Fish goes with rice ~ all the way!

That is, when both are grown together, says s ananthanarayanan

A MILLENNIUM-OLD practice in southern China of rearing fish in rice fields has been known to be ecologically stable, with yields of rice as good as in other rice fields but with far less inputs of pesticides and fertiliser. Scientists at the College of Life Sciences, Zhejiang University, Hangzhou, and the Department of Ecology at the Agricultural University, Guangzhou, report in the *Proceedings of the National Academy of Science of the USA* a detailed review of how this comes about.

With the rising importance of growing the most food we can with the least ecological impact, which means less chemicals and conserving water, this heritage and "green" method of cultivating both rice and fish may be the route the world needs to follow.

There is evidence of this kind of farming in southern China since about 2,000 years. There are early excavations and writings that suggest fish and rice being grown together and a record of the ninth century is a clear prescription of how it is to be done, "In Xin, Long and other prefectures, land on the hillside is wasted but the flat areas near the houses are hoed into fields. When spring rains come, water collects in the fields around the houses. Grass carp fingerlings are then released into the flooded fields. One or two years later, when the fish are grown, the grass roots in the plots are all eaten.

This method not only fertilises the fields but produces fish as well. Then, rice can be planted without weeds. This is the best way to farm." While this is one way of farming — that is, to plant rice after the fish have been there — the other method is to grow fish and rice in the field simultaneously. Major problems in rice cultivation are the aquatic or terrestrial weeds and phytoplankton and photosynthetic bacteria which compete with the rice for nutrients in the soil. And then there are different pests that harm the plant or damage the grain. Fish that live in the rice fields have been found to both feed on and eliminate the weeds and other organisms and also eliminate, in different ways, some of the pests and parasites. And the co-presence of fish and rice plants is found to promote the growth, without fertiliser, of both participants.

The UN Food and Agriculture Organisation has designated this traditional Chinese cultivation method a "Globally Important Agricultural Heritage System", a technique that has grown organically over centuries thanks to indigenous societies living in harmony with nature, promoting biodiversity and viability.

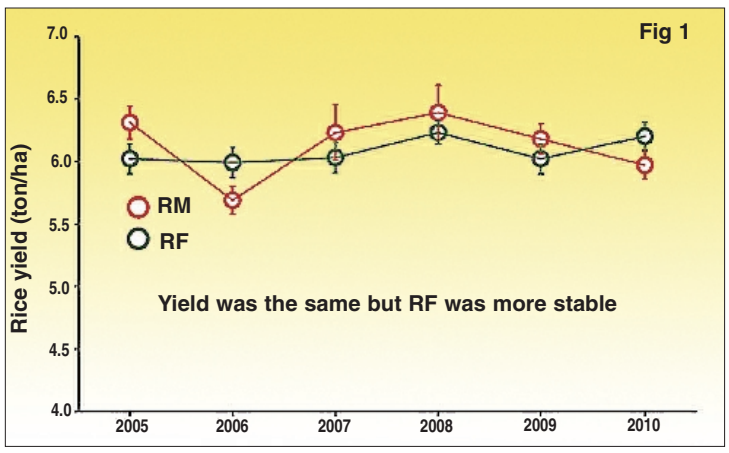
The benefits of fish-rice co-culture have been known and some formal research was started in the early 20th century. In 1935, there was a study in China's Jiangsu province where a number of varieties of carp were cultured and distributed to farmers for seeding rice paddies.

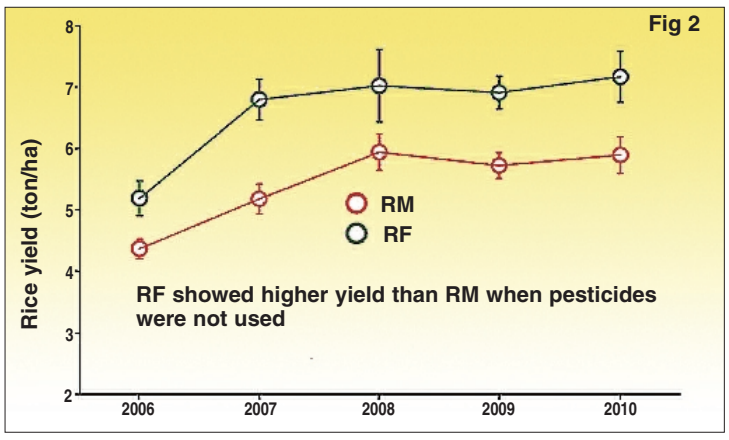
Rice-fish cultivation was promoted in the People's Republic and vast hectares came under the system. The movement has seen its ups and downs, with the rise of new rice varieties, the use of fertiliser and pesticides and political and cultural influences, but the importance of the system, which continues to survive, has been appreciated. However, the ecological mechanisms underlying the system were not examined in depth, till the time of the present study.

