Research Article

Test of Intercropping Myxocyprinus asiaticus in the Eriocheir sinensis Pond

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Abstract: In order to reveal whether the Myxocyprinus asiaticus and the mitten crab Eriocheir sinensis be intercropping well in pond-culture and whether have any influence on speciation, production and benefit of the river crab, During March to November, 2011. We chose three mitten crab Eriocheir sinensis ponds of similar hydrology condition and environmen in Liu farm, Taizhou city, Jiangshu province to start the test of intercropping Myxocyprinus asiaticus in the mitten crab pond. The control pond mainly cultivates Eriocheir sinensis auxiliary with Macrobrachium nipponense, siver carp and Siniperca chautsi, while the testing ponds intercropping Myxocyprinus asiaticus juveniles additional. Stocking density of the 2nd pond and the 3rd pond is, respectively 750 and 900 fish/hm² with averaging 10 cm in body length. After 250 days' cultivation, the average weight of each one is 997.8 g with survival rate of 91.2%. The average output of the 2nd pond is 342 kg/hm² and the 3rd pond is 405.75 kg/hm². Compared with the contrast pond’s 35,505 yuan/hm² net profit, the 2nd pond and the 3rd pond separately has 22,995 and 27,032 yuan/hm² more net profit with growth rate at 64.77 and 76.14%. The average specification of the Eriocheir sinensis in these three ponds is 169 g/one. Specification of the Eriocheir sinensis in the intercropping pond has no obvious difference with the one in the control pond.

Keywords: Eriocheir sinensis, intercropping, mitten crab, Myxocyprinus asiaticus, pond

INTRODUCTION

The mitten crab Eriocheir sinensis due to its special savor, nutrition and commercial value, it becomes more and more popular with the aquaculturists in China. Investigation in 2009 shows that the area of pond crab farming in the whole country is ca 930,000 hm² producing ac 640,000 t of fresh crabs (Dai et al., 2012).

Myxocyprinus asiaticus is a kind of endemic species of fish in China. It has peculiar figure and distinct color. The young Eriocheir sinensis is one of the rarities in pet fish family and the adults can be eaten because of its delicacy flesh and rich nutrition. Also have features of fast-growing, tame nature, extensive eating habit, strong disease-resistance and high capture rate. The fish is only distributed naturally in Changjiang (Yangtze) and Minjiang Rivers, but the stock of the fish distributed in Minjiang River may be disappeared at present. The population of the fish living in Changjiang River has gone down quickly in the past two or three decades. The fish has been designated by the state as the second rank of aquatically protected animals (Zhang et al., 2000). Researches regarding the biological nature and cultivation technique of the Eriocheir sinensis and Myxocyprinus asiaticus and their intercropping with other species are relative plente (Chen, 2008; Gui, 2004; Tang, 2011; Wang, 2004; Wang et al., 2011a, b), but reports in respect of mixed culture between mitten crab and Myxocyprinus asiaticus is rare. In March 2012, the writer introduced Myxocyprinus asiaticus from Wanzhou district, Chongqin to Taizhou city, Jiangsu province. This test has been successfully accomplished. After 250 days exploration and research, the writer analyzed and contrasted the culture benefit of intercropping Myxocyprinus asiaticus in Eriocheir sinensis pond profit. This report aims to provide reference for the aquaculturists to increase output and profit. The test result is summarized as below.

MATERIALS AND METHODS

Testing pond and condition: This test chose three ponds which possess regular Eriocheir sinensis cultivation condition. Pond 1 (area: 3.07 hm²) is the control group mainly cultivates Eriocheir sinensis auxiliary with Macrobrachium nipponense, siver carp and Siniperca chautsi, without Myxocyprinus asiaticus; Pond 2 (area: 2 hm²) and Pond 3 (area: 0.67 hm²) intercropping with Myxocyprinus asiaticus additional.

