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Shrimp farming in greenhouses: a profitable model to culture *Penaeus vannamei* in China

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Shrimp farming in China has made great progress since the turn of the millennium. From marine areas to fresh water, from south to north, from east to west – even in the highlands of Xinjiang province – the important and popular vannamei (whiteleg shrimp) has seen production increase from 848,400 tonnes in 2002 to 1.3 million tonnes in 2012. With its 1.4 billion-strong population, China has still become a net shrimp importer, as local farmers can't meet the domestic demand. Lower shrimp supply means higher shrimp prices in the market, especially during the winter season where temperatures in China are very low, and commercial shrimp can't be farmed with traditional methods in regular ponds.

Guangdong is one of the most important provinces for commercial vannamei farming, with total production accounting for more than 55 percent of the national output in 2012.

Within Guangdong, the Pearl River Delta is the traditional aquaculture region, and owing to its superior geographic location, plentiful water supply, relatively high temperatures, skilled farmers and strong aquaculture service infrastructure, it leads the development of shrimp cultivation in China. The marine, brackish and freshwater areas of the Delta allow for a wide variety of shrimp farming models, and in freshwater farming specifically, it acts as a bellwether for practices across the country. Already, techniques developed in the Pearl River Delta have been applied to other inland river areas of China.

However, the progress of shrimp farming in the area has been beset with problems in the past decade of growth, including degener-

the offending diseases are directly or indirectly caused by new trends in rainfall, wind and temperature, which implicates climate change as another threat to shrimp farmers' profits and livelihoods.

Greenhouses: a departure from the usual model

So, how to keep winter shrimp farming delivering high survival rates and good returns on investment? To achieve this dream, the hard work of farmers and feed enterprises has pointed to a new way of shrimp cultivation in the Pearl River Delta. More and more farmers are doing their winter vannamei farming in greenhouses. The facilities, which are also known as winter-houses, white-houses or

Table 1: Materials and specifications for greenhouse construction

Material	Specification
Wood column	Main column: 6m/pc, side column: 4m/pc, side piling: 1m/pc, beams: 4m/pc
Plastic film	Thickness: 0.7~0.8mm
Steel rope	Diameter: 0.24~0.26cm, 7 pieces of steel wire tightened
Iron wire	12#(to bind woods)/14#(to bind bamboos)/18#(to fix steel ropes)
Miscellaneous	Sand bags, bamboo canes, nails, steel rope puller, pliers, heavy hammers, etc.

ation of seeds, over-intensive and unscientific farming practices, the increasing cost of feed and land, the threat of disease, and the fluctuating market price for commercial shrimp. In the past two years, Early Mortality Syndrome (EMS) has hit the Chinese shrimp industry hard, and 2013's bad shrimp broodstock and post-larvae quality has exacerbated the situation. Because of China's clearly defined four seasons, some of the poor success rate for shrimp farming should also be attributed to climate change. New research indicates that

warm-houses, are mainly constructed with plastic film and wooden columns, which has so far proved the most effective way to improve operational performance.

The main difference between the new greenhouse technique and traditional cultivation systems lies in temperature control. Normally the suitable temperature for vannamei shrimp is between 15 and 34 °C, and water temperature should be between 28 and 32 °C. At water temperatures below 18 °C, shrimp stop their feed intake and are

Figure 1: Working procedure for greenhouse construction

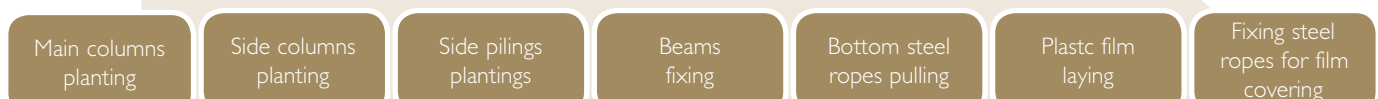
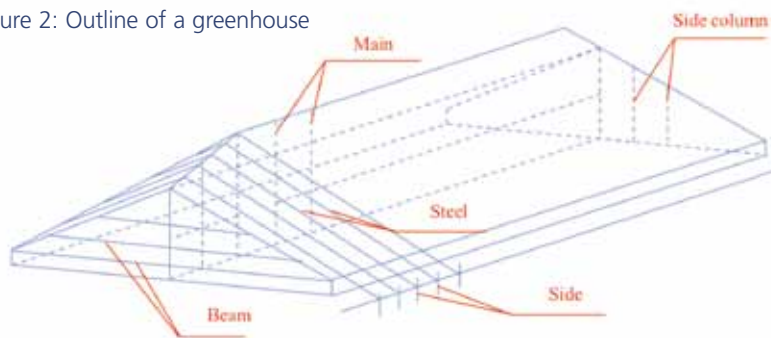


