J. Mar. Biol. Ass. U.K. (1999), **79**, 361–363
Printed in the United Kingdom

Observations of the echiuran worm *Bonellia viridis* in the deep basin of the northern Evoikos Gulf, Greece

D.J. Hughes*, S.J. Marrs†, C.J. Smith‡ and R.J.A. Atkinson†

*Centre for Coastal & Marine Sciences, Dunstaffnage Marine Laboratory, PO Box 3, Oban, Argyll, PA34 4AD, Scotland. †University Marine Biological Station, Millport, Isle of Cumbrae, KA28 0EG, Scotland. ‡Institute of Marine Biology of Crete, PO Box 2214, 710 03 Iraklio, Crete, Greece

Towed underwater TV observations at 440 m in the northern Evoikos Gulf, Greece, revealed a soft mud plain heavily bioturbated by the thalassinidean *Calocaris macandreae*, with *Callianassa subterranea* and *Nephrops norvegicus* also present. Ejecta mounds and feeding traces indicated the presence of a large echiuran, provisionally identified as *Maxmuelleria gigas*. The locality also supported a dense population of a second echiuran, *Bonellia viridis*, a species not previously recorded as an inhabitant of sedimentary environments.

The deep-burrowing 'megafauna' (Atkinson, 1986) of sublittoral sediments have attracted considerable research interest recently, spurred partly by a recognition that their bioturbative activities may have important consequences for benthic biogeochemistry (Ziebis et al., 1996). Megafaunal burrowing communities have been best characterized around the British coasts, involving the use of SCUBA for *in situ* observations and burrow identification (Atkinson & Chapman, 1984; Nickell et al., 1995) and towed underwater TV for larger-scale surveys beyond the effective range of air diving (Hughes & Atkinson, 1997). Less published information exists on the composition of such communities in the Mediterranean, although many of the decapod crustaceans, echiuran worms and burrowing fish studied in British waters are known to occur there. Towed camera surveys carried out in 1996 as part of an EC-funded study of *Nephrops norvegicus* (L.) stock assessment techniques (Marrs et al., 1996) recorded intensely-bioturbated muds at a number of sites in the Adriatic and Aegean Seas and provided much new information on the distribution and abundance of burrowing megafauna. Here we describe the community observed in the northern Evoikos Gulf, Greece (Figure 1), notable for a dense occurrence of the echiuran worm *Bonellia viridis* Rolando in a habitat quite unlike that normally considered typical for the species.

The northern Evoikos Gulf is an almost landlocked, depositional basin lying between the island of Evia and the Greek mainland (Friligos, 1985), and reaches a maximum depth of about 440 m. On 15 July 1996 a transect approximately 2.5 km

Figure 1. Map showing the location of the northern Evoikos Gulf (shaded) on the Aegean coast of Greece.

long extending through the deepest part of the basin was observed using towed underwater TV. Starting and finishing points were at 38°48.892′N 23°06.602′E (depth 444 m) and 38°48.785′N 23°08.220′E (depth 442 m), respectively. Observations were made with a Simrad Osprey OE1362 fixed-focus camera mounted on a lightweight aluminium sled, with illumination provided by two Bowtech Versabeam lamps. Images were recorded on VHS tape. The ship's position and distance covered were recorded at 5-min intervals using Global Positioning System. Tow duration was 120 min, beginning at 1044 hours. On viewing the tape, surface bioturbation features and epifauna were counted along a 70 cm wide strip, using a field-of-view calibration established prior to the tow.

