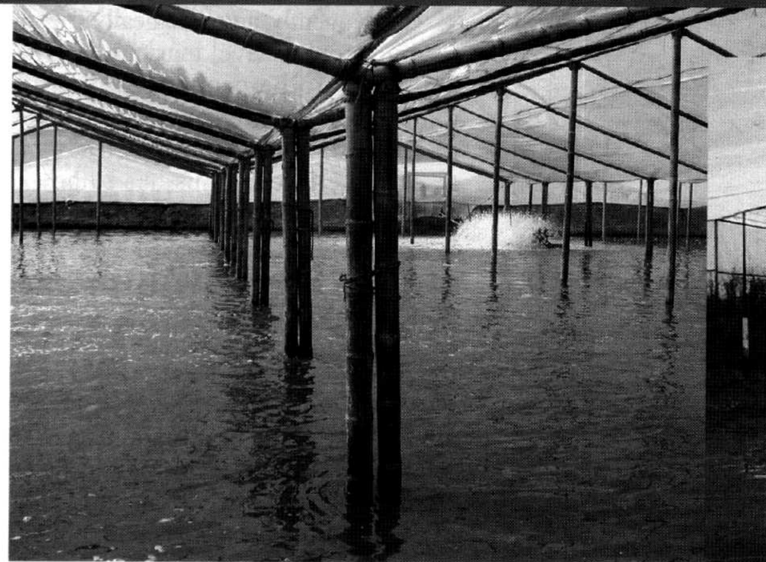

Pond covers built with bamboo poles (left) are functional and initially inexpensive, but may not last as long as covers constructed with more permanent materials.

Greenhouse Systems Promising Technique Against WSSV in Ecuador

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Researchers at Ecuador's Centro Nacional de Acuicultura e Investigaciones Marinas (National Center for Aquaculture and Marine Research, CENAIM) and elsewhere have documented the effects of hyperthermia on the immune systems of Pacific white shrimp, *Litopenaeus vannamei*, and their survival when challenged with White Spot Syndrome Virus (WSSV). Greater survival and response of cellular defense mechanisms (including increased haemocytes and tissue infiltration, and cell pyknosis and karhyorrexis) were the primary observations reported in these studies of WSSV-infected shrimp at water temperatures above 32° C.

Greenhouse Pond Systems

Based on previous laboratory evidence, CENAIM researchers undertook a series of shrimp production tests in 0.05- and 0.25-ha greenhouse-earthen pond systems. The Council of Flemish Universities in Belgium provided financial support for the project.

The first production results were reported in the August 2002 *Global Aquaculture Advocate*. Yields of 1,500-3,000 kg/ha/cycle with survivals of 63-70% at stocking densities of 24-42 shrimp/m^2 encouraged further production cycles. A total of 20 nursery and nine growout production experiences were carried out in greenhouses until June 2003.

Several commercial shrimp farms started pilot greenhouse projects during 2002 to verify the findings. At present, an estimated 200 ha of shrimp ponds are covered with greenhouse structures in Ecuador.

Greenhouse Structures

The main differences in greenhouse designs involve the type and quality of construction materials. The most economical designs use bamboo structures with construction costs that range U.S. \$1.20-1.50/m^2. Their durability and maintenance costs will be determined in the next few months.

Concrete and metallic structures are more expensive, but stronger and more durable. They provide better support for the plastic film covers. Drainage of rainwater and resistance to wind are key elements to be considered in material selection and structural design. Investments for the more permanent structures run U.S. \$2.00-6.00/m^2, but can be amortized over a longer period.

CENAIM's greenhouse production trials were carried out at the commercial Pesglasa shrimp farm, located in the Taura region of Ecuador's Guayas Province. The CENAIM greenhouse structure designs there are based on concrete, PVC-protected metal columns, and polypropylene ropes. Building costs were U.S. \$1.80-2.00/m^2, depending on pond size.

Cover Material

Greenhouse designs and the plastic polymer material used to cover the greenhouses need to be improved to allow maximum heat gain and reduced heat escape. The thermal polyethylene polymers commercialized in Ecuador are formulat-

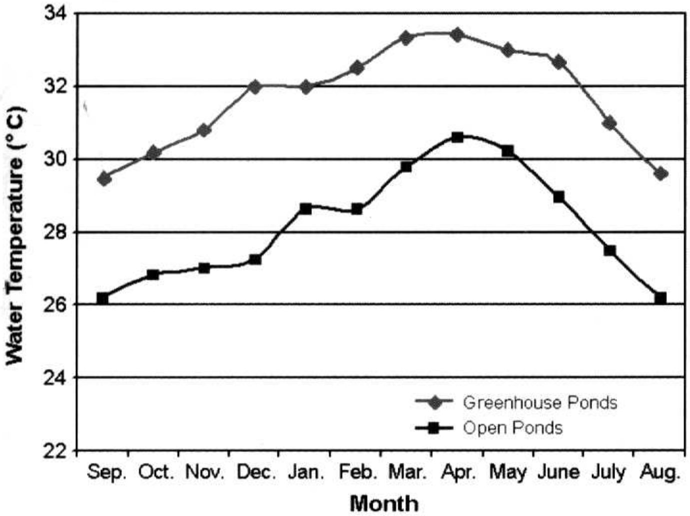

Figure 1. *Monthly water temperatures registered in greenhouse-earthen ponds and open ponds.*