Figure 2: Outline of a greenhouse



greater investment. Moreover, the harvest of greenhouse-reared shrimp will be smaller, albeit bringing better prices. Greenhouse shrimp are always harvested in the spring or early summer, when there are very few shrimp on the market. For this reason, successful greenhouses can command high prices and make good profits. Shrimp of 120–140 pcs/kg, for instance, will cost around 14 yuan/kg. Another obvious difference from the usual model is the longer cultivation period: the first harvest begins more than 90 days into the total period of 120–180 days. Finally, the total cost of shrimp grown with this method is typically 4–6 yuan/kg higher.

Building a shrimp greenhouse

A high quality greenhouse requires a high wind loading rating, good heat conservation and reasonable costs. These requirements determine the materials and working procedure used for construction. Essential materials are listed in Table 1.

After preparation of the materials, construction proceeds according to Figure 1.

Technical points for farm management

Pond conditions: A rectangular or square pond, far away from high voltage power lines, with south-north orientation and an area of 0.53–0.8 ha is most suitable for health vannamei

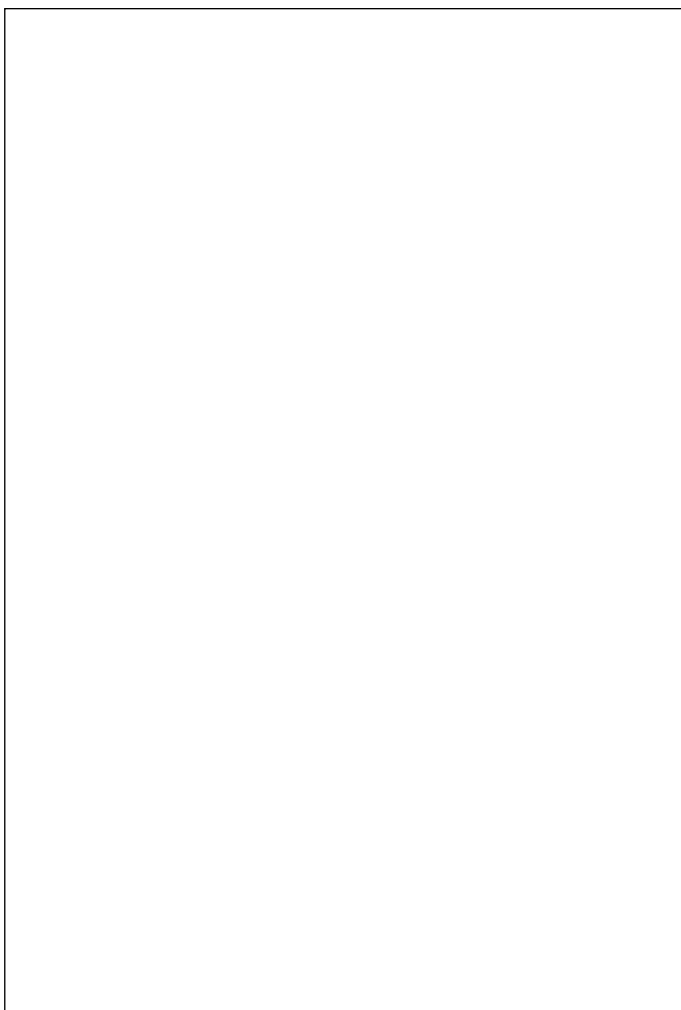
in danger of freezing to death. In the winter, the temperature at the Pearl River Delta is commonly between 10 and 25 °C, and regularly below 18 °C at night. Outside of greenhouses, where water temperature is

generally between 18 and 28 °C, vannamei therefore can't be grown naturally.

