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Artemia, the ‘magic powder’ fueling a multi-billion-dollar industry

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By James Wright

Hatcheries depend on the brine shrimp *artemia* — microscopic creatures facing climate change and overharvesting threats — as feed in larviculture. Innovation is facing the challenge head on.

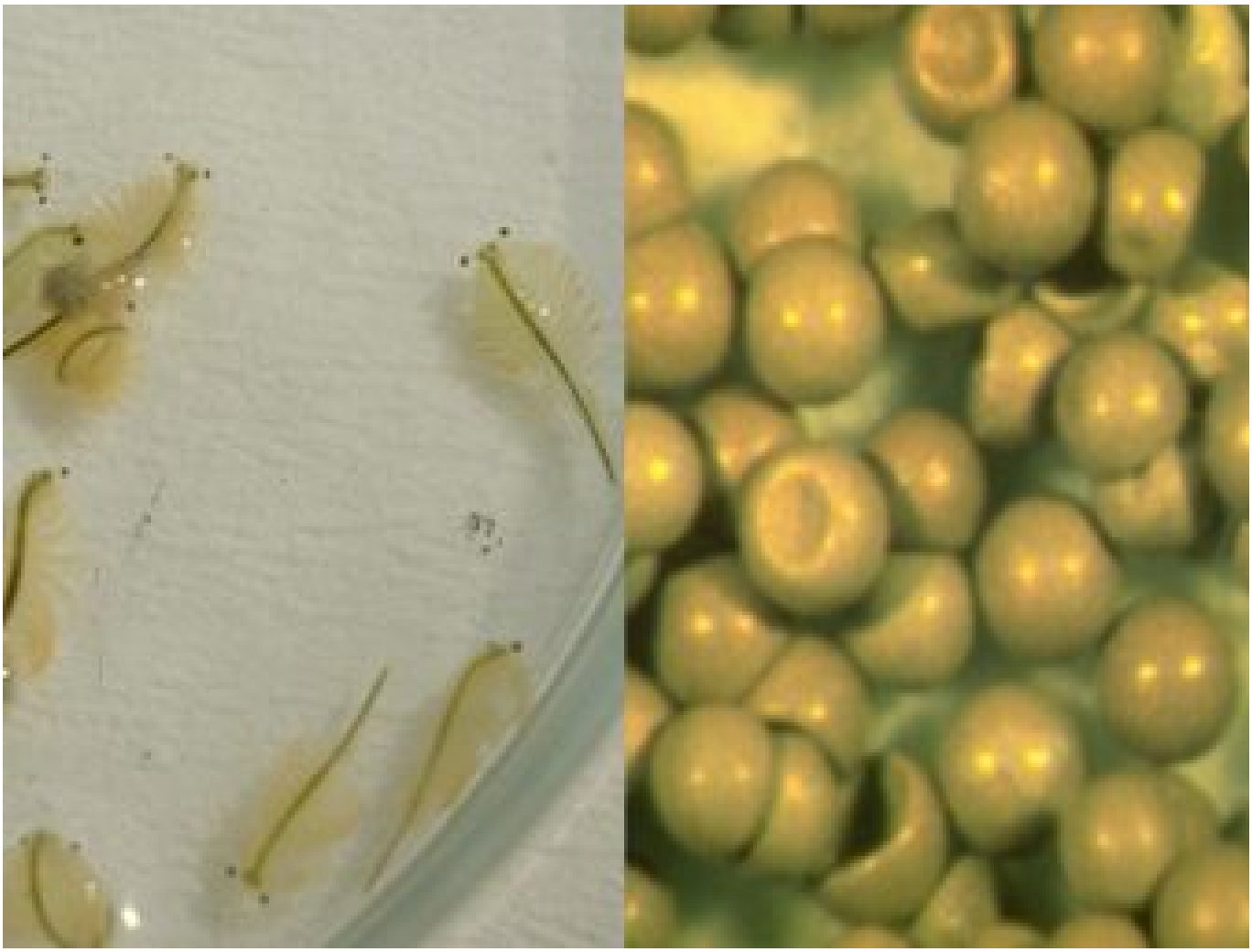
Some salt farmers in Vietnam also produce artemia, microscopic brine shrimp that aquaculture hatcheries use as feed. Photo courtesy of Patrick Sorgeloos.