The first point of study was the stability of the yield, in the rice-fish (RF) co-culture, over the rice-monoculture (RM). The study was made through data collected from farmers over six years and from experimental plots for five years. The result of the study was that while the yield did not vary between RF and RM, the constancy of the yield around its mean over the period of the study was higher in the case of RF (Figure 1).

More significant was the finding that in the case of RF, there was 68 per cent less use of pesticides and a 24 per cent saving in fertiliser. The use of pesticides in the case of RF was also less variable. In fact, in field trials where pesticides were not used, the yield in the case of RF was higher than in RM (Figure 2).

Yield, of course, is affected by many factors. During the six years of the study, the varieties of rice, the irrigation method and the fertilisation levels were kept unchanged and it turned out that the temperature, relative humidity and rainfall also remained unchanged. What varied was the level of pesticide use, with the year-to-year variation in the abundance of pests. A study of the stability of yield, over the years, against the level of pesticide use shows that in the case of RM, the yield is more stable when more pesticides are used, but in the case of RF, the use of pesticides does not affect the stability of yield to the same extent. This indicates that the use of pesticides is important to keep the yield stable in the case of RM, but the stability of yield in the case of RF seems to arise more from the presence of fish.





Pest control

To understand why pesticide use does not affect stability of yield in the case of RF, the incidence of rice pests, diseases and weeds was studied during the five-year period in test fields where no pesticides were used. It was found that the *rice planthopper*, which strikes in August/September, was more abundant in RM than in RF, but the numbers *rice stem borer*, which attacks the upper parts of the plants, did not materially differ. Among diseases, *rice sheath blight* was significantly lower in RF and the incidence of *rice blast*, another important rice disease in the area, was about the same at the beginning of the season, with a slight increase in RM in the later growing period. As for weeds, the biomass of weeds was much lower in RF than in RM.

The lower incidence of rice planthoppers gets explained by an interesting fish activity, which was revealed by video surveillance. It was noticed that the elimination of planthoppers comes about when they fall off the plant and into the water. It was also noticed that planthoppers often fell when the plant was jarred by a fish bumping into the stem. Both RF and RM fields were cordoned off and fish activity in the RF fields watched with video cameras. The numbers of planthoppers that fell into the water were also counted, in both fields. The result was something like 27 fish hits per day in the RF field and planthopper falls of 174 in the RF but only 79 in the RM fields. Some of the planthopper falls, naturally, were due to "non-fish" reasons, like wind. But there was a difference in the numbers and it worked out that some 97 planthoppers were removed each day by fish activity. It is not established whether the fish could learn to buffet plant stems to shake down planthoppers as food!

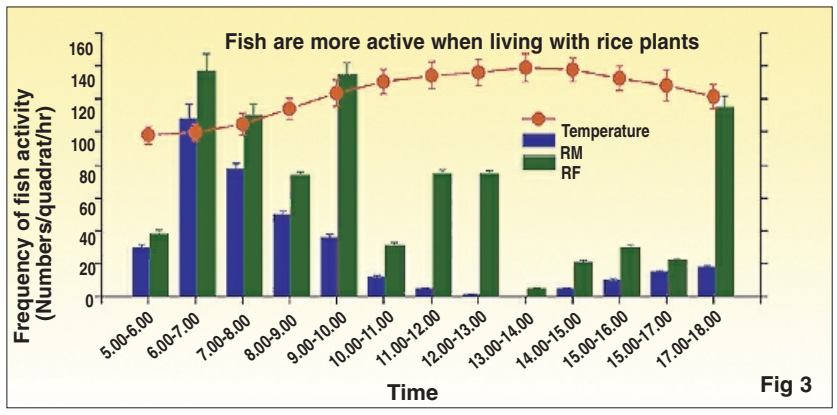
Benefits for the fish

The fish were also seen to be more active in fields where there were rice plants than when they had the field to themselves (*Fish monoculture* – FM). This again was discovered through video surveillance and a significant finding was the great difference in the level of fish activity between the hours of 11 am and 3 pm! The reason seems to be the higher temperature and light levels in shallow water in FM fields, particularly during July-August. The level of ammonia-nitrogen in the water was also seen to be controlled by the presence of rice plants. These findings would be important in the case of fish culture.

