

SHORT COMMUNICATION

A case of simultaneous hermaphroditism in the Azorean endemic limpet *Patella candei gomesii* (Mollusca: Patellogastropoda), a gonochoristic species

LUÍS CUNHA¹, GUSTAVO M. MARTINS^{1,2,3}, ANDRÉ AMARAL^{1,4} and ARMINDO RODRIGUES^{1*,4}

¹*Department of Biology, University of the Azores, Apt 1422, 9501-855 Ponta Delgada, Portugal
Tel. +351 (296) 650109; Fax +351 (296) 650100; email: rodrigues@uac.pt*

²*Marine Biological Association, Citadel Hill, Plymouth PL1 2PB, UK*

³*Marine Biology and Ecology Research Group, University of Plymouth, Plymouth PL4 8AA, UK*

⁴*CIRN, Ponta Delgada, Portugal*

Received 14 September 2007; Accepted 23 November 2007

Summary

A case of simultaneous hermaphroditism was observed in *Patella candei gomesii*, an Azorean endemic species, which has been considered a gonochoristic species. Here we show that simultaneous hermaphroditism can occur within the family Patellidae.

Key words: Limpets, gonochoristic, simultaneous hermaphroditic, Azores

Although the genus *Patella* is found worldwide, it is best represented along the coasts of NE Atlantic and Mediterranean. It can also be found in warmer waters of the Indo-Pacific, extending to Japan, eastward to Central America, and southward to the Kermadec Islands and the temperate waters of southern Australia (Powell, 1973). The revision of the Patellidae was recently undertaken by Titselaar (1998), who reported two species as occurring in the Azores: *Patella candei gomesii* Drouët, 1858 and *Patella ulyssiponensis* Gmelin, 1791.

P.c. gomesii, a common intertidal subspecies of the Azores (Hawkins et al. 1990; Weber and Hawkins 2002), is heavily exploited for consumption and its fishery collapsed in 1988 (Ferraz et al. 2001). The

species exhibits two eco-morphs with variations in the shell sculpture which are thought to depend on the substrate and exposure to wave action (Hawkins et al., 1990), although genetic (Pagarete et al., 2005) and histological (Cúrdia et al., 2005) evidence support the conspecificity of these eco-morphs. Cúrdia et al. (2005) have shown that while *P.c. gomesii* is able to spawn throughout the year, there is a major spawning event during summer, with synchrony of genders. Whereas sequential hermaphroditism has been suggested for several members within the Order Patellogastropoda, based on indirect observations (Orton, 1919; Bacci, 1947; Branch, 1974; Thompson, 1979; Creese et al., 1990), *P.c. gomesii* has invariably been regarded as gonochoristic (Martins et al., 1987; Cúrdia et al., 2005).

*Corresponding author.

