Marine Biology,
University of Vienna, Althanstrasse 14,
1090 Vienna, Austria

Materials and methods

The remotely operated vehicle (ROV) "Victor 6000" was used in the Fram Strait during the expedition ARK XV/1 of RV "Polarstern" from 23 June to 19 July 1999 (Krause 1999). The dimensions of the ROV are 3.1 × 2.2 × 2 m; the weight is about 3.7 tonnes in air, and the maximum diving depth is 6,000 m. The vehicle was equipped with seven cameras, a slurp gun, water sampler and a manipulator arm. The last can be combined with a claw-like shovel ("pac-man" claw) for sampling objects from the seafloor (for further technical details see Soltwedel et al. 2000). During a deployment on 4 July 1999, a decapod carcass was discovered at 79°08.4′N, 02°49.85′E at a depth of 5,551 m. The carcass was densely covered by lysianassoid amphipods feeding on it. The feeding behaviour of the amphipods was video-recorded, and both the carcass and the majority of scavengers were collected using the manipulator arm of the vehicle. At the institute, a total of 693 amphipod individuals was analysed according to species, length-frequency distribution, sex ratio and reproductive stage. The remains of the decapod were identified and the carapace length measured to the nearest 0.1 mm, as were the amphipods, using a semi-automatic image analysing system. At a second location investigated with the ROV at 79°03.8′N, 04°10.9′E, at a water depth of 2,376 m, fish bait was deployed. About 12 h later, the location was revisited with the ROV. The scenario around the fish bait was video-recorded and the fish remains, together with hundreds of amphipods clinging to it, sampled with the manipulator arm and transferred into a sampling box of the underwater vehicle.

Results

Several hundred lysianassoid amphipods were discovered on the seafloor of the Molloy Deep, the deepest trough of the Fram Strait, feeding on a carcass of the bathypelagic shrimp *Pasiphaea tarda* Krøyer, 1845. Both the carcass (31 mm carapace length) and amphipods were collected (Fig. 1a, b). The feeding behaviour of the amphipods was video-recorded and a total of 693 individuals were analysed for length-frequency distribution, sex ratio and reproductive stage.