The floor of the deep basin consisted of a fine mud plain densely pitted with small burrow openings (mean 42.9 holes m^{-2}). The hole clustering pattern indicated that the predominant burrower was the thalassinidean crustacean *Calocaris macandreae* (Bell). This microtopography was supplemented by occasional (0.23 m^{-2}) large conical or domed mounds up to 30 cm in diameter. The fresh ejecta of which these were composed often contrasted strongly with the background sediment (Figure 2A). An apical burrow opening was sometimes present. These mounds and ejecta patches appeared identical to those formed by the large bonelliid echiuran *Maxmuelleria lankesteri* (Herdman) in Scottish waters (Hughes et al., 1996). A similar species *M. gigas* Müller is known from the Adriatic (Zavodnik, 1994). Provisional attribution of the Evoikos mounds

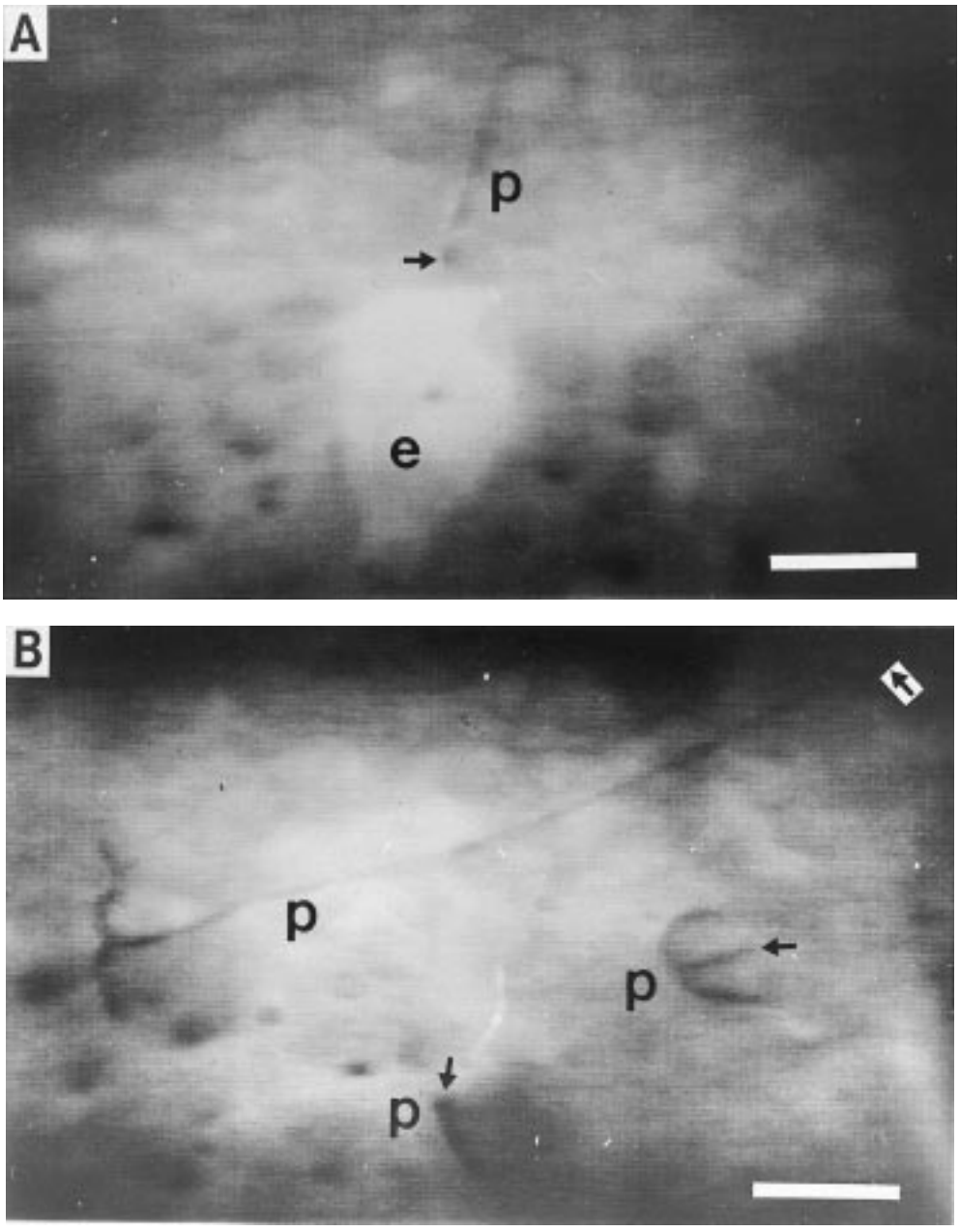

Figure 2. Still photographs taken from towed underwater TV recordings of the sea-floor at approximately 440 m in the northern Evoikos Gulf. (A) A patch of pale sediment ejecta (e) probably vented by the echiuran *Maxmuelleria gigas*. The proboscis of a *Bonellia viridis* (p) is seen extending towards the top of the frame. (B) Proboscides of three individuals of *B. viridis* (p) in different stages of extension. The strong bifurcation of the proboscis tip is clearly seen in the upper two examples. Arrows in both photographs indicate the burrow openings from which the proboscides are extended. The surrounding sediment is also heavily burrowed. Scale bars: 10 cm.

https://doi.org/10.1017/S0025315498000411 Published online by Cambridge University Press

to *M. gigas* was supported by rare sightings of stellate feeding traces on the sediment surface, similar to those produced by *M. lankesteri* (Hughes et al., 1996). Small sediment mounds may have been the work of the thalassinidean *Callianassa subterranea* (Montagu), which has been recorded as common in the northern Evoikos Gulf (Thessalou-Legaki, 1987). The large burrow openings of the Norway lobster *Nephrops norvegicus* were unmistakable but very rare, only five being seen during the tow.

No littoral or terrestrial plant debris was seen on the sediment surface, and there were no signs of any recent trawling. Epifauna were scarce, the most common species being the squat lobster *Munida rugosa* (Fabricius) (0.03 ind m^{-2}). An unidentified anemone, possibly a cerianthid, with a pale column and long, pale or dark tentacles occurred at a density of 0.02 ind m^{-2}. Two macrourid fish, tentatively identified as *Nezumia sclerorhynchus* (Valenciennes) and *Coelorhynchus coelorhynchus* (Risso) were seen.