They appear, to the untrained eye, as fine grains of sand. About a quarter-million artemia – tiny brine shrimp that can exist in spherical eggshells, or cysts, in a state of zero metabolism for decades – together weigh about one gram.

Dried artemia cysts, measuring 250 to 300 microns (0.2 to 0.3 millimeters) in diameter, look like deflated capers under the microscope. But these incredibly unique animals, which are endemic to the world’s salt lakes and which in a seeming miracle of nature spring to life when added to saltwater, are the worker ants of aquaculture, quietly fueling a multi-billion-dollar global industry that now produces half of the world’s seafood.

Experts say that populations of artemia – currently facing threats from overharvesting and climate change, but gradually becoming a secondary crop for salt farmers in Southeast Asia – have played an essential role in making aquaculture what it is today. A half-century after a bulk, dry product first became commercially available in cans, newly hatched artemia nauplii remain the best and most nutritious “live diet” for the youngest stages of larval fish and crustacea.

Conservation of artemia has never been more important, as the aquaculture industry continues its pace



Under the microscope: The live, or biomass, form or artemia can be seen at left, while the image on the right is a view of dry artemia cysts. Photos courtesy of Patrick Sorgeloos.

as the world’s fastest-growing food sector and places growing demands on a precious resource. Consequently, artemia consumption has increased 30-fold since 1980, to current levels of 3,000 metric tons per year.

“Artemia is an essential live food source in hatcheries for shrimp and marine fish. You will see that practically all the hatcheries are using it. A few have gone away from artemia, using only artificial diets, but at this moment, and in practically all cases, it’s at the expense of the quality of the fry being produced,” said Patrick Lavens, new business development and innovations director at INVE Aquaculture, a Benchmark Holdings company with offices in Belgium, Thailand and Salt Lake City, Utah.

Innovation leads to efficiency

It’s in Utah’s Great Salt Lake where the world’s healthiest artemia resource can be found, according to many experts, including Patrick Sorgeloos, professor emeritus at the **University of Ghent**

These cans were among the first commercialized forms of artemia, produced in the 1960s. Photo courtesy of Patrick Sorgeloos.

(http://www.aquaculture.ugent.be/index.htm) in Belgium. The population there is under the purview of the state Division of Wildlife Resources and is widely regarded as the best-managed artemia resource in the world. The **Great Salt Lake Brine Shrimp Cooperative** (http://www.gsla.us), based in Mountain Green, Utah, is the largest harvester and processor.

Until about 25 years ago, the Great Salt Lake was the predominant commercially viable source of artemia, accounting for 90 percent of the global supply, according to Philippe Léger, CEO of INVE. New sources were found in the mid-1990s, he added, and today the Great Salt Lake supplies between 35 and 50 percent of the world harvest with Russia, Kazakhstan and China accounting for most of the remainder.

[Editor's note: Sorgeloos, Lavens and Legér are among the world's foremost artemia experts and three of the five authors of the "Manual for the Culture and Use of Brine Shrimp Artemia in Aquaculture," prepared for the United Nations Food and Agriculture Organization (FAO) in 1986.]

Sorgeloos, who retired three years ago but remains involved in research and expert workshops administered by FAO, completed his Ph.D. on artemia more than 40 years ago, and was involved with the formation of the FAO Artemia Reference Center in 1978 after a severe shortage was noted in the 1960s. **At a technical conference on aquaculture in Japan in 1976** (http://www.fao.org/docrep/005/AC863E/AC863E00.htm), many feared there was no future for artemia. How could we develop aquaculture in Asia if small-scale farmers there had to rely on a product from the United States?

