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# Spawning of tiger grouper *Epinephelus fuscoguttatus* and squaretail coralgrouper *Plectropomus areolatus* in sea cages and onshore tanks in Andaman and Nicobar Islands, India

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ABSTRACT

The broodstock of two grouper species, tiger grouper *Epinephelus fuscoguttatus* and squaretail coralgrouper *Plectropomus areolatus*, were maintained in sea cages near Rutland Island, Andaman and Nicobar Islands, India, and their spawning performance was monitored from June 2007 to December 2010. *E. fuscoguttatus* generally spawned monthly in association with the new moon phase, for 8–9 months each year. Each year, they underwent a 3- to 4-month refractory period between February and June then recommenced spawning in May–July. *P. areolatus* showed a different spawning pattern to *E. fuscoguttatus*, spawning for less than 6 months each year, also in association with the new moon, and demonstrating much longer refractory periods (up to 15 months) than *E. fuscoguttatus*. Analysis of temperature data from the sea cage site showed that water temperature was significantly lower during spawning events than during comparable non-spawning periods. We postulate that one factor inhibiting spawning is higher water temperatures exceeding the upper thermal inhibitory limit for both grouper species during the hotter months of the year. Selected broodstock fish of both species were also maintained in onshore tanks fitted with recirculating filtration systems, but the spawning performance of both grouper species in the onshore tanks was inferior to broodstock held in the sea cages. *E. fuscoguttatus* maintained in onshore tanks spawned during only 5 months of the 42-month study period, whereas *E. fuscoguttatus* held in the sea cages spawned during 29 months over the same time frame. *P. areolatus* held in onshore tanks over the same period did not spawn, whereas *P. areolatus* held in sea cages spawned during 16 months out of the 42-month study period.


## 1. Introduction

The aquaculture production of groupers (subfamily Epinephelinae, family Serranidae) is expanding globally in response to continuing market demand, particularly in China and Hong Kong Special Administrative Region, and restricted supply from capture fisheries due to overexploitation of wild stocks (Briones, 2007; Sadovy et al., 2003). In 2011, a total of around 95,000 tonnes of grouper was produced from aquaculture, valued at about USD 550 million (FAO, 2013). Almost all of this production comes from Asia: China is the largest producer, followed by Taiwan, Indonesia and Malaysia (FAO, 2013).

Although India produces substantial quantities of penaeid shrimp, freshwater prawn and freshwater finfish through aquaculture (FAO, 2013), there has been little development of brackish water or marine finfish aquaculture. In 2005, the Marine Products Export Development Authority of India (MPEDA), through its research and development arm the Rajiv Gandhi Centre for Aquaculture (RGCA), commenced a project to adopt grouper aquaculture technology by a combination of technical exchanges, training and original research. The Andaman and Nicobar Islands were selected as the project site by virtue of the easy availability of the broodstock of several grouper species, the availability of hatchery sites with good water quality, the availability of sheltered sites suitable for the development of grow-out farms and the lack of other aquaculture development facilitating high levels of biosecurity. Two of the grouper species selected for aquaculture development were the tiger grouper *Epinephelus fuscoguttatus* and the squaretail coralgrouper *Plectropomus areolatus*. These were chosen on the basis of the availability of broodstock in the Andaman and Nicobar Islands, the existence of

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an established hatchery production technology for *E. fuscoguttatus* and the relative value of these species in the live reef food fish trade where both are categorised as 'medium' value species (Petersen, 2007; Sadovy et al., 2003).

*E. fuscoguttatus*, like many other grouper species, is a protogynous hermaphrodite (Craig et al., 2011), although in *E. fuscoguttatus*, not all females will change sex (Pears et al., 2007). Although the reproductive biology of *P. areolatus* has not been examined in detail, it is assumed to be a protogynous hermaphrodite as is the case with several of its congenerics (Craig et al., 2011). During the spawning season, *E. fuscoguttatus* and *P. areolatus* form spawning aggregations at discrete sites (Pears et al., 2007; Pet et al., 2005; Rhodes and Sadovy, 2002; Rhodes and Tupper, 2008; Sadovy De Mitcheson et al., 2008; Wilson et al., 2010). Both species commonly share the same aggregation sites, often with aggregations of *Epinephelus polyphekadion* as well as other reef fish species (Craig et al., 2011; Sadovy, 2005), although Pet et al. (2005) described one aggregation site that contained *P. areolatus* only. Reported seasonality and lunar periodicity of spawning in *E. fuscoguttatus* and *P. areolatus* is summarised in Table 1. In most cases, peak spawning by both species at the aggregation sites occurs just prior to, or at, new moon phase (Table 1); less commonly, these spawning aggregations are associated with full moon phase (Pet et al., 2005).

In captivity, *E. fuscoguttatus* broodstock exhibit similar spawning periodicity, with fish held in sea cages and in onshore tanks spawning in conjunction with the new moon phase (Chao and Lim, 1991; Lim et al., 1990; Sudaryanto et al., 2004; Sugama et al., 2012). Sudaryanto et al. (2004) described *E. fuscoguttatus* spawning in multiple pairs, giving the appearance of group spawning, and noted that spawning events usually occurred between 2100 h and midnight.