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With loam substrate, the pond possesses complete drainage and irrigation equipments, while the downside is laid by microporous aerator pipes (Fig. 1) which is fixed 10-20 cm from the bottom (Liu et al., 2009). With slope ratio 1:3-1:4, the aquaculture pond bulges out in the middle and the around deep sunken circumambience area accounts for 40%. The dent area is 30-40 cm lower than the middle of the pond. Juvenile crab is cultivated in the deep sunken circumference area whose width is 5-8 m and height of maximum water level is about 1.6-1.8 m. The middle area is used to plant aquatic weed and its maximum water level is about 0.8-1.2 m. Prevent-escaping facility is made of regular calcium-plastic board.

The cultivation water is abundant from Yangtze River. pH 7.2-8.5 and the Dissolved Oxygen (DO) is above 6 mg/L. Each pond has an individual irrigation and drainage system to prevent disease spread. The water quality standard for fisheries (GB 11607-89) and level III of Environmental quality standards for surface water (GB 3838-2002) are taken as the evaluation criteria of water environment investigation of the *Eriocheir sinensis* cultivation area (Table 1). The other monitoring indicators including Total Nitrogen (TN), Total Phosphorus (TP), sulphide, COD$_{Mn}$, ammoniacal nitrogen (NH$_3$-N) and so on.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>pH</th>
<th>DO</th>
<th>Total Nitrogen (TN)</th>
<th>Total Phosphorus (TP)</th>
<th>Ammoniacal nitrogen (NH$_3$-N)</th>
<th>Sulphide</th>
<th>COD$_{Mn}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water quality standard for fisheries (GB 11607-89)</td>
<td>6.5-8.5</td>
<td>≥5</td>
<td>-</td>
<td>-</td>
<td>≤0.2</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Level III of environmental quality standards for surface water (GB 3838-2002)</td>
<td>6-9</td>
<td>≥5</td>
<td>≤1.0</td>
<td>≤0.2</td>
<td>≤1.0</td>
<td>≤0.2</td>
<td></td>
</tr>
</tbody>
</table>

Pond preparation: Before stocking the crablets, we need to drain the pond and dig up redundant sullage. After the exposure to the sun or freeze ac 15-20 days, the pond should be filled with 30-50 cm filtered fresh water and every 666.7 m$^2$ of the whole pond should be disinfected with melted quicklime 100-150 kg which can eliminate the pests and pathogen and improve the substrate to help the exuviation and growth of the *Eriocheir sinensis*.

Water fertilization: Water fertilization aims to provide manure for the aquatic weed as well as other phytoplankton. The decomposed organic fertilizer added with slight quicklime is placed at approximate 30-40 cm depth and its top should be sealed with sediment which render them gradually released in the pond. Fertilizing amount can be refer to 2250 kg/hm$^2$ and this amount can be changed according to the state of pool water and sullage. It can be replaced by 150 kg/hm$^2$ inorganic compound fertilizer.

Planting weeds and stocking spiral shell: The culturist need to plant waterweed around February and grow *Hydrilla verticillata* and *Vallisneria spiralis* around Tomb-Sweeping Day. After then, stocking density of the spiral shell by 4500-7500 kg/hm$^2$ and to let it naturally grow and breed. It can provide *Eriocheir sinensis* and *Myxocyprinus asiaticus* with their favorite animal diets, so as to decrease the cost, increase output and improve quality. After stocking spiral shell, the culturist should keep the water transparency less deep than 20 cm which can restrain lichen’s growth. During August, the culturist needs to supplement spiral shells once more with amount at 1500 kg/hm$^2$.