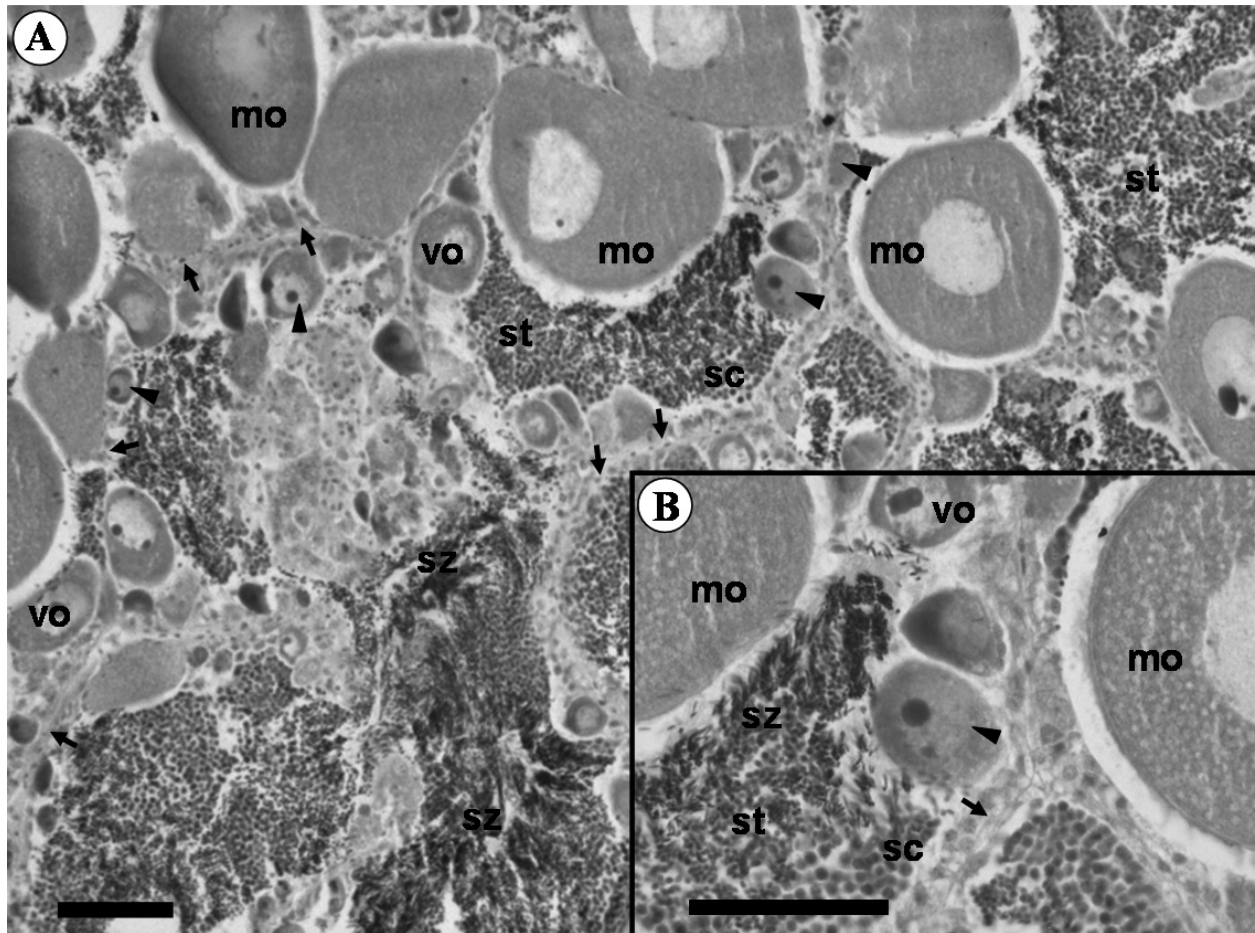


Fig. 1. Histological section of a *Patella candei gomesii* gonad. A. General view. B. View highlighting the coexistence of spermatogenic and oogenic stages interspersed in a mosaic shape. Germinal layer indicated by arrows; previtellogenic oocytes indicated by arrowheads. vo, vitellogenic oocytes; mo, maturing oocytes; sc, spermatocytes; st, spermatides; sz, spermatozoa. Both scale bars = 50 μ m.

During January of 2007, 56 *P.c. gomesii* individuals were collected at a moderately exposed site of São Miguel Island as part of an ecotoxicological study. Shell length was measured *in situ* using a pair of vernier callipers and the individuals sexed by histological observation of gonads, corroborating the overwhelmingly gonochoristic status of the species.

Assumptions of protandric hermaphroditism are usually based on sexual dimorphism in size-classes (Orton, 1919; Branch, 1974; Thompson, 1979; Creese et al., 1990), with the occurrence of a small number of simultaneous hermaphrodites in intermediate size classes (Bacci, 1947; Branch, 1974; Creese et al., 1990). Nevertheless, for the large Californian acmaeid, *Lottia gigantea* (Wright and Lindberg 1982), direct observations have confirmed the pattern, as also, more recently, for the patellid, *Patella vulgata* (Le Quesne and Hawkins, 2006).

In the present study, we encountered one hermaphroditic individual (Fig. 1) with a shell length of 18 mm, which is smaller than the intermediate size class of this species, which contrasts with the pattern typically observed in protandric species. Mature oocytes and spermatozoa, and all the oogenic and spermatogenic stages, were found interspersed in the gonadal tissue in a mosaic form, resembling that encountered in the transitional stage from male to female in protandrous hermaphroditic species.

The individual is most likely an aberration. Although the sampling site is largely free of anthropogenic pollution, limpets are intensively harvested in these islands (Martins et al., 1987; Ferraz et al., 2001), which may explain the induction of hermaphroditism in the case reported here. When a dioecious and poorly motile species, such as *P.c. gomesii*, is greatly reduced in abundance, the probability of encountering a conspecific of

the opposite sex is low (Martins et al., 1987). In such circumstances, the simultaneous hermaphrodite gains advantage when searching for mates, according to the low density model (Meyer, 1888; Ghiselin, 1969), since any encounter may lead to the production of fertilized gametes.

