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Artemia production in southern Vietnam: geographical, soil structure, climatic and culture technique updating

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Abstract

Influenced by monsoon climate and located in the Mekong Delta in southern Vietnam, Vinh Chau solar saltworks typically present a wet- and dry-season per year. The annual precipitation often reaches more than 2,200 mm during the wet-season, washes out saline water, and these biotopes become suitable for brackish species as salinity fluctuates around 5 to 15 ppt. However, in the dry-season, the area turns into salt-fields and produces several hundred thousand tons of table-salt per year through evaporation of seawater. Because of heavy rain, the Mekong Delta of Vietnam has no natural population of *Artemia* as these brine shrimp could only survive when salinity remains constantly higher than 80 ppt to avoid predation. However, as a need of *Artemia* cyst for promotion of aquaculture activities arose, Vietnamese scientists were supported by the *Artemia* Reference Center (Ghent University, Belgium) to introduce *Artemia* into local saltworks in the early 80's. Fortunately, *Artemia* culture procedure has been established in Vinh Chau in the late 90's and gradually expanded into nearby areas. Recently, Vinh Chau saltworks reached yields of as much as 50-60 tons of raw cysts a year, of which part is being used for aquaculture hatcheries, and the rest for exportation. This paper introduces the site of Vinh Chau, where thousands of hectares of saltworks could be switched into *Artemia* farming. Geographical, climatic condition, soil structure and general farming procedure for *Artemia* culture in these biotopes are presented.

Key Words: *Artemia* farming, solar saltworks, soil structure, climatic condition

1. General introduction of the Mekong Delta coastal line and its climatic conditions

1.1 Geomorphology

The Mekong Delta is situated at the lower course of the Mekong River in southern Vietnam (Fig. 1). In the southeast, it borders the East Sea (South China Sea). It mostly consists of Holocene fluviatile brackish water and marine sediments that were deposited during the last 5,000 years.

The relief of the coastal zone is flat. Average elevation is in the order of 0.80m + Mean Seawater Level (MSL) and this leads to frequent flooding. However, with the typical climate of two alternating monsoons, the combined actions of intense river sediment deposition, prevailing winds and the sea have created a slightly higher coastal belt in which flooding is less severe than further inland. Thus, average land elevations of some 1.6-1.8 m + MSL extending over fringes of 200 -1,500 m wide are frequent along the eastern coast between the Co Chien River mouth and the Ca Mau peninsula. Low dunes exist on some locations, *e.g.* in Tra Vinh. The coastal zone is intersected by an extensive system of natural and man-made channels that are connected with the main Mekong and Bassac River branches and the sea, thereby creating a vast number of "islands" so characteristic for an estuary.

Eight main physiographic units have been distinguished in the Delta, but the current study was performed in the saltworks (coastal plain) of Vinh Chau and Bac Lieu along the coastal line. The coastal zone is affected by two tidal movements that surround the Delta: the semi-intensive-diurnal (twice daily) tides in the South China Sea with an amplitude of 2.00-3.75 m, and, the diurnal (daily) tides in the Gulf of Thailand with an amplitude of only 0.4 to 1.2 m. This coastal line is characterized by level tidal flats and relatively small areas of sandy ridges. At high tides, most of the coastal plain inundates with saline water from creeks or main river branches, if not protected by coastal embankments, artificial levees or high bunds around the fields.

From Fig. 2 it is obvious that the delta coastal line displays significant dynamic features, and is characterized by active processes of erosion (abrasion) and accretion. In affecting coastal stretches of extensive lengths (20-80 km), these phenomena are naturally caused by prevailing coastal currents, tidal range, wind set-up effects and wave action.

1.2 Soil

Of the 12 main soil groups recorded from the Delta, only 4 are found in the fringe of the coastal plain. These are:

Sandy soil: These soils are found on narrow inland ridges between Bac Lieu and the southeastern point of Soc Trang Province, and on a number of parallel ridges further inland in Tra Vinh Province. These soils have a high cation exchange capacity but fertility is very low due to salinity.

