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#GCA2020

SDG-aligned Artemia Aquaculture Workshop

22 September 2021

Background

With the expansion of hatchery production, the demand for *Artemia* cysts has continued to increase. Annual consumption is now estimated at 3,500 – 4,000 tonnes, underpinning the production of over 900 billion crustacean post larvae and fish fry by a hatchery industry valued at more than USD 2 billion and the final production of over 10 million tonnes of high-value aquaculture species. With approximately 90 percent of the current *Artemia* production harvested from inland salt lakes, the future of the hatchery industry could be at risk and requires urgent attention.

A new international interdisciplinary approach is needed to tackle these *Artemia* issues and opportunities, like the breakthrough in *Artemia* use in aquaculture following the 1976 FAO Kyoto conference. The purpose of the workshop was to explore needs and opportunities for a new international initiative to guarantee a more sustainable provision of *Artemia*, both from natural sources and from controlled extractive *Artemia* farming integrated with salt production and other fish/crustacean aquaculture.

The workshop was held in conjunction with the Global Conference on Aquaculture Millennium +20 in Shanghai, China with international participation via video conference. The programme included technical presentations and a Q&A session with participants and an expert discussion panel. Over 400 people participated in the workshop, both locally in China and via video conference.

The workshop was organised by:

- Food and Agriculture Organization of the United Nations.
- Laboratory of Aquaculture and *Artemia* Reference Center, Ghent University.
- Network of Aquaculture Centres in Asia-Pacific.
- *Artemia* Association of China.
- Asian Regional *Artemia* Reference Center.

Report

The programme is available in **Table 1**. Presentations are summarized below, but are available for viewing on YouTube at:

- https://www.youtube.com/playlist?list=PLZxXgR0J17z0MeAdFe9P7qzc8PFRjlXyr

Patrick Sorgeloos (Ghent University) made a presentation on *From Kyoto 1976 to Shanghai 2021: Brief history of Artemia use in Aquaculture*. He described the key life cycle traits of *Artemia* and its crucial role in the commercial hatchery production of fish and crustacean species, beginning with the first commercial sources of *Artemia* cysts in the 1960s, and the first concerns about *Artemia* as a potential bottleneck at the FAO Technical Conference on Aquaculture in 1976. FAO had supported early work to verify the characteristics of *Artemia* and to investigate the feasibility of inoculating salt flats for integrated salt-*Artemia* production. In 1978 the *Artemia* Reference Center was established at Ghent University upon the suggestion of FAO. The International Study on *Artemia* was launched as an interdisciplinary study of *Artemia* strains, producing over 50 papers on aspects of the biology of *Artemia* and its application in aquaculture, culminating in the publication of the Manual for the Culture and Use of brine Shrimp *Artemia* in Aquaculture in 1986 (the "*Artemia* Manual"), and a chapter on *Artemia* in the FAO Manual on the Production and Use of Live Food for Aquaculture in 1996. Over time *Artemia* has come to underpin a significant fraction of commercial hatchery production for the aquaculture industry. Localised production provided security for local aquaculture industries. Concerns regarding the *Artemia* resource include sustainable harvesting, the protection of habitats, and preservation of the gene pool. The International *Artemia* Aquaculture Consortium has been established to address these concerns and to expand sustainable use of *Artemia* in aquaculture, involving 28 different countries.

Meezanur Rahman (WorldFish Centre) and **Nguyen Van Hoa** (Can Tho University) gave a Report of the 15 June 2021 webinar *International workshop on Artemia pond production*. The *Artemia*4Bangladesh project aimed to enhance food and nutrition security in Bangladesh through climate smart innovation, including introduction of integrated salt-*Artemia* systems and increased productivity in marine aquaculture in Cox's Bazar. The purpose of the workshop was to share information between public, private and academic stakeholders and to promote *Artemia* culture and research in different countries. More than 70 participants from 14 countries attended. Presentations gave an overview of farmed *Artemia* biomass and cyst production practices in different countries including Vietnam, India, Iran, Kenya, Cambodia, Myanmar, Bangladesh, China, Thailand, and Malaysia. Recommendations included integrating *Artemia* artisanal salt farming in Asia and Africa, desert/arid and salt-affected areas, conducting more work on species / strain selection and improvement for aquaculture applications, improving the resilience of *Artemia* pond culture to climate change events, and selecting suitable agricultural by-products as a food source for *Artemia*.

