# ARTEMIA PRODUCTION IN ARTISANAL SOLAR SALTWORKS: HOW TO INTRODUCE A VIETNAMESE SUCCESS STORY IN AN AFRICAN CONTEXT

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## ARTEMIA AND ITS ROLE IN AQUACULTURE

The brine shrimp *Artemia* is an Anostracan branchiopod crustacean occurring worldwide in hypersaline lakes, ponds, and lagoons, as well as in man-operated solar saltworks. In addition to its unique osmoregulatory capacity, brine shrimp is adapted to this harsh and often unstable environment by the capacity to produce dormant embryos ("cysts") when the conditions turn too unfavourable (Fig. 1). Cysts can be produced in massive numbers. Once harvested and properly processed they can be stored for several years until they are hatched under appropriate conditions (Lavens and Sorgeloos, 1987). The emerging instar I nauplius is a convenient substitute for the natural plankton diet of fish and shrimp larvae (Sorgeloos et al., 2001). Ever since the first application of the strain from San Francisco Bay (SFB), USA, as live food for the pet market in the 1930's, and in spite of partial research successes to replace *Artemia* by artificial diets, brine shrimp (meta)nauplii have enjoyed increasing popularity as an indispensable live food item in most marine finfish and shellfish hatchery operations. This is largely due to the general availability, nutritional quality, ease and versatility of use of *Artemia* cysts (Dhont and Van Stappen, 2003; Kolkovski et al., 2004). Presently about 3000 tons of dry commercial cyst product finds its way to aquaculture applications worldwide. More than 90 % of this quantity is harvested as natural product originating from Great Salt Lake (GSL), USA. Smaller quantities (in the order of tens of tons) are produced in solar saltworks. The ponds in these salt production systems may be managed more or less intensively for the purpose of combined salt and *Artemia* production.

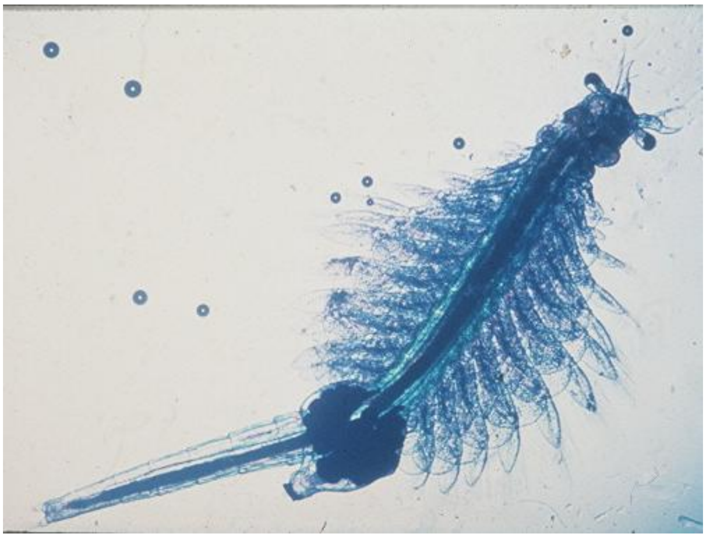

**Figure 1**. Adult *Artemia* female (about 1 cm size) carrying cysts in brood pouch

## ARTEMIA POND PRODUCTION IN THE MEKONG DELTA, VIETNAM

Ever since the first introduction trials of San Francisco Bay (SFB)-type *Artemia franciscana* in the mid 1980s, pond production of *Artemia* cysts, and more recently of *Artemia* biomass, is a technology developed over the past decades especially in the Mekong Delta, Vietnam. This has been achieved through a sustained effort of experts of the College of Aquaculture & Fisheries of Can Tho University (CTU), Can Tho, Vietnam, in collaboration with the Laboratory of Aquaculture & Artemia Reference Center (ARC) of Ghent University, Belgium. Integrated production of *Artemia* and salt provides an additional income for the salt farmer through the production of highly valued *Artemia* cysts and/or biomass. Moreover, due to its filter-feeding behaviour, brine shrimp removes excessive phytoplankton and detritus particles from the water column, which negatively interfere with salt precipitation.

