Evidence of Strong Density-dependent Losses Soon after Settlement for *Sparisoma* Parrotfishes Along the West Coast of Barbados

Indicios de Fuertes Pérdidas Dependientes de Densidad de Peces Loro (*Sparisoma*) Recién Asentados en la Costa Oeste de Barbados

Indication de Fortes Pertes Dépendantes de la Densité pour des Poissons Perroquet (*Sparisoma*) Récemment Recrutées sur la Côte Ouest de la Barbade

HENRI VALLES[1]*, DONALD L. KRAMER[2], and WAYNE HUNTE[1]
[1]*Department of Biological and Chemical Sciences, The University of the West Indies at Cave Hill, Barbados.*
**hevals@gmail.com*
[2]*Department of Biology, McGill University, 1205 Avenue Docteur Penfield, Montreal, Quebec H3A 1B1, Canada.*

EXTENDED ABSTRACT

Parrotfishes help sustain coral reef fisheries in many locations across the Caribbean (Munro 1983) and perform key ecological functions on the reefs (Bonaldo et al. 2014). Whereas there has been considerable research focusing on parrotfish biology and ecology (Bonaldo et al. 2014), we know little about the factors influencing parrotfish distribution and abundance soon after settlement, a critical period in the life history of reef fishes.

In this study, we monitored biweekly the distribution and abundance of recently settled *Sparisoma* parrotfishes (size range: 1 - 5 cm standard length (SL)) within three 36 m^2 permanent quadrats deployed at each of three fringing reef sites (depth: 8 - 11 m) at least 2.5 km apart along the west coast of Barbados. Monitoring took place over a four-month period and included a natural synchronous peak in *Sparisoma* settlement at all sites (for details, see Valles et al. 2008).

We used these *Sparisoma* distribution and abundance data to:

i) Examine microhabitat associations of four mutually exclusive *Sparisoma* size classes (< 1.3 cm, < 2 cm, < 3 cm and < 5 cm SL) within and across quadrats;,
ii) Examine variability in density-independent and –dependent post-settlement *Sparisoma* losses across quadrats following peak settlement, and
iii) Investigate associations between post-settlement *Sparisoma* losses and microhabitat features.

To examine *Sparisoma* microhabitat associations within quadrats, i.e. over small spatial scales, we divided each quadrat into 36 1-m^2 cells and used Redundancy Analysis (RDA) to assess links between *Sparisoma* abundance and microhabitat features at the 1 m^2 scale. To examine associations between *Sparisoma* and microhabitat features across quadrats, i.e. over larger spatial scales, we used linear regressions between *Sparisoma* abundance and microhabitat variables with data aggregated at the quadrat level. To assess the contribution of density-independent and density–dependent effects to post-settlement losses, for each quadrat we fitted a modified density-dependent Beverton-Holt model (following Doherty et al. (2004)) and a density-independent (but age-dependent) model to the temporal patterns of *Sparisoma* abundance data and compared model fits.

The RDA revealed significant evidence ($p = 0.001$) of a shift in microhabitat use from dead coral covered by turf algae to dead coral covered by encrusting coralline algae (ECA) within the smallest *Sparisoma* size classes (i.e. from < 1.3 cm to < 2 cm SL), with no clear microhabitat associations thereafter (> 2 cm SL). Moreover, the microhabitat association with dead coral covered by turf algae over small spatial scales was maintained over larger spatial scales (i.e. across quadrats and sites; $p = 0.012$), indicating that turf algae can help predict abundance of *Sparisoma* immediately after settlement (< 1.3 cm SL) over a range of spatial scales.

Model fit comparison of temporal patterns in *Sparisoma* abundance indicated that the density-dependent Beverton-Holt model provided the most parsimonious fit to the data, with reasonably good overall fits across all quadrats ($_{adj}R^2 \geq 0.70$). This supported an important role of density-dependent effects in *Sparisoma* post-settlement losses. Furthermore, the magnitude of these density-dependent losses varied 8-fold across quadrats, which contributed to distort spatial patterns established at settlement. Finally, across quadrats, the magnitude of density-dependent losses was significantly negatively associated with amount of ECA ($p = 0.012$), suggesting an increasingly important role for this microhabitat type (and associated benthic correlates) as *Sparisoma* increases in body size.

In conclusion, this study has identified spatial associations between *Sparisoma* parrotfishes and specific functional groups of algae (i.e. turf algae and ECA) soon after settlement. Furthermore, this study provides evidence that ECA is associated with density-dependent losses in *Sparisoma*, suggesting that *Sparisoma* populations along the west coast of Barbados are subject to a population bottleneck driven by the availability of suitable early post-settlement microhabitat. Overall, our study sheds new light onto a poorly known phase in the life history of *Sparisoma* parrotfishes.

KEYWORDS: Parrotfish, recruitment, density-dependence, mortality, *Sparisoma*

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