Simon Wilkinson (Network of Aquaculture Centres in Asia-Pacific) gave a report of the 2 September 2021 webinar *Status of the use of Artemia cysts in fish and crustacean hatcheries around the world*, which was attended by 359 people from 53 countries and facilitated by the International *Artemia* Aquaculture Consortium.The workshop had featured presentations on contemporary hatchery practices from around the globe, which were described. The presentations revealed a wide diversity in hatchery practices, variations in efficiency and many deviations from the standardised protocols of the *Artemia* Manual. Allowing *Artemia* development to progress to instar II posed a biosecurity risk, as nauplii become contaminated by *Vibrio* and other potentially pathogenic bacteria once they begin to feed. The application of the umbrella stage of a particularly small *Artemia* strain (Vin Chau salt ponds) in mud crab hatchery production was highlighted. It was clear that there were significant

opportunities to improve both *Artemia* utilisation and production. It was timely to reconsider publication of good aquaculture practices and standardised protocols for *Artemia* production and use in hatcheries, with a view to improving both the efficiency of cyst use and the biosecurity of *Artemia* as feed. The webinar recommended updating the FAO *Artemia* Manual and convening localised training courses for hatchery staff to facilitate uptake of good practices. The presentations from this workshop are available separately on YouTube at:

- https://www.youtube.com/playlist?list=PLZxXgR0J17z3oahrQdjZw1S6602KifbUa

Thomas Bosteels (Great Salt Lake Brine Shrimp Cooperative) gave a presentation *Sustainable harvesting of natural Artemia resource: the Great Salt Lake (Utah, USA) as model case*. Around 90% of *Artemia* was still harvested from natural resources, highlighting the importance for sustainable management of wild *Artemia* and their salt lake habitats. Salt lakes were sensitive environments and vulnerable to anthropogenic influences. The progressive development of management measures for the Great Salt Lake and its *Artemia* resources was described. Salinity and nutrient management were the two main drivers for *Artemia* population health, with the optimum salinity range being 120-160 g/L to avoid predation and physiological issues, and adequate nutrient loading to support the population, as the lake is primarily nitrogen limited, with a co-limitation of phosphorus. A causeway allows adaptive management of the flow and salinity within the south arm of the lake which is the primary *Artemia* resource. Water inflows are regulated by government agencies at both State and Federal level, with input from the Great Salt Lake Advisory Council, a cooperative process involving stakeholders from many sectors.

Gonzalo Gajardo (Los Lagos University) gave a presentation *Artemia species and strains diversity: threats and potential*. Wild genetic resources included six regional sexual species and asexual types. Genetic diversity in key traits were often harboured in locally adapted populations. Incipient farmed types with useful characteristics such as improved thermal tolerance had emerged following translocation of *Artemia* to new sites. There was a need for systematic monitoring of genetic diversity to assess impacts of climate change, habitat loss and other adverse factors. Loss of intraspecific genetic diversity was a hidden biodiversity crisis. *Artemia* provided an excellent model to study genotype-environment interactions for key aquaculture or adaptive traits.

Gilbert Van Stappen (Ghent University) gave a presentation *Availability of Artemia genome: R&D opportunities*. The majority (90%) of the *Artemia* genome had recently been published and was now available through the ORCAE platform (for access contact Prof. Peter Bossier, Laboratory of Aquaculture and *Artemia* Reference Center, Ghent University, peter.bossier@ugent.be). This data had considerable potential to assist with characterisation of *Artemia* strains and to inform selective breeding programmes. A gene for salt tolerance had been found (De Vos et al. 2021, The genome of the extremophile *Artemia* provides insights into strategies to cope with extreme environments, BMC Genomics Vol. 22, Art. 635), and *Artemia* was expected to provide a new model organism for gene discovery.

Q&A / Panel discussion

A question-and-answer session was held with panellists providing feedback on questions from participants:

- Regarding biosecurity measures in *Artemia* production, biosecurity starts with protection of the resource, for example not allowing aquaculture within catchments used for natural cyst production. Hyper-saline conditions were beneficial in excluding potential hosts from the

environment. With good disinfection procedures during processing, it was possible to produce cysts that did not contain human or aquaculture pathogens. However, pathogens could enter during the hatching process in the hatchery, if care was not taken to maintain good conditions.

- Many parthenogenetic *Artemia* strains occurred in China, it was likely that there would be some differences between them, but it was necessary to test different strains in order to document their characteristics.
- Africa had considerable potential for *Artemia* production, but wild populations were little studied and commercial developments were limited at present.
- *Artemia* availability was unlikely to become a constraint to future aquaculture development, assuming the ongoing trend of improving utilisation efficiency continued, and given the high potential for investments in *Artemia* research to deliver improved strains or farmed *Artemia* as a supplement to wild sources.