The most remarkable aspect of the burrowing community was the abundance of bonelliid echiuran worms, revealed by numerous long proboscides extended across the sediment surface, invariably retracting slowly as the camera sled approached (Figure 2A,B). The narrow, ribbon-like proboscides were up to 120 cm long and measured up to 35 cm across their strongly bifurcated tips. Each proboscis emerged from a small circular burrow opening, sometimes surrounded by a pale sediment deposit, but clearly not associated with the large ejecta mounds described previously (a proboscis of this morphology would also not create the stellate surface traces attributed to *M. gigas*). A count of extended proboscides originating within the 70 cm wide transect gave an estimated density of 0.63 ind m^{-2}, probably an underestimate given that the worms may not all have been extended above the surface. Even using this minimum density, and assuming an average proboscis extension of 1 m, the combined sediment surface area accessible to the worms considerably exceeds the total area of sea-floor surveyed (1731.4 m^2), illustrating the potential of these animals to affect the sediment surface throughout this locality.

A proboscis of the observed form and dimensions is fully consistent with that of *Bonellia viridis* (Jaccarini & Schembri, 1977), and differs from that of any other echiuran known to occur in the Mediterranean. However, until now, *B. viridis* has been typically recorded as an inhabitant of calcareous rock crevices in the shallow sublittoral (Schembri & Jaccarini, 1978; Zavodnik, 1994). Schembri & Jaccarini (1978) stated that the animal was never found in soft substrata and made no attempt to penetrate sand when presented with it. The species has been found at several other sites in the Aegean down to 200 m, always associated with hard substrata (C.J. Smith, personal observation). Our observations in the Evoikos Gulf suggest that *B. viridis* may be far more adaptable in its choice of habitat than previously believed. The association of this echiuran with deep mud substrata may not be confined to the Evoikos Gulf. A photograph in Piccard & Dietz's (1961) account of the 'Bathyscaph' expeditions shows what are clearly bonelliid proboscides extending over a soft substratum at 276 m off the island of Capri. Galil & Goren (1994) collected *B. viridis* from 1000 to 1390 m off the coast of Israel. Habitat details were not given, but the use of a beam trawl indicates a sedimentary substratum. *Bonellia viridis* may turn out to be a widespread component of megafaunal burrowing communities in the Mediterranean, and at the densities observed in the northern Evoikos Gulf could potentially have an important influence on processes at the sediment–water interface.

