tion too. The success of the famous *A Brief History of Time* by Stephen Hawking points to the fact that scientists can reach millions not only by their inventions or patents, but by their popular science books which have a far-reaching consequence in the minds of people.

The meagre availability of popular science books in our country can be attributed to many reasons. Firstly, in India where different linguistic communities have their education in regional languages, it is desirable to have popular science books translated and also written in these languages. Regional languages like Bangla, Marathi, Tamil and Kannada have quite a large number of books for children but other languages, including Hindi do not have adequate numbers so as to reach the masses. National Book Trust and Children's Book Trust are publishing popular books for middle aged children. In English, journals like *Resonance* and *Science Reporter* (NISCOM) have grown in popularity immensely during the last few years.

Popular science books have tremendous book value in the real sense and NISCOM should actively engage in arranging science writers/scientists to publish more books for the general readers. Moreover, the pace of scientific and technological development cannot be maintained without a steady influx of bright young students. To nurture the scientific curiosity and temper among the students, it is imperative to reach them through the print medium. This would also create awareness and interest among intelligent laymen and also help youngsters in getting a broad-based knowledge about scientific frontiers. The CSIR golden jubilee series of books has been a very successful venture in this regard. Universities Press, Hyderabad has also published quite a number of titles of popular science topics by writers like John Gribbin, G. Venkataraman and many others.

By integrating scientific principles and applications with history, graphics and humour, a large number of very popular series are available in the West, e.g. *Know About Series* by Ranger Ricks Foundation, Washington DC, USA; *Tell Me Why?* series by Simon and Schuster and many others. The presentation of these books leaves an indelible impression on the minds of young readers. Unfortunately in India these books remain in the libraries of only a few select schools and institutes and are beyond the reach of common readers.

It is therefore suggested that, as is being done with computer books which have obtained copyrights for publishing in India, agreements can be entered into by Indian publishers with their Western counterparts for reprints of Indian editions of such books so that they can reach a large number of readers at an affordable price.

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Shrimping footprints in the sands of time

The mindless enthusiasm for unrestrained shrimp culture growth sensibly curbed an onrushing calamity – an environmental ill that if not utilized properly would spoil the entire industry. In 1993, India produced 62,000 mt of *Penaeus monodon*. A year later the number reduced to 44,000 mt because of the onslaught of virulent diseases. It is obvious that these diseases were the impact of total mismanagement of the ecosystem. The disaster should be considered a model lesson for aquatic farmers. This paper looks into several factors, which most likely precipitated the recent crisis.

The rapid growth of shrimp culture in India can be traced through several milestones starting from 1980. The period that followed saw the dissemination of culture practices throughout the coastal region of India. In 1985, formulated feeds entered the market, facilitating the culture on a commercial scale. The succeeding years (1990–1992) were characterized by a dramatic climb in production. Peak production figures were registered in the year 1993. Subsequently, the challenge that confronted the fisheries industry in the form of a killer disease cannot be ignored, as *P. monodon* is one of the country's most valuable aquacultural crops. The lofty expectations generated by the impressive track record left the industry initially unprepared to face the killer disease. It is unlikely that a single factor can be isolated as the main cause. Only a combination of factors seems to make sense, viz. seed-stock, over-intensified grow out practices, water pollution, pond deterioration and diseases[1].

Under the traditional polyculture and extensive culture systems no major problems were encountered, except for the occurrence of natural disasters and the presence of predators and competitors. As the culture systems shifted to semi-intensive and intensive styles, stocking densities were raised and formulated feeds were used. Intensive production was targeted on ponds with unsophisticated inlet/outlet systems, shallower depths unprepared to treat pond bottom, lesser aeration equipment/ha and insufficient water volumes. Intensive systems have greater needs for water treatment, chemicals and drugs for diseases, prophylaxis and treatment. Misuse of these had serious consequences. Water quality and the general culture environment became difficult to manage and culture species became more susceptible to various diseases. Eventually various types of infection such as protozoan epicommensals, entozoic algae, black gill disease, gill decay, telson damage, body cramp and red discoloration were reported to affect the prawn.

Single-phasic grow out system deteriorated the pond bottom. It seemed that infection with the virus might indeed be lethal, but most commonly some physiological or biochemical stress relating to poor husbandry, whether related to water quality, nutrition or handling gave the virus the opening it needed to become established in a population. This in turn led to debilitation and infection with a secondary *Vibrio* pathogen[2], which caused the high and rapid mortality[3], associated with white spot disease.

