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Domestication of Pacific white shrimp revolutionizes aquaculture

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Faster growth and disease resistance fuel a worldwide phenomenon



The traits of fast growth and disease resistance have established domesticated white shrimp as the world's top cultured shrimp species.

Shrimp farming has a long and colorful history whose development can be divided into three distinct periods: Start-Up Era, Hatchery Era and Breeding Era. Key characteristics of these periods are summarized in Table 1 and Fig. 1.

Wyban, Characteristics of shrimp-farming, Table 1

Era	Years	Annual Production (x 1,000 mt) Start	Annual Production (x 1,000 mt) Finish	Growth Rate Gain	Growth Rate (%/Year)
Start-Up	1982-87	84	604	520	103%
Hatchery	1988-96	604	693	89	2%
Breeding	1997-present	693	2,000	1,307	21%

Table 1. Characteristics of shrimp-farming eras.

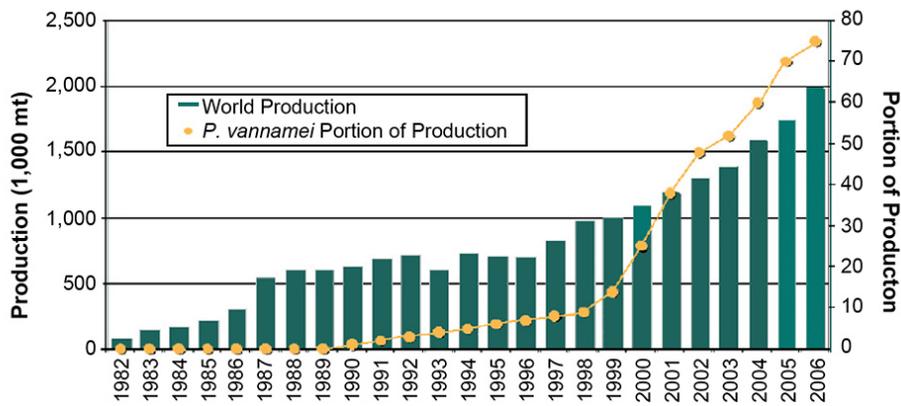


Fig. 1: Domesticated *P. vannamei* contribution to world production of farmed shrimp, 1982-2006.

Start-up era

During the Start-up Era of the 1980s, nearly all stocking material was wild postlarvae gathered from the sea. In Asia, farms raised primarily black tiger shrimp (*Penaeus monodon*), while in the Western Hemisphere the industry used Pacific white shrimp (*P. vannamei*). During this era, annual production increased over 100 percent per year. Growth was driven by the combination of very strong market acceptance and demand for farmed shrimp, and a relative absence of disease that allowed simple pond culture methods to succeed.

Hatchery era



Specially bred broodstock have largely replaced wild animals as sources for quality postlarvae.



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During the 1988-1996 Hatchery Era, postlarvae (PL) were produced in land-based hatcheries. While cultured, these PL were genetically wild animals because the parents were collected in the sea. Shrimp farming in the West was dominated by *P. vannamei* production, while Asian farming was dominated by *P. monodon*.

Asian shrimp production was at least five times greater than Western production throughout this era, so production statistics were dominated by *P. monodon*. Total world production rose from 604,000 to 693,000 metric tons (MT), with an average annual gain of only 2 percent.

The main obstacle to growth was widespread shrimp disease that moved through the industry with the hatchery-produced PL, because the hatcheries paid little attention to animal biosecurity. Diseases carried by wild broodstock were passed to the PL offspring in the hatcheries, then introduced to farms when the PL were stocked.

The other obstacle to growth was the continued reliance on wild animals. During this period, shrimp farming production reached an effective “carrying capacity” for the use of wild shrimp. While farmers tried to use higher stocking densities to increase yields and profits, their wild animals – which often carried disease – were not well suited to intensive culture systems.