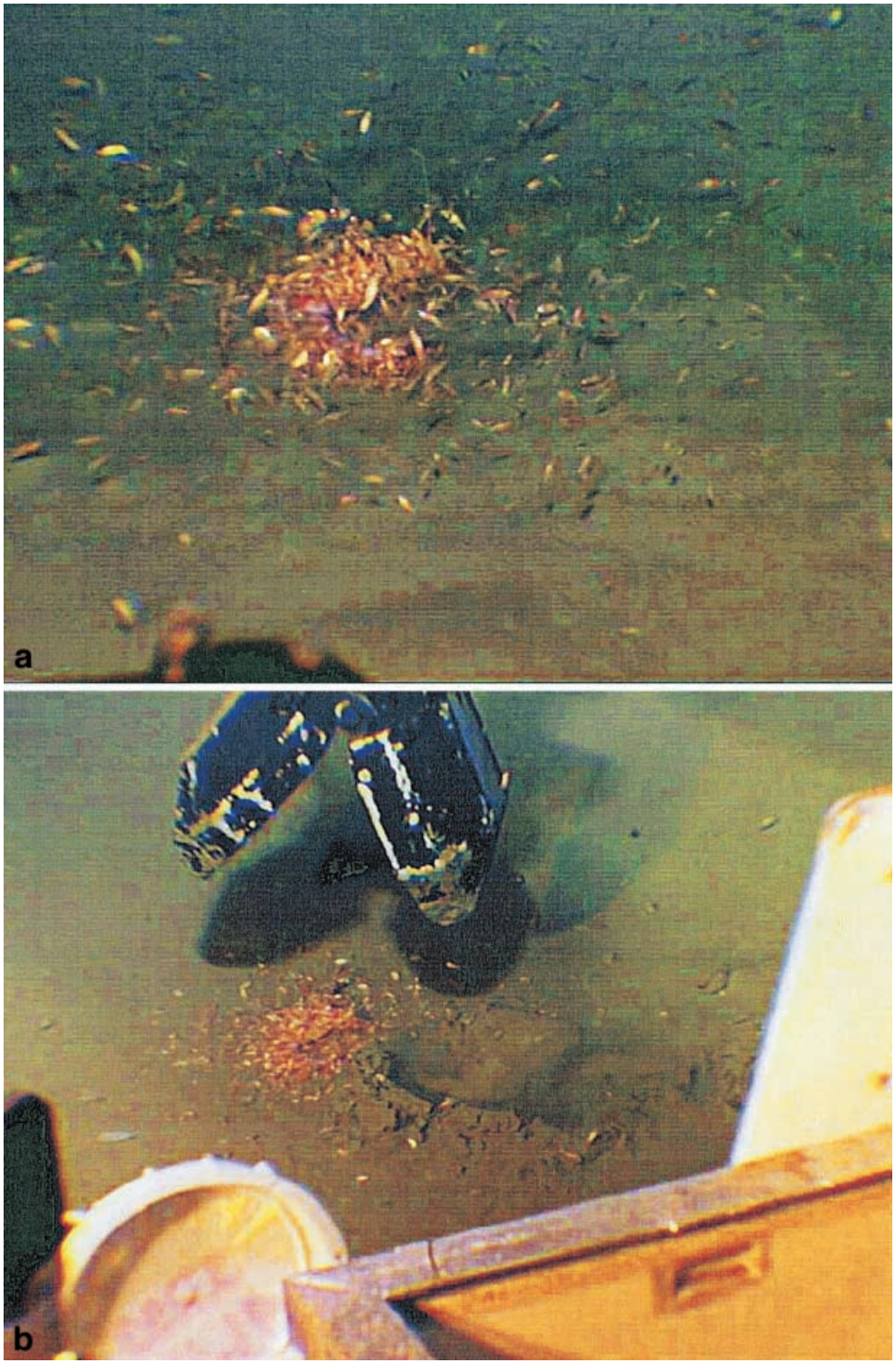

Fig. 1 **a** The carcass of *Pasiphaea tarda* at a depth of 5,551 m covered by hundreds of individuals of the lysianassoid amphipod *Uristes* sp. **b** Sampling of the carcass and amphipods using the pac-man claw attached to the manipulator of the ROV

All amphipods were identified as *Uristes* sp., probably new to science. The presence of four ovigerous females between 8.9 and 12.3 mm length indicates maturity and adult size (Fig. 2).

Except for the last two abdominal segments, where some muscle tissue was still visible (with three amphipods inside the exoskeleton clinging to it), all internal organs of the pasiphaeid shrimp had been ingested by the scavengers.

Two other amphipod species were collected using fish bait at a shallower site adjacent to the Molloy Deep (79°03.8′N, 004°10.9′E; 2,376 m): the large *Eurythenes gryllus* (Lichtenstein, 1822) and a smaller, as yet unidentified, lysianassoid species of up to 10 mm length,

