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Performance and physiological responses of combined t-bar and PIT tagged giant mud crabs (*Scylla serrata*)

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ABSTRACT

Mud crabs (*Scylla* spp.) are intensively caught throughout South-East Asia and support a very substantial commercial, recreational fishing and aquaculture industry. Identification of individual animals is important to improve understanding and management of this species. However, tagging of crustaceans is difficult as they frequently molt and internal tags can pose a hazard to consumers. In this pilot study we tested a new method combining passive integrated transponder tags and t-bar tags externally. 45 giant mud crabs (*Scylla serrata*) were captured from the wild and kept in tanks for a maximum of 10 months. We inserted tags into the abdomen of 35 giant mud crabs and tested a modified method where the combined t-bar/PIT-tag was inserted into the muscle tissue of the rear leg between the dorsal carapace plate and the top of the abdominal flap. Tagged crabs with the modified method showed 85% tag retention for molting crabs. We tested the same method in the field where 852 individuals were tagged with combined t-bar/PIT-tags of which 82 were recaptured showing 100% tag retention but without any evidence of molting having occurred. The tested method of combined t-bar/PIT-tags in giant mud crabs can further improve monitoring for wild and aquaculture populations and can be deployed widely with low cost.

1. Introduction

Crabs of the genus *Scylla* are distributed throughout the Asia-Pacific region, representing a valuable fishery resource. Fisheries currently exist in South Africa, Pakistan, Japan, Taiwan, Philippines, Malaysia and Australia (Knuckey, 1999). Though not formally reported or reviewed, significant fisheries are also present in Vietnam, China, and other parts of Southeast Asia. Mud crabs are an important component of small-scale coastal fisheries, particularly in tropical and subtropical Asia, where their capture generates significant revenue for coastal communities (Le Vay, 2001). The giant mud crab, *Scylla serrata* (Forskål, 1775), is generally favored by fisheries and for aquaculture due to its fast growth, large size and extended distribution. Giant mud crab farming is largely based on the capture and fattening of wild caught juvenile crabs (Nurdiani and Zeng, 2007). However, aquaculture studies have demonstrated potential for breeding (Quinitio et al., 2010). Identification of individuals is important for selective breeding but also to determine habitat preference, improving growth and management of wild stocks. Mark and recapture approaches allow giant mud crab population dynamics including population size, distribution, migration, mortality, growth and maturity to be studied (Barnes et al., 2002; Lebata et al., 2007).

There are a number of existing external tagging methods. They include rostrum ablation, branding, anchor tags and more advanced internal methods such as fluorescent elastomer, fluorescent alphanumeric, passive integrated transponder and microwire tags. Each method has its advantages and disadvantages. Anchor tags can cause death, especially in juveniles (McPherson, 2002) and passive integrated transponders can be costly albeit being more reliable than anchor tags (Jefferts et al., 1963; Le Vay et al., 2007). Visible implant elastomers (Liu et al., 2011) are difficult to see in larger individuals and are not practical in the adult stages. Overall it is desirable to have a fast and reliable way of identification without impacting on consumer safety (e.g. when using internal PIT tags) (Frusher et al., 2009).

T-bar or anchor tags have been used previously to tag the giant mud crab *S. serrata* (Hay and Calogeras, 2000; Hill, 1975; Hyland et al., 1984; Perrine, 1978; Pillans et al., 2005; Tait et al., 1985). Tagging of *S. serrata* with t-bar tags is a method first described by

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Table 1
Overview of t-bar tagging studies on *S. serrata*.

Reference	Method	Number tagged individuals	Size CW in mm	Time in liberty	Molting	Comments
Hill (1975)	Anchor tags inserted with a tagging gun into the posterior region at junction of carapace and abdomen; put in slightly off-center	2100	>80	1 day–13.5 months/mean 99 days	14%	Molted crabs 23–414 days in liberty, up to two molts (40 mm CW growth increment)
Perrine (1978)	Same as Hill, 1975, but tagging gun was forced up along the underside of the carapace	502	>100	Up to 7 month	2%	Reported scars from lost tags; molted crabs 71–90 days in liberty, ~20 mm CW growth increments
Hyland et al. (1984)	Same as Hill, 1975	6233	>100	36 weeks/mean 28 days	No	
Tait et al. (1985)	Same as Hill, 1975	3059	>80	Up to 8 month	Yes	Longer times in liberty with growth: ♂ = 300 days; ♀ = 170 days
Hay and Calogeras (2000)	Not described	2519	>120	9–11 months	No	
Pillans et al. (2005)	Same as Hill, 1975	472	>100	8–223 days/mean 80 days	No	One male 17 cm CW = 300 days (no molting)
Butcher et al. (2002)	Same as Hill, 1975	1412	>70	N.A.	N.A.	Insufficient data on recapture