Breeding era

The Breeding Era, from 1997 to the present, saw a resumption of growth, which jumped to more than 20 percent per year for more than 10 years. This rapid industry growth was primarily driven by the domestication, breeding, and worldwide spread of *P. vannamei* from the West into Asia. World shrimp farming production using *P. vannamei* expanded from only 10 percent of total production in 1998 to 75 percent of total world production in 2006. Thailand’s shrimp revolution, characterized by the use of domesticated *P. vannamei* bred for faster growth and disease resistance, perhaps best illustrates the worldwide white shrimp phenomenon.

Economic impacts

The use of domesticated stocks has allowed farmers to continually refine their systems to optimize production economics based on market demands and pricing. Domesticated stocks have generally reduced disease episodes and the “gambling” nature of shrimp farming typical of earlier eras. Domestication has also allowed corporate investment in the industry and a general industry consolidation.

Because of the great increases in production resulting from the use of domesticated *P. vannamei*, shrimp farming is now suffering from its own success. Shrimp prices have declined substantially as a direct result of the tremendous gains in supply.

Viral resistance

Development of specific pathogen-free (SPF) *P. vannamei* in the United States in the early 1990s led to dramatic increases in U.S. shrimp farming production. Following initial production trials, the entire U.S. shrimp industry was stocked in 1992 with PL derived from SPF *P. vannamei* broodstock cultured in Hawaii. Production doubled as a direct result of this innovation and persisted through 1995.

But by 1996, Taura Syndrome Virus (TSV) marched through Central America and struck a deadly blow to the Texas, USA, industry, dropping production by 50 percent. While devastating to farmers, this disaster was the second major event in the history of *P. vannamei* domestication – U.S. shrimp farmers asked researchers to develop shrimp resistant to this virus. While many scientists were skeptical that virus resistance could be achieved using selective breeding, several groups initiated programs to do just that.

High Health Aquaculture, Inc., one of the world leaders in shrimp domestication and scientific breeding, initiated a breeding program to develop fast-growing, TSV-resistant *P. vannamei* in 1997. To date, 10 generations of selection have been completed.

High Health uses a combination of family and within-family selection and line-crossing to produce hybrid stocks that are both fast-growing and TSV-resistant. Its most advanced SPF stocks are now commonly used in Thailand and Indonesia.

Economics

Domestication and breeding of *P. vannamei* have significantly improved the economics and reliability of shrimp farming. The driving force in Asia's switch to *P. vannamei* was based on the much higher profits achieved with *P. vannamei* compared to *P. monodon* (Table 2).

Wyban, Production parameters and profits, Table 2

Parameter	<i>P. monodon</i>	<i>P. vannamei</i>	Difference
Density (PL/m ²)	40-50	120-200	300%
Crop duration (days)	110-140	105-120	27%
Harvest size (g)	22-28	21-25	5%
Yield (mt/ha/crop)	8	24	300%
Crop value (U.S. \$/ha)	\$45,000	\$96,000	220%
Crop costs (U.S. \$/ha)	\$32,000	\$60,000	187%
Profit (U.S. \$/ha)	\$13,000	\$36,000	280%

Table 2. Production parameters and profits of typical *P. monodon* and *P. vannamei* culture systems in Thailand.

With the continuing decline in shrimp prices caused by increased supply, farmers need to lower their costs of production. The biggest opportunity to lower costs is through the use of top-quality seedstock that carry high-performance genetics, are free of disease, and are cultured under optimum hatchery conditions to maximize their growth potential.

Domestication and breeding, and the subsequent adoption of *P. vannamei* in Asia added tremendous value to the world shrimp industry. During the Hatchery Era, the annual shrimp production of nearly 700,000 MT per year had a total crop value of about U.S. \$3.5 billion, based on an average price of \$5 per kilogram. Despite declining prices from increased supply, shrimp production today is worth more than \$6.0 billion, based on a worldwide price of \$3 per kilogram.

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