Fingerlings stocking: The quality requests of the crablets that stocked in March: even specification, bright shell, robust constitution, complete appendage, agile creep, no injury and disease and no attachment. If the crablets are bought from other places, they should be bathed for around 3-5 min and be soaked for the
same time again after wash away the foam for a while. After repeating for three times, the crablets should be disinfected with salt solution of 4.6% consistency for about 3-5 min or 15 g/m² solution for about 10-20 min. After then, the crablets should be reinforced cultivated in the prior prepared small area which is about 1/5 of the bigger pond. When the aquatic plants grow to 50% of the bigger pond surface and the spiral shells have been bred to a certain amount, the crablets can be removed to the bigger pond. The tested *Eriocheir sinensis* fingerlings are bought from Wanzhou district, Chongqing municipality. The total 2100 fingerlings’ average length is 10 cm per individual (Fig. 2). They are of even specification and have sound scales and fins. In March, the fingerlings should be stocked into the temporary cultivation pond to breed for a while. Before stocking the fingerlings, the culturist should open aerator and accomplish the task of disinfecting and cleaning up the pond and testing the water. When *Myxocyprinus asiaticus* complete the task of water quality and bait domestication in the temporary cultivation pond, they will be transferred to the *Eriocheir sinensis* test pond. Before the transfer, the *Myxocyprinus asiaticus* should be bathed for about 10 min in the 4.6% density solution which is blended by the test pond water and salt. In order to fully utilize the cultivation water, the *Eriocheir sinensis* in the pond can intercrop with other species (Table 2).

**Water quality and substrate management:** *Eriocheir sinensis* and *Myxocyprinus asiaticus* are both fond of fresh water with plenty dissolved oxygen. At the beginning of the breeding, the water level should be kept around 0.4-0.5 m and it should be gradually increase the water level to 0.6-0.8 m during April and May. In the hot season, the water level should be controlled around 1.3-1.5 m and at the same time the culturist should pay attention to the fresh water supplement. During June and September, the water need to be changed every 7-10 days; Every two weeks, the water need to be drained first and irrigated to the height of 20-30 cm afterwards in spring and autumn. Moreover, the water quality state, water temperature, the content of dissolved oxygen, nitrite, hydrogen sulfide, ammonia nitrogen and pH in the *Eriocheir sinensis* pond need to be tested regularly. The culturist needs to use microporous aerator to supplement oxygen every night and supply the oxygen timely in special weather. The culturist need to periodically use substrate modifier such as calcium oxide, zeolite and so on, it also need to supplement photosynthetic bacteria, EM bacteria liquid, composite bacillus and other biological promoting agent every half or one month to maintain the water in a good circulation. During the breeding test period, the pH maintain at about 7.8-8.5, ammonia nitrogen (NH₄-N) <0.02 mg/L, nitrite (NO₂-N) <0.1 mg/L, sulfide <0.2 mg/L, dissolved oxygen above 5 mg/L. Water testing method can be refer to ‘Water and Wastewater Monitoring and Analysis Method ’4th Edn (China State Environmental Protection Administration, 2002).

**Feeding and daily management:** Period of the *Myxocyprinus asiaticus* temporary breeding and domestication. Owing to the Chinese sucker’s small mouth and high quality protein required, this test chose river crab special artificial compound feed supplied by Taizhou Haida Fodder company which containing above 38% protein and diameter 2 mm. The phagostimulant that made from water worm, fish meat