Permanent saline soil: On the sea side of the sandy soils, and along the southern and western coast of the Ca Mau peninsula a saline soil with permanent character is situated. These soils are relatively fertile and acid accumulation is limited.

Permanent saline acid soils: The majority of the inland southern Ca Mau peninsula consists of acid soils. These soils can roughly be divided in Saline and Potential Acid Sulphate Soils (SPASS) and Saline and Actual Acid Sulphate Soil (SAASS). Actual distribution of these two types within the potential study area remains unclear, but generally speaking, all lands that have been uprooted for shrimp pond construction classify as SAASS and experience acidification problems.

Dry season saline soils: Further inland of the three soil groups mentioned above.

Exposure of acid soils to the air, for instance after excavation (for canal or pond construction), leads to oxidation of pyrite and formation of sulphuric acid, which acidifies soil and water. This leads to low pH values, that beyond certain threshold levels, inhibit most aquatic life as well as plant and crop growth. Values of pH 3 or less are frequently

Fig. 1: Mekong Delta (South of Vietnam) with the location of Vinh Chau and Bac Lieu, where *Artemia franciscana* (SFB, USA) was introduced.

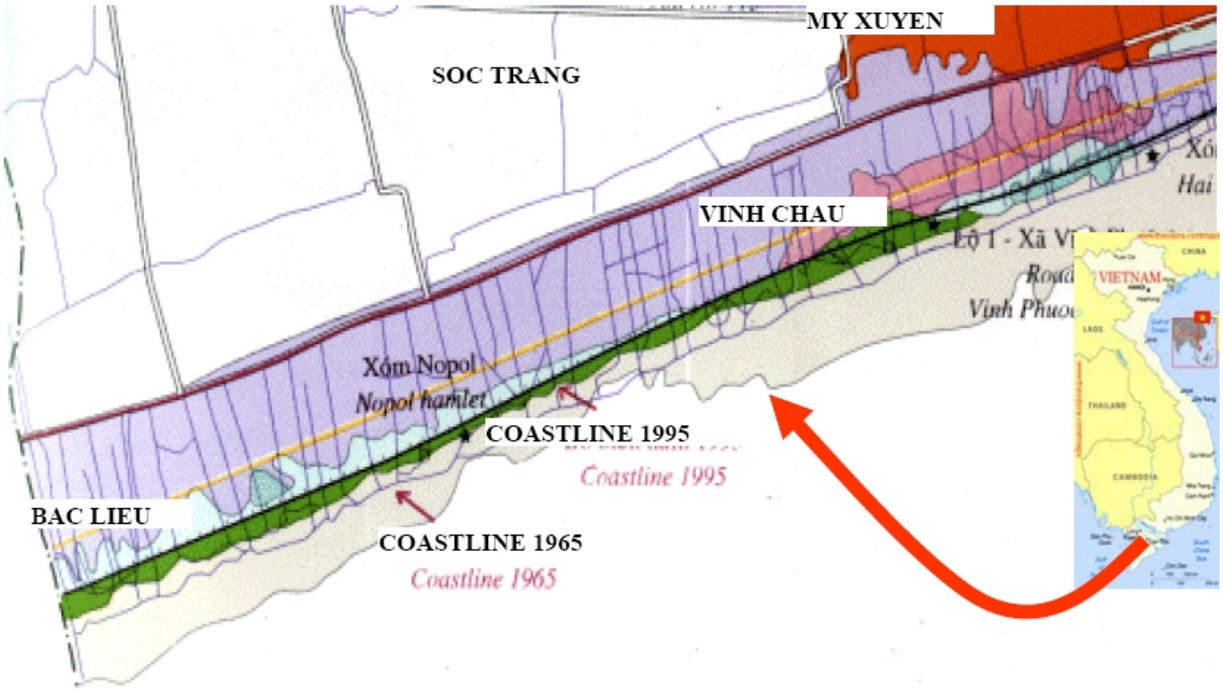

Fig. 2: Lay out of Vinh Chau - Bac Lieu saltworks (Mekong Delta, Vietnam) and erosion (small arrows indicating previous coastlines) along the coastal line.

encountered in the coastal zone in particular at the start of the rainy season.

