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The supergiant amphipod *Alicella gigantea* (Crustacea: Alicellidae) from hadal depths in the Kermadec Trench, SW Pacific Ocean

A.J. Jamieson [a,*], N.C. Lacey [a], A.-N. Lörz [b], A.A. Rowden [b], S.B. Piertney [c]

[a] Oceanlab, Institute of Biological and Environmental Sciences, University of Aberdeen, Main Street, Newburgh, Aberdeenshire AB41 6AA, UK
[b] National Institute of Water and Atmospheric Research (NIWA), 301 Evans Bay Parade, Wellington 6021, New Zealand
[c] Institute of Biological and Environmental Sciences, University of Aberdeen, Zoology Building, Tillydrone Avenue, Aberdeen AB24 2TZ, UK

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ABSTRACT

Here we provide the first record of the 'supergiant' amphipod *Alicella gigantea* Chevreux, 1899 (Alicellidae) from the Southern Hemisphere, and extend the known bathymetric range by over 1000 m to 7000 m. An estimated nine individuals were observed across 1500 photographs taken *in situ* by baited camera at 6979 m in the Kermadec Trench, SW Pacific Ocean. Nine specimens, ranging in length from 102 to 290 mm were recovered by baited trap at depths of 6265 m and 7000 m. Mitochondrial and nuclear DNA sequences obtained indicate a cosmopolitan distribution for the species. Data and observations from the study are used to discuss the reason for gigantism in this species, and its apparently disjunct geographical distribution.

1. Introduction

Alicella gigantea Chevreux, 1899 (Alicellidae) is the largest known amphipod, measuring up to 340 mm total body length (Harrison et al., 1983 in Barnard and Ingram, 1986). These 'supergiant' amphipods (*sensu* Barnard and Ingram, 1986) have previously only been recorded in the Northern Hemisphere (Chevreux, 1899; Barnard and Ingram, 1986; Hasegawa et al., 1986; De Broyer and Thurston, 1987; Hessler et al., 1972) and remain somewhat enigmatic given such a low frequency of observations despite a seemingly enormous bathymetric and geographic range. The species is hitherto known to inhabit the deep abyssal plains of the Northern Hemisphere in the North Atlantic Ocean (off the Canaries, Cape Verde and in the Demerara Basin) and in the vicinity of the Hawai'i Islands in the North Pacific Ocean (Barnard and Ingram, 1986; Hasegawa et al., 1986; De Broyer and Thurston, 1987). These two localities are approximately 12,800 km (6900 nm) apart and separated by the American continental land mass. Furthermore, in both these known areas of occurrence, the specimens have been captured (albeit in low numbers) multiple times but never at more frequently studied areas around the associated ocean rims. Limited observations of *A. gigantea* are also surprising given an apparent vast bathymetric range. Although the majority of samples have been recovered from the lower abyssal plains (4850–6200 m), a single juvenile female was captured at 1720 m in the central North Pacific Ocean (Barnard and Ingram, 1986). This record provides the bathymetric range for *A. gigantea* of around 4480 m, which this study extends by 1000 m. The question then arises as to why a relatively large deep sea animal with such a large bathymetric and geographic range is so infrequently found whilst other, smaller amphipods, with similarly large extents are so frequently caught in high abundance (e.g. *Eurythenes gryllus*; 184–7800 m; Barnard, 1961; Thurston et al., 2002; De Broyer et al., 2004; Stoddart and Lowry, 2004, and *Abyssorchomene* spp.; France, 1994; Havermans et al., 2010; Jamieson et al., 2011).

Here we report on the recovery of specimens and *in situ* images of *A. gigantea* in the Southern Hemisphere (Kermadec Trench, SW Pacific Ocean) and at hadal depths (6265–7000 m). We use these observations to address questions about the distribution patterns of *A. gigantea*. We also provide mitochondrial and nuclear DNA sequences to facilitate analysis of the phylogenetic relationships of *A. gigantea* with other amphipod species in the future, and as a reference DNA barcode for future species identification.

