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Wild Black-lip Pearl Oyster (*Pinctada margaritifera*) Spat Collection in Tanzania

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Abstract—Pearl farming is a growing aquaculture activity in Tanzania but requires sufficient young pearl oysters to make it feasible. Collection of spat in the wild is the most viable way of doing this and was tested to establish whether it would yield sufficient juvenile pearl oysters to support an industry. A total of 4263 *Pinctada margaritifera* spat were collected over a year at sites considered suitable for spat collection: Bweleo and Nyamanzi on Zanzibar, and Tawalani in Northern Tanzania. Spat "yield" exhibited seasonal variations at these sites in a pattern similar in annual trend at Tawalani and Bweleo but different at Nyamanzi. Generally, the dry season (June-November) yielded a higher number of spat than the wet season (December-May). During the dry season, Tawalani, Bweleo and Nyamanzi produced 877, 942 and 1176 *P. margaritifera* spat respectively, while, during the wet season, these numbers were 503, 730 and 35. A few other pearl oysters such as *Pteria penguin* were inadvertently collected at Nyamanzi during the study. Three different types of spat collectors were used during the study, comprising coconut shells, spat bags and rubber tiles. There was significant variation in the number of spat collected on these materials ($P < 0.01$). The yield was always greater on spat bags and rubber tiles than on coconut shells. The study showed that it is possible to collect sufficient numbers of wild spat for the culture of black-lip pearl oysters at some sites along the coast of Tanzania.

INTRODUCTION

Marine pearl culture is one of the most valuable aquaculture industries in the world (Tisdell & Poirine, 2000). Pearl oyster species of the genus *Pinctada* support the majority of commercial marine pearl culture operations in developing countries in South Asia (Gervis & Sims, 1992). It is apparent that the small-scale production of cultured pearls could offer opportunities for income generation in coastal communities in East Africa and may contribute to the management of the resources in coastal ecosystems for their sustainable use (Southgate *et al.*, 2006).

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The pearl culture industry emerged from discoveries made in the late 19th and early 20th centuries by Japanese researchers who were able to produce hemispherical pearls (half-pearls), and later completely round pearls (Alagarswami & Qasim, 1974). The principle of culture-pearl formation is to put a solid substance, commonly known as a nucleus, as an irritant in the mantle tissue of a mollusc (Alagarswami & Sivarajan, 1975). In response to the irritation, the mollusc secretes a substance called nacre around the irritant and the formation of a pearl commences (Alagarswami & Qasim, 1974). Large numbers of cultured pearl oysters are grown on pearl farms, the nucleated pearl oysters being cared for over 9-12 months for growth of a half-pearl or 2-5 years for a round pearl in a pearl oyster such as *Pinctada margaritifera* (Haws, 2002).

Just as in any other forms of aquaculture, a reliable and consistent supply of seed (juveniles) is an integral requirement for the success of a pearl industry. Typically, pearl oysters juveniles, also commonly known as spat, are obtained by one or both of two methods depending on the circumstances. Oyster spat may be hatchery-produced (Southgate & Beer, 1997) or obtained through wild spat collection. Wild spat are collected on artificial substrata designed to offer a convenient site for drifting oyster larvae to settle and grow safely into spat. Spat collectors are generally cheap and unsophisticated, providing a reliable method of spat collection to

