Density effects on reproduction in natural populations of the staghorn damsel, Amblyglyphidodon curacao.

Author
Pankhurst, Ned, Fitzgibbon, Quinn, Pankhurst, Patricia, King, Harry

Published
2008

Journal Title
CYBIUM

Copyright Statement
Copyright 2008 Cybium. The attached file is reproduced here in accordance with the copyright policy of the publisher. Please refer to the journal's website for access to the definitive, published version.

Downloaded from
http://hdl.handle.net/10072/26362

Link to published version
http://www.mnhn.fr/
Density effects on reproduction in natural populations of the staghorn damsel, *Amblyglyphidodon curacao*

by

Ned PANKHURST (1, 2), Quinn FITZGIBBON (2), Patricia PANKHURST (2) & Harry KING (2)

**ABSTRACT.** - Staghorn damselfish *Amblyglyphidodon curacao* were sampled underwater over 2 reproductive seasons from 4 reefs of differing coral cover on Australia’s Great Barrier Reef. Plasma levels of estradiol (E$_2$) [females], 11-ketosterone (11KT) [males], and testosterone (T) [both sexes] were correlated with reproductive development, and population density at each of the sites. In year 1, females from the site where population density was highest were smaller than fish from other sites, and fecundity was lowest. There were no site differences in plasma levels of T or 11KT in males, or T in females. Plasma E$_2$ levels of females varied but not in relation to fish density. In year 2, fish densities were again highest at the same site as in year 1 and again females tended to be smaller than at other sites. Fecundity, plasma E$_2$ and T of females, and plasma 11KT levels in males were highest in fish from the site of lowest population density. The results suggest that high-density sites are characterised by small fish, lower fecundity, and on occasion, reduced plasma levels of T and E$_2$ in females. High density was not accompanied by elevated androgen levels in males. The effects may result from increased competition for planktonic food at high density, and are consistent with similar effects in the brooding damsel *Acanthochromis polyacanthus*. These results are at variance with studies on temperate damselfishes where increased population density results in elevated plasma levels of gonadal steroids in males, suggesting that food availability may be the prime driver of reproductive function in tropical systems.

Key words. - Damselfish - Coral reefs - Gonadal steroids - Density - Fecundity.

**Introduction**

Studies of temperate damselfishes show that increased population density is accompanied by increased territorial encounters and spawning events, and corresponding increases in plasma levels of T, 11KT and 17,20β-dihydroxypregn-3-one (17,20βP) in males (Pankhurst, 1995). Increases in androgens appear to result from increased territorial challenge, whereas increased 17,20βP levels are generated by increased participation in spawning (Pankhurst, 1995). The present study examined this phenomenon in the tropical staghorn damselfish, *Amblyglyphidodon curacao*. Fish of this genus are found throughout the tropical Indo-Pacific and spawn asynchronously for several months, with territorial males defending nests, typically on dead upright *Acropora* coral colonies (Goulet, 1998). Populations on Australia’s Great Barrier Reef (GBR) are also characterized by variable density with location, but there is no information on the possible effects of population density on reproductive events. On the basis of temperate studies, this study investigated the prediction that high population density will be accompanied by elevated plasma androgens in males.

**Methods**

Staghorn damselfish were captured during the peak spawning period (October to November) in 2000 and 2002 by fence netting as described in Pankhurst et al. (2008), from reefs in the Lizard Island-Cooktown sector of the GBR. Sampling was conducted over separated seasons to confirm that any observed effects were temporally consistent. Sampling locations were Mermaid Cove (MC) (a site of low coral cover with a high proportion of dead coral and coral rubble); North Direction Island (NDI) (a site with high coral cover of *Acropora* and substantial *Porites* colonies); MacGillivray’s Reef (MR) (a large sand cay reef with a mixed colony coral community but characterized by large *Acropora* colonies); and Yonge Reef Bommies (YRB) (a series of coral-rich flat-topped bommies [coral mounts]). Ten transects were conducted at each site to determine damselfish density. Divers made a visual census of a 10-m wide strip on either side of a 50-m transect tape, recording numbers of territorial fish (territorial males), and the total numbers of adults present.

Immediately after capture, fish were bled underwater by caudal puncture, and then killed by brain-spiking. At the end of the dive, fish and blood samples were placed on ice and returned to the Australian Museum’s Lizard Island Research Station for processing. At the laboratory, total body and gonad weights were determined, and gonads macroscopically staged. Relative fecundity (follicles g$^{-1}$ body weight) of females was determined by counting the vitellogenic follicles present in the ovary. Blood samples were centrifuged to separate plasma, which was extracted with ethyl acetate and dried down for transport to the laboratory where levels of 11KT in males, 17β-estradiol (E$_2$) in females and T in both sexes were measured by RIA using the protocol described in Pankhurst et al. (2008). Assay detection limits were 0.30 ng ml$^{-1}$ for all steroids.

