

## Research Article

### Test of Intercropping *Myxocyprinus asiaticus* in the *Eriocheir sinensis* Pond

<sup>1</sup>Xiao-Jiang Chen, <sup>1</sup>Jian Wang, <sup>2</sup>Yong-Yong Zhu and <sup>1</sup>Jian-Sheng Ye

<sup>1</sup>Department of Aquatic Science and Technology, Jiangsu Agri-Animal Husbandry

Vocational College, Taizhou City, 225300, Jiangsu Province, China

<sup>2</sup>Chongqing University of Education, Chongqing, 400067, China

**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 specification, 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 environment 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 2<sup>nd</sup> pond and the 3<sup>rd</sup> pond is, respectively 750 and 900 fish/hm<sup>2</sup> 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 2<sup>nd</sup> pond is 342 kg/hm<sup>2</sup> and the 3<sup>rd</sup> pond is 405.75 kg/hm<sup>2</sup>. Compared with the contrast pond's 35,505 yuan/hm<sup>2</sup> net profit, the 2<sup>nd</sup> pond and the 3<sup>rd</sup> pond separately has 22,995 and 27,032 yuan/hm<sup>2</sup> 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 hm<sup>2</sup> 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 plenty (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 hm<sup>2</sup>) is the control group mainly cultivates *Eriocheir sinensis* auxiliary with *Macrobrachium nipponense*, siver carp and *Siniperca chautsi*, without *Myxocyprinus asiaticus*; Pond 2 (area: 2 hm<sup>2</sup>) and Pond 3 (area: 0.67 hm<sup>2</sup>) intercropping with *Myxocyprinus asiaticus* additional.

**Corresponding Author:** Xiao-Jiang Chen, Department of Aquatic Science and Technology, Jiangsu Agri-Animal Husbandry Vocational College, Taizhou City, 225300, Jiangsu Province, China, Tel.:+86-0523-86356598

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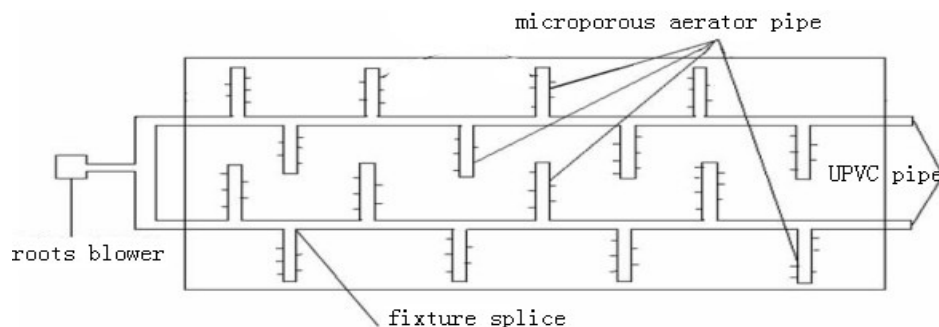


Fig. 1: Microporous aerator pipe pictorial drawing

Table 1: Water quality criteria

Criteria	pH	Concentration (mg/L)					COD <sub>Mn</sub>
		DO	Total Nitrogen (TN)	Total Phosphorus (TP)	Ammoniacal nitrogen (NH <sub>3</sub> -N)	Sulphide	
Water quality standard for fisheries (GB 11607-89)	6.5-8.5	≥5	-	-	-	≤0.2	-
Level III of environmental quality standards for surface water (GB 3838-2002)	6-9	≥5	≤1.0	≤0.2	≤1.0	≤0.2	≤6

With loam substrate, the pond possesses complete drainage and irrigation equipments, while the down-side 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 circumambience 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<sub>Mn</sub>, ammoniacal nitrogen (NH<sub>3</sub>-N) and so on.

**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<sup>2</sup> 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<sup>2</sup> and this amount can be changed according to the state of pool water and sullage. It can be replaced by 150 kg/hm<sup>2</sup> 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<sup>2</sup> 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<sup>2</sup>.

**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



Fig. 2: Fingerlings of *Myxocyprinus asiaticus*

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/m<sup>3</sup> potassium permanganate 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 *Myxocyprinus asiaticus* 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 7-8.5, ammonia nitrogen (NH<sub>3</sub>-N) <0.02 mg/L, nitrite (NO<sub>2</sub><sup>-</sup>-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' 4<sup>th</sup> 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

