Predation mortality on juvenile mud crab *Scylla serrata*: Importance of habitat and size

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Abstract

The early juvenile stages in many different marine benthic organisms are considered a bottleneck in survival due to predation mortality. Complex habitat may play an important part in the survival of the juveniles as they often are concentrated there in high numbers seeking refuge from predation. In Tanzania today there is an aquaculture on the mud crab *Scylla serrata* where small adult mud crabs (>300 g; approximately >120 mm CW) is collected from the wild and kept until they reach the markets requirements. The mortality in the aquaculture is estimated to be much higher than the natural mortality making the aquaculture less sustainable than the traditional fishing today. The aim of this study was to see if predation mortality of *S. serrata* is size and habitat dependent.

The tethering experiment was conducted on Mafia Island, Tanzania with juvenile mud crabs in two different habitats (mangrove fringe and subtidal seagrass) for 24 h. The relative predation mortality was largest for the smallest size class (6-12 mm CW: 72% 24h⁻¹) and decreasing with an increasing size (11-24 mm CW: 37% 24h⁻¹; 37-67 mm CW: 9% 24h⁻¹; 72-87 mm CW: 0% 24h⁻¹). There was no significant difference between the two habitats even though it was an apparent higher structural complexity in the subtidal seagrass. This might indicate that the intertidal constitute a refuge from fish and other aquatic predators that compensates for a lower complexity in the mangrove fringe. If small seed crabs of *S. serrata* with high predation mortality could be caught to the aquaculture and reach a size that meet the markets request it could be sustainable ecologically compared to the crab fattening today.
1. BACKGROUND

In many marine benthic organisms the early juvenile life stages are a critical period since the predation mortality is high, creating a bottleneck in survival (Gaines and Roughgarden, 1987; Smith and Herrnkind, 1992; Eggleston and Armstrong, 1995; Gosselin and Qian, 1997; Moksnes et al., 1998; Moksnes, 2002). In support to this concept juvenile benthic organisms are often concentrated in high numbers in complex structures that can provide refuge from predation (Heck and Orth, 1980; Herrnkind and Butler, 1986; Whale and Steneck, 1991; Eggleston, 1995). The predation mortality rate is often habitat specific and is thought to be a factor for a non-random distribution of juvenile benthic organisms (Smith and Herrnkind, 1992; Fernandez et al., 1993), but there has also been shown that in portunid crabs, both settlers and juveniles, actively chose complex habitat and that this also can be a factor for non-random distribution (Moksnes, 2002; Moksnes and Heck, 2006). It has also been shown that juveniles and settlers chose different habitat as refuges from predation resulting in one or several ontogenetic habitat shifts (Smith and Herrnkind, 1992; Eggleston, 1995; Moksnes, 2002). The predation mortality is believed to increase with lower latitude (Heck and Wilson, 1987; Heck and Coen, 1995), but little is known about the predation mortality in the tropics since most studies have been carried out in temperate regions.

Mud crab, *Scylla* ssp., is a large portunid crab that inhabits coastal mangrove habitats in the West Indian Ocean. Even if the mud crab is a multimillion dollar business in the Indo-Pacific region very little is known about its basic biology and ecology (Keenan, 2003) and in particular about the larval and juvenile stages. Nothing is known about the predation mortality; if it is size specific and if the predation mortality varies among different habitats.

In Southeast Asia, aquaculture of the mud crab has been practiced for many years by taking wild seed crabs to the farms. The result of this is an overexploitation that makes it difficult to obtain wild seed crabs to the farms today in many areas (Allan and Fielder, 2003). Tanzania has extensive areas of mangrove forests and is believed to have sustainable populations of the mud crab *Scylla serrata*. Aquaculture of the mud crab is believed to have potential to develop into important alternative source of income for coastal villages in East Africa (Barnes et al., 2002) in the last 5-10 years many attempts have been made to start small scale mud crab aquacultures in Tanzania using “crab fattening”. “Crab fattening” is when small adult mud crabs, with a weight of >300 g, is collected from the wild and kept until they reach the market requirements (Shipton and Hecht, 2007). The average mortality in the farms is 10% month$^{-1}$ which is much higher than the natural mortality in the mud crabs that is estimated to be 2% month$^{-1}$ (Mahika et al., 2005). This makes the traditional fishing after adult mud crabs more sustainable than the “crab fattening” aquacultures. Because of this there is a need to find a more sustainable alternative way to obtain seed crabs to the aquacultures.

