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Research Article

A note on life-history traits and conservation concerns for viviparous Australian seastars (*Parvulastra parvivipara* and *P. vivipara*)

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Abstract

The asterinid seastars *Parvulastra parvivipara* and *P. vivipara* share atypical viviparous reproductive modes that have made them of interest for research on life-history evolution and population genetics. This article briefly reviews life-history traits of these endemic Australian species and information on distribution and rarity, as well as providing some additional new analysis. Almost exclusive self-fertilisation has led to extreme genetic poverty in both species and viviparity limits dispersal potential causing relatively small geographical ranges. There is some evidence that the number of intertidal boulder-fields harbouring *P. parvivipara*, and the overall geographical range, may have become reduced in recent years. In addition, approximately 25 % of boulder-fields with *P. parvivipara* have been colonised by invasive oysters (*Magallana gigas*). To understand potential effects of oysters on *P. parvivipara*, we tested for correlations between *P. parvivipara* abundances and cover of oyster encrustations that included this invader (native + non-native oyster shells were assessed together because they produced similar encrustations and largely could not be differentiated). Linear regression showed no evidence, however, for any correlation. For *P. vivipara*, population survey data from the mid 1970's to present shows marked decline in areas of previous abundance. Parallel with this decline, the boulder habitat has experienced infill and siltation and cementing of the substratum by *M. gigas*,

sponges and other encrusters as well as anoxia. Important future research outcomes on consequences of atypical life-history traits may be allowed by continued research on these seastars but only if their populations are able to persist within the small number of boulder-fields where they occur. Current trends may indicate a need for conservation intervention.

Keywords

Intertidal boulder-field, boulder reef, rock pool, *Crassostrea gigas*, marine conservation

1. Life-history traits

Parvulastra parvivipara (Keough & Dartnall, 1978) and *P. vivipara* (Dartnall, 1969) are Australian small range endemic seastars occurring on coasts of western Eyre Peninsula (South Australia) and southeast Tasmania, respectively. Both species have atypical life-histories involving a diminutive size, simultaneous hermaphroditism, almost exclusive self-fertilisation, and brooding offspring in the gonads to an advanced juvenile which is achieved by sibling cannibalism (Byrne 1996). Birth occurs through the gonopore of the parent (Fig. 1a). Adult *P. parvivipara* are among the world's smallest seastars reaching a diameter of only 11 mm while *P. vivipara* are slightly larger. Both species have extreme poverty of genetic diversity (Keever et al. 2013).

Both species use habitat underneath intertidal boulders, although *P. vivipara* is also associated with mussel beds. During night they emerge from under boulders (Prestedge 1998, Roediger and Bolton 2008) to graze on microalgae similar to the much studied *P. exigua* (Martinez et al. 2016).

2. Rarity

The overall distribution of *P. parvivipara* is limited to seven granitic headlands with the largest population occurring over 3924 m^2 at the site "Smooth Pool" (Roediger and Bolton 2008). The other populations occur over smaller areas (approx. 1500 m^2 per site; Roediger and Bolton 2008) raising the question of their vulnerability to extinction, especially since large within-site population fluctuations occur (Roediger and Bolton 2008). For example, the researchers who discovered this species (Keough and Dartnall 1977) stated that a single specimen was found at D'Anville Bay (200 km south of the other populations) but surveys by Roediger and Bolton (2008) failed to find it there recently. Similarly, a small population at a site south of Ceduna (Whittleby; Roediger and Bolton 2008) was not observed by Liversage (2015) despite extensive searching.

P. vivipara is known from six sites in southeast Tasmania (Prestedge 2001), two of which it was artificially introduced to. Population decline is clear from surveys of the most populous site, Pitt Water, from 1976-1983 (Prestedge 1998) and in 2001-2004 (Ecomarine 2014)

(Fig. 1d). The site was previously ideal habitat for the species (Fig. 1c) but there has since been widespread habitat deterioration e.g. extensive siltation, encrusting species that cement boulders together, and black anoxic conditions under the boulders. Attempts to find *P. vivipara* in 30 min timed-search surveys found 68 and 47 individuals in 2016 and 2018, respectively, down from 287 in 2009 (M. Byrne, personal observation).