The reported spawning period for *E. fuscoguttatus* in the wild in the southern hemisphere generally falls between September and February each year (Table 1). Sugama et al. (2012) noted that *E. fuscoguttatus* held in onshore tanks in Bali, Indonesia, spawn throughout most of the year, with a refractory phase associated with lower water temperatures (around 25 °C) in July and August each year. Reported spawning periods for *P. areolatus* show substantial variability (Table 1).

This paper describes the spawning performance of both species in sea cages and in onshore tanks over the period July 2007 to December 2010. The major objective of this research was to reliably and predictably supply good quality eggs of both *E. fuscoguttatus* and *P. areolatus* to the RGCA hatchery at Kodiyaghat, Andaman and Nicobar Islands. Most grouper hatcheries prefer to provide an environment where spawning occurs naturally because hormonally induced spawning usually results in low egg fertilisation rates and poor quality larvae (Lim, 1993). To achieve this, the broodstock of *E. fuscoguttatus* and *P. areolatus* were held in both sea cages and in onshore tanks. Initially, we expected that the onshore tanks would provide the main source of fertilised eggs and larvae for the hatchery and that the sea cages would be used primarily as a reservoir of mature fish that could be transferred to the onshore tanks as required. However, as described below, grouper held in the sea cages spawned more frequently than those held in the onshore tanks, and the sea cage broodstock became an important source of fertilised eggs for the hatchery. In contrast, fish held in the onshore tanks spawned on only a few occasions. In light of the relatively poor performance of the grouper broodstock held in the onshore tanks, this paper also examines environmental factors that may help explain the disparate spawning performance of *E. fuscoguttatus* and *P. areolatus* held in sea cages and in onshore tanks.

## 2. Materials and methods

### 2.1. Sea cages

A sea cage facility comprising 13 sea cages (each 3 m × 3 m ×3.5 m deep) was established near Chidiyathapu, adjacent to Rutland Island (latitude 11°29′N, longitude 92°40′E). Grouper broodstock were collected by local fishers using hook and line gear from around South Andaman Island. Fish were transported to the sea cage site using a 200-L fibreglass tank filled with sea water, which was changed hourly. As a quarantine measure, the newly captured fish were held initially in a separate cage. The cage was enclosed in a plastic tarpaulin, and then treated with 200 mg $L^{-1}$ formalin for 1 h to reduce the incidence of parasites before the fish were stocked into the broodstock cages. Only healthy fish, free from major injuries or sign of disease, in the range 1.5–9 kg body weight were selected for stocking in the broodstock cages. *E. fuscoguttatus* and *P. areolatus* were stocked in the sea cages starting April 2006. During the study period (July 2007–December 2010), there were 4–5 cages stocked with *E. fuscoguttatus*, containing a total of 44–92 individual fish, and 1–2 cages of *P. areolatus* containing 8–12 individual fish. Variation in fish numbers was due to occasional mortalities and removal of fish to stock the onshore tanks.

Shade cloth netting was provided on top of each cage to reduce light levels in the cages. Sea cage nets were changed monthly, or more frequently if necessary, to reduce biofouling accumulation. Workers regularly dived around the sea cages to check that nets were not damaged and to monitor fish behaviour. In line with accepted 'best practice' for broodstock health management, broodstock fish were prophylactically bathed each month with freshwater to reduce the likelihood of parasitic infestations (Sugama et al., 2012). Grouper broodstock were fed with fresh fish (mainly mackerel and sardines) every second day to satiation, and about once weekly with squid or cuttlefish.

During 2007, water quality (temperature, salinity and pH) data were collected from the sea cage site twice daily at 0600 and 1700 h. Comparison of morning and afternoon water quality data showed that there were only occasional minor differences between the morning and the afternoon samples; hence, from Febuary 2008, the frequency of water quality data collection was reduced to once daily, at 0600 h.

**Table 1**
Summary of reports of spawning seasonality in *E. fuscoguttatus* and *P. areolatus*.

| Species | Location | Spawning period | Moon phase | Reference |
|---|---|---|---|---|
| *E. fuscoguttatus* | Great Barrier Reef, Australia | November–January | | Pears et al. (2007) |
| | Komodo National Park, Indonesia | September–February | Full moon | Pet et al. (2005) |
| | Seychelles | November–January | | Robinson et al. (2004) |
| | New Ireland Province, Papua New Guinea | March–July; July–November | New moon | Hamilton et al. (2011) |
| | Palau | May–September | New moon | Johannes et al. (1999) |
| *P. areolatus* | Komodo National Park, Indonesia | September–February; April–July | New moon | Pet et al. (2005) |
| | New Ireland Province, Papua New Guinea | March–July; July–November | New moon | Hamilton et al. (2011) |
| | West Papua Province, Indonesia | September–January | Prior to new moon | Wilson et al. (2010) |
| | Palau | January–September/December[1] | New moon | Johannes et al. (1999) |

Notes:
[1] Substantially variability in spawning aggregation patterns between years and between sites.