The aquaculture could be more sustainable if early juvenile stages of the mud crabs were used as seed crabs and farmed to market size in grow-out aquacultures. The use of small juveniles as seed crabs could have a lower impact on the population of the mud crabs than the present crab fattening if the natural mortality is decreasing with the size of the crabs. If the mortality in the grow-out farms were lower than in nature, the aquaculture would increase the natural production and be more sustainable than the traditional fishing. However, at present little is known about the natural mortality of juvenile mud crabs. The aim of this study was to investigate if the predation mortality on juvenile *Scylla serrata* is size and habitat dependent.

2. MATERIAL AND METHODS

2.1 Study area

To assess if the predation mortality in juvenile *Scylla serrata* is size and habitat dependent a field experiment was carried out on Mafia Island, Tanzania. Four size classes of juvenile mud crabs in two different habitats and three locations were used. The experiment was conducted in February-
Fig 1. Map showing Mafia Island and the three study-sites.

Mars 2009 in the Chole bay within the Mafia Island Marine Park (MIMP). MIMP is the largest Marine Protected Area (MPA) in Tanzania with the purpose to manage the area for a sustainable development and to protect the coastal and marine environments. An effective enforcement of park regulations gives a lower fishing pressure within the park than outside MIMP (Francis et al. 2002). The waters outside Mafia Island is affected by a semi-diurnal tide with an average amplitude of 3.3 meters (McClanahan, 2000), and has an average surface salinity of 34.4 ppt and average surface temperature of 27°C (Newell, 1959).

2.2 Study sites

The three sites (Utende, Kilole and Kichangani; Fig 1.) that were used in the experiment were randomly chosen based on the criteria that they contained mangrove trees along the shore but also intertidal and subtidal seagrass beds.

**Utende**

The mangrove at Utende had a small backflat (e.g., an area without any vegetation behind the mangrove trees) and consisted of *Rhizophora mucronata* and *Sonneratia alba*. The mangrove fringe consisted of a 3-5 meter wide area of air-roots of *S. alba*. In front of the mangrove fringe were some seagrass (*Halodule* sp.) and filamentous green algae (*Chaetomorpha crassa*) with coverage of 30-50% of the bottom. At low tide, the width between the mangrove fringe and the subtidal was a 100-150 meters. The intertidal sandflat had a patchy distribution of the seagrass *Thalassaia hempricii* and in the low intertidal a lot of sea anemones. In the subtidal area, a more continuous seagrass meadow was found, that was dominated by *Enhalus acoroides* mixed with smaller amount of *T. hempricii*, *Syringodium isoetifolium* and the calcium algae *Halimeda* sp. Utende had also some small coral patches with a diameter of ~30 centimetres in the subtidal.

**Kilole**

Kilole was similar to Utende with some exceptions. The location had the largest backflat of all
the three sites and the largest intertidal sandflat. The width, at low tide, between the fringe and the
subtidal was 150-200 meters. In the subtidal, Kilole had lower abundance *E. accoroides* and
*Halimeda* sp. in comparison to Utende, and no *S. isoetifolium* was found. Kilole had large patches
of hardcorals (~4 meters in diameter) in the subtidal that housed many different fish species.

**Kichangani**

Kichangani was also similar to Utende but did not have any mangrove backflat. The mangrove
consisted of a mix of *R. mucronata*, and *S. alba*. The intertidal sandflat was about 150-200 meters.
The subtidal seagrass bed was dominated by *E. accoroides*, no *T. hempricii* and *S. isoetifolium*, and
only low abundance of *Halimeda* sp. was found. Many sea urchins and small coral patches (~30
centimetres in diameter) were observed in the subtidal seagrass.

### 2.3 Tethering experiment

To assess if predation mortality in juvenile mud crabs is size and habitat dependent, a tethering
experiment was conducted using 4 size-classes of mud crabs in two different habitats. The habitats
that were used in the tethering experiment were the mangrove fringe and the subtidal seagrass. They
were chosen because they are different kinds of habitats located separately and also different in their
complexity. Complex habitats have in different studies shown to give protection from predation
mortality compared to sand (Moksnes et al., 1998; Fernandez et al., 1993; Heck and Thoman,
1981). New results have also shown that juvenile *S. serrata* only can be found in the mangrove
fringe during the night and that they probably hide in the subtidal seagrass during the day (Karlsson,
2009).