1.3 Climate

The coastal plain is dominated by a rainy south-west monsoon from end of April till October (85% of the annual rainfall), and a dry north-east monsoon from November till April (15% of the annual rainfall). The average annual rainfall varies from about 2,250 mm on the west coast to 1,250 mm in southern Tra Vinh.

Within the Delta, the annual average temperature varies little and is 26-27 °C, also the monthly mean temperature shows little variation, *i.e.* from 28.5 °C in the warmest month (April) to 25.0 °C in the coldest month (January). Annual evaporation rates range from 1,600 to 2,000 mm with highest values in March (2.0-5.5 mm/day) and lowest in October (1.8-2.0 mm/day). When combining rainfall and evaporation the data show that in most of the coastal zone rainfall exceeds evaporation during six months of the year.

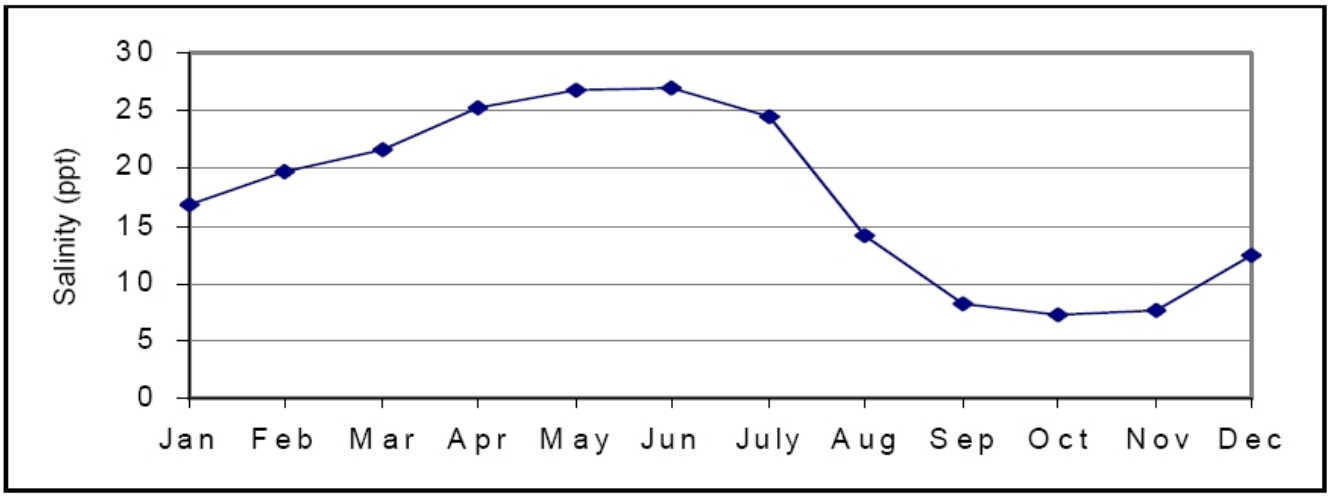

Fig. 3: Average seasonal salinity (ppt) fluctuation in Vinh Chau solar saltworks.

The relative humidity is highest from August to October (84-90%) and lowest from February to March (65-80%). Sunshine and radiation vary with the seasons: highest monthly averages occur towards the end of the dry season, February to March (9-10 h/day and 450-550 cal/m^2, respectively) and are lowest in August to September/October (5-7 h/day and 360-400 cal/m^2, respectively).