That was before new sources of artemia were located in Siberia and Central Asia, and before intensive research and innovation led to expanded knowledge and refined practices.

Local production of artemia in salt fields will have a socioeconomic dimension because poor salt farmers can produce another product and [have] a chance to develop aquaculture with local artemia.

"The technology of using artemia in fish and shrimp hatcheries year after year was perfected," said Sorgeloos. "The quantities that were used increased, and there were more sophisticated hatcheries. This became in the coming decades a multibillion dollar industry – just the hatchery sector."

Artemia (six species including the common *Artemia franciscana* and *Artemia salina)* usage in larviculture traces back to the 1930s, but in the early years the product was mainly used for ornamental fishes, which needed relatively small amounts compared to commercial fish farming operations of today. And 1960s American pop culture enthusiasts will of course remember a hybridized artemia product called Sea-Monkeys, advertised in comic books as a novelty aquarium pet.

While both fish and shellfish larviculture depend on artemia for feed, shrimp producers are by far the largest user. According to Leger at INVE, about 99 percent of shrimp hatcheries worldwide producing quality fry use artemia, so the company has invested heavily in research and technology to help producers stretch the resource.

"We think that we have a responsibility in assisting the in development and expansion of the aquaculture market," said Lavens.

INVE Aquaculture is one of the world’s leading innovators in artemia procurement and usage. The company has patented technology designed to make efficient use of a precious resource.

While overall usage of artemia has increased from 100 metric tons (MT) in 1980 to current levels of 3,000 MT per year, hatcheries are far more efficient today. Whereas artemia used to comprise 35 percent of a hatchery diet with 65 percent dry ingredients, the ratio today is closer to 15:85.

“And we are further stretching that one,” said Lavens, who will soon share “solid data” that a 5 percent artemia inclusion rate is feasible. “We are working on how we can further reduce artemia, that way allowing more hatcheries to produce more PLs (postlarvae), because the demand for PLs and fry will increase in the near future.”

INVE (http://www.inveaquaculture.com/our-solutions/nutrition/) in 2012 released two innovative products that allow users to get the most out of their supplies – HIGH5 artemia boasts a consistently high hatching rate, and SEP-Art achieves full separation of the live nauplii from cyst shells with a non-toxic magnetic coating on the cyst. The two innovations are being combined into one product.

“It’s a patented technology, considered a ‘next move’ in artemia usage in hatcheries,” said Lavens, who developed the technology over a course of 10 years. “In Europe, more than 90 percent of artemia usage is by means of SEP-Art technology. It’s particularly effective on the fish side, because cyst shells can block the digestive system of fish larvae … killing them.”

Sorgeloos said the importance of artemia to aquaculture cannot be overstated. “It’s thanks to artemia that we have a successful shrimp industry. Formulated feeds have been important, and breeding programs have been crucial but artemia has been vital,” he said, unsure if aquaculture can ever break its dependence on artemia.

"Reduce? Yes. Replace? I'm skeptical," he said. "I think we've come a long way but the last replacement is the most difficult one."

Limited production, growing knowledge

According to the research that Sorgeloos presented at an FAO workshop in Tianjin, China, in November, to produce 1 million Pacific white shrimp (*Litopenaeus vannamei*) or black tiger (*Penaeus monodon*) PLs for sale to shrimp farmers, as little as 3 kilograms of artemia are required. It takes roughly the same amount to produce just 5,000 fingerlings of cobia, a large, carnivorous whitefish species (*Rachycentron canadum*) growing in popularity in the U.S. market.

A new species being farmed in Vietnam is the mud crab (*S. paramamosain*). To produce 1 million mud crab PLs, a far larger sum of 30 kilograms of artemia is needed. Which begs the question if it's responsible to produce such a species when others are far more efficient.

"As you see the figure now, yes, it would be. But as we introduce a new species we will have limited knowledge," Sorgeloos said. "We'll see in the years to come that it will go down from 30 to 20 to 15 and so on, as people will be able to use alternative diets and reduce the time period of feeding artemia. I guarantee you it will take only a few years to be down to around 3 kilograms, because we will not have to do over again the nutritional research we had to do with vannamei and monodon."