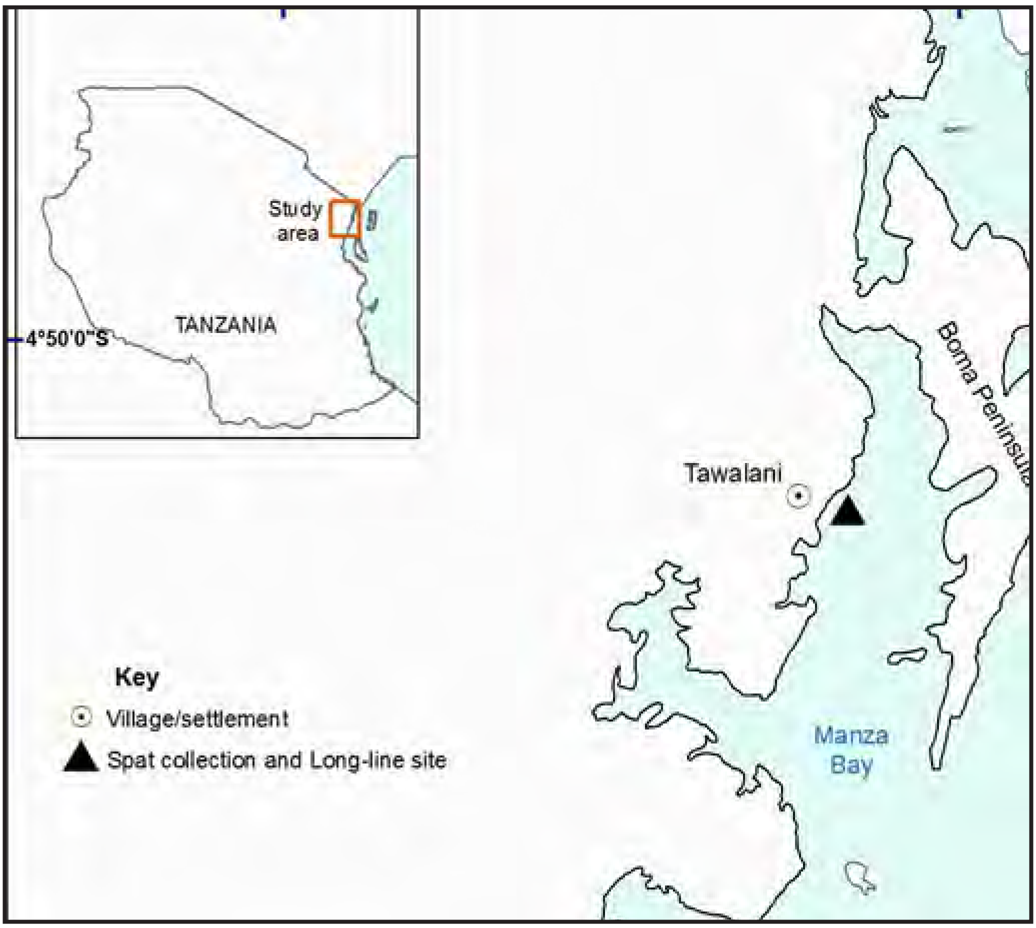

Figure 1. Location of the *Pinctada margaritifera* spat collection site at Tawalani on the Tanzanian mainland.

support a range of industry scales, from small to large. Since hatchery production is costly, wild spat collection should constitute the first option when industry development is considered (Haws & Ellis, 2000; Oengpepa *et al.*, 2006).

The availability of pearl oysters in Tanzanian coastal waters offers an opportunity to grow commercial cultured pearls. Several feasibility studies suggest that this presents an opportunity to establish a thriving pearl culture industry in this region at Mafia in Tanga, and Zanzibar (Mmochi *et al.*, 2005; Southgate *et al.*, 2006; Hamed & Jiddawi, 2007). Given that pearl farming has been identified as a potential aquaculture activity for Tanzania, there was a need to determine whether spat collection would efficiently provide a consistent supply of pearl oyster spat in Tanzania.

This paper reports the findings of a one-year sampling programme to assess the spatial and temporal variation in abundance of spat at selected sites along the Tanzanian coast. The effectiveness of different types of spat collectors was also assessed.

MATERIALS AND METHODS

Study sites

Pearl oyster spat were collected at two sites on the Fumba Peninsula in Zanzibar (Bweleo and Nyamanzi) and one in Tanga (Tawalani) (Fig. 1 and 2). These sites were selected for spat collection because they are close to areas with a natural abundance of *Pinctada margaritifera* in calm areas ideal for the retention of their larvae (Friedman *et al.*, 1998).

