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Vulcanolepas scotiaensis sp. nov., a new deep-sea scalpelliform barnacle (Eolepadidae: Neolepadinae) from hydrothermal vents in the Scotia Sea, Antarctica

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Abstract

A new deep-sea stalked barnacle, *Vulcanolepas scotiaensis* **sp. nov.** is described from hydrothermal vents at depths of 2400–2600 metres along segments of the East Scotia Ridge and from 1400 metres in the Kemp Caldera. Both locations are areas of volcanic activity that lie on the Antarctic-South American Ocean Ridge complex near the South Sandwich Islands. This discovery confirms a wide distribution in southern seas for *Vulcanolepas*, complementing the previous records from deep-sea vents in the Lau Basin and Kermadec Ridge in the southwest Pacific, and the Pacific Antarctic Ridge in the southeast Pacific. *V. scotiaensis* **sp. nov.**, the third described species of *Vulcanolepas* shows an extraordinary range in morphology, requiring a reassessment of the original diagnosis for *Vulcanolepas*. Although the morphological envelope of *V. scotiaensis* **sp. nov.** includes representatives with a peduncle to capitulum ratio similar to that observed in most neolepadines, the peduncle generally shows greater proportional length than in species in any neolepadine genus except *Leucolepas*; it is distinguished from other species of *Vulcanolepas* by a broader capitulum, much smaller imbricating scales on the peduncle and more ornamented capitulum plates. The morphological diversity of *V. scotiaensis* **sp. nov.** is interpreted as having arisen due to abrupt changes in water temperature.

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Key words: Crustacea, Cirripedia, Scalpelliformes, Neolepadini, *Vulcanolepas*, hydrothermal vent taxa, Scotia Sea, Antarctica

Introduction

The cirripedes discussed here were collected in 2010 from the slopes of sub-sea volcanoes to the southeast of South Georgia, in the Scotia Sea, i.e. to northeast of the Antarctic Peninsula (Figure 1). The expedition, 'JC 42', was carried out by the RRS *James Cook* and visited hydrothermal vents and diffuse flow sites on East Scotia Ridge (ESR) segments E2 and E9 and in a caldera near the Kemp Seamount (Figure 1) (Rogers *et al*. 2012). The compact vent field at E2 is at ~2600 m depth and has numerous relict and active venting chimneys of up to 15 m height. At E2, the cirripedes are found adjacent to fissures in pillows of basaltic lava where temperatures range from 3.5ºC to 19.9ºC, background water temperatures are ~0ºC and pH is 2.9 (Rogers *et al*. 2012: 4). The vent sites at E9 are at ~2400 m depth and are situated along a north-south running fissure, with wide, diffuse flow fields in lava back-drain features and broken pillow lava and intermittently distributed black smokers of varying intensity (Rogers *et al*. 2012). At E9, the cirripedes are concentrated as "barnacle assemblages" (Marsh *et al.,* 2012) in areas where hydrothermal vent temperatures in basaltic pillow lava range from 5ºC to 19.9ºC and pH is ~3.3; at E9, background water temperatures vary from -0.11ºC to -1.3ºC (Rogers *et al*. 2012: 4). The micro-distributions of the faunal assemblages in the E9 hydrothermal vents field are described in Marsh *et al.* (2012).

The collection was made during surveys of ESR segments E2 and E9 following detection of hydrothermal plumes after deploying a CTD equipped with light scattering and redox potentials sensors. Subsequently, these plumes were visually confirmed as black smokers using a lowered camera system (Rogers *et al*. 2012). The follow-

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permits acceptable feeding without a need to divert resources to produce longer peduncles. The specimens at "Dog's Head" are also heavily encrusted with minerals and as hydrothermal activity is much reduced at E2, it is likely that this build-up represents prolonged exposure to vent fluids, suggesting that these individuals may be older than their E9 counterparts.

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References

Buckeridge, J.S. (1983) The fossil barnacles (Cirripedia: Thoracica) of New Zealand and Australia. *New Zealand Geological Survey Paleontological Bulletin*, 50, 1–151.

Buckeridge, J.S. (2000) A new deep-sea vent barnacle, *Neolepas osheai* sp. nov. (Cirripedia: Thoracica) from the Brothers Caldera, South-west Pacific Ocean. *New Zealand Journal of Marine and Freshwater Research*, 34, 409–418. http://dx.doi.org/10.1080/00288330.2000.9516944

Buckeridge, J.S. (2009) *Ashinkailepas kermadecensis*, a new species of deep-sea scalpelliform barnacle (Thoracica: Eolepadidae) from the Kermadec Islands, southwest Pacific. *Zootaxa*, 2021, 57–65.

Buckeridge, J.S. & Grant-Mackie, J.A. (1985) A new scalpellid barnacle from the lower Jurassic of New Caledonia. *Geologie de la France,* 1, 77–80.

Buckeridge, J.S. & Newman, W.A. (2006) A revision of the Iblidae and the stalked barnacles (Crustacea: Cirripedia: Thoracica), including new ordinal, familial and generic taxa, and two new species from New Zealand and Tasmanian waters. *Zootaxa*, 1136, 1–38.