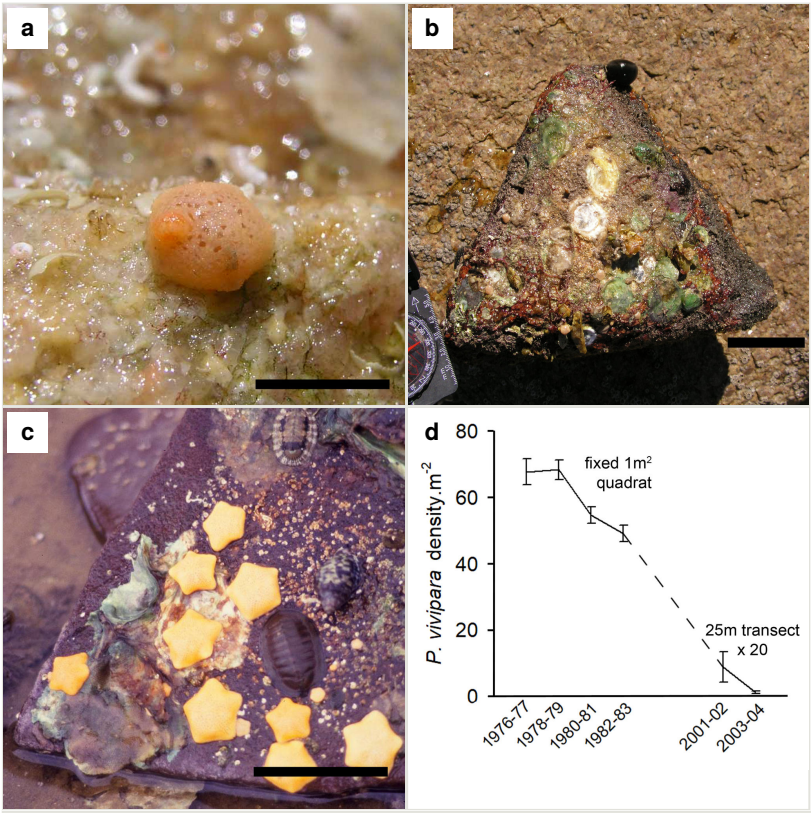

Figure 1.

Photographs from *P. parvivipara* and *P. vivipara* habitat, and graph of *P. vivipara* population trends.

a: Photograph taken during surveys of Liversage (2015) showing *P. parvivipara* giving birth, with the bright orange juvenile emerging from parent's dorsal side (bar = 1 cm). doi

b: Photograph of a boulder underside in *P. parvivipara* habitat with extensive encrustation of oyster shells that includes invasive Pacific oysters (bar = 5 cm). doi

c: Photograph of *P. vivipara* during 1992 at Pit Water. Populations have become reduced in subsequent years which may be associated with increased siltation and overgrowth from encrusting species (bar = 5 cm). doi

d: Trends from the largest *P. vivipara* population at Pitt Water. Each point is the mean of adult densities from numerous sampling events over each 2 year period. During 1976-83 a fixed 1 m ^{2} quadrat was sampled (Prestedge 1998) while a different method was used from 2001-04 involving 25 m transects being sampled across the site (Ecomarine 2014). Other survey types (timed-search) have also found large population declines (see section 2.). doi

3. Interactions with invasive species

Approximately 25 % of sites where *P. parvivipara* occur have been colonised by the non-native Pacific oyster *Magallana gigas* (Thunberg, 1793). *M. gigas* co-occurs with the seastar and other native oysters underneath boulders. One aim of this study was to use photographs of boulder undersurfaces in *P. parvivipara* habitat, taken by Liversage (2015), to analyse potential correlations (linear-regression) between *P. parvivipara* and oysters. Shells of native oysters could not be differentiated from those of juvenile *M. gigas*, so shells (alive and dead) of all oyster species were analysed together. The photographs were imported into SketchUp v5 (www.sketchup.com) and the programme was used to calculate % oyster cover.

The result showed that oyster shells reached covers up to 36 % (Fig. 1b), although the mean is 4.65 and 1.12 % at two invaded sites (Cape Vivonne (n = 30 boulders) and Point Brown (n = 22), respectively). Any potential effects of oysters are uncertain at this stage; oyster encrustations clearly change habitat structure but the linear regression between oyster % cover (arcsine transformed) and *P. parvivipara* density (boulders pooled from abovementioned sites) showed no correlation (R^2 = 0.002, F = 0.12, $P > 0.05$). This result suggests that any effect of *M. gigas* on *P. parvivipara* may only occur if the invader reaches higher densities than are currently present. *M. gigas* also co-occurs with *P. vivipara* in Tasmania; further research in both regions will be required to understand any potential impacts on these rare seastars.

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Ethics and security

This project complies with the Estonian Code of Conduct for Research Integrity (http://www.eetika.ee/en/ethics-estonia/estonian-code-conduct-research-integrity).

Conflicts of interest

The authors declare no conflicts of interest.

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