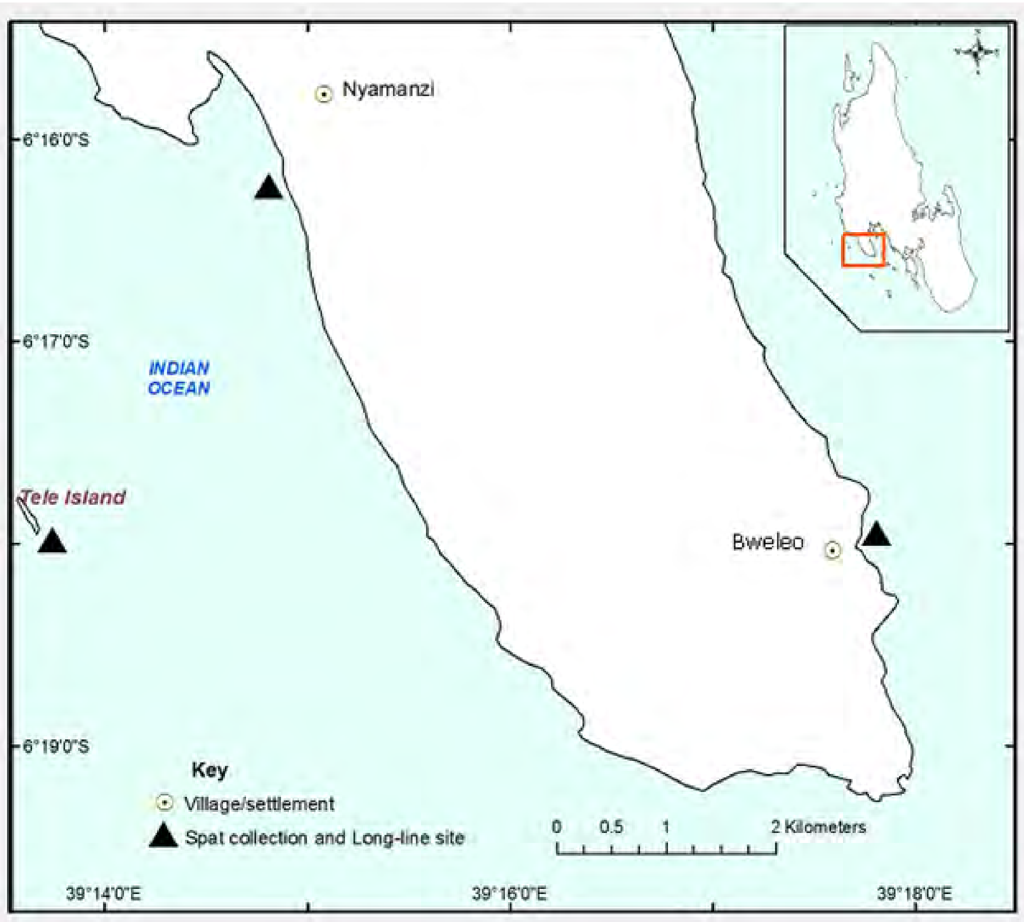

Figure 2. Location of the *Pinctada margaritifera* spat collection sites at Bweleo and Nyamanzi on Zanzibar.

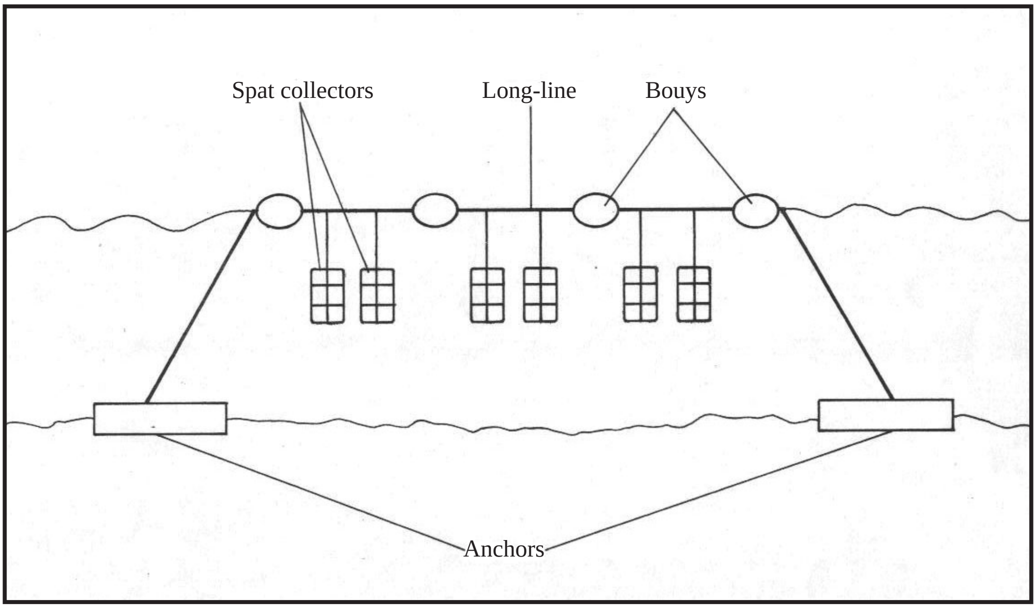

Figure 3. Diagram of long-line with spat collectors set for *Pinctada margaritifera* spat.