We thank the captain and crew of the RV 'Philia' for their assistance in the field, and acknowledge the valuable help given by Ms Nadia Papadopoulou and Ms Shona Magill. This work was funded by the European Commission as part of a study project in support of the Common Fisheries Policy, reference no. 94/069.

REFERENCES

Atkinson, R.J.A., 1986. Mud-burrowing megafauna of the Clyde Sea area. *Proceedings of the Royal Society of Edinburgh*, B **90**, 351–361.

Atkinson, R.J.A. & Chapman, C.J., 1984. Resin casting: a technique for investigating burrows in sublittoral sediments. *Progress in Underwater Science*, **9**, 15–25.

Friligos, N., 1985. Nutrient conditions in the Euboikos Gulf (west Aegean). *Marine Pollution Bulletin*, **16**, 435–439.

Galil, B.S. & Goren, M., 1994. The deep sea Levantine fauna–new records and rare occurrences. *Senckenbergiana Maritima*, **25**, 41–52.

Hughes, D.J., Ansell, A.D. & Atkinson, R.J.A., 1996. Distribution, ecology and life-cycle of *Maxmuelleria lankesteri* (Echiura: Bonelliidae): a review with notes on field identification. *Journal of the Marine Biological Association of the United Kingdom*, **76**, 897–908.

Hughes, D.J. & Atkinson, R.J.A., 1997. A towed video survey of megafaunal bioturbation in the north-eastern Irish Sea. *Journal of the Marine Biological Association of the United Kingdom*, **77**, 635–653.

Jaccarini, V. & Schembri, P.J., 1977. Locomotory and other movements of the proboscis of *Bonellia viridis* (Echiura, Bonelliidae). *Journal of Zoology*, **182**, 467–476.

Marrs, S.J., Atkinson, R.J.A., Smith, C.J. & Hills, J.M., 1996. *Calibration of the towed underwater TV technique for use in stock assessment of* Nephrops norvegicus. Final Report to the European Commission, Reference no. 94/069, 155 pp.

Nickell, L.A., Hughes, D.J. & Atkinson, R.J.A., 1995. Megafaunal bioturbation in organically enriched Scottish sea lochs. In *Biology and ecology of shallow coastal waters. Proceedings of the 28th European Marine Biology Symposium, Iraklio, Crete, September 1993* (ed. A. Eleftheriou et al.), pp. 315–322. Fredensborg: Olsen & Olsen.

Piccard, J. & Dietz, R.S., 1961. *Seven miles down: the story of the bathyscaph 'Trieste'*. London: Longmans.

Schembri, P.J. & Jaccarini, V., 1978. Some aspects of the ecology of the echiuran worm *Bonellia viridis* and associated infauna. *Marine Biology*, **47**, 55–61.

Thessalou-Legaki, M., 1987. On a population of *Callianassa subterranea* (Crustacea, Decapoda, Thalassinidea) in the N. Euboikos Gulf, Greece. *Investigación Pesquera*, **51**, supplement 1, 457.

Zavodnik, D., 1994. Distribution and ecology of Echiura and Priapulida on the Adriatic Sea. *Periodicum Biologorum*, **96**, 459–462.

Ziebis, W., Forster, S., Huettel, M. & Jørgensen, B.B., 1996. Complex burrows of the mud shrimp *Callianassa truncata* and their geochemical impact in the sea bed. *Nature, London*, **382**, 619–622.

Submitted 21 August 1997. Accepted 13 March 1998.