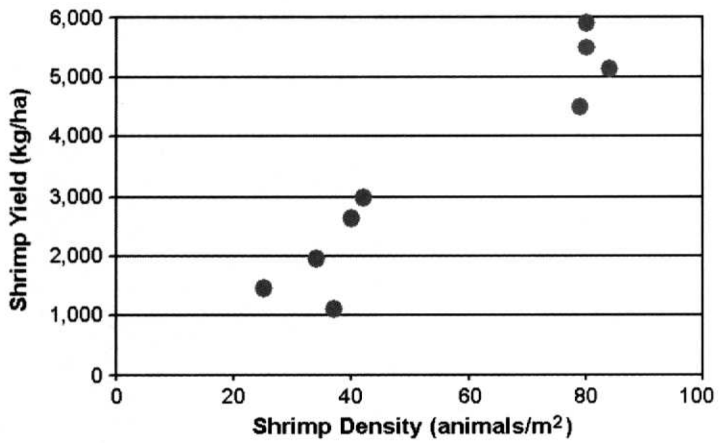

Figure 2. *Relationship of shrimp yield and stocking density in greenhouse shrimp growout production trials.*

ed mainly for horticulture temperature, moisture, and luminous conditions.

Properties of greenhouse polymers for shrimp culture should be based on maximum transparency for visible light radiation and retention of short- and long-wave infrared radiation. Dust accumulation on the outside and water condensation inside reduce light penetration, thus hindering heat gain by the water body enclosed. Illumination records showed a 30-40% light reduction inside a CENAIM greenhouse.

Water Temperature

The temperature difference between open ponds and greenhouses ranged 3.5-5° C on average, depending on season and daily weather conditions (Figure 1). The water temperature curve followed an annual pattern, reaching values of 32° C and more from December to June. The lowest temperatures occurred during the southern winter season, which is characterized in Ecuador by prolonged cloud coverage.

Temperatures below 31° C may pose a risk for WSSV outbreaks. However, mortalities associated with WSSV were not documented during this part of the year in production trials. At least one farmer reported WSSV-associated mortalities as greenhouse temperatures dropped below 31° C.

The authors expect that improvements in polymer properties could result in the 1-2° C water temperature gain required for the colder season. Through a joint project with Repsol YPF, Spain's largest oil company, CENAIM is currently evaluating the effect of four different polymer formulations on water temperature.

Natural Productivity, Oxygen and Water Quality

Supplemental aeration to each of CENAIM's 0.25-ha greenhouse-earthen ponds was provided through an 8-hp paddlewheel aerator. The systems operated continuously throughout the production cycle.

The effectiveness of aeration management on dissolved oxygen levels could not be established because primary productivity levels were relatively high, as evidenced by the diurnal cycles of dissolved oxygen occluding the external aeration supplement. An apparent negative effect of plastic cover or elevated water temperatures on natural productivity in the greenhouse structures was therefore not evident. Oxygen levels below 3 mg/l were rare, and almost never dropped below 2 mg/l. Total ammonia levels were relatively low and always below 1.2 mg/l.

Production Results

Production results showed a strong correlation between shrimp density and final yield (Figure 2). Stocking densities in the nursery phases varied 16-275 postlarvae/m^2, reaching productions of 748-5,255 kg/ha, while yields in the growout phase (8-10 weeks after transference) ranged 1,113-5,900 kg/ha with stocking densities of 25-84 shrimp/m^2. Final survivals in both production phases were independent of shrimp densities. Average shrimp growth was 0.8 g/week.

The value of greenhouse production was evidenced when shrimp in surrounding open ponds were continuously affected by WSSV mortality outbreaks, while those in greenhouse ponds were not.

Conclusion

The value of greenhouse production was evidenced when shrimp in surrounding open ponds were continuously affected by WSSV mortality outbreaks at different levels of intensity, while those in greenhouse ponds were not.

Greenhouse structures maintained water temperatures 3-5° C above open pond temperatures. Greenhouse pond water reached temperatures of 29-32° C during the colder July-November season, which may still pose a risk for WSSV outbreaks. Although only 60-70% of visible light passed through the greenhouse plastic film used, it did not affect natural primary productivity.

Production levels were density-dependent, while survivals were not. Production up to 5,900 kg/ha was achieved in the greenhouse-earthen pond structures.