Conclusion and recommendations

The workshop made the following specific recommendations:

- Develop improved guidelines for bio-secure production and use of *Artemia* in hatcheries, including an update of the FAO *Artemia* manual and convene regional *Artemia* training courses for local hatcheries, to disseminate good practices and facilitate adoption of standardised protocols.
- In view of the large variety of species and strains of *Artemia* that are now available in the market their specific characteristics should be studied to identify their most suitable application for specific species of fish and crustaceans. This could relate to their nutritional composition, synchrony in hatching or enrichment characteristics.
- Initiate strain selection and selective breeding to develop improved *Artemia* strains for aquaculture applications, noting the availability of the *Artemia* genome.
- Investigate the use of umbrella *Artemia* as successfully applied in the Vietnamese crab hatcheries for wider application in aquaculture, as a new source of live food in earlier larval stages, be it for shrimp or in fish.
- Reconsider a wider use of *Artemia* enrichment techniques in hatcheries, as it is now restricted to applications in marine fish and crab production. This method not only allows enhancement of the nutritional value of the nauplii but can also be used as a vector to deliver, for example pre- or probiotics to the larvae.
- Investigate the impact of climate change on *Artemia* production in inland lakes and coastal saltworks.
- Develop science-based protocols to assure sustainable harvesting of wild *Artemia* sources, especially in central Asia.
- Conserve *Artemia* biodiversity through means such as a cyst banks, species identification, “wild” vs “farmed” species, genotyping and strain characterisation.
- Investigate integration of extractive *Artemia* farming with intensive fish/crustacean aquaculture.
- Investigate the use of *Artemia* biomass as high value protein ingredient in human diets.
- Consider integration of *Artemia* production in artisanal salt farming in Asia and Africa, desert/arid and salt-affected areas.

Closing remarks

The closing remarks were given by **Matthias Halwart**, FAO. He recounted the hypothesis of Patrick Sorgeloos at the 1976 FAO Technical Conference on Aquaculture in Kyoto, concerning the potential for *Artemia* to play a role in aquaculture, which FAO assisted in verifying, leading to *Artemia* becoming a widely accessible and suitable live food for fish and shrimp hatchery developments that were just taking off at that time. Over subsequent decades improvements in *Artemia* availability, sources and optimisations in utilisation had contributed to continued expansion of the fish and crustacean aquaculture. He noted that FAO had undertaken to prepare an updated *Artemia* manual to ensure more sustainable and bio secure use of this important food source. He noted the workshop's advice to invest more in the study of *Artemia* biodiversity, sustainable exploitation, and management of salt lake resources in a changing climate, and the parallel need to explore farmed production of *Artemia*. He indicated that FAO's Sub-Committee on Aquaculture would be informed of the progress highlighted by the workshop for member countries to consider further work on *Artemia*.

Table 1: Technical Programme / List of Speakers

Speaker	Presentation	Email
Sui Liying, Asian Regional *Artemia* Reference Center, Tianjin University of Science & Technology, China	Local moderator	suily@tust.edu.cn
Min Jiang, Shanghai Ocean University, and **Wang Qingyin**, Chinese Fisheries Society, China	Welcome	
Rodrigo Roubach, FAO Rome	Aim of the workshop	Rodrigo.roubach@fao.org
Patrick Sorgeloos, Ghent University, Belgium	From Kyoto 1976 to Shanghai 2021: brief history of *Artemia* use in aquaculture	patrick.sorgeloos@ugent.be
Meezanur Rahman, WorldFish Centre, Bangladesh, and **Nguyen Van Hoa**, Can Tho University, Vietnam	Report of 15 June 2021, Webinar "International workshop on *Artemia* pond production"	Muhammad.Rahman@cgiar.org nvhoa@ctu.edu.vn
Simon Wilkinson, NACA	Report of 2 September 2021, Webinar "Status of the use of *Artemia* cysts in fish and crustacean hatcheries around the world"	simon@enaca.org
Thomas Bosteels, Great Salt Lake Brine Shrimp Cooperative, USA	Sustainable harvesting of natural *Artemia* resource: the Great Salt Lake (Utah, USA) as model case	thomas@gsla.us
Gonzalo Gajardo, Los Lagos University, Chile	*Artemia* species and strains diversity: threats and potential	ggajardo@ulagos.cl
Gilbert Van Stappen, Ghent University, Belgium	Availability of *Artemia* genome: R&D opportunities	gilbert.VanStappen@ugent.be
Plenary session panel	Q&A, discussion, conclusions, and recommendations	-
Matthias Halwart, FAO Rome	Closing remarks	Matthias.Halwart@fao.org