NE wind prevails during the dry season, with velocities between 3-5 m/s, reaching 10 m/s in March and November/December, sometimes damaging the coastline. SW wind dominates during the rainy season and is also generally of low velocity. Typhoons, frequent in the central area of Viet Nam, are rare in the Delta.

1.4 Vinh Chau saltworks: specific characteristics of the study area

Geographic situation: Location: Latitude 106°05' - 106°42' N; Longitude 9°22' - 9°24' (see Fig. 3 and 2). In the East and the South bordering the South China Sea; in the West adjoining to Bac Lieu province; in the North adjoining to My Xuyen and Long Phu districts, Soc Trang province.

Topography: Vinh Chau belongs to Soc Trang and Bac Lieu territory. The soil profile characteristics are clay (55-60%), mud (19-20%), and sand (21-22%). There are three main soil groups identified in the area; all classified with humic, flavic and salic specifics, which are characteristic for marine

inundation areas.

Climate and hydrology: See section 1.3 and Table 1.

Hydrology: Seawater enters the area directly from the East Sea (South China Sea). Semi-diurnal tidal regime affects the area directly from the East Sea with a large magnitude (i.e. 2.5 m to 4.5 m).

Salinity of the area fluctuates in time (Fig. 3) and highest salinities are recorded from May to June (the end of the dry season). However, because this period coincides with the rainy season, salinity in the area remains quite low. Moreover, as *Artemia* ponds are usually shallow (Brands, 1992), and heavy rains quickly dilute the pond salinity, pond culture of *Artemia* is not feasible during the rainy season.

Table 1: Overview of the weather conditions in Vinh Chau (Soc Trang province)

Month	Air temperature (°C)		Sun-hours (hrs/wk)	Rain-fall (mm/month)	Humidity (%)	Evaporation (mm/wk)
	max	min				
JAN	30.47±0.49	22.02±0.53	87±7	4.43±5.42	79.11±1.72	34.73±2.45
FEB	31.51±0.55	22.06±0.64	87±6	17.60±24.89	78.56±0.96	34.44±3.18
MAR	32.71±0.33	23.29±0.72	96±7	13.88±13.57	77.11±1.54	43.05±4.82
APR	34.27±0.55	24.58±0.51	90±6	39.60±30.97	77.22±0.78	40.78±4.08
MAY	33.32±0.65	24.77±0.17	67±4	235.29±155.53	82.56±1.60	27.98±4.01
JUN	31.83±0.47	24.65±0.28	53±4	301.87±66.66	86.83±1.01	20.36±3.18
JUL	31.29±0.90	24.27±0.18	58±9	370.38±104.41	87.83±0.66	19.71±2.88
AUG	30.58±0.31	24.12±0.15	52±7	387.71±75.94	88.50±1.26	18.01±2.17
SEP	30.59±0.54	24.22±0.15	51±10	377.76±86.37	89.28±0.95	16.94±2.69
OCT	30.38±0.47	24.22±0.30	55±12	316.16±88.81	88.17±1.96	15.66±1.46
NOV	30.27±0.45	23.69±0.34	68±14	125.70±51.61	85.22±2.65	20.62±5.05
DEC	29.88±0.62	22.53±0.23	72±13	45.60±49.01	83.00±1.32	23.56±3.07

(Source: Meteorological field station, Soc Trang province)

2. Overview of *Artemia* culture in Southern Vietnam

2.1. Review of *Artemia* cyst production in Vietnam

The first inoculation of *Artemia* in the central area of Vietnam took place in 1982 (Vu Do Quynh and Nguyen, 1987) with Macau (Brazil), Great Salt Lake (USA) and Chinese strains. However, in Vinh Chau and Bac Lieu (southern Vietnam, East coast of the Mekong Delta), the first inoculation attempts were mainly made since 1984 (De Graaf, 1985) and successful cyst production was recorded with SFB *Artemia* only in 1986 (Rothuis, 1986).