2. Materials and methods

2.1. Sampling equipment

Two autonomous deep-submergence vehicles were used in this study. The first was a free-fall baited camera lander (*Hadal-Lander* B; Jamieson et al., 2009a, 2011) and a new free-fall fish and invertebrate trap (*Latis*). The *Hadal-Lander* B camera was a five megapixel still image camera (OE14-208, Kongsberg Maritime, Norway)

* Corresponding author. Tel.: +44 1224 274410; fax: +44 1224 274402.
E-mail address: a.jamieson@abdn.ac.uk (A.J. Jamieson).

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programmed to take one picture every 60 s during deployment with a field of view of 0.31 m^{-2} (665 × 498 mm) of seafloor. Approximately 500 g of Jack Mackerel (*Trachurus declivis*; Jenyns, 1841) was used to attract bait-attending fauna. The lander was equipped with a temperature, pressure and salinity probe (SBE-17plus CTD probe; SeaBird Electronics, USA), which sampled at 10 s intervals throughout the deployment. It was equipped with an acoustic Doppler Current Sensor (ZPulse™ 4520; Aanderaa Data Instruments, Norway) coupled to a bespoke control and logger system (Oceanlab, University of Aberdeen, U.K.).

The second autonomous lander, Latis, was a free-fall fish and invertebrate trap, comprised of two fish cages (40 × 40 × 100 cm cuboid) with a square funnel opening of 14 × 14 cm recessed 25 cm into the trap. The traps were lined with 1 cm mesh and each baited with ~500 g of Jack mackerel (*T. declivis*). Inside both fish traps were two small baited invertebrate funnel traps; 12 cmØ × 30 cm long. The traps were attached either side of a 1 m^{-3} aluminium frame. *Latis* was also equipped with a temperature and pressure sensor (SBE-39; SeaBird Electronics, USA) which recorded at 30 s intervals throughout. The traps were positioned such that they were in contact with the seafloor upon landing.

2.2. Study sites

Samples and images were taken using the two landers in the mid section of the Kermadec Trench in the SW Pacific Ocean (Fig. 1). The Kermadec Trench is one of only five trenches where depths exceed 10,000 m (Angel, 1982). The trench runs for 1500 km off the NE tip of New Zealand where it joins the Tonga Trench (separated by the intersection of the Louisville Seamount Chain). The area lies within the South Pacific Subtropical Gyre (SPSG) province which has an average primary production rate of 87 g C m^{-2} yr^{-1} (Longhurst et al., 1995). The trench is ventilated by the Lower Circumpolar Deep Water mass (LCDW) originating from Antarctica resulting in bottom temperatures from 1.2 to 1.8 °C (Belyaev, 1989).

The *Hadal-lander* and *Latis* were deployed seven and twelve times respectively at depths ranging from 6097 to 9908 m in the vicinity of 32°S by 177°W on the eastern flank of the trench (Fig. 1). The mean deployment times (hh:mm) were 14:22 ± 05:18 and 10:00 ± 03:02 respectively.

2.3. Species identification and morphometrics

Identification of *A. gigantea* was obtained using three methods: (a) comparison with the re-description of type specimens of Chevreux (1899) and description of specimens from both the North Atlantic and Pacific by De Broyer and Thurston (1987); (b) direct comparison with a single male specimen (TL=240 mm), 5851 m, Central North Pacific Ocean (30°18.0′N, 157°50.9′W, ID C10951; University of California, San Diego Benthic Invertebrate Collection) and; (c) DNA sequence comparisons between the Kermadec Trench samples and the confirmed Central North Pacific individual. The DNA sequence comparisons involved both the classical DNA barcoding targets of mitochondrial cytochrome oxidase I and 16S rRNA genes, as well as a nuclear 18S rRNA marker. Use of both nuclear and mitochondrial polymorphisms obviates issues associated with selective sweeps following introgressive hybridisation causing spurious similarity in mitochondrial sequence data across taxa (Hurst and Jiggins, 2005). For the amphipoda, 18SrRNA is sufficiently variable to resolve species-level differences.