Proper biological management to steer the *Artemia* population therefore results in better quality salt, fetching a better market price. *Artemia* production protocols still go through a constant process of optimisation and tailoring according to changing market needs. Yet thanks to a favourable combination of factors the technology has been adopted by a relatively important group of households in the Mekong delta involved in family-style solar salt production. Artisanal *Artemia*-cum-salt production is an economic reality in this area (Anh et al., 2010), to the extent that the establishment of this new sector has recently resulted in a first econometric study on the subject (Son, 2010). After an initial period (1980s and 1990s) with relatively high fluctuations in productivity, the total production in this area has now stabilized since the turn of the century at values around 20 tons wet weight (33 % of which is dry commercial product) and yields are generally in the range 50-60 kg wet weight/ha/crop; each crop corresponds with a production run of a few weeks and depending on the length of the dry season two or three successive production runs can be undertaken per production season (Fig. 2).

**Figure 2**. Harvesting of *Artemia* cysts in salt pond, Mekong delta, Vietnam
*(courtesy: Can Tho University, Vietnam)*

In the climatological context of the Mekong delta, where *Artemia* and salt production is limited to the dry season of about 6 months at most and where no natural brine shrimp populations occur, *Artemia* is introduced in the ponds each year at the onset of the dry season. After a production history of 2-3 decades in the Mekong delta, the locally produced *A. franciscana* has substantially differentiated from the mother material originating from San Francisco Bay, USA. This apparent selection has taken place under the influence of several factors, such as the production procedure that implies the use of a batch of previous year's harvest as inoculation material for the subsequent dry season, the genetic flexibility of the species, and the divergence in abiotic conditions (especially the temperature regime) between the Mekong delta and the habitat of the original material, San Francisco Bay (Kappas et al., 2004).

## DISSEMINATION OD ARTEMIA POND PRODUCTION TECHNOLOGY

*Artemia* pond production techniques in the Mekong delta have been firmly established, to a point allowing dissemination of know-how to other areas in Vietnam and consultancy abroad (Fig. 3). Over the past few years CTU experts have provided guidance and training for similar activities in Asian countries such as China, India and Sri Lanka.

Nevertheless, the expansion of this technique, which is largely based on empirical grounds, to an increasingly wider and more sociologically diverse group of salt farmers, has encountered limitations in the Mekong delta, reflected in lower yields, total production and culture area. This is the result of a combination of factors, such as the expansion of the production area without appropriate planning, the superficial knowledge and variable socio-economic background of the farmers newly joining the activity, the inpredictability of weather conditions, and fluctuations in the output market. Dissemination and consultancy, especially in new areas of development, should take into account possible interference from these factors. In spite of the relatively long history of expertise, a fully sustainable development of *Artemia* production in the Mekong delta (and elsewhere) needs to combine firm scientific research on the one hand with permanent and socio-economically sustained dissemination of knowhow to artisanal salt farmers on the other.

**Figure 3**. Extension of *Artemia* production protocols by CTU staff to local salt farmers, Mekong delta, Vietnam *(courtesy: Can Tho University, Vietnam)*

## AQUACULTURE DEVELOPMENT IN SUB-SAHARA AFRICA

Aquaculture has enormously expanded over the past few decades with high diversification of culture systems, species, and degrees of intensification. Aquaculture is the fastest growing food production sector with an average annual growth of 9% over the past 20 years (FAO, 2010). Yet hardly any initiatives have been taken in sub-Sahara Africa: Africa produces less than 1% of the world production. In sub-Sahara Africa, fast population growth and uncertain yields from traditional agriculture and terrestrial husbandry due to climatic changes press governments to explore diversification of food resources. There is a growing awareness of the stagnation Africa faces in aquaculture development. Various macro- and micro-economical, financial, social and cultural factors can be held responsible for this stagnation. In spite of the important freshwater and marine resources of several African countries, present aquaculture activities are largely traditional, extensive, and operate below capacity. Generally aquaculture is limited to production of freshwater fish (e.g. catfish, tilapia) in small to medium size earthen ponds. Dams and other impoundments used for storing water are sometimes stocked with fish and harvested periodically. Statistical data on aquaculture production are incomplete and lack reliability.

Until recently governmental policy in most African countries to address the various problems was incoherent and resulted in rather scattered initiatives. Policy makers and research entities in Africa, as well as donor organizations, are now increasingly aware of this situation, especially in view of the aggravating food situation in many countries. This shift in attitude is illustrated by current governmental policies in several African countries, where some form of aquaculture development is given a more prominent role at the level of other food production sectors such as agriculture and terrestrial husbandry. As an example, aquaculture is a point of focus in Uganda's National Aquaculture Development Strategy (2008) and in its recent Aquaculture Parks policy. In Kenya, the present Aquaculture Research and Development Programme is responsible for various aspects of aquaculture development. Development of aquaculture is also increasingly regarded by governmental bodies as one of the tools for community development and is therefore a point of focus in official national poverty reduction plans.