Spat collection

The method used to collect spat in this study was based on those recommended by Haws and Ellis (2000) and employed in the culture of pearl oysters in French Polynesia and the Cook Islands (Friedman *et al.*, 1998). A 50 m long-line of 12 mm polypropylene rope was set at each site to support spat collectors (Fig. 3). The long-lines were supported at the surface by buoys 35 cm in diameter and were deployed so that the spat collectors hung at 1 m depth in the water. The depth of the spat collectors was important as larval oysters tend to frequent the upper water column prior to settlement (Monteforte *et al.*, 1995). Spat collectors were deployed and checked for spat after two months when the spat were harvested (Table 1). This procedure ensured that the surface of the collectors had developed a biofilm and was conditioned for the settlement of oyster larvae (Friedman & Bell, 2000), and that they had metamorphosed and grown sufficiently to be recognized.

The collectors comprised mesh bags, rubber tiles cut from car tiles and strings of six coconut husks, in each with a surface area of 0.9 m^2. They were deployed in replicates of 20, totalling 60 collectors on each long-line, and were randomly allocated attachment points along the long-line. Records were kept of the number of juvenile oysters harvested from collectors deployed in the “wet” (Nov-May) or “dry” season (June-October) at each site.

Table 1. Deployment (D) and harvest (H) sequence of spat collection at the study sites in Tanzania.

SITE	Oct-07	Dec-07	Feb-08	Apr-08	Jun-08	Aug-08	Oct-08
Bweleo	D1	D2/H1	D3/H2	D4/H3	D5/H4	D6/H5	H6
Nyamanzi	D1	D2	D3/H1	D4/H2	D5/H3	D6/H4	H5
Tawalani	D1	D2/H1	D3/H2	D4/H3	D5/H4	D6/H5	H6

Data Analysis

Differences in spat collection between sites, season and type of collector were assessed by three-way ANOVA (mixed model) using STATISTICA (ver.5.5) at a confidence level of 0.01. "Site" was treated as the random factor with season and type of collector the fixed factors (Zar, 1999). All data were log-transformed to base 10 and tested for homogeneity of variances and normality using the Cochran test. Differences in means were identified using the post-hoc Tukey HSD test.

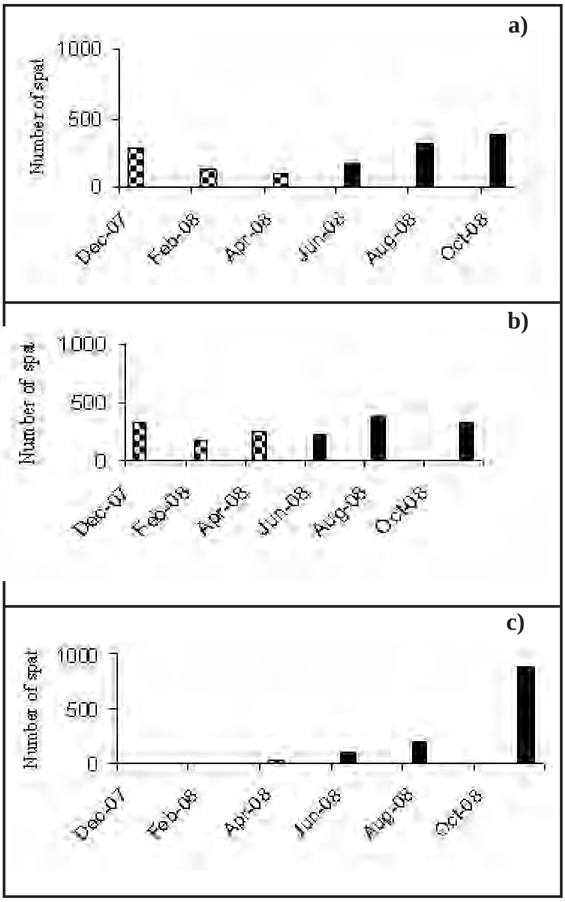

Figure 4. *Pinctada margaritifera* spat collected at a) Tawalani, b) Bweleo and c) Nyamanzi. Partially-shaded histograms comprise spat harvested in the rainy season, black histograms spat harvested during the dry season.