Burmeister, H. (1834) *Beiträge zur Naturgeschichte der Rankenfüsser (Cirripedia)*. G. Reimer, Berlin, 60 pp.

Darriba, D., Taboada, G.L., Doallo, R. & Posada, D. (2012) jModelTest 2: more models, new heuristics and parallel computing. *Nature Methods,* 9, 772–772. http://dx.doi.org/10.1038/nmeth.2109

Darwin, C. (1854) *A Monograph on the Sub-Class Cirripedia. The Balanidae and Verrucidae*. Ray Society, London, 684 pp.

Ewing, B. & Green, P. (1998) Basecalling of automated sequencer traces using phred. II. Error probabilities. *Genome Research*, 8,186–194. http://dx.doi.org/10.1101/gr.8.3.175

Folmer, O., Black, M., Hoeh, W., Lutz, R. & Vrijenhoek, R. (1994) DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. *Molecular Marine Biology and Biotechnology*, 3, 294–297.

Gage, J.D. (2004) Diversity in deep-sea benthic macrofauna: the importance of local ecology, the larger scale, history and the Antarctic. *Deep-Sea Research,* 51 (Pt, II), 1689–1708. http://dx.doi.org/10.1016/j.dsr2.2004.07.013

Guindon, S. & Gascuel, O. (2003) A simple, fast, and accurate algorithm to estimate large phylogenies by maximum likelihood. *Systematic Biology*, 52, 6967–04.

Hoch, J.M. (2011) Effects of crowding and wave exposure on cirrus morphology of the acorn barnacle, *Semibalanus balanoides. Journal of Crustacean Biology,* 31 (3), 401–405. http://dx.doi.org/10.1651/10-3430.1

Jones, D.S. (1993) A new *Neolepas* (Cirripedia: Thoracica: Scalpellidae) from an abyssal hydrothermal vent, southeast Pacific. *Bulletin of Marine Science*, 52 (3), 937–948.

Linse, K., Jackson, J.A., Fitzcharles, E., Sands, C.J. & Buckeridge, J.S. (2013) Phylogenetic position of Antarctic Scalpelliformes (Crustacea: Cirripedia: Thoracica). *Elsevier: Deep-Sea Research I.,* 73, 99–116. http://dx.doi.org/10.1016/j.dsr.2012.11.006

Littlewood, D.T.J. (1994) Molecular Phylogenetics of Cupped Oysters Based on Partial-*28s* Ribosomal-Rna Gene-Sequences. *Molecular Phylogenetics and Evolution,* 3, 221–229. http://dx.doi.org/10.1006/mpev.1994.1024

Marsh, L., Copley, J.T., Huvenne, V.A.I., Linse, K., Reid, W.D.K., Rogers, A.D., Sweeting, C.J. & Tyler, P.A. (2012) Microdistribution of Faunal Assemblages at Deep-Sea Hydrothermal Vents in the Southern Ocean. *Plos One*, 7 (10), 1–19. http://dx.doi.org/10.1371/journal.pone.0048348