Pond	Area (hm <sup>2</sup> )	Stocking			Harvest				
		Stocking species	Stocking season	Average weight (g)	Stocking density (/ha)	Weight (Kg)	Unit yield (kg/hm <sup>2</sup> )	Unit price (Yuan/kg)	Output (Yuan)
No. 1	3.07	<i>Eriocheir sinensis</i>	Mar.	8 g	7,500 crab	1610	525	140	225,400
		<i>Macrobrachium nipponense</i>	May	2-3 cm	45 kg	322	105	35	11,270
		<i>Silver carp</i>	Mar.	250 g	300 fish	1518	495	3	4,554
		<i>Siniperca chautsi</i>	Jun.	5 cm	150 fish	230	75	30	6,900
No. 2	2	<i>Eriocheir sinensis</i>	Mar.	8 g	7,500 crab	1044	522	140	146,160
		<i>Myxocyprinus asiaticus</i>	Apr.	10 cm	750 fish	682.5	342	80	54,600
		<i>Macrobrachium nipponense</i>	May	2-3 cm	45 kg	204	102	35	7,140
		<i>Silver carp</i>	Mar.	250 g	300 fish	930	465	3	2,790
No. 3	0.67	<i>Siniperca chautsi</i>	Jun.	5 cm	150 fish	150	75	30	4,500
		<i>Eriocheir sinensis</i>	Mar.	8 g	7,500 crab	347	520.50	140	48,580
		<i>Myxocyprinus asiaticus</i>	Apr.	10 cm	900 fish	270	405.75	80	21,638
		<i>Macrobrachium nipponense</i>	May	2-3 cm	45 kg	71	106.50	35	2,485
		<i>Silver carp</i>	Mar.	250 g	300 fish	310	465	3	920
		<i>Siniperca chautsi</i>	Jun.	5 cm	150 fish	50	75	30	1,500

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 crabs' 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 carbon 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/hm<sup>2</sup> 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 crab 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 chuatsi* fry and silver 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 silver carp, 12,900 yuan *Siniperca chautsi* 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<sup>2</sup>; Profits of Pond 2 is 117,000 yuan, that is 58,500 yuan/hm<sup>2</sup>; Profits of Pond 3 is 41,900 yuan, that is 62,537 yuan/hm<sup>2</sup>.

**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<sup>2</sup> more than Pond 1's, reaching an increase of 64.77%; *Myxocyprinus asiaticus* intercropping Pond 3's profit is 27,032 yuan/hm<sup>2</sup> 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 aquaculture 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*'s 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<sup>2</sup> (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 silver carp can control water plankton and intercropping *Siniperca chautsi* 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 aquaculture 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



Fig. 3: *Myxocyprinus asiaticus* after 250 days cultivation

*Myxocyprinus asiaticus* and Pond 1 (control group) has no remarkable differences in aspect on the *Eriocheir sinensis*' specification and output ( $p < 0.05$ ), which can prove that the specification and yield of *Eriocheir sinensis* is not affected by *Myxocyprinus asiaticus* intercrop.

**Large size *Myxocyprinus asiaticus* fry can shorten the cultivation period:** Ma J.G. intercropped *Myxocyprinus asiaticus* of about 15 cm length in the adult fish pond with density of 750-825 fish/hm<sup>2</sup>. After 240 days growth, its average survival rate and commodity rate is respectively 89.05 and 100% and yield reaches 697.5 kg/hm<sup>2</sup>; Intercropping 3-5 cm length *Myxocyprinus asiaticus* fry, its average survival rate decrease to 79% and commodity rate is down to 89 (Ma, 2010). 72500 fry and fingerlings of *Myxocyprinus asiaticus* in the length of 5-7 cm were released into Yangtze River by Wang (2004) and it reached 350-450 g at the end of the year, 1000 g in July 2006 (Wan *et al.*, 2007). This test chose *Myxocyprinus asiaticus* fry with average 10 cm in body length, after 250 days cultivation, the average survival rate is 91.2% and commodity rate is 100%. The stocking density of Pond 2 and Pond 3 is separately 750 and 900 fish/hm<sup>2</sup>. Per unit yield of the *Myxocyprinus asiaticus* is, respectively 342 and 405.75 kg/hm<sup>2</sup> with average 997.8 g in body weight. It is lower than the yield of Ma's test but higher than Wan's test. Hence, the fry size is one of their main influencing factors.

**Build a good ecological environment to prevent diseases occurrence:** There is no extensive disease occurred during the test, which relies on the perfect prevention study and improving the marine ecological environment. Disinfect the ponds thoroughly before stocking crablets and fingerlings; Set down reasonable stocking density; Adjust the water periodically with probiotics; Turn on microporous aerator frequently to maintain the water with sufficient dissolved oxygen; Manage and Control the growth of the aquatic plant; Add Vc, rhubarb, scutellaria, cortex phellodendri, immune polysaccharide, garlicin and other medicine in bait during the high disease incidence season (June to October) to strengthen its own immunization for preventing disease.

## 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<sup>2</sup>) is 62,537 yuan/hm<sup>2</sup> which is 27,032 yuan/hm<sup>2</sup> 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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