## ARTEMIA PRODUCTION IN SUB-SAHARA AFRICA AS A TOOL FOR AQUACULTURE DEVELOPMENT

From a technological point of view, development of aquaculture in Africa is hindered by various factors. Among these factors the reliable and cost-effective availability of hatchery produced fish and shrimp larvae for subsequent nursery and grow-out culture is a critical bottleneck. To achieve this hatchery production, a relatively steady local supply of *Artemia* cysts at a reasonable price is one of the cornerstones. The application of *Artemia* in fish and shellfish larviculture is highly recommended by the FAO as a means of facilitating rapid production of hatchery seed in Africa, in order to consolidate aquaculture production and to expand aquaculture practices to other indigenous species. As for *Artemia* biomass, this product can potentially substitute for expensive fish meal in aquaculture feeds, which can subsequently bring down feed prices, which make up a high operational cost in aquaculture, eroding on farm profitability.

Natural *Artemia* resources in sub-Sahara Africa (such as in inland salt lakes or coastal salinas) are hardly scientifically studied and not exploited at all (Kaiser et al., 2006). Dependence of alternative *Artemia* resources, such as those available on the world market, is generally cost-prohibitive for artisanal aquaculture activities. Local market prices of *Artemia* cysts in the order of 100-300 USD/kg, depending on quality, greatly limit their application in aquaculture hatcheries with consequent low survival rates and high cost of fry. Over the past 20 years there have been loose and uncoordinated initiatives (by private partners, governmental institutes, NGO's) related to *Artemia* inoculation in local saltworks and to the development of the hatchery sector in general, but these have not resulted in any major breakthrough. This is largely due to the absence of a sufficient critical mass of local expertise and to lack of interest and follow-up post-project in general. Now, local governments and external donors in sub-Sahara Africa show growing or renewed attention to the development of local *Artemia* production in existing salt production systems.

## CURRENT INITIATIVES IN ARTEMIA POND PRODUCTION IN AFRICA

In recent years, the model developed and the experience gained in Vietnam has been used for similar initiatives in sub-Sahara Africa, albeit with the necessary adaptations. The Laboratory of Aquaculture & Artemia Reference Center (ARC) of Ghent University, Belgium, has been and is still involved in a number of initiatives to develop *Artemia* pond production in solar saltworks in African countries, such as Kenya, Mozambique and Uganda, funded by various Belgian donor organizations. Given their experience in this field, south-south consultancy provided by CTU is an important element in these initiatives, either by consultancy missions to Africa performed by Vietnamese experts (Fig. 4), or by training of the African counterpart's staff members at CTU's experimental *Artemia* production site in Vinh Chau, Mekong delta. Though these projects are different in terms of duration, overall national and local framework and set of objectives, the development of a small-scale *Artemia* production pilot site is always among the primary project objectives. This pilot site consists of a series of interconnected experimental ponds with the necessary water supply and drainage system, where artisanal-style integrated production of *Artemia* and salt can be tested and adapted to the local conditions and where the project's achievements can be disseminated to the local salt farmers. Formally, the African counterparts are governmental institutes or universities involved in the development of aquaculture and fisheries. But additionally a broad array of local stakeholders (such as individual fish farmers, cooperatives of farmers, private companies, universities and institutes) is involved in order to enhance project awareness, to increase the critical mass of expertise and to consolidate the project's realizations post-project. Adoption of the *Artemia* production technology by the local salt-producing rural communities for the ultimate benefit of aquaculture development is the final target.

The preliminary experience gained so far in these countries illustrates that techniques, ideas and routines, applicable in Vietnam, can not necessarily be adopted as such in the new environment. A first factor of importance is the local or regional presence/absence of autochthonous or previously introduced allochthonous *Artemia* strains. These may be considered as candidate population(s) for local production. In the case of coastal saltworks in Kenya, previous attempts of inoculation of SFB in the mid 1980s have resulted in a locally established population of *A. franciscana*. To what extent this population has differentiated in comparison with the original inoculum strain is the subject of scientific investigation. The situation is more complex when, as in Kenya, the *Artemia* population present around the pilot site is a conglomerate of populations being the result of a series of successive disparate inoculation initiatives with different strains but without proper management. Irrespective of the presence of a local or regional population, the strain(s) to be produced is always an issue. Generally Vietnamese *A. franciscana* (named Vinh Chau strain) is used for this purpose due to its interesting characteristics for aquaculture applications and its tolerance for high temperatures. Nevertheless the performance of this strain in the new environment and its capacity to adapt to its new conditions remain to be studied.