### Table 2: Stocking and harvest status of the three ponds

<table>
<thead>
<tr>
<th>Pond</th>
<th>No.</th>
<th>Stocking species</th>
<th>Stocking season</th>
<th>Area (hm²)</th>
<th>Average weight (g)</th>
<th>Weight (Kg)</th>
<th>Unit yield (kg/hm²)</th>
<th>Unit price (Yuan/kg)</th>
<th>Output (Yuan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 1</td>
<td>3.07</td>
<td><em>Eriocheir sinensis</em></td>
<td>Mar. 8 g</td>
<td>3.07</td>
<td>7,500 crab</td>
<td>1610</td>
<td>525</td>
<td>140</td>
<td>225,400</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Macrobrachium nipponense</em></td>
<td>May 2-3 cm</td>
<td>3.07</td>
<td>45 kg</td>
<td>322</td>
<td>105</td>
<td>35</td>
<td>11,270</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Silver carp</em></td>
<td>Mar. 250 g</td>
<td>3.07</td>
<td>300 fish</td>
<td>1518</td>
<td>495</td>
<td>3</td>
<td>4,554</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Siniperca chaanti</em></td>
<td>Jun. 5 cm</td>
<td>3.07</td>
<td>150 fish</td>
<td>230</td>
<td>75</td>
<td>30</td>
<td>6,900</td>
</tr>
<tr>
<td>No. 2</td>
<td>2</td>
<td><em>Eriocheir sinensis</em></td>
<td>Mar. 8 g</td>
<td>2</td>
<td>7,500 crab</td>
<td>1044</td>
<td>522</td>
<td>140</td>
<td>146,160</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Myxocyprinus asiaticus</em></td>
<td>Apr. 10 cm</td>
<td>2</td>
<td>750 fish</td>
<td>682.5</td>
<td>342</td>
<td>80</td>
<td>54,600</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Macrobrachium nipponense</em></td>
<td>May 2-3 cm</td>
<td>2</td>
<td>45 kg</td>
<td>204</td>
<td>102</td>
<td>35</td>
<td>7,140</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Silver carp</em></td>
<td>Mar. 250 g</td>
<td>2</td>
<td>300 fish</td>
<td>930</td>
<td>465</td>
<td>3</td>
<td>2,790</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Siniperca chaanti</em></td>
<td>Jun. 5 cm</td>
<td>2</td>
<td>150 fish</td>
<td>150</td>
<td>75</td>
<td>30</td>
<td>4,500</td>
</tr>
<tr>
<td>No. 3</td>
<td>0.67</td>
<td><em>Eriocheir sinensis</em></td>
<td>Mar. 8 g</td>
<td>0.67</td>
<td>7,500 crab</td>
<td>347</td>
<td>520.50</td>
<td>80</td>
<td>48,580</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Myxocyprinus asiaticus</em></td>
<td>Apr. 10 cm</td>
<td>0.67</td>
<td>900 fish</td>
<td>270</td>
<td>405.75</td>
<td>35</td>
<td>21,638</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Macrobrachium nipponense</em></td>
<td>May 2-3 cm</td>
<td>0.67</td>
<td>45 kg</td>
<td>71</td>
<td>106.50</td>
<td>30</td>
<td>2,485</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Silver carp</em></td>
<td>Mar. 250 g</td>
<td>0.67</td>
<td>300 fish</td>
<td>310</td>
<td>465</td>
<td>3</td>
<td>920</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Siniperca chaanti</em></td>
<td>Jun. 5 cm</td>
<td>0.67</td>
<td>150 fish</td>
<td>50</td>
<td>75</td>
<td>30</td>
<td>1,500</td>
</tr>
</tbody>
</table>
and swan mussel is blended with river crab special artificial compound feed to feed the *Myxocyprinus asiaticus*. The bait can be reduced day by day, when the *Myxocyprinus asiaticus* can stably go to the bait terrace. After 7-10 days’ domestication, the *Myxocyprinus asiaticus* can be transferred to the *Eriocheir sinensis* pond to intercrop with *Eriocheir sinensis*.