Newman, W.A. (1979) A new scalpellid (Cirripedia) ; a Mesozoic relic living near an abyssal hydrothermal spring. *Transactions of the San Diego Society of Natural History*, 19 (11), 153–167.
Newman, W.A. (1985) The abyssal hydrothermal vent invertebrate fauna: a glimpse of antiquity? *In*: Jones, M.L. (Ed.), The hydrothermal vents of the eastern Pacific: an overview. *Bulletin of the Biological Society of Washington,* 6, 231–242.
Newman, W.A. (1996) Sous-Classe des Cirripèdes (Cirripedia Burmeister, 1834). Super-Ordres des Thoraciques et des Acrothoraciques (Thoracica Darwin, 1854—Acrothoracica Gruvel, 1905). *Ed. et Trans.* J. Forest. *Traité de Zoologie Anatomie, Systématique, Biologie*, 7, 453–540.
Newman, W.A. (2004) Nomenclatural emendations (Cirripedia, Pedunculata) involving the family-group names Priscansermarinidae Newman, 1996, Neolepadinae Newman, 1996 & Zeugmatolepadidae Newman, 1996. *Zootaxa,* 756, 1–6.
Newman, W.A. & Ross, A. (1971) Antarctic Cirripedia. American Geophysical Union. *Antarctic Research Series*, 14, 1–257. http://dx.doi.org/10.1029/ar014
Newman, W.A., Yamaguchi, T., Southward, A.J. & Segonzac, M. (2006) Arthropoda, Crustacea, Cirripedia. *In*: Desbruères, D., Segaza, M. & Bright, M. (Eds.), *Handbook of deep-sea hydrothermal vent faunaDenisia*, 18, 349–361.
Rambaut, A. (2002) Se-Al sequence alignment editor. *In*: Department of Zoology, University of Oxford.
Rambaut, A. & Drummond, A.J. (2007) Tracer: MCMC Trace Analysis Tool v1.4. Available from: http://tree.bio.ed.ac.uk/software/tracer/ (accessed 27 November 2013)
Reid, W.D.K., Sweeting, C.J., Wigham, B.D., Zwirglmaier, K., Hawkes, J.A., McGill, R.A.R., Linse, K. & Polunin, N.V.C. (2013) Spatial differences in East Scotia Ridge hydrothermal vent food webs: Influences of chemistry, microbiology and predation on trophodynamics. *Plos One* 8 (6), e65553. http://dx.doi.org/10.1371/journal.pone.0065553
Rogers, A.D., Tyler, P.A., Connelly, D.P., Copley, J.T., James, R.H., Larter, R.D., Linse, K., Mills, R.A., Naveiro-Garabato, A., Pancost, R.D., Pearce, D.A., Polunin, N.V.C., German, C.R., Shank, T.M., Boersch-Supan, P.H., Alker, B., Aquilina, A., Bennett, S.A., Clarke, A., Dinley, R.J.J., Graham, A.G.C., Green, D.R.H., Hawkes, J.A., Hepburn, L., Hilario, A., Huvenne, V.A.I., Marsh, L., Ramirez-Llodra, E., Reid, W.D.K., Roterman, C.N., Sweeting, C.J., Thatje, S., & Zwirglmaier, K., (2012) The discovery of new deep-sea hydrothermal vent communities in the Southern Ocean and implications for biogeography. *PloS Biology,* 10 (1), e1001234. http://dx.doi.org/10.1371/journal.pbio.1001234
Ronquist, F. & Huelsenbeck, J.P. (2003) MRBAYES 3: Bayesian phylogenetic inference under mixed models. *Bioinformatics*, 19, 1572–1574. http://dx.doi.org/10.1093/bioinformatics/btg180
Savill, N.J., Hoyle, D.C. & Higgs, P.G. (2001) RNA sequence evolution with secondary structure constraints: comparison of substitution rate models using maximum likelihood methods. *Genetics*, 157, 399–411.
Shimodaira, H. & Hasegawa, M. (1999) Multiple comparisons of log-likelihoods with applications to phylogenetic inference. *Molecular Biology and Evolution,* 16, 1114–1116. http://dx.doi.org/10.1093/oxfordjournals.molbev.a026201
Southward, A.J. (2005) Systematics and ecology of a new species of stalked barnacle (Cirripedia: Thoracica: Scalpellomorpha: Eolepadidae: Neolepadini) from the Pacific-Antarctic Ridge at 38ºS. *Senckenbergiana maritime*, 35, 147–156. http://dx.doi.org/10.1007/bf03043683
Southward, A.J. & Jones, D.S. (2003) A revision of stalked barnacles (Cirripedia: Thoracica: Scalpellomorpha: Eolepadidae: Neolepadinae) associated with hydrothermalism, including a description of a new genus and species from a volcanic seamount off Papua New Guinea. *Senckenbergiana maritime*, 32, 77–93. http://dx.doi.org/10.1007/bf03043086
Southward, A.J. & Newman, W.A. (1998) Ectosymbiosis between filamentous sulphur bacteria and a stalked barnacle (Scalpellomorpha, Neolepadinae) from the Lau Back Arc Basin, Tonga. *Cahier de Biologie Marine,* 39, 259–262.
Stamatakis, A. (2006) RAxML-VI-HPC: Maximum likelihood-based phylogenetic analyses with thousands of taxa and mixed models. *Bioinformatics,* 22, 2688–2690. http://dx.doi.org/10.1093/bioinformatics/btl446
Stamatakis, A., Ludwig, T. & Meier, H. (2005) RAxML-III: a fast program for maximum likelihood-based inference of large phylogenetic trees. *Bioinformatics,* 21, 456–463. http://dx.doi.org/10.1093/bioinformatics/bti191
Steiner, G. & Hammer, S. (2000) Molecular phylogeny of the Bivalvia inferred from 18S rDNA sequences with particular reference to the Pteriomorpha. *In:* Harper, E.M., Taylor, J.D. & Crame, J.A. (Eds.), *The Evolutionary Biology of the Bivalvia*. Geological Society, London, pp. 11–29.
Stocsits, R.R., Letsch, H., Hertel, J., Misof, B. & Stadler, P.F. (2009) Accurate and efficient reconstruction of deep phylogenies from structured RNAs. *Nucleic Acids Research*, 37, 6184–6193. http://dx.doi.org/10.1093/nar/gkp600
Suzuki, Y., Suzuki, M., Tsuchida, S., Takai, K., Horikoshi, K., Southward, A.J., Newman, W.A. & Yamaguchi, T. (2009) Molecular investigations of the stalked barnacle *Vulcanolepas osheai* and the epibiotic bacteria from the Brothers Caldera, Kermadec Arc, New Zealand. *Journal of the Marine Biological Association of the UK*, 89 (4), 727–733. http://dx.doi.org/10.1017/s0025315409000459
Yamaguchi, T., Newman, W.A. & Hashimoto, J. (2004) A cold seep barnacle (Cirripedia: Neolepadinae) from Japan and the age of the vent/seep fauna. *Journal of the Marine Biological Association of the United Kingdom,* 84, 111–120. http://dx.doi.org/10.1017/s0025315404008975h