Data were analysed by one-way ANOVA and subsequent Tukey’s b means comparison tests using the SPSS for Windows (version 13.0) statistical package. Where necessary,
data were log10 + 1 transformed to satisfy requirements for homogeneity of variances, proportion data were arcsin transformed, and analyses used a critical value of \( p = 0.05 \).

**Results and Discussion**

In both years, the NDI site had the highest population density and MC the lowest (Fig. 1). In 2002, there was also higher density of territory-holding males at NDI compared with MC. Low fish density at MC reflected low coral cover at that site, whereas NDI had high coral cover and complexity (Pankhurst et al., 2008). This is consistent with the positive correlation between coral cover and complexity, and the size of associated damselfish populations (Holbrook et al., 2002). Adult size was variable but the smallest females occurred at NDI in both study years (Tab. 1). The largest females were found at MR in both years whereas MC and YRB had larger females in 2000 but not 2002. The largest males occurred at MR in both years. Relative fecundity was low at NDI in both years, and high at MC, and not closely correlated with body size (Fig. 1). Females from MR and YRB had elevated fecundity in 2000 but not 2002. The consistent features of both study years of smaller female size and lower fecundity at the high density site, and high fecundity at low population density are thought to be related to competition for planktonic food. Planktivorous fishes are very effective at reducing down-current density of plankters, with the result that species or individuals constrained to hold a particular position over the reef, have reduced feeding opportunities (reviewed in Pankhurst et al., 2008). This effect has been observed in the site-specific brood-caring damselfish *Acanthochromis polyacanthus* (Pankhurst et al., 2008). The fact that this effect appears here in among non-territorial females suggests that they may be holding location in relation to shelter and, or the position of male nesting territories.

Nutritional status and fecundity are closely linked in other species (Lambert et al., 2000), the endocrine basis of which is thought to involve the effects of nutrition on thyroid hormone and insulin-like growth factor I levels, which in turn have permissive or stimulatory effects on reproductive function (reviewed in Pankhurst et al., 2008). In the spiny damselfish, *A. polyacanthus*, reduced fecundity in fish at sites of high population density was also accompanied by low plasma T and E2 levels, and reduced gonadal in vitro steroidogenic activity (Pankhurst et al., 2008). Female staghorn damselfish in the present study did show low levels of E2 in both years, and T in 2002 at NDI, the site of high density and low fecundity (Fig. 2). However, high fecundity at MC (low fish density) was accompanied by elevated T and E2 levels in 2002 but not 2000 (when E2 levels were in fact lowest at MC). The apparent uncoupling of plasma E2 levels and fecundity may relate to subtle variations in oocyte stage in vitellogenic fish. Earlier work on staghorn damsels has shown that maximal E2 levels occur only when a full range of vitellogenic classes is present in the ovary, irrespective of the stages of the largest follicles present (Pankhurst and Pankhurst, 2003).

Male staghorn damsels showed no significant differences in plasma T or 11KT levels in 2000, whereas in 2002, 11KT levels were elevated at MC compared to fish from MR (Fig. 2). In the temperate damselfish *Chromis dispilus*, increased population density is associated with increased behavioural interaction (spawning and territorial defence) and increased levels of T, 11KT and 17,20\( \beta \)P (Pankhurst, 2002).

**Table 1.** - Size (g) of damselfish captured from different sites (see methods for details) in 2000 and 2002. Values are mean ± SE (n). Different superscripts denote significant difference (\( p < 0.05 \)).

![Figure 1. - Fish density and fecundity at different sites (see methods for details). Other details as for table I.](image-url)
1995). This is an illustration of the challenge hypothesis demonstrated for a range of species and taxa, whereby behaviourally-relevant hormone levels are modulated by social factors so as to keep the intensity of behavioural responses appropriate to the prevailing social conditions (reviewed in Pankhurst 1995). This effect is apparently not present in staghorn damsels where high androgen levels might have been expected among fish from the high density site at ND1. The absence of the effect in staghorn damsels suggests that either social conditions do not change with density, or that other factors apply. In one study year at least, higher population density was associated with closer territory spacing suggesting that the social implications of higher density are unlikely to be different from in temperate systems or in other tropical species (eg. Cardwell and Liley, 1991). This may suggest that nutritional effects of the type proposed for females may also act in male staghorn damsels.

Conclusions
The present study has shown that low coral cover and quality is not associated with reduced reproductive performance, that food competition at high population density may reduce reproductive output, and that expected effects of increased population density on androgen levels in territory-holding males were absent.

Acknowledgements. - This study was supported by an Australian Research Council Large Grant and the facilities of the Lizard Island Research Station.

References