Total DNA was extracted from individual muscle samples (3 mm^3) using a modified salting out approach (Bruford et al., 1992). Partial fragments of the mitochondrial 16sRNA, mitochondrial cytochrome

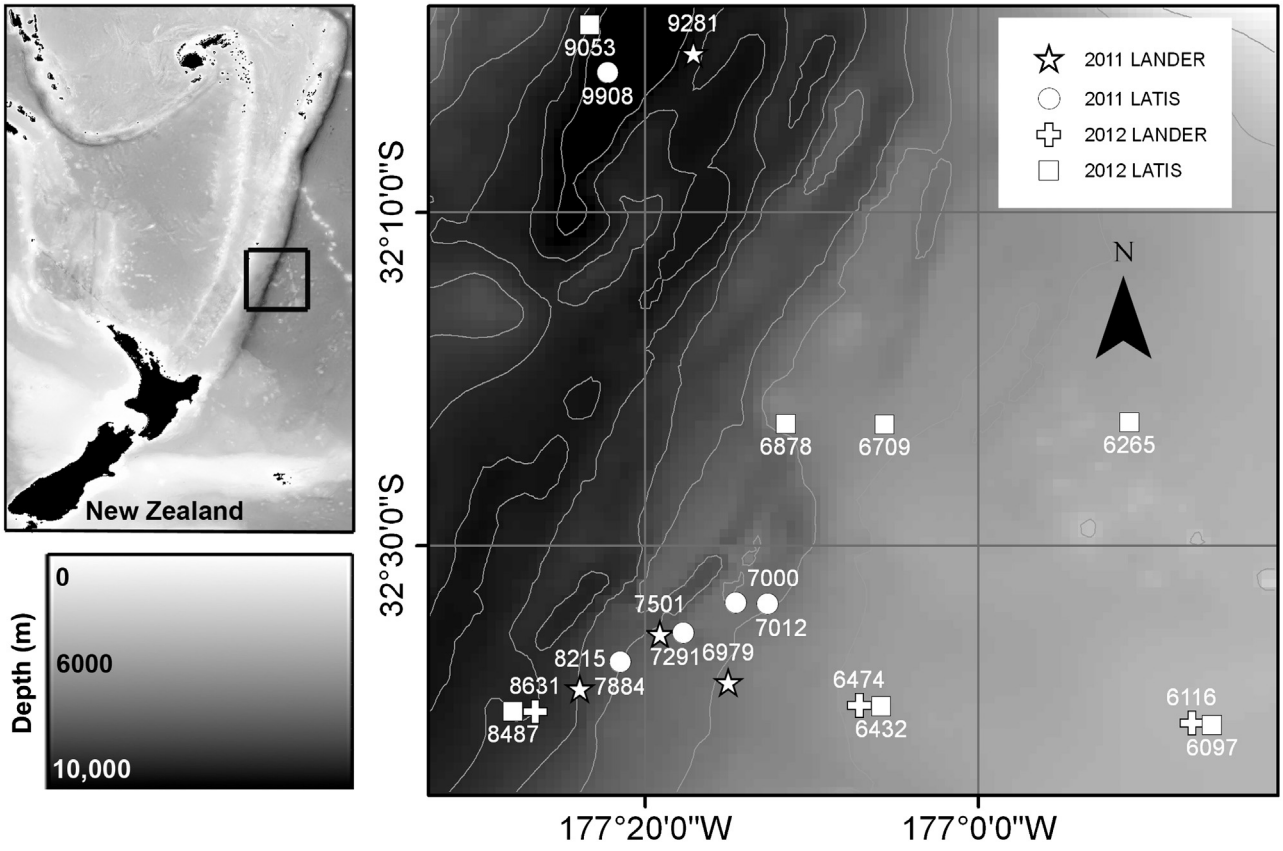

Fig. 1. Map of the study site in the Kermadec Trench. The *Alicella gigantea* samples were found at the 6265, 6979 and 7000 m locations.