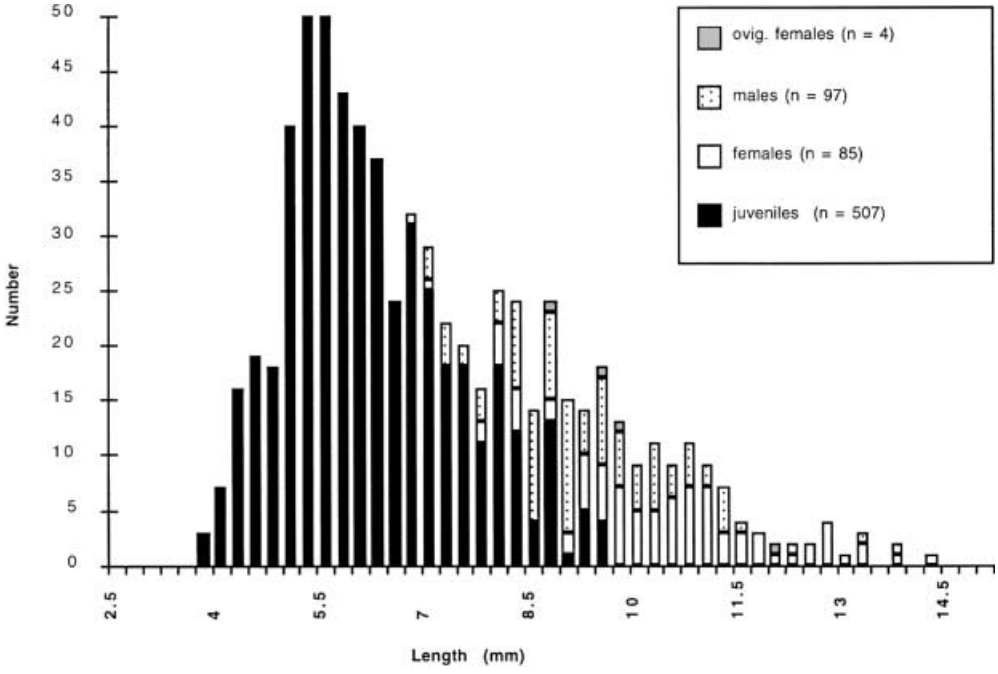

Fig. 2 Length-frequency distribution of *Uristes* sp. The size (measured from tip of rostrum to the end of the telson along the dorsal edge) spectra cover a range from 3.8 to 14.5 mm. The majority of individuals were juvenile (507), while 89 specimens were female (4 ovigerous) and 97 individuals were male

which was feeding on tissue remains on the bones of fish bait. All amphipods collected at this site were still alive after recovery of the ROV, whereas *Uristes* sp. did not survive the transfer to the surface, apparently being adapted to high pressure as are other abyssal amphipods (Yayanos 1981). Additionally, four bundles of dead fishes each weighing about 10 kg were deployed for future analysis of the impact of large food falls on the sediment community. Two hours after deployment, several individuals of *E. gryllus* and of another species, probably *Abyssorchomene* sp., were clinging to some of the fishes.

Discussion

Food supply for the deep-sea benthos originates mainly from particulate organic matter settling to the seafloor, but an as yet undetermined fraction consists of carcasses of dead invertebrates and vertebrates. Except for the remains of whale falls found and documented at various localities in the deep sea, we have observed and sampled for the first time a natural food fall of a dead natant decapod at 5,551 m water depth. Results of baited traps and time-lapse photography have revealed that deep-sea scavenging amphipods are attracted in large numbers by artificial food falls such as fish bait. Consistent with observations where small species of genera such as *Paralicella*, *Abyssorchomene* and *Orchomenella* dominate the scavenger aggregations in terms of numbers if not biomass (Shulenberger and Hessler 1974; Thurston 1990; Christiansen 1996), in the Molloy Deep also a tiny species was feeding on the carcass.

The largest *E. gryllus* collected at the shallower site investigated measured 71 mm, about 6 times the size of the largest *Uristes* specimen. Published data on minimum and maximum length measured in 13 deep-sea lysianassoid amphipods (Fig. 3) suggest that there are 2 groups of necrophagous amphipods in the deep sea, clearly distinguished by the size spectra they occupy. Genera like *Hirondellea*, *Eurythenes* and *Alicella* attain lengths of 37–320+ mm whereas the others rarely exceed 20 mm. Genera of the first group were selected by Sainte-Marie (1992) according to morphological and physiological criteria as representatives of a deep-water feeding guild sharing characters such as shearing mandibles suited for efficient ingestion of flesh, capacious guts for food storage and low metabolic rates. Genera such as *Abyssorchomene*, *Orchomenella* and *Uristes* have, in contrast, much more basic mandibles, lacking, for example, the corpus mandibulae but with a partially triturative molar; they have smaller guts, probably higher metabolic rates and they process food less efficiently than members of the other guild. It is likely that they represent a group of facultative necrophages, also able to feed on other food-like detritus, perhaps phytodetritus and smaller macrofauna.