Import of broodstock from Sri Lanka and Thailand in the mid-boom phase could have led to vertical transmission of the virus. Import of used aquacultural tools

infested with *Barnacles* and *Lepas* also could be a causative factor. Diseased virus-positive mothers were not culled in the hatchery through proper means. Most unhealthy shrimp seeds not accepted by farmers were released into the creeks. Integrated effluent-treatment systems were absent in all the semi-intensive/intensive farms. With soaring breeder prices, possibly virus-positive mother prawn meat were then ignorantly fed as fresh biological feeds for broodstock.

As long as culture conditions were optimal, *P. monodon* appeared to be able to tolerate light-to-moderate infections. However, it is obvious that farms failed to maintain an ideal culture environment. In many cases, outbreaks have most likely been predisposed by stressors, such as poor water quality and deteriorating environmental conditions[2], poor nutrition, etc. Several pathogenic viruses have been identified, namely MBV, MBV + bacteria, SEMBV, WSV. When the disease struck, growers were often willing to try anything that might solve the problem.

Larvae failed to develop resistance to natural conditions due to the use of high temperature to accelerate larval growth (immersion heater instead of room thermostats). Collection of virus-latent wild seeds was an eco-terrorism favouring horizontal transmission of viruses. Increased production cycles/year leading to improper tilling and drying of bottom soil, deteriorated the ponds, further leading to immature aging. Unquestioned increase of stocking densities to unreasonably high levels, beyond the carrying capacity of the environment, led to it being abused or overloaded. The culture environment eventually became conducive to the outbreak of disease. Indiscriminate use of medicine and antibiotics and excessive application of antibiotics and chemicals to improve the prawn's resistance to disease, provided only temporary results. Once exposed to harsh or unfavourable natural conditions in the grow out phase, the prawn became susceptible to infection again.

Marketers who sold innumerable drugs to farmers (for trial) were themselves even less aware of the chemical implication in the animal's body and sometimes unavoidable use of polluted water, the culture water source gets contaminated with effluent discharged from aquaculture farm. Waste water which included diseased shrimp, fish and refuse was distributed along the coast in the vicinity of the water intake for the shrimp farms and pathogens were therefore transmitted rapidly from one shrimp farm to another.

Epizootic disease would seldom arise if husbandry and environment were perfect. Analysing the causes of the poor conditions, which frequently led to disease, it had been found that the fundamental factor was purely location. If sites were chosen for spurious reasons, failure would certainly result. A thorough study of climate, topography and local water conditions is to be made for site selection, apart from an economically viable price, suggesting that all the technical needs of the cultured animals could be adequately met. Failing to recognize this is the largest single cause of failure in aquaculture. The second cause was failure to recognize the limitations of the learning curve. Then, concentration on the hardware to the detriment of the software is a grave mistake. Design and engineering must be adequate and must provide resources in terms of water flow, space, oxygen and food distribution to meet the needs of planned stock and production[4].

The impressive performance of the flourishing *P. monodon* culture industry and the rising prosperity of those who had entered it, beckoned a large number of enthusiastic entrepreneurs. In their eagerness to put up their own farms and rake in a profit, many of them did not acquire a basic knowledge and proper training on the technical aspects of semi-intensive and intensive culture first, before embarking on a farming enterprise.

Absence of a reliable effective sanitation system has left hatchery facilities and grow out ponds highly vulnerable to contamination by harmful micro-organisms and has facilitated the spread of disease. Some farmers were plainly unaware, while others neglected the possible far-reaching consequences of poor sanitary practice.

The unwieldy competition for pumping estuarine water during high tides, which was already stained with industrial waste discharges resulted in a serious depression of the water quality profile. Lack of technical training of farmers is partly a contributing factor, nevertheless demanding urgent attention and action.

Consultants also were sometimes justifiably the subjects of suspicion, but when chosen carefully, they could become indispensable. Experimental consultants introduce technologies and methods perfected elsewhere.

Proper shut down or dry out between any two crops was lacking. Additional crop was imposed between narrowing fallow periods due to compulsion by the capitalistic corporate heads. Analysis of the fundamental causes of diseases revealed that most of the factors were man-made and could be averted. Absurdly encouraged shrimp seed brokerage system became a slow suicide. The Ministry of Environment did not monitor the ecological footprints from earlier periods of commercial shrimp farming.

Twenty years is a short time for a new industry to grow into a major one. But that was all it took. There is always a price to pay for development, especially one that proceeds to fast. The price was in the form of diseases and a damaged ecosystem. These problems crept in insidiously over the years, but were never grave enough to interrupt the smooth ascent. At least, this was a painful lesson to learn, for the industry. A perfect moulting should help a natural post-moulting growth.

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