During the intercropping period, the main feed type is special river crab artificial compound diet, supplemented with raw fish and spiral shell collocated with slight corn, soybean, wheat and other botanical feed, which is in accordance with ‘safety food-dose limit of fishery compound feeds’ (NY 5072-2002, 2002). The feeding principle is fine feed forwards and afterwards and botanical bait in the middle and also persist with the ‘Four Observation’ feeding principle, that is observing season, weather, water color and activity. Among March to June, the proportion between animal bait and botanical bait is 60:40 and daily bait amount is 5% of the total carbs’ weight and total amount of this period accounts for 25-30% of the annual bait weight; From later June to the middle of September, the proportion should be changed to 45:55 and the bait amount changed to 3-4% of the total crabs’ weight and the total bait of this period accounts for about 20-25% of the annual bait weight. Since the middle of September when the water temperature goes down, the *Eriocheir sinensis* enters into the fatten period. Then the proportion should be adjusted to 65:35 and daily bait amount is 5-8% of the total crabs’ weight and the total amount of this period account for 45-50% of the annual bait amount. The culturist should patrol the pond at least once both in the morning and afternoon to observe the feed state, activity state and leftover bait state of the *Eriocheir sinensis* and *Myxocyprinus asiaticus* on the basis of which the amount is adjusted. The sick and dead *Eriocheir sinensis* and *Myxocyprinus asiaticus* should be fished out and the remains and ordure should also be cleared away. In sunny day bait can be more feeding, while in cloudy and rainy day with less feeding and supplemented with more oxygen. The culturist should uphold the ‘Four Definition’ feeding principle that is definite time, place, quality and amount. The bait should be feed twice. One time is around 6-7 am and the other time is around 4-5 pm. The bait should be linear scattered at the shallow water area along the pond bank. The distance between two bait points is 20 cm. The bait should be combined by botanical, coarse and fine fodder together, the rotten and deteriorate baits is forbidden. The biological fodder accounts for 40% while coarse fodder and botanical fodder account for 25 and 35%, respectively. The daily bait amount in the morning and afternoon takes a percentage of 30 and 70%, respectively.

During the intercropping, the culturist should pay close attention to the growth of aquatic and control the water height and the aquatic density. When the temperature is too high, the culturist should moderately eliminate the aquatic and supplement of the carbon source, so as to avoid the water quality from the pollution by the massive death of the aquatic which are caused by the shortage of the carton source. From the end of August to September, the culturist needs to check the guard facilities to prevent the *Eriocheir sinensis* from escaping.

**Disease control:** The culturist replies mainly on ecology prevention with chemical control subsidiary and actively promotes *Eriocheir sinensis* ecological breeding technique in order to achieve the goal of no or less sickness and using no or less drug. Main means: Crablets can be bathed in potassium permanganate, salt or other chemical solution for 10-20 min’ disinfection. Every 15 days the pond need to use 75-150 kg/hm² quicklime at one time during the growing season, which can disinfect and prevent disease, improve water quality, adjust pH and increase calcium and aid the exuviation of the carb and shrimp. The water quality needs to be adjust by the probiotics every two weeks in the growing season. The crablets need to be fed with bait to add 0.5 g garlicin per kilogram one time a month, feed twice a day in three successive days. In addition, the fertilizer, aquatic, instruments and so on require frequent disinfection.

**RESULTS AND ANALYSES**

**Growth and output state:** From March to December, *Eriocheir sinensis* and other species are fished out one after the other. During that period, *Eriocheir sinensis* and *Myxocyprinus asiaticus* are growing in good condition without any extensive disease. Survival rate of *Myxocyprinus asiaticus* is 91.2%. The average weight of fish is about 997.8 g and the heaviest individual is 1120 g. The average weight of *Eriocheir sinensis* is 179 g. Each species’ output and output value of the three ponds are listed in Table 2.