The experimental method that was used is similar to the tethering-techniques described by Heck
and Thoman (1981) and Moksnes et al. (1998). Tethering is an experimental method where the
organism is attached to a line and placed in a natural habitat and after a period of time the predation
is assessed. Tethering has been used in the field to measure the relative predation mortality for many
different species of decapods (Moksnes et al., 1998; Johnson et al., 2008; Barshaw and Able, 1990;
Heck and Thoman, 1981). It was not intended to measure the absolute predation mortality for the
mud crabs since artefacts from the tethering could affect the behaviour and flight response of the
crabs, but to assess the relative predation mortality that could be comparable between crab sizes and

![Fig 2. *Scylla serrata* with a glued line to carapace and secured with an extra line tied to the ninth lateral tooth.](image-url)
Table 1. Size classes with size and length of line and line material.

<table>
<thead>
<tr>
<th>Size classes</th>
<th>Size (mm)</th>
<th>Length line (cm)</th>
<th>Line (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>72-87</td>
<td>50</td>
<td>Coated stainless wire</td>
</tr>
<tr>
<td>B</td>
<td>37-62</td>
<td>40</td>
<td>Monofilament nylon line</td>
</tr>
<tr>
<td>C</td>
<td>11-24</td>
<td>20</td>
<td>Monofilament nylon line</td>
</tr>
<tr>
<td>D</td>
<td>6-12</td>
<td>15</td>
<td>Monofilament nylon line</td>
</tr>
</tbody>
</table>

habitats, assuming that the artefacts were constant across treatments. The relative predation mortality for *S. serrata* would likely constitute an overestimate of natural predation rates due to artefacts from the tethering.

Four size-classes of mud crabs: A: 72-87 mm, B: 37-62 mm, C: 11-24 mm, D: 6-12 mm was collected in the mangrove back-flat from a location near the Mafia Island Marin Park station (MIMP) during night when the high tide was going out. The mud crabs were housed in buckets with beach sand and covered with branches of mangroves. The claws of the bigger crabs were tied to minimize damage on other crabs and to be able to handle them without risk of getting hurt. The mud crabs were prepared the day before the experiment was started. A monofilament nylon line was attached to the C and D mud crabs with super glue (cyanoacrylate). The bigger crabs in the class range A and B were also secured with an extra line tied to the ninth lateral tooth that a coated stainless wire or the monofilament nylon line was attached to (Fig 2). Lines of different length and material were used for different size classes of crabs to make the experimental artefact of the tether more similar between size-classes (Table 1). One crab of each size class were then, prior to being placed into the water, tied on a 4 meter long line with enough space between them to inhibit any interaction. The line was pushed down in the sediment and secured with J shaped metal sticks. The experiment was started during the day and run for 24 h. At the termination of the experiment, the mud crabs were checked and any predation noted. Predation was only noted if a broken piece of carapace remained on the line or if the line was cut for any mud crab in size-class B, C and D. To be sure to not overestimate the predation mortality, unclear losses of crabs were excluded from the data. Crabs in size class A were excluded when the line was cut in a way that indicated that it was torn off by the crab itself. This was done because crabs of this size class at times were seen pulling the line and scraping it against the edge of their carapace, a behaviour that slowly stripped the coated stainless wire. This behaviour and effect on the line could not be seen in any other size-class. Crabs were excluded when only a piece of glue remained on the tether because of eventual bad glue that released from the carapace.

Four size classes of crabs, two habitat-types and three sites were used in a 4x2x3 orthogonal design with 3 replicates and a total of 6-9 crabs per treatment. The relative predation mortality of *S. serrata* in each size class, habitat and site for each time was calculated by: number of eaten crabs / number of tethered crabs, which constituted one replicate. Three crabs of each size-class were used to estimate the proportional predation rate for each replicate. Occasionally only two mud crabs were used per replicate due to shortage of crabs. The replicates were achieved by repeating the trial three times at each site. In total, 169 crabs were assessed in the tethering experiment.