The specific local ecological and climatological conditions are another set of parameters to be taken into account. Factors such as local temperature regime, precipitation, phytoplankton species composition and abundance in intake water and possible presence of halotolerant *Artemia* predators are inherent to the local situation and have to be taken into consideration when introducing *Artemia* and developing management protocols. Also these aspects require adequate scientific monitoring, combined with readily available information (such as scientific literature or governmental records). Much of the appropriate management discipline (e.g. to avoid *Artemia* predators, to keep sufficiently high salinity and nutrient levels) should be acquired by proper training of the receptor communities. These communities should be instructed to be alert for elements of the production protocol that are essential to obtain culture success, and which can thus not be compromised.

**Figure 4.** Stocking *Artemia* ponds with nauplii in *Artemia* production pilot site in Malindi area, Kenya, with consultancy provided by CTU staff.
*(courtesy: Can Tho University, Vietnam, and Kenya Marine Fisheries and Research Institute, Mombasa, Kenya)*

In addition to the biological and climatological conditions, also organizational, logistic, socio-economic and cultural aspects contribute to success or failure of these initiatives. Cooperation with a new partner requires sufficient acquaintance with its administrative and working procedures in general, with its hierarchical structure and decision making processes. The location and accessibility of the pilot plant and the security of project workers and goods are factors not to be overlooked in a rural environment where social and economic inequality may be sharp and the control by public authorities may be weak. Different labour and social organization, traditional perceptions and language problems may interfere with work planning, especially at the level of the receptor communities. In subsistence economies such as in rural Africa competition for natural resources as land and intake water is tough and may hinder the implantation of the pilot plant, its operation or expansion. Land property and tenure issues are often not well established and may lead to conflict situations during project operation.

Finally, regular involvement of these communities is needed in order to maintain their goodwill towards the new initiatives. In impoverished areas expectations raised by this new type of activity and by the financial benefits it may bring about must be set to a realistic level: it should allow generating steady interest and cooperation from the receptor communities, but it should avoid that slow or poorly tangible progress results in general disappointment and hence disinterest. As the initiatives described above are still in progress, nothing definitive on their final outcome can be said. But it is likely that, whatever their local impact, it will have an important role in how local or regional aquaculture initiatives are further developed in these countries.

**REFERENCES**


1. Anh N.T.N., Hoa N.V., Van Stappen G., Sorgeloos P., 2010. Effect of partial harvesting strategies on *Artemia* biomass production in Vietnamese salt works. Aquaculture Research 41: e289-e298.
2. Dhont J., Van Stappen G., 2003. Biology, tank production and nutritional value of *Artemia*, 65-121. In: Live feeds in marine aquaculture. Støttrup J.G., McEvoy L.A. (Eds). Blackwell Science Ltd., 318 pp.
3. FAO, 2010. http://www.fao.org/fishery/statistics/en
4. Kaiser H., Gordon A.K., Paulet T.G., 2006. Review of the African distribution of the brine shrimp genus *Artemia*. Water SA 32: 597-603.
5. Kappas I., Abatzopoulos T.J., Van Hoa N., Sorgeloos P., Beardmore J.A., 2004. Genetic and reproductive differentiation of *Artemia franciscana* in a new environment. Marine Biology 146: 103-117.
6. Kolkovski S., Curnow J., King J., 2004. Intensive rearing system for fish larvae research. II. *Artemia* hatching and enriching system. Aquaculture Engineering 31: 309-317.
7. Lavens P., Sorgeloos P., 1987. The cryptobiotic state of *Artemia* cysts, its diapause deactivation and hatching: a review, 27-63. In: *Artemia* research and its applications. Vol. 3. Ecology, culturing, use in aquaculture. Sorgeloos P., Bengtson D.A., Decleir W., Jaspers E. (Eds). Universa Press, Wetteren, Belgium, 556 p.
8. Son N.P., 2010. Socio-economic efficiency and development potential of *Artemia* production on salt-based area in the Mekong Delta, Vietnam. PhD thesis, University of Antwerp, Belgium, 227 pp.
9. Sorgeloos P., Dhert P., Candreva P., 2001. Use of the brine shrimp, *Artemia* spp., in marine fish larviculture. Aquaculture 200: 147-159