RESULTS

Spatial variation in the abundance of spat

A total of 4263 *Pinctada margaritifera* spat were collected during the study at the various sites as follows: Tawalani 1380 (Fig. 4a), Bweleo 1672 (Fig. 4b) and Nyamanzi 1211 (Fig. 4c). A total of 121 *Pteria penguin* spat were also collected at Nyamanzi. Tawalani and Bweleo yielded relatively high numbers of *P. margaritifera* spat, the mean numbers per collector per site being 2.5 ± 0.07 S.E (n = 60) and 3.1 ± 0.09 S.E (n = 60) respectively. Nyamanzi yielded relatively low numbers of spat, the mean number per collector being 0.9 ± 0.05 S.E (n = 60). Spatfall was distinctly seasonal at all study sites. Three-way ANOVA indicated that there was significant variation in the abundance of spat between the three sites (P < 0.01; Table 2). Tukey's HSD test indicated that Bweleo and Nyamanzi did not differ in terms of the mean number of spat per collector at these sites, but they differed from Tawalani.

Seasonal variation in the abundance of spat

Spat were most abundant on collectors deployed after the end of rain season and harvested during the dry season in August to November. Bweleo and Nyamanzi manifested more or less the same pattern of seasonality in spat abundance (Fig. 4a and b). Three-way ANOVA (Table 2) indicated that interactions between site and season and site and type of collector were significant (P <0.01), implying inconsistency in spat yield between sites. However, Nyamanzi (Fig. 4c) yielded very low numbers of spat during the wet season (December-April) and disproportionately high numbers during the dry season (June-November).