### 2.4 Statistic

The relative predation mortality served as the dependent variable in a 3-factor mixed-model ANOVA with size, habitat (fixed factors) and site (random factor) as the independent variable. Size class D was excluded from the first ANOVA-model because it was just tested in one site (due to shortage of small crabs in the beginning of the experiment). Since no significant effect of sites were found (p>0.05), a second unbalanced 2-factor ANOVA-model (type III) without site as a factor was carried out, which included size-class D as a level of the independent size-variable. The assumption of homogeneity was tested with Cochran’s C-test. A multiple comparison post-hoc test was done with the Student-Newman-Keuls (SNK) method.
3. RESULT

The relative predation mortality was highest for the smallest mud crabs and decreasing with an increasing size in the tethering experiment. During the tethering the mud crab showed a natural behaviour as it did hide itself in the sand or made burrows. In total, 20 missing crabs were excluded from the analyses because predation could not be clearly determined (constituting 11.8% of all tethered crabs). Seven mud crabs of size class A were excluded mainly because the line showed signs of being tear off by the crabs. In size class B, C and D, 4, 8 and 1 crab were excluded, respectively, because only glue remained on the carapace or because of unclear loss (e.g. when predation could not be clearly determined).

The 3-factor ANOVA showed a significant main effect of size, but no other significant effects (Table 2, Fig. 3). Because all factors containing the site-variable were clearly insignificant (p>0.64)

Table 2. 3-factor mixed model ANOVA tables. Proportional relative predation mortality rate of *Scylla serrata* as a function of size, habitat and site from the field tethering experiment.

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Error term</th>
<th>SS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size (A)</td>
<td>2</td>
<td>A x C</td>
<td>207.03</td>
<td>35.93</td>
<td>0.003</td>
</tr>
<tr>
<td>Habitat (B)</td>
<td>1</td>
<td>B x C</td>
<td>3.76</td>
<td>1.28</td>
<td>0.37</td>
</tr>
<tr>
<td>Site (C)</td>
<td>2</td>
<td>Residual</td>
<td>8.93</td>
<td>0.45</td>
<td>0.64</td>
</tr>
<tr>
<td>A x B</td>
<td>2</td>
<td>A x B x C</td>
<td>4.39</td>
<td>0.86</td>
<td>0.49</td>
</tr>
<tr>
<td>A x C</td>
<td>4</td>
<td>Residual</td>
<td>11.52</td>
<td>0.29</td>
<td>0.88</td>
</tr>
<tr>
<td>B x C</td>
<td>2</td>
<td>Residual</td>
<td>5.90</td>
<td>0.30</td>
<td>0.74</td>
</tr>
<tr>
<td>A x B x C</td>
<td>4</td>
<td>Residual</td>
<td>10.17</td>
<td>0.29</td>
<td>0.90</td>
</tr>
<tr>
<td>Residual</td>
<td>36</td>
<td></td>
<td>355.25</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig 3. Mean percent relative predation mortality (+SE) on three size classes (A: 72-87 mm, B: 37-62 mm, C: 11-24 mm) of juvenile *Scylla serrata* tethered in two different habitats (mangrove fringe and subtidal seagrass) and three different sites for 24 h.
the factor site was excluded from the ANOVA-model and a second analysis was performed that included size-class D. The 2-factor ANOVA also showed a strong significant effect of size, but no significant effects of habitat (Table 3, Fig. 4). There was a significant difference between all tested size classes except between size class A and B. The average relative predation mortality in the largest size class A was 0% 24h\(^{-1}\) in B it was 9\% 24h\(^{-1}\), in C 37% 24h\(^{-1}\) and in D 72% 24h\(^{-1}\) (Fig. 5). In the subtidal seagrass, the average relative predation mortality for size class A, B, C and D was 0, 20, 44 and 66% 24h\(^{-1}\), respectively, and in the mangrove fringe it was 0, 7, 29 and 78% 24h\(^{-1}\) (Fig. 4).

Table 3. 2-factor model ANOVA tables. Proportional relative predation mortality rate of *Scylla serrata* as a function of size and habitat from the field tethering experiment.