The post-larvae stocking density is higher in greenhouses than regular farms, requiring a higher level of dissolved oxygen as well as



Figure 3: Bird's eye view of a greenhouse



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growth. Meanwhile, sufficient supply of river and salt water should be guaranteed. It is also better for the shrimp if the pond bottom is neutral or alkaline, containing silt or mixed sand and mud.

Aeration: Impeller and waterwheel

aerators are usually applied together in shrimp ponds, and the power configuration is around 1.5 kW/mu. Generally, from the 0–10 day period, one set of aerators is required to run all day. After 10 days an

additional set is needed for nighttime until day 20. From days 20–40, two sets are required during the day and three sets at night. Between days 40 and 60 this increases further to three and four aerators respectively, and after that, the units should be kept running all day.

However, aerator usage is dependent on weather conditions and the level of dissolved oxygen in the water. For this reason, operators should be flexible when it comes to deploying them. Sometimes oxygenation is needed for high shrimp densities or for rainy nights, or to remedy high nitrite levels or poor water quality.

Ventilation: In early winter water temperature is higher than air temperature. Because of this, the greenhouse should not be totally enclosed with film, and air inlets and outlets should be made for air circulation. If during the course of cultivation the water temperature reaches 24–25 °C, and greenhouse air temperature reaches 28–30 °C, the air inlets and outlets should be opened or the film covering should be dispensed with altogether. This ensures good ventilation and dissolved oxygen levels by improving aerator function.

Film maintenance:

After heavy rain, water can gather on top of the greenhouse's plastic film covering. It should be checked periodically and precipitation removed to keep it in good shape. Broken plastic film can't protect the shrimp inside, a particular problem in February when ground

heat dissipates before the onset of the rainy season.

Harvest: Dragon-shaped cages are an effective tool for partial harvest in greenhouses, as they do little damage to the ponds themselves. The cages are set up as follows: a loop of dragon-shaped cage is laid 2 metres away from the pond sides and feed is spread within its limits. After half an hour the cage is collected, taking with it a maximum harvest of around 50 kilos per cage, although yields of 15–25 kilos are more usual. The second application of the cage generally gains 10–20 percent of the initial 'catch'.

Partial harvest is the usual way to gather greenhouse-cultivated shrimp. A common way of scheduling batches is as follows:

- First harvest after 50–60 days, yield 750–1,500 kg/ha
- Second harvest after 60–70 days, yield 1,500–2,250 kg/ha
- Final harvest after 70–80 days, either with electronic net or continuing partial harvest method

Cost: The cost of modifying a common pond is higher owing to structural materials and labour. However, initial investment is greatly offset by the high price fetched by shrimp in winter, when supply from traditional farms is low.

Conclusion: environmental factors key to success

Compared with usual shrimp farming habits, with winter greenhouse farming a shrimp pond can yield three crops in a year, making greenhouses an attractive option for farmers trying to maintain year-round cashflow. The ponds are fully utilised and production is consequently increased. These advantages do not take into account the great boost to profits delivered by harvesting before or after the shrimp sales peak. Moreover, greenhouses can effectively protect shrimp from rainfall, reducing morbidity and improving product quality.

With the success seen in South China, the greenhouse model has been accepted in several shrimp farming areas in East China, Jiangsu, Shanghai and Zhejiang. Farmers in those areas build the greenhouse in early spring, and stock their ponds with shrimp post-larvae from February, three months earlier than the traditional method. As a result their shrimp can usually go to market in June with very attractive prices. The greenhouses used in East China are smaller than in South China for easier management, and with high success rates for shrimp producers, they are becoming more and more popular.

Greenhouse cultivation could effectively extend the shrimp farming season into the winter and spring months where water temperatures drop below 18 °C, with the associated boost to aquaculture producers' profits. However, there are some problems threaten-