In the event of more simultaneous hermaphroditic individuals being found, further studies will be needed to understand whether hermaphroditism in this species is a phenotypic plasticity response or a punctual aberration, and whether the mature gametes produced are functional or not.

Acknowledgements

G.M.M. was supported by a grant of FCT (SFRH/BD/22009/2005). This work was supported by CIRD/UAç and by the DRCT/Government of the Azores.

References

- Bacci, G., Sex reversal in *Patella coerulea* L. and *Diodora gibberula* (Lam). *Nature*, 160 (1947) 94–95.
- Branch, G.M., Ecology of *Patella linnaeus* from Cape Peninsula, South-Africa. 2. Reproductive-Cycles. *Trans. R. Soc. S. Afr.*, 41 (1974) 111–160.
- Creese, R.G., Schiel, D.R. and Kingsford, M.J., Sex change in a giant endemic limpet, *Patella kermadecensis*, from the Kermadec Islands. *Mar. Biol.*, 104 (1990) 419–426.
- Cúrdia, J., Rodrigues, A.S., Martins, A.M.F. and Costa, M.J., The reproductive cycle of *Patella candei gomesii* Drouet, 1858 (Mollusca: Patellogastropoda), an Azorean endemic subspecies. *Invert. Reprod. Develop.*, 48 (2005) 137–145.
- Ferraz, R.R., Menezes, G.M. and Santos, R.S., Limpet (*Patella* spp.) (Mollusca: Gastropoda) exploitation in the Azores, during the period 1993–1998. *Arquipélago — Life Mar. Sci. Suppl.*, 2 (Part B) (2001) 59–65.
- Ghiselin, M.T., Evolution of hermaphroditism among animals. *Q. Rev. Biol.*, 44 (1969) 189–208.
- Hawkins, S.J., Burnay, L.P., Neto, A.I., Tristão-da-Cunha, R. and Martins, A.M.F., A description of the zonation patterns of molluscs and other important biota on the south coast of São Miguel, Azores. *Açoreana*, (Suppl.) (1990) 21–38.
- Le Quesne, W.J.F. and Hawkins, S.J., Direct observations of protandrous sex change in the patellid limpet *Patella vulgata*. *J. Mar. Biol. Ass. UK*, 86 (2006) 161–162.
- Martins, H.R., Santos, R.S. and Hawkins, S.J., Exploitation of limpets (*Patella* spp.) in the Azores with a preliminary analysis of the stocks. *Int. Council Explor. Sea*, K53 (1987) 1–18.
- Meyer, E., Studien über den Körperbau der Anneliden. IV. Die Körperform der Serpulaceen und Hermellen. *Mitt. Zool. Sta. Neapel*, 8 (1888) 662.
- Orton, J.H., Sex-phenomena in the common limpet (*Patella vulgata*). *Nature*, 104 (1919) 374.
- Pagarete, A.J.P., Costa, M.J. and Brito, C., Genetic conspecificity in two habitat morphs of the limpet *Patella candei gomesii* Drouët (Mollusca: Gastropoda: Patelidae) reinforces limpet morphological plasticity. *J. Young Invest.*, 12 (2005) 5.
- Powell, A.W.B., The patellid limpets of the world (Patellidae). *Indo-Pac. Mollusca*, 3 (1973) 75–206.
- Titselaar, F.L.M., A revision of the recent European Patellidae (Mollusca: Gastropoda). The patellidae of the Azores, Madeira, the de Selvagens and the Canary Islands. *Vita Mar.*, 45 (1998) 21–62.
- Thompson, G.B., Distribution and population—dynamics of the limpet *Patella aspera* (Lamarck) in Bantry Bay. *J. Exp. Mar. Biol. Ecol.*, 40 (1979) 115–135.
- Weber, L.I. and Hawkins, S.J., Evolution of the limpet *Patella candei* d'Orbigny (Mollusca, Patellidae) in Atlantic archipelagos: human intervention and natural processes. *Biol. J. Linn. Soc.*, 77 (2002) 341–353.
- Wright, W.G. and Lindberg, D.R., Direct observation of sex change in the patellacean limpet *Lottia gigantea*. *J. Mar. Biol. Ass. UK*, 62 (1982) 737–738.