In the period between 1986 and 1990, different culture systems, *e.g.* the static system, flow-through system, and pond management procedures were developed. In late 1989 and early 1990, a few salt farmers in the area were selected to introduce *Artemia* into their salt farms for cyst production. Cyst production was successful and resulted in higher profits (3-5 folds) for farmers compared to the low income from traditional saltworks. These results stimulated the salt-cooperatives and more farmers to engage in *Artemia* culture. In 1991, more than 2,700 kg of raw cysts were collected from 40 ha culture area, which made the product available for commercialization (Fig. 4).

Table 2: Cyst quality of Vinh Chau *Artemia* (SFB origin, source: Aquaculture and Fisheries Sciences Institute, University of Cantho, Viet Nam)

Cyst diameter	235.2 ± 1.3 μm
Hatching efficiency (HE)	> 300,000 Nauplii/g
Moisture content	< 5 %
Hatching percentage (24 h ; 28°C)	> 90 %
HUFA (highly unsaturated fatty acid)	≈ 17 mg/g

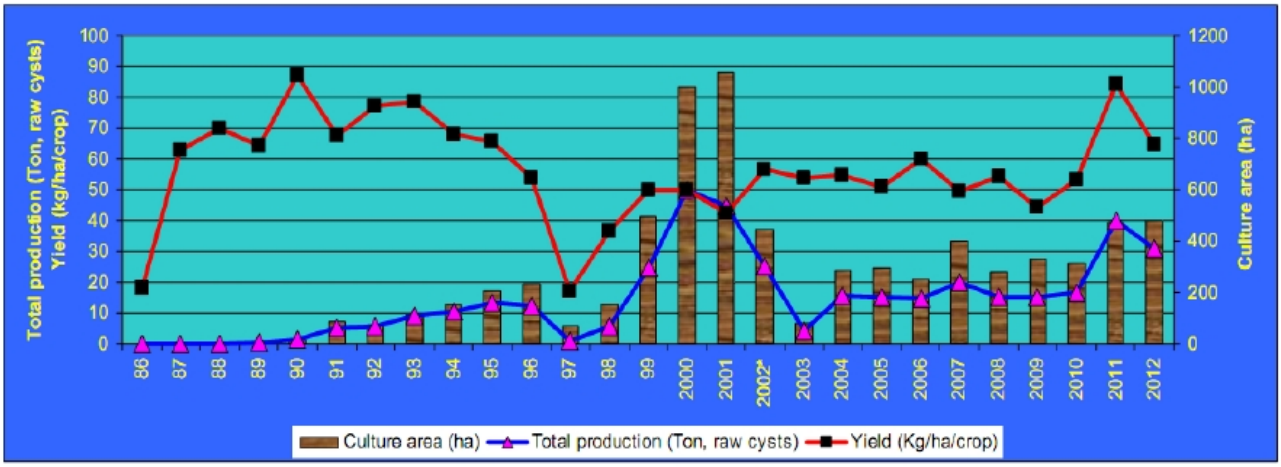

Fig. 4: Cyst production in Vinh Chau, Vietnam.
(updated 2012; source: College of Aquaculture and Fisheries, Cantho University)

By 2001, the number of production sites increased to approximately 1,200 ha along Vinh Chau and Bac Lieu coastal lines, yielding almost 50 tons of raw cysts (College of Aquaculture and Fisheries, Cantho University, unpublished data). Since 2002, however, with a boom of shrimp farming in the site, farmers switched their land into shrimp culture. Besides, the drop of raw cyst selling price led a number of farmers back to their traditional salt production. Nonetheless, this region is nowadays an important supplier of high-quality cysts (see Table 2 and Fig. 4).