Figure 4: Main columns



Figure 5: Side columns



Figure 6: Greenhouse beams



Figure 7: Side pilings

Table 2: Cost analyses of shrimp culturing in greenhouse in Pearl River Delta

Pond information			
Area/Depth	8mu/pond (0.53ha/pond), water depth is 0.8m, 5 aerators		
Culturing period	Nov. 1, 2011 Apr. 2, 2012, 150days in total		
Post Larvae	400,000PL with 1cm body length. 16.8yuan/1000PL (USD2.75/1000PL)		
Output			
Average size	Production	Farm gate price	Sales Volume
100pcs/kg	2,950kg	40yuan/kg (USD6.56/kg)	118,000yuan (USD19,344)
Farming analysis			
1. High quality feed for Vannamei with FCR 1.3			
2. Feed cost: 1.3*8yuan/kg=10.4yuan/kg. Post larvae: 2.28yuan/kg (USD0.37/kg). Labor: 4yuan/kg (USD0.66/kg). Water and electricity fee: 3yuan/kg (USD0.49/kg). Animal protection cost: 1.6yuan/kg (USD0.26/kg). Pond rent: 1400yuan/mu*12months, 1.58yuan/kg (USD0.26/kg). Greenhouse construction cost: 3000yuan/mu*5years, 1.63yuan/kg (USD0.27/kg). Plastic film cost: 1000yuan/mu, 2.71yuan/kg (USD0.44/kg). Other depreciation expense: 10000yuan/8mu, 3.39yuan/kg (USD0.56/kg). The total cost is about 30.59yuan/kg (USD5.01/kg). The net profit is round 9.41yuan/kg (USD1.54/kg).			
3. Shrimp size could reach 100pcs/kg in 150days with a survival rate of 73.75%.			
4. The average production is 368.75kg/mu (0.55kg/m2 or 5,531.25kg/ha).			
5. The net profit is 9.41yuan/kg*368.75kg/mu=3469.94yuan/mu (USD 8,532.64/ha), the total net profit for 8mu (0.53ha) is 27,759.5yuan (USD4550.74).			

Case study

Zhongshan

The greenhouse farming model described above has been applied since 2010 by Mr Zheng, a shrimp farmer in Zhongshan in Guangdong province. In 2011, Zheng turned a profit of around 3,500 yuan/mu (US\$ 8,500/ha). A detailed breakdown of cost, revenue and profit is given in Table 2.

It has been reported that Zheng achieved a better harvest in 2012, producing 11,250 kg/ha of shrimp with a farm gate price of 50 yuan/kg (US\$ 8.20/kg) and a size of 90 pcs/kg. Although plenty of farmers are still sitting on the fence given the required level of investment and technical expertise, some farmers are trying to replicate Zheng's success.

ing greenhouse farming, the greatest headache of all being low quality shrimp post-larvae.

High investment doesn't make the pond any easier to manage, and since the greenhouse model is a new one some farmers struggle to adapt to its demands, which include the longer cultivation period, and day-

to-day challenges like higher larvae stocking density, and more complicated climate and water quality management.

More research is required to ensure stable water quality in the future. The service teams of Guangzhou Hinter Biotechnology and feed cooperatives are engaged in these projects as part of their supply of service and solutions to shrimp farmers. The following points should be noted:

- Choose high quality post larvae. It seems that some F1 post larvae of the imported bloodstock haven't performed well in 2012 and 2013.
- It is easy to allow oxygenation levels in pond water to drop. Since the greenhouse is covered with a plastic film, a layer of water vapour will form which may affect sunlight shining into the facility. This will weaken the photosynthesis effect within the pond, slowing phytoplankton growth and reducing the input of oxygen to the system. In addition, the plastic film prevents the exchange of air inside and outside the greenhouse, again influencing the volume of dissolved oxygen in the shrimp habitat.
- Too much water exchange may dramatically influence water temperature. However, when too little water is allowed to enter the pond from outside, a harmful monoculture of algae can

develop. Worse still, extreme weather like snowstorms, hail and typhoons can damage or destroy the greenhouse.

- Water quality tends to be diminished by high levels of ammonia nitrogen and nitrite during the later stages of cultivation. If this is not controlled, shrimp will develop problems at these stages.
- Try to maintain water quality with prebiotics and probiotics. For food safety reasons, prohibited medicines shouldn't be used.
- For sustainable development, ensure reasonable amounts of water are being used for shrimp farming, and carry out water treatment for its discharge. Polyculture and mixoculture can make use of some of the waste water.

More information:

Ju Peng, Dong Quifen, Dr Zhang Song and Dr Yang Yong are experts in aquaculture health and nutrition from Guangzhou Hinter Biotechnology. As the biggest aquafeed premix supplier in China, Hinter delivers a whole practical solution for mills, helping them produce high quality aquatic feeds.

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