A salt farmer in Vietnam who also produces artemia for the local region's aquaculture producers. Artemia are microscopic brine shrimp that aquaculture hatcheries use as feed. Photo courtesy of Patrick Sorgeloos.

In Southeast Asia, where so much of today's farmed seafood is produced, there are no natural artemia resources. Since the late 1970s, however, during the four- to five-month dry season, small salt farmers have produced small quantities of the "biomass" form of artemia. It is a live product that is traded daily

among small farmers in parts of Vietnam, Sorgeloos, said, and it can even be used as a source of food for human consumption. Production levels there are small, only 40 to 50 tons per year, less than 5 percent of artemia consumption in Vietnam, one of the world's largest sources of farmed shrimp and other fish species.

"It's nothing compared to 3,000 tons, but in certain regions and especially in countries where aquaculture is just starting and taking off, local production of artemia in salt fields will have a socioeconomic dimension because poor salt farmers can produce another product and [have] a chance to develop aquaculture with local artemia," said Sorgeloos.

Household income is nearly three times higher for salt farmers who also grow artemia, he added.

Just add water

That overharvesting and climate change will threaten current populations is a shared concern. A new artemia resource popped up about a decade ago, after rivers that once fed the Aral Sea in Central Asia were diverted to cotton plantations. The heightened salinity levels in the Aral unveiled a new source of artemia, but Sorgeloos fears it could fade just as quickly.

"The east part of the Aral Sea is dry and we are talking several thousand square kilometers," he said. "Salt lakes are disappearing because of human activity and because of climate change."

A common comic book advertisement for Sea-Monkeys.

Legér of INVE said most significant artemia sources have been identified and are being exploited. "There's probably hundreds of other small sources out there that do not justify commercial exploitation or the investment; they're not big enough to consider investing in significant harvesting efforts," he said.

While Sorgeloos, Lavens and Legér agree that a global artemia shortage is not imminent, existing resources would benefit from better-regulated harvesting practices, such as those employed in Utah. In Siberia and Kazakhstan, on the other hand, poaching is rampant.

"We could really say mafia practices," said Sorgeloos. "I visited last September, to lakes where there are [harvest restrictions] but you see several hundred – and I'm not exaggerating – poachers, collecting 5 kilos here, 10 kilos there. Multiply it by a hundred and you are again in the tens of hundreds of tons that are harvested illegally."

The hearty artemia is euryhaline, meaning it can withstand many different salinity levels, up to 180 grams of salt per liter of water (sea water is 35 g/L, while the Great Salt lake is 150 g/L). As rivers and lakes may vanish due to climate change or human intervention, there is also a chance that freshwater

lakes today will eventually turn salty, revealing new artemia sources. However, Lavens and Legér say there are currently no viable candidates.

Artemia have predators other than humans, although none can survive in waters above the 100 g/L salinity threshold. In lower salinities, there’s no real protection, making their existence seem especially tenuous.

This fragility contradicts the fact that artemia, a strange and wonderful creature, can survive for ages at a state of zero metabolism. That means the teensy crustacean inside the cyst is not merely dormant – it switches off its life functions entirely until recalling them to service later. Perhaps centuries later.

“You should see these cysts like plant seeds … ancient cysts have the capacity to hatch for several hundreds of years,” said Lavens.

The full sequencing of the artemia genome, which Sorgeloos and his colleagues in artemia research throughout the world have completed, could help to solve vexing riddles in science and medicine. The gene in artemia responsible for turning life on and off has been studied as a potential treatment to halt the growth of human cancer cells.

“We can talk for hours about its uniqueness and why it’s one of the feed sources so commonly used in shrimp hatcheries around the world. Why? It’s available as a dry product,” said Lavens. “You put it into saltwater and the next day you have a live creature.”

“I call it the magic powder,” said Sorgeloos.

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