contacts than by attraction at a distance. Extracellular cAMP may be crucial for the formation of aggregates at the low cell densities that may occur under natural conditions. Also, because aggregation is the first step of a defensive response to a stressful environment, it stands to reason that more rapidly the subsequent development ensues, the better. In short, there is no doubt that the wild type combination of *acaA* and *pkaC* confers a higher fitness under certain conditions than the *acaA*$^-$ (*pkaC*) construct does. The implication is that cAMP is not 'redundant' in the usual sense of the term (the *acaA*$^-$ mutant is unable to develop). But, because normal development can be restored by over-expressing *pkaC* in an *acaA*$^-$ background, the system must have means available whereby it can make do without cAMP: not a backup pathway, perhaps, but certainly other gene products whose functions overlap with those of cAMP. The upshot is an organism that exhibits a degree of resilience far beyond anyone's expectation.

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Micro-organisms as fish feed in fish industries

Prakash B. Bhosale

Aquaculture has emerged as an important industry during last decade and is practised in more than 150 countries in the world. Global aquaculture industry is worth about 30 billion US $ (ref. 1) and is growing at the rate of about 10%. Asia is considered to be cradle for aquaculture. Asian countries contribute 85% of the total production and Japan shares a major part of it. Considerable part of Japanese economy relies on the fish market. Various new efforts are always in action to improve the quality of the fish as well as to flourish the market. Feed and feeding are crucial elements of aquaculture. Feed cost ranges from 30 to 60% of the total culturing cost depending upon the type of fish and culture system. Various rotifers, plant extracts, stout's viscera, soyabean meal, etc. are normally employed as the feed. Although there are reports of micro-organisms causing mortality of fish fauna[2], from last few years thrust has been on the use of micro-organisms as the feed.

Various algae, yeasts and bacteria have been employed as a primary and/or secondary feed in the recent years. Algae such as *Chlorella*, *Haematococcus*, *Spirulina* were found to be useful for growing young fish. In the recent times, purple sulphur bacteria (PSB), *Rhodobacter capsulatus*, has been employed in the artificial feed of the fish larvae. Microbial cells as food supply additional nucleic acids, proteins, vitamins and various minerals along with the carotenoids. Micro-organisms are nutritious source of energy. *Phaffia rhodozyma*[3,4], *Rhodotorula* and other pigmented yeasts impart red fleshy colour to the meat of salmon, trout and Red seas bream and thus are used as the product quality feed. Astaxanthin is a major pigment present in *Phaffia* *rhodozyma* along with β-carotene, zeaxanthin, lutein, salmoxanthin, etc. All of which are supplemented well with L-ascorbic acid, 2-glucoside, potato starch, soyabean meal, krill powder and other base substances. Fish given this feed appears to accumulate more of the pigment in the tissue and thus appears red which naturally draws better market. Astaxanthin-supplemented diet has been found to shorten the moulting cycle of the prawn *Panaeus japonicus*[5]. Carotenoids avoid lipid peroxidation which increases the shelf life of the fish. β-carotene is also employed as the source of vitamin A for those fishes which can split the carotene molecule. Care should be taken to avoid oxidation and degradation of the carotenoids and is done by incorporating glutathione in the feed.

When the importance of the micro-organisms as feed became noticeable, lots of trials were also done to get best growth of the micro-organisms. in the recent years, *Phaffia rhodozyma*[3,4] has been studied and mutagenized with the help of the mutagens such as ethylmethylsulphonate, NTG, and by UV to produce high quantity of the astaxanthin. Cultural conditions are also modified to optimize growth. It is shake cultured in the medium containing yeast extract, polypeptone, sucrose at 20°C for three days and at 25°C for five days. Chlorella[6] is grown in the transparent bioreactor under aeration. This enables fast and high density growth of the algae. Fish normally prefer feed in granulated form which is obtained by treating it with alkali. Alkali treatment to the feed also gives the stability which does not allow it to get dispersed into the water, thus avoiding pollution. Algae and yeasts were subjected to the alkali treatment immediately after achieving suitable growth with sodium hydroxide to achieve pH of 12.5 (ref. 7). This treatment replaces the use of alkali metal salt. *Rhodobacter capsulatus* is employed as the secondary feed for Japanese flounder larvae and juveniles. It was found to act as an antioxidant which decreases the formation of the lipid peroxide in the juveniles[8]. A major part of the normally employed fish feed having squid viscera, plant material such as corn gluten meal is fermented with yeast and molds to get better feed. The disease resistance of fish can be strengthened by using better quality fish feed and can minimize use of antibiotics like chloramphenicol[9] in the fish feed. Use of micro-organisms as fish feed is found safe for human consumption. Thus micro-organisms employed as the fish feed agent present a bright prospects for fish industry and to human being too.

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Association of *Frerea indica* Dalz., an endangered plant species with *Euphorbia neriifolia* L. and its importance in habitat conservation

Frerea indica, often described as an illusive plant[1], is a monotypic genus in the family Asclepiadaceae. The species is believed to be one of the rarest plant species[2–11] and is listed as one of the 12 most endangered plants on earth by the International Union for Conservation of Nature and Natural Resources. The distribution of the species is restricted only to Maharashtra state in India. The distribution range is limited to six localities of three districts, namely Pune, Satara and Raigad. Except Mahabaleshwar, the presence of the species is confirmed in the other four localities. The species is basically a high-altitude plant (> 1000 m), with a characteristic distribution in nature. A typical habitat of *F. indica* consists of steep slopes (> 60°), preferably the crest region with a thin layer of soil between lateritic rocks (Figure 1 *a*, *b*). Except fire, the habitat is in general, inaccessible, and is free from human disturbance[12].

In all the localities studied, *F. indica* was found associated with *Euphorbia neriifolia* (Euphorbiaceae), growing either under its bushes or somewhere closer. *F. indica* plants resemble young *E. neriifolia* plants and it is difficult to distinguish them. In fact, this has been the experience of earlier workers as well[13,14]. Other plant species found in the habitat include *Notonia grandiflora* DC., *Carvia callosa* Bremek., *Lantana camara* L., *Ensete superbum* (Roxb) Cheesman, *Chlorophytum* spp. and grasses. During our attempts in conservation of endangered species, we propagated *F. indica* in nurseries at NGCPR, Shindewadi. We found all the plants infested and severely damaged by the caterpillars of the milk weed butterfly, *Danus chrysippus*. Milk weed butterflies normally feed on species of Asclepiadaceae, including *Calotropis*[15]. However, we had not encountered these caterpillars on *F. indica* in its natural habits during our field studies. This prompted us to hypothesize, whether the presence of *E. neriifolia* plants in the vicinity of *F. indica* in the natural habitats in some way protects the latter species.

To test this hypothesis we conducted two related experiments. In the first experiment, we quantified the association relationship between *F. indica* with *E. neriifolia* in its natural habitat. In the second experiment, we tried to find out whether *E. neriifolia* exhibits any repellent properties to caterpillars of plain tiger.

For the association studies we collected