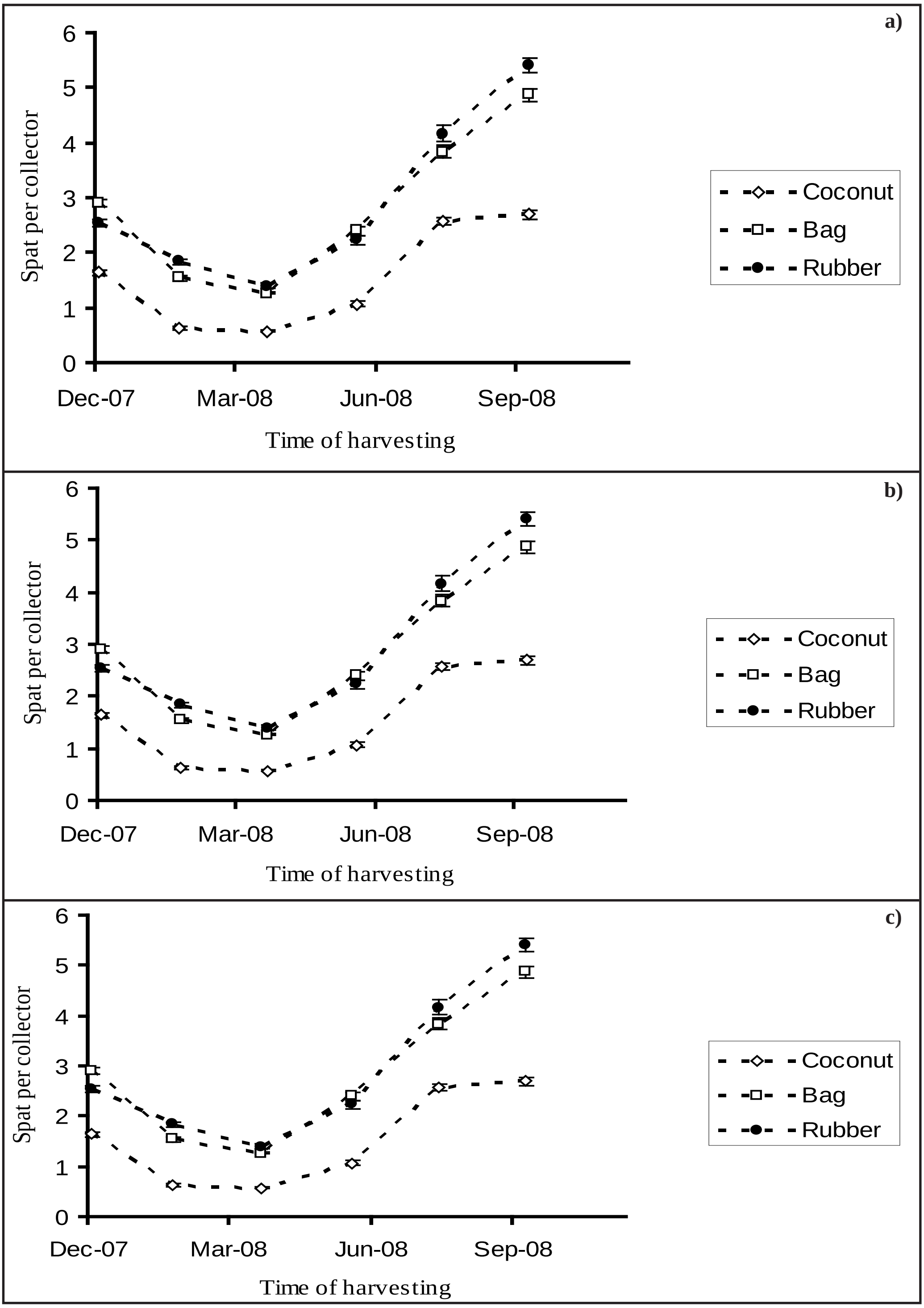

Figure 5. Seasonal variation in mean abundance of *Pinctada margaritifera* spat per collector at a) Tawalani, b) Bweleo and c) Nyamazi.

The interaction between season and type of collector was not significant (P >0.01; Table 2), suggesting that the abundance of spat collected was not affected by season and the primary factor that influenced the settlement of larvae on the collectors was the nature of their material.

Variation in abundance of spat due to type of collector

Two-way ANOVA showed that the variation in the mean number of spat per type of collector (Fig. 5a-c) was significant. The post-hoc Tukey's HSD test showed that significantly larger numbers of spat settled on the spat bags and rubber collectors (Fig. 6a and b) than on coconut shells at all sites (Table 2).

Table 2. Results of a three-way ANOVA of effects of site (random factor), season and type of collector (fixed factors) on the abundance of *Pinctada margaritifera* spat. Bold means did not differ significantly according to Tukey's HSD test.

Source of variation	*df*	MS	F	P
Sites	2	2.351	24.428	0.000
Seasons	1	16.727	8.194	0.103
Collectors	2	9.830	19.912	0.008
Site × Seasons	2	2.041	21.211	0.000
Site × Collectors	4	0.494	5.130	0.000
Season × Collectors	2	1.174	2.423	0.204
Sites × Seasons × Collectors	4	0.485	5.036	0.000

Mean number of *P. margaritifera* per collector

Coconut	Bag	Rubber
1.66	**3.57**	**3.46**

a) b)

Figure 6. The spat collectors which proved to be most effective during the study: **a)** Spat bag and **b)** rubber tile.

DISCUSSION

During this study, it was demonstrated that it is possible to collect *Pinctada margaritifera* spat from nearshore coastal waters in Tanzania, yielding over 4500 spat at the three sites. The sites had different potential in this regard. While spat collection was similar at Bweleo and Tawalani, the site at Nyamanzi yielded very few spat during the entire wet season.

The geography of the sites is likely to have affected the spat catch. Bweleo and Tawalani are similar in configuration as both sites are located on a peninsula and are nearly completely shielded from prevailing winds. This perhaps leads to a slower exchange rate of water at these sites and they retain more larvae (Haws, 2002; Salvat & Richard, 1985); this may explain their higher catch.

However, an increase in spat yield was observed at all sites at the beginning of the hot season, peaking in October-November (Fig. 4). It is possible that the climate in East Africa, which is usually humid and hot during this time of the year (Kijazi & Reason, 2005), affected the spawning of P. margaritifera. This is supported by the study of Pouvreau *et al.* (2000), and just about every other study on natural pearl oyster spawning, which showed that *P. margaritifera* spawning takes place throughout the year but peaking at warmer times. It is not clear, however, what caused the decline of spat catch towards the beginning of January, yielding the lowest spat settlement at the peak of the rainy season (March-April).

The effectiveness of spat collectors made from rubber tyres and spat bags was possibly due to the rough surface texture of the rubber surface and the multi-stranded structure of the spat bags, providing a right microhabitat for the oyster larvae to settle, grow and avoid predation (Friedman & Bell, 1996). These were not severely fouled with cyanobacteria and other macro-algae, unlike spat collectors made of coconut shells which proved rather ineffective as spat collectors (Buitrago & Alvarado, 2005).

In conclusion, the results show that there is considerable potential for the capture and culture of wild *P. margaritifera* spat in Tanzania. At least two of the study sites yielded spat throughout the year although it differed seasonally. At all sites, spatfall was significantly higher at the start of the hot and wet season (September-December). However, it is recommended that the economic viability of pearl farming in Tanzania will also depend on several other factors that should be addressed. Further research is required in particular to establish the long-term (>2 years) consistency in spatial and temporal abundance of *P. margaritifera* spat. This will help to determine the location of breeding oyster populations, enabling placement of spat collectors in areas that will maximise spat collection.

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