While at the shallower study site, at least two lysianassoid species were attracted by either fish bait deployed for 12 h or the long-term deployed fish bundles, the decapod carcass in the Molloy Deep was utilized by a single small species only.

A number of foraging strategies for the detection of carrion have been suggested for lysianassoids (Sainte-Marie 1992). Our observation supports the idea that larger species like *E. gryllus*, most likely permanently swimming in search of food and even collected close to the north pole (B.T. Hargrave, personal communication), are specialists on large parcels of carrion while smaller epibenthic lysianassoids are more generalist,

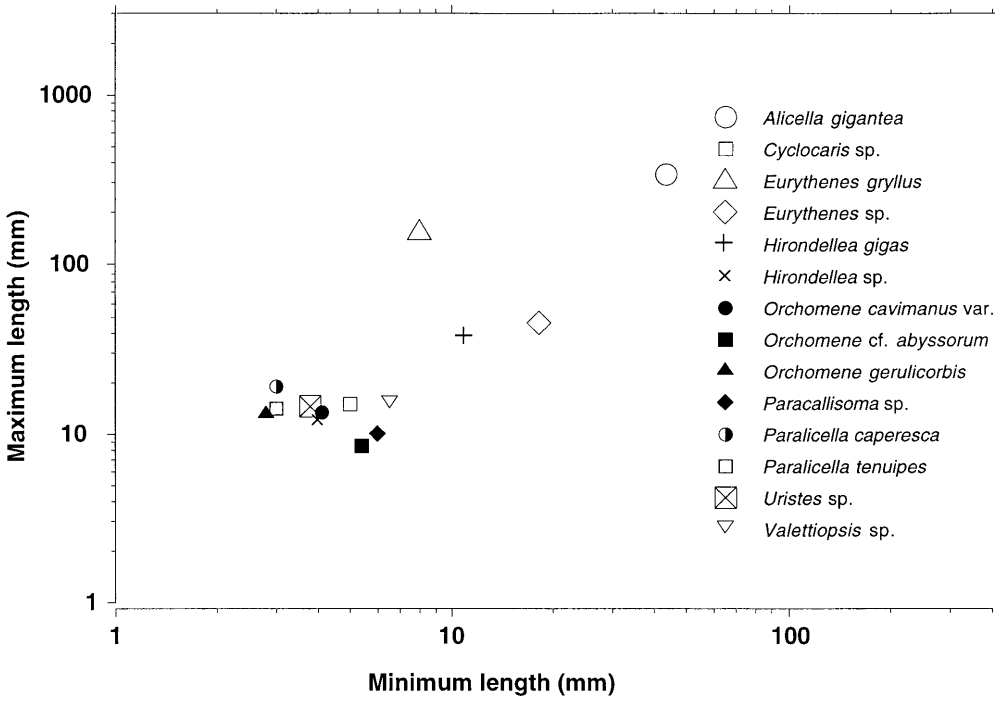

Fig. 3 Log/log plot of size spectra of 13 lysianassoid scavenging deep-sea amphipods (data, except for *Uristes* sp., from the literature)

feeding on a variety of food items including smaller carcasses or zooplankton remains, of which the latter may contribute significantly to the carbon flux to the seafloor (Sokolova 1994; Weslawski and Legezynska 1998). If so, smaller carcasses might be utilized with higher probability by local populations of facultative necrophages while larger ones may be utilized by temporary invaders. Although somewhat speculative, there might be a similarity with terrestrial ecosystems where ants and beetles, for example, compete with larger scavengers for carcasses (Begon et al. 1998).

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