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>SS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size (A)</td>
<td>3</td>
<td>30608.71</td>
<td>17.01</td>
<td>0.0001</td>
</tr>
<tr>
<td>Habitat (B)</td>
<td>1</td>
<td>39.12</td>
<td>0.07</td>
<td>0.80</td>
</tr>
<tr>
<td>A x B</td>
<td>3</td>
<td>318.64</td>
<td>0.53</td>
<td>0.66</td>
</tr>
<tr>
<td>Residual</td>
<td>52</td>
<td>596.95</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig 4. Mean percent relative predation mortality (+SE) on four size classes (A: 72-87 mm, B: 37-62 mm, C: 11-24 mm, D: 6-12 mm) of juvenile *Scylla serrata* tethered in two different habitats (mangrove fringe and subtidal seagrass) for 24 h.
Fig 5. Mean percent relative predation mortality (+SE) on four size classes (A: 72-87 mm, B: 37-62 mm, C: 11-24 mm, D: 6-12 mm) of juvenile *Scylla serrata* tethered for 24 h. Different letters above bars indicate significantly (p< 0.05) different means.

4. DISCUSSION

This study is the first made on predation mortality on juvenile *S. serrata* and it shows that the relative predation mortality decreases with an increasing size, independent of habitat and location. This result is consistent with Gosselin and Qian (1997) that there is a general trend of high juvenile mortality among benthic marine invertebrates that is decreasing with size. This suggests that predation can cause a bottleneck (Moksnes et al. 1998; Smith and Herrnkind 1992) in the population in early juvenile stages of *S. serrata*.

In other studies with tethering the predation mortality has been different between habitats with lower relative predation mortality in complex habitat (Moksnes et al., 1998; Fernandez et al., 1993; Herrnkind and Butler, 1986). In this study, no significant difference could be found between the two habitats, the mangrove fringe and the subtidal seagrass. The structural complexity was much higher in the subtidal seagrass habitat where a mix of several species of seagrass and algae with different morphology created a complex canopy that covered almost 100% of the bottom. In comparison, unvegetated mud dominated the mangrove fringe habitat, where air-roots of *Sonneratia alba*, and occasional patches of *Halodule* sp. and filamentous algae (*Chaetomorpha crassa*) constituted all the vegetation. However, it was more than the complexity that differed between the habitats, as the mangrove fringe was exposed to air at low tide, approximately 2x6 hours daily, which affected abundance and composition of predators in the two habitats. The similar predation rates in the two different environments despite the apparent higher structural complexity in the subtidal seagrass can indicate that the low tide constitute a refuge from fish and other aquatic predators that compensate for a lower complexity in the mangrove fringe.

During the low tide in the mangrove fringe, birds are probably the most important source to predation on the mud crab on Mafia Island while during the high tide it is likely different crabs (adult *S. serrata* and *Thalamita* sp.) and fishes (e.g. juvenile moray eels, barracuda, circular batfish, eel-catfish and adult squid, which were observed in the study areas during the night). In the subtidal seagrass, the dominant potential predators are coral fishes (pers. obs.).

This is the first experiment that has been made on predation mortality in tropical waters on brachyuran crabs. The predation mortality rate is lower than expected in this study considering the
argument by Heck and Wilson (1987) and Heck and Coen (1995) that state that the predation mortality should increase with lower latitudes because of a higher diversity of predators and reduced seasonality in tropical seas that eliminate spatial and temporal refuges from predation. The relative predation mortality for juvenile blue crab, *Callinectes sapidus* in eelgrass beds in the USA, range between 23-100% per 24 h for similar size-classes used in this study (Johnson et al., 2008; Heck and Coen 1995; Pile et al., 1996; Spitzer et al., 2003), which is higher than for the predation rates on *S. serrata* found in the present study (0-72% 24h⁻¹ on average). The predation rates for *Carcinus maenas* on the Swedish west coast (Moksnes et al., 1998) and for *Cancer magister* on the Pacific NW coast of the USA (Fernandez et al., 1993), are more similar to the relative predation mortality of the mud crab found in the present study.

One possible explanation for the lower than expected predation rates in the present tropical system is the lack of seasons and its potential effect on juvenile density and possibly cannibalism. Because recruitment of juvenile crabs are concentrated to a limited time of the year in temperate and subtropical areas (peak settlement often occurring within 1-3 months period), densities of juveniles are much higher during recruitment in temperate areas in comparisons to tropical areas where recruitment is spread out during the whole year. For example, the crab density of juvenile portunid crabs in nursery habitats at higher latitudes is typically 30-1300 times higher (e.g. *Callinectes sapidus* in the USA: 2-92 crabs/m²; Heck and Coen, 1995, Pile et al., 1996; *Carcinus maenas* in Sweden: 4-49 crabs/m²; Moksnes, 2002) in comparison to juvenile *S. serrata* in the this study area (on average 0.071 crabs/m²; Karlsson, 2009). Cannibalism is thought to be the dominant source of mortality for juvenile crabs in many systems (Fernandez et al. 1993, Moksnes et al. 1997, Moksnes et al. 1998) and to increase at both during higher cannibal and prey densities (Moksnes et al. 1997, Moksnes 2004). Thus, the continuous recruitment and the lower juvenile densities in the study area may decrease predation rates from larger cannibals, in comparison to temperate areas.