2.2. General description of a traditional salt street and an *Artemia* culture system

2.2.1. Description of a traditional salt street

Salt production in Vinh Chau and Bac Lieu follows the traditional system, the so-called solar saltworks, in which each salt street includes a reservoir, primary and secondary evaporation ponds, storage ponds, and finally, crystallizers for salt precipitation. In such a salt street, crude salt is being produced by evaporation of seawater under the influence of solar radiation. The system is illustrated in Fig. 5 and operates as follows: seawater of 35 ppt (part per thousand) from the reservoir will flow into the next basin, evaporation pond 1, by gravitational force. Evaporation takes place and salinity reaches 70 ppt within a couple of days depending on temperature, wind speed, water viscosity *etc*. Secondly, this saline water will be transferred into evaporation pond 2, and the following basins for further evaporation. This process continues until salinity reaches 170 ppt to 250 ppt, approximately. Finally, high saline water or brine will be fed into crystallizers, in which sodium chloride salt precipitation takes place within 10 to 15 days per production cycle. A complete cycle of seawater to crystallizers for the first batch of salt precipitation will take place in approximately 45 days, but towards the end the dry season because of the heat increased and salty water available, the following batches for salt precipitation will be shortened. Normally, 4 to 6 salt production cycles are completed during the dry season in this area.

2.2.2. General description of *Artemia* culture in Vinh Chau saltworks

The *Artemia* culture system in Vietnam is referred to as “semi-intensive” (Tackaert and Sorgeloos, 1991) and static (Vu Do Quynh and Nguyen, 1987). The term “semi-intensive” is used to denote small seasonal man-managed systems in which brine shrimp are inoculated at high densities (> 20 nauplii/l). Ponds are managed intensively (*i.e.* inoculation of selected strains, manipulation of primary and secondary production, predator control, etc.). Contrary to the more common flow-through

systems (Tackaert and Sorgeloos, 199l), ponds in static systems are not interconnected. *Artemia* is inoculated in ponds with the appropriate salinity. Once stocked, the ponds are managed as separate units.

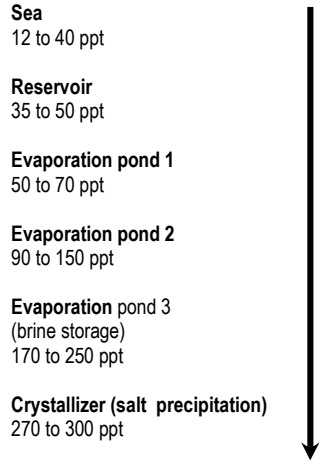

Fig. 5: Scheme of a salt street in Vinh Chau, Mekong Delta, Vietnam, with direction of seawater flow into consecutive ponds prior to salt precipitation (not to scale).

In the previously described salt street, *Artemia* can be introduced into ponds where salinity reaches 80 ppt to 120 ppt. Most of the *Artemia* ponds in Vinh Chau and Bac Lieu saltworks are the second evaporation ponds, *i.e.* where salinity varies from 90 ppt to 150 ppt (see Fig. 5). However, the brine storage basin and even sometimes the crystallizers of the salt street can be inoculated if salinity is managed in a suitable range. An *Artemia* pond of 0.5 to 0.7 ha is manageable. A pond with its axis directed towards the local wind orientation is necessary for more oxygen diffusion into the water column. Wind action also helps to drive the floating cysts into the accumulation corners. As salt ponds are usually shallow, excavation of the pond bottom and/or heightening of the pond dikes to increase the pond volume are necessary. In every culture system, a "kitchen pond" to produce green water as feed for *Artemia,* is recommended. Green water is pumped from a common fertilization pond and if needed mixed with brine, to maintain high salinity levels (>80%) in the culture ponds (Vu Do Quynh and Nguyen, 1987; Baert *et al*., 1997). Two to three weeks after inoculation, *Artemia* commonly starts to reproduce. Two reproduction modes (*i.e.* ovoviviparous and oviparous) are observed in SFB *Artemia*. High production of cysts usually occurs in February to March as water temperature is less than 35 °C. Towards the end of the dry season, high water temperature and food limitation cause a population collapse. Sometimes ponds are re-inoculated but higher water levels are then needed in order to avoid excessive water temperatures. In average, cyst production in Vinh Chau varies from less than 5 kg/ha/month to 40 kg/ha/month, depending on the culture system (extensive vs. semi-intensive, respectively), and the climatic conditions.