Further symbiotic relationship was revealed in the efficiency of nitrogen use. It was found that the yield of RF fields was significantly higher if the fish were fed with nitrogen-rich fish feed. The yield in these plots was higher even than RM plots, that is without fish, where a 36.5 per cent higher nitrogen input was provided. While adding fish feed always increased rice yield, it was estimated that only 11-14 per cent of the nitrogen in fish feed was assimilated by the fish. It was the rice plants that took up the remaining nitrogen, scrubbing the environment of leftover nitrogen sources.

The study demonstrated that the fish-rice co-culture generated ecosystem properties that made this traditional system stable and sustainable. The saving of petroleum-based fertiliser and chemical insecticides, which need water to wash away, would be significant in a warming world with changing climate, shrinking water resources and growing numbers of mouths to feed.

The writer can be contacted at simplescience@gmail.com



Discrepant crossover events

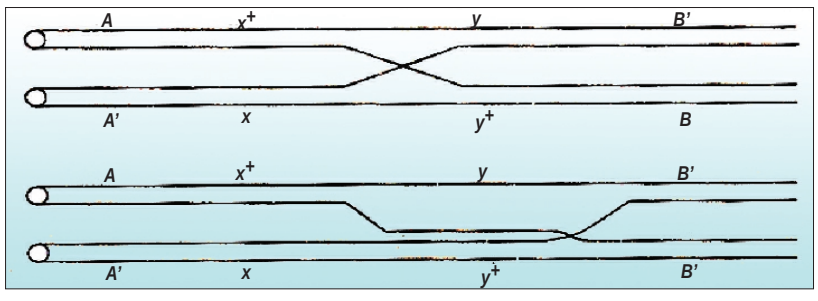
Earlier views of this phenomena are in need of extension in terms of time of occurrence, spacing along the chromosome and reciprocity of products, writes tapan kumar maitra

CERTAIN assumptions are made in any discussion on crossing over. This is considered as a reciprocal event that takes place at the four-strand stage of meiosis, and between non-sister chromatids. Crossovers, furthermore, are thought to be spaced so that adjacent crossovers are at some distance from each other; that is, within 10 map units, double crossovers are not recovered.

Studies of a recombination in micro-organisms do not, in general, invalidate the above assumptions in so far as they relate to higher organisms, but the data obtained indicate that earlier views of crossing over are in need of extension in terms of time of occurrence, spacing along the chromosome and reciprocity of products.

Two kinds of crossing-over phenomena pose a problem in terms of conventional crossing over. These are the clustering of crossovers for closely linked loci (high negative interference within the cluster), and nonreciprocal crossovers.

Clustering of crossovers between closely linked loci (map distance of less than 0.1 between loci) has been found in a number of organisms — Neurospora, in particular. When such closely linked loci are marked on either side by more distantly located loci, the outside markers are also involved in the crossover. The event, therefore, does not seem to be different in nature, but it does in spacing, from more conventional crossovers. The number of crossovers per cluster cannot be large to yield these results, and is probably no more than three, but some mechanism, as yet not understood, causes a very high negative interference to operate.



A possible scheme to account for the occurrence of aberrant ratios encountered in Neurospora and yeast. Top, crossing over as it occurs in the conventional manner to give standard ratios among the recovered chromatids. Bottom, crossing over occurring in such a manner that *n* on reciprocity is encountered at the *y* locus, giving *3y+:1y*. Whether this is the manner by which nonreciprocity occurs is not yet known.