In tropical waters cannibalism is probably not the most important factor for the predation mortality as in higher latitudes but instead there are other predators that are more important. The different predation rates and size refuge in different systems likely reflect the composition of dominant predators at different latitudes. *C. maenas* has a size refuge from predators when it is bigger than 4 mm CW (carapace width) (Moksnes et al., 1998) and the blue crab has a size refuge when it is 40-50 mm CW (Johnson et al., 2008). That the size refuge for the blue crab is larger than for *C. maenas* can mean that there are larger predators in the blue crab system. The size-refuge for

![Fig 6. Pooled numbers of Scylla serrata found during 9 nights transects in a predefined set of size classes (mm CW). Crabs <100mm CW are considered as being juveniles. MI; mangrove inner and MF; Mangrove fringe (Karlsson, 2009).](image-url)
S. serrata in the present study was 24 mm, which can indicate that the predators are relatively small compared to the blue crabs predators. None of the potential predators that were observed in the present study appear to be able to eat crabs larger 30 mm CW due to the predator’s small size. No bigger predators (sharks, rays, etc.) were seen during this experiment that could be a potential predator on the bigger crabs (>70 mm CW). Thus, the lack of large predators likely explains the relatively small size-refuge for mud crabs in the study system.

Implication for aquaculture

The present study and results from a recent field survey in the area provide support that collection of small juvenile seed crabs for grow-out aquaculture of mud crabs is possible and more sustainable than the ongoing mud crab fattening. In a study by Karlsson (2009) juvenile S. serrata on Mafia Island was found to aggregate in the mangrove fringe and backflats during the night. At low tide a few juvenile crabs were still found in the puddles in the inner mangrove but none were found there during the day. According to Karlsson (2009) it is possible that the crabs migrate in with the high tide and then migrate back out before dawn and that the mud crabs can be found in the intertidal or subtidal zone during the day. According to personal observations it is possible to collect high number of juvenile mud crabs in the mangroves during the night between high and low tide and this was confirmed by Karlsson’s (2009) transects. If the predation mortality is much higher for smaller mud crabs compared to larger crabs, as indicated in the present study, collection of small seed crabs for aquaculture would have a smaller negative effect on the local population than collecting larger crabs, since more of the small crabs would naturally perish in nature due to the size specific predation rates. If mortality rates in grow-out farms would be lower than the high rates of predation mortality indicated for the smaller crabs in the present study, then the aquaculture would increase the production of crabs in an area. However, the absolute natural mortality rates of juvenile mud crabs are still unknown.

According to Karlsson (2009), the abundance of juvenile S. serrata is largest in the size range 16-20 mm (Fig. 6). The predation mortality (Fig. 5) was highest in the smallest size class that was 6-12 mm (72% 24h⁻¹) but even so the predation mortality was still high in the 11-24 mm size class (37% 24h⁻¹) and significantly higher in comparison to juvenile crabs >72 mm CW with 0% 24h⁻¹. If crabs <24 mm CW were caught as seed crabs to aquaculture the effect on the crab stock should be substantially lower than when using bigger crabs (>300 g; approximately >120 mm CW) that are collected for the present crab-fattening activity (Shipton and Hecht, 2007).

This study is the first to show the relative predation mortality on Scylla serrata; that the predation mortality is decreasing with an increasing size. But some questions are still to be answered as a result of this study: When is the predation mortality highest, at low or high tide? Is complex habitat an important factor for survival from predation mortality?

If coastal villages could catch the small seed crabs with a high predation mortality to their aquaculture and be able to grow them to a size that reach the markets request it could be sustainable ecologically compared to the crab fattening today. This would not only have a small impact on the mud crab stock but could also give an important extra alternative source of income to the coastal villages (Barnes et al., 2002).

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