**Analysis of the benefits:**

**Cost:** The total cost that was invested into the cultivation is 270,500 yuan, including 32,000 yuan juvenile *Eriocheir sinensis* payment, 11,000 yuan *Myxocyprinus asiaticus* fry payment, 8,000 yuan *Macrobrachium nipponense* larvae, *Siniperca chaotis* fry and siver carp fry payment, 50,000 yuan artificial compound bait payment, 19,500 yuan spiral shell payment, 20,000 yuan fingerlings payment, 40,000 yuan salary, water and electricity fees and aquacultural drugs payment, 80,000 yuan pond rent and 10,000 yuan the escaping prevention facility payment. The total cost of Pond 1 is about 139,100 yuan; Pond 2’s total cost is about 98,200 yuan; Pond 3’s total approximate cost is 33,200 yuan.
Output value: Total output value is 538,400 yuan, including 420,100 yuan *Eriocheir sinensis*, 20,900 yuan *Macrobrachium nipponense*, 8,300 yuan siver carp, 12,900 yuan *Siniperca chaunci* and 76,200 yuan *Myxocyprinus asiaticus*. The output value of these three ponds is, respectively: 248,100 yuan of Pond 1; 215,200 yuan of Pond 2; 75,100 yuan of Pond 3.

Profits: Profits of Pond 1 is 109,000 yuan, that is 35,505 yuan/hm\(^2\); Profits of Pond 2 is 117,000 yuan, that is 58,500 yuan/hm\(^2\); Profits of Pond 3 is 41,900 yuan, that is 62,537 yuan/hm\(^2\).

Input and output proportion: The input and output proportion of Pond 1 is 1:1.78; The input and output proportion of Pond 2 is 1:2.19; The input and output proportion of Pond 3 is 1:2.26. Through our analysis, we find the Pond 3 is the high-test in profit and input-output proportion, while Pond 2 and Pond 1 rank second and last respectively. *Myxocyprinus asiaticus* intercropping Pond 2’s profit is 22,995 yuan/hm\(^2\) more than Pond 1’s, reaching an increase of 64.77%; *Myxocyprinus asiaticus* intercropping Pond 3’s profit is 27,032 yuan/hm\(^2\) more than that of Pond 1, achieving an increase of 76.14%.

**DISCUSSION**

Intercropping mode: The large size mitten crab is much more expensive than middle and small size ones, so that cultivate large size mitten crab maximize the aquiculture profits. There are a lot of reports in respect of monoculture and polyculture mode of large size mitten crab with average weight from 138 to 182 g (Chen, 2008). In this test, stocking density of the *Eriocheir sinensis* is 7500/ha with average 8 g in body weight. After 250 days’ cultivation, the *Eriocheir sinensis’* average specification reaches 169 g in body weight with male one reaches 198 g and female one reaches 152 g and the average yield is 522 kg/hm\(^2\) (Fig. 3). *Macrobrachium nipponense* intercropped in the *Eriocheir sinensis* pond can eat leftover bait and they can be fished by turn, so as to release the *Eriocheir sinensis* pond’s burden and increase profits. Intercropping siver carp can control water plankton and intercropping *Siniperca chaunci* can control wild fish and shrimp scramble for bait. Both way can bring down the cultivation cost and increase extra profits. *Myxocyprinus asiaticus* is the most popular high added value aquiculture species. The gentle temper *Myxocyprinus asiaticus* is fond of peace. It swims slowly and lives at the middle or lower layer of water. The environment of the *Eriocheir sinensis* pond can satisfy their growth requirement. Intercropping *Eriocheir sinensis* with *Myxocyprinus asiaticus* can make full use of the water and the biological bait in the pond, so as to achieve the goal of being more efficient and increasing the output and profits. Through variance analysis, Pond 2 and Pond 3 that intercropped...
CONCLUSION

Myxocyprinus asiaticus fingerlings with average 10 cm length introduced from Chongqing municipality to Taizhou city, Jiangsu province can adapt to the water environment in Jiangsu area. After 250 day’s growth, their survival rate is 91.2% and the average weight of each is 997.8 g reached commercial specification. Profits of the Eriocheir sinensis pond that intercropped with Myxocyprinus asiaticus (900 strip/hm$^2$) is 62,537 yuan/hm$^2$ which is 27,032 yuan/hm$^2$ more than the control pond that is of 76.14% increase. The input and output proportion is increased from 1:1.78 to 1:1.26. Specification and output of Eriocheir sinensis in both the test ponds and the control pond are not obviously influenced.

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