Recently, culture techniques have been gradually improved into intensive culture techniques, in which the main concepts are: excavated pond is preferred as to increase the water level to at least 50 cm from the bottom; stocking density up to 100 nauplii/ l; management of green water to stimulate more suitable algae (e.g. diatom, green algae) at appropriate concentration prior to outflow to the *Artemia* production pond; additional feeding with early formulated marine shrimp feed (circa 40% protein); and finally, aeration of the culture pond culture in order to promote higher survival, growth and reproduction rates. Interestingly, such a system now can now end up with cyst production yields of up to 150-200 kg of raw cysts (wet weight) per hectare/season (90-120 days) and thus considerably improve farmer income (US$ 7,000 to US$10000 per household/season).

Conclusion

Thanks to the wide tolerance of *Artemia* franciscana (SFB strain), this species was intentionally introduced at the beginning and now shows its ability to adapt to a new habitat, namely Vinh Chau and nearby saltworks; together with farming system development, the production of *Artemia* in Vinh Chau saltworks now shows its high potential in production (both cysts and biomass) and thus contributes considerably not only to local aquaculture development but also to the

improvement of the living standard of local poor farmers. Last but not least, successful introduction of SFB to Vinh Chau is a good example for other areas/countries located in tropical or sub-tropical belts regarding the introduction of *Artemia* culture with the aim to produce local *Artemia* cysts for aquaculture development.

Acknowledgement

The author expresses his deep and sincere thanks to the *Artemia* Reference Center (Ghent University, Belgium) led by Prof. Sorgeloos, who installed a milestone for *Artemia* study and application in Vietnam. Through his excellent advices, the brand-name of *Artemia* Vinh Chau (SFB origin) is well-known in the world and scientists involved with the *Artemia* project are able to contribute their knowledge with high confidence to several countries/areas, especially to the developing or poor countries, where *Artemia* is being considered as a primary step for aquaculture development.

References

Baert P., Anh N.T.N., Vu Do Quynh and Hoa N.V. (1997) Increasing cyst yields in *Artemia* culture ponds in Vietnam: the multi-cycle system. Aquaculture Research, 28: 809-814.

Brands J.T. (1992) Research into the development of an integrated and sustainable system of penaeid shrimps, *Artemia* and salt in the operating *salina*s in the coastal area of the Vietnamese Mekong Delta, Report no. 4 on DG XII project 004/2179, contract nr. TS2-0278-NL (GDF).

De Graaf G.J. (1985) *Artemia* culture in the southern provinces of Vietnam. Report on a visit to Socialist Republic of Vietnam, 38 pp.

Rothuis I.A. (1986) Report of the activities on the culture of *Artemia salina* and *Macrobrachium rosenbergii* in Can Tho and Vinh Chau in southern Vietnam, 81p.

Tackaert W. and Sorgeloos P. (1991) Biological management to improve *Artemia* and salt production at Tangu saltworks in the P.R. China, Proceedings, International Symposium on Biotechnology of Salt Ponds, 78-83.

Vu Do Quynh and Nguyen N.L. (1987) Inoculation of *Artemia* in experimental ponds in central Vietnam: an ecological approach and a comparison of three geographical strains, In: *Artemia* Research and its Applications, Vol. 3, Proceedings of the Second International Symposium on the brine shrimp *Artemia*, P. Sorgeloos, D.A. Bengtson, W. Decleir, E. Jaspers (Eds). Universa Press, Wetteren, Belgium, 253-269.