Nonreciprocal crossing over occurs in both yeast and Neurospora, where all products of a single meiotic cell can be recovered. If we employ the combination of genes, we would normally expect to find that when crossing over occurs between *x* and *y*, the *x+ y+* recombinant should be accompanied by an *xy* recombinant as well as by the *x y+* and *x+ y* non-recombinants. However, an occasional ascus shows the following:

Ax+yB
Ax+y+B'
A'xy+B
A'xy+B'

The *y* locus shows a *3y+:1y* rather than the expected 2:2 ratio. At the same time, the loosely linked *A* and *B* loci, as well as the more closely linked *x*, show normal segregation. A possible explanation of the non-reciprocity of *y* to *y+* segregation has been advanced, but our lack of knowledge of chromosome structure and behaviour at the time of crossing over leaves doubt as to the true basis of the phenomenon.

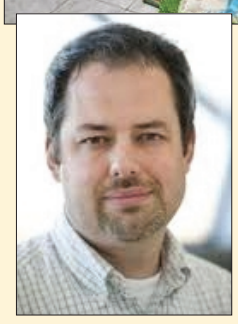
The writer is associate professor and head, Department of Botany, Ananda Mohan College, Kolkata.

The beginning of the end?

A discovery by British scientists has transformed the fight against malaria, the world's deadliest disease. steve connor **reports**

YOU wait for years for a breakthrough in the battle against malaria, and then two come along in two weeks. But the advance announced on Monday by scientists at the Wellcome Trust Sanger Institute in Cambridge is potentially far more significant than last month's news of an experimental vaccine made by GlaxoSmithKline (and part-funded by Bill Gates), which showed partial success in early clinical trials. Scientists involved in those trials emphasised that the vaccine would only be able to contribute to the control of malaria.

The Cambridge scientists' discovery offers hope of something far more thrilling: the complete global eradication of the disease. That tantalising goal is significantly closer, thanks to the discovery of the critical component of human red blood cells that



Dr Julian Rayner.

appears to be vital for the malaria parasite to complete its lifecycle within the human body. In effect, the deadly parasite's "Achilles heel" has been identified.

This means that it should be possible to design a vaccine that blocks the parasite's development within an infected person — which, researchers believe, should prevent both the disease and its mosquito-borne transmission.

Malaria is one of the world's biggest childhood killers. Nearly a million people a year die from it, mostly children under five living in sub-Saharan Africa. Scientists have spent decades trying to devise vaccines that protect people against infection or can control the parasite's development once it is inside the body. However, the complexity of the parasite's lifecycle has frustrated the design of effective vaccines.

But now, said Julian Rayner of the Sanger Institute, the crucial protein "lock" on the surface of human red cells that allows the mosquito to insert its "key" and gain entry had been found. "The interaction (between malaria parasite and red blood cell) that we have found has the potential to be the basis of a vaccine that would save millions of lives," Dr Rayner said. "This is possibly the most exciting vaccine target for the past 10 years."

The work behind the breakthrough, published in the journal *Nature*, focuses on the second phase of the malaria lifecycle in the human body, after it leaves the liver to invade the red blood cells during its "merozoite" stage.

The Sanger Institute scientists were able to identify a human protein called *basigin* on the surface membrane of the human red blood cells that the parasite appears to need to unlock the membrane and invade the cell.

"The malaria parasite shuttles between mosquitoes and humans. But the stage that actually causes the symptoms of the disease is where the parasite invades human red blood cells," Dr Rayner said. "It has to get inside a red blood cell to divide, spread and multiply – it's essential for the parasite's survival. But it's also a potential target for attack."

Once the scientists had identified the key protein "receptor" on the membrane of the red cells, they devised experiments to see if it was possible to block the interaction between malaria parasite and cell. They succeeded with antibodies designed to recognise and stick to the corresponding receptor protein on the parasite — blocking the "key" used by the parasite to unlock red cells.

"We can show that if we use antibody against the receptor we can completely block all detectable invasion by the parasite," said Gavin Wright, whose laboratory at the institute devised the techniques for making pure malaria parasite proteins. "We have done experiments where we've raised antibodies against the parasite protein and again we've shown very strong inhibition of the invasion process. As a starting point for vaccine development, you couldn't hope for better."

Professor Adrian Hill of the Jenner Institute in Oxford said the breakthrough could improve future vaccines. "Reports of positive results from ongoing trials in Africa are encouraging, but in the future more effective vaccines will be needed if malaria is to be eradicated," he said. "The discovery of a single receptor that can be targeted offers the hope of a far more effective solution."

The Independent, London