Hill (1975) and Hill et al. (1982) using Floy anchor tags and a Dennison tagging gun. Tags were placed slightly off center at the junction of the carapace and the abdomen in the hope that this would reduce any effects of the tag at molt. Recapture data suggested that tags remained with the crabs after molting, but outcomes were highly variable and dependent on the number of individuals tagged, their size and the duration of the study. During a field study, Hill (1975) tagged 2500 *S. serrata* and recaptured 23 molted crabs with the t-bar tag. This method was also applied in other studies and modified by Perrine (1978). There has been no aquaculture study on the effectiveness of this method to date. A summary of t-bar tag studies for *S. serrata* is provided in Table 1. Based on these studies we propose a variation that ensures higher tag retention. The modified method places the t-bar tag actively into the muscle tissue of the rear leg between the dorsal carapace plate and the top of the abdominal flap.

Here we aim to (a) test combined t-bar/PIT tag deployment methods on giant mud crabs, (b) examine giant mud crab survival in two environments and (c) examine tag retention in a field study.

2. Methods

2.1. Sampling

A total of 45 *S. serrata* were captured from the wild in Moreton Bay, Queensland and kept in aerated seawater tanks for up to seven days prior to tagging to look for any abnormalities and allow the animals to adjust. All animals came from the same area and were caught within a few days before the start of the experiment. Only crabs between 80 and 130 mm carapace width (CW) were selected. The impact of t-bar tagging on crabs smaller than 80 mm was likely to cause major harm and even death (McPherson, 2002) and animals larger than 130 mm were unlikely to molt within a short time frame (3 month). T-bar tags were combined with PIT tags by using heat shrink tubes (similar to Frusher et al., 2009). The animals serum was tested prior to tagging. A sample was taken from the rear leg near the carapace and tested for Refractive Index (RI) values greater than 1.355 as an indication for molting within a few weeks (Mayze et al., 2014). Size and weight of animals were determined at the start and end of each treatment and infections, tag and molting status were checked and recorded frequently. Crabs were kept in two environments to see if the tank environment would influence overall survival.

2.2. Treatment 1

A first trial using Hill's method (Treatment 1) with the combined t-bar/PIT tags was run for 90 days. In Treatment 1, five crabs (CW 117–130 mm, 2 F, 3 M) were kept in a temperature controlled room at 27 °C, in separate 20 L glass tanks with a half cut plastic tube for shelter. An air bubbler was inserted into each tank and the seawater (30 ppt) was changed every 3–4 days. Another 20 crabs (CW 84–130 mm; 9 F, 11 M) were kept in a flow through system in separate plastic containers (20 × 20 × 24 cm). In both tank environments crabs were fed approximately 20% of their body weight and food included prawns (Penaeidae) and pipis (*Plebidonax deltoides*) once every day (excluding weekends).

2.3. Treatment 2

In Treatment 2 the combined t-bar/PIT tag was inserted between the dorsal carapace plate and the top of the abdominal flap toward the right side approximately half way from the center and placed in the muscular tissue of the back rear leg determined by triggered movement of the rear leg (Fig. 1 a and b). This method was tested on ten crabs (CW 110–132 mm, 5 F, 5 M) for 90 days in aerated tanks and on ten crabs (CW 86–119 mm; 4 F, 6 M) for 213 days in the flow through system. A control with untagged crabs was not introduced for this treatment as there were no changes to the tank environments following the first experiment.

2.4. Field study

A total of 852 *S. serrata* were tagged with the modified method (Treatment 2) between January 2012 and March 2013. *S. serrata* were caught with round "pop-up" pots made out of galvanized steel, covered with a 55 mm mesh, commonly used for commercial fisheries. The pots were baited with a mixture of mullet (*Mugil cephalus*) and heads of snapper (*Pagrus auratus*). The captured *S. serrata* were sexed and their size and weight measured. Only *S. serrata* without major injuries (e.g., loss of appendages) were tagged with a combined t-bar/PIT-tag in accordance to Treatment 2 where