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An appraisal of methods used in coral recruitment studies

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Abstract A new method for attaching individual artificial settlement plates directly to the reef surface using small stainless steel base plates is described. Recruitment of corals to settlement plates attached to the reef substratum and to steel mesh racks is compared. The effects of differences in depth, settlement plate angle, and local topography on recruitment of corals were also investigated. No significant difference in mean recruit density was found between settlement plates deployed using the two attachment methods. Small differences in depth and plate angle among replicate plates explained less than 6% of the variability in coral recruitment on replicate settlement plates. The direct-attachment method is less obtrusive, more cost and time efficient, and settlement plates can be deployed at precise locations. Additionally, because settlement plates are deployed individually rather than grouped on racks or frames, the direct-attachment method avoids complications associated with assumptions of independence implicit in most statistical procedures.

Key words Coral · Recruitment · Settlement plates · Larvae

Introduction

Recruitment of corals to artificial settlement plates is often used to provide a measure of the relative abundance of coral recruits in time and space (Harrison and Wallace 1990). Since the early studies of Vaughan (1912), a wide variety of methods for fixing settlement plates to the reef substratum have been utilised, including concrete blocks (Birkeland et al. 1981; Tomsacck 1991), PVC pipe frames (Baggett and Bright 1985; Hunte and Wittenberg 1992; Smith 1997), steel mesh racks (Sammarco and Carleton 1981; Harriott and Fisk 1987); plastic bases (Rogers et al. 1984); iron frames (Gleason 1996; Nzali et al. 1998) and oceanographic moorings (Sammarco and Andrews 1989).

Previously, variability in recruitment rate associated with settlement plate size (Birkeland et al. 1981) and settlement plate type (Harriott and Fisk 1987) have been considered. The angle of settlement plates relative to the substratum is also an important source of variability in studies of coral recruitment (Sammarco 1991). Surprisingly, the effect of the method of attaching settlement plates to the reef substratum on coral recruitment has received little critical attention, despite the potential differences in physical parameters among methods that might influence settlement of coral larvae.

The most common method for plate attachment that has been used in recruitment studies on Western Pacific coral reefs is the steel mesh rack method (e.g. Sammarco and Carleton 1981; Wallace and Bull 1981; Wallace 1985; Harriott 1985; Harriott and Fisk 1987; Babcock 1988; Fisk and Harriott 1990; Sammarco 1991; Harriott 1992; Baird and Hughes 1997; Dunstan and Johnson 1998). The conditions encountered by coral larvae contacting settlement plates attached to raised structures such as steel mesh racks probably differ from conditions encountered on nearby natural substrata. These differences include light conditions, sediment accumulation, grazing intensity, and the assemblage of other encrusting organisms. The effect of raised structures on water flow can also introduce “trapping artefacts” (Butman 1987), influencing the supply of larvae to settlement plates on raised structures, or the accumulation of sediment on settlement plates. However, whether the variable conditions presented by different attachment methods bias estimates of coral recruitment rate or affect the
taxonomic composition of recruits is unknown. Similarly, it is uncertain if recruitment data obtained from settlement plates attached to the reef substratum by different methods are comparable.

In a recent study of small-scale spatial patterns in coral recruitment (Mundy 1996), a method for attaching a large number of artificial settlement plates within a small area (10 m × 20 m) was required. The study required the deployment of settlement plates at a density of 2 plates/m² throughout the site, without impacting upon the corals or the aesthetics of the site. The use of racks or frames in a study of this intensity undoubtedly would have altered flow patterns across the site and may have modified patterns of recruitment (Keough 1983). Consequently, a new method of attaching individual settlement plates directly to the reef substratum using a fixed base plate was developed (Mundy 1996). The new method (direct attachment) also better simulates conditions encountered by coral larvae on natural substrata, and thus is more likely to give representative information that reflects natural recruitment patterns.

Because of the small-scale topographic complexity of most coral reefs, individual settlement plates attached directly to the substratum may differ in terms of depth, plate angle and also in surrounding topography (sunken, raised). Small-scale differences in surrounding topography (Birkeland et al. 1981; Snelgrove 1994) could also influence supply of larvae, and therefore recruitment of corals to replicate settlement plates. Consequently, the effect of these physical variables on coral recruitment when using the new direct-attachment method was considered.

This paper describes the direct-attachment method and compares it to the popular steel mesh rack method in order to determine if the attachment method affects recruitment rate and taxonomic composition of corals on artificial settlement plates. The direct-attachment method is then applied in a study of the effects of the physical environment (depth, plate angle, topography) on recruitment of corals to artificial settlement substrata. No significant differences in recruit density were found among the plate attachment methods tested. Initial concerns that small differences in depth, plate angle and surrounding topography among replicate plates would contribute additional unexplained variance to estimates of recruit density were also unfounded.

**Materials and methods**

**Study site**

The study was carried out on the north slope of Heron Reef (23°26'S, 151°57'E), southern Great Barrier Reef, at two sites separated by approximately 500 m. The settlement plates used in the experiments were unglazed terracotta tiles (110 mm × 110 mm × 10 mm). Numerous pits and grooves (up to 1 mm deep and 1 mm wide) covered the upper and lower tile surfaces, providing a rough texture. All settlement plates were placed on the reef in late September 1994 and were retrieved in early February 1995. After retrieval, plates were rinsed gently to remove sediment, bleached overnight in a chlorine solution to remove algae and soft tissue animals, and then rinsed in fresh water and dried. The plates were examined microscopically and coral recruits on the upper, lower and vertical sides of the plates were counted and placed in one of six taxonomic categories; acroporids (ACR; not including isororans), isororans (ISO), pocilloporids (POC), poritids (POR), other taxa (OT), and unidentifiable/damaged (UI). Recruitment was standardised to recruits/100 cm² in comparisons of attachment methods.

**Description of the direct-attachment method**

Settlement plates were attached directly to the reef using a small stainless steel base plate (100 mm × 50 mm × 0.6 mm), with a stainless steel bolt secured to the centre of the plate (Fig. 1). The base plate is attached to the substratum with two nylon expansion plugs (10 mm × 30 mm; Panduit product code MPMH-38LO), inserted through holes in the steel base plate into holes (10 mm diameter by 20 mm deep) which have been drilled into consolidated non-living reef substratum using a pneumatic drill. The settlement plate (which has a hole drilled through the centre) is secured to the base plate with a stainless steel wing nut (Fig. 2). The base plate lies flush with the substratum and the heads of the nylon plugs provide a gap of 8 mm between the settlement plate and the base plate, creating a “gap habitat” (Harriott and Fisk 1987). The direct-attachment method described here is similar in concept to that used...