

Conclusion

The overall impact of tilapias in the region can best be assessed in the following context: (a) its present and future contribution to the well-being of the society; (b) perceived impact as a group of aliens that have become an integral component of the current ichthyo-fauna of the region; (c) present and future impacts that tilapias have on biodiversity. The positive outcomes of introduced tilapias in the Asia and the Pacific are:

- establishment and sustenance of capture fisheries in certain countries in the region;
- an important aquaculture species group in most countries in the region, appropriate for a wide range of aquaculture operations including integrated aquaculture operations;
- a source of inexpensive animal protein in developing countries; and
- a source of money through local and international trade.

The above have, undoubtedly and significantly, impacted the socio-economic milieu of various sectors of the communities involved. There had been direct and indirect beneficiaries from these impacts; the former being those involved in the production, both capture and culture of the tilapias as well as aspects of marketing of the produce; the latter being the general populace through the access to an affordable animal protein source. The benefits in exact economic terms, considering the value of the produce, are difficult to estimate. The same will be true of the impact of tilapias on the overall nutritional status of rural communities, which in turn could have a profound influence on their wellbeing.

In a similar fashion, tilapias are beginning to make a marked impact on food fish production in parts of the tropical belt in North and South America, through the establishment of self-sustaining fisheries in both culture-based fisheries and aquaculture sectors. However, unlike in the Asia and the Pacific, these developments are beginning to take root and are likely to reach a peak in the coming decade. As in Asia, the impacts are widespread favouring a vast range of socio-economic strata in the community.

There is no other alien aquatic species or a species group in the tropics that currently makes a contribution of such high magnitude to fish food production as tilapias do. The significance of tilapias as food fish is doubly important because it is an affordable animal protein source to most poor communities in developing countries. For example, in Bangladesh, tilapias are regularly stocked and maintained in the home-garden ponds together with major carps. More often than not, these small-scale aquaculture operations produce tilapias for household consumption and carps for generating cash income (Barman *et al.*, 2002; see also Table 8). On the other hand, tilapia capture fisheries in lakes and reservoirs, which in most instances happened to be located in rural areas (e.g. in Sri Lanka and Indonesia), tend to provide an accessible and an affordable animal protein source to communities living in the vicinity of these water bodies.



Nile tilapia from ponds and rice fields in Yunnan province, China

As such, tilapias play an important role in food security and poverty alleviation. It will be hard to replace this position with another indigenous group of fish. The success of tilapias in food production is similar to other sectors where total food supplies are mainly derived from alien species. Approximately 95 percent of livestock products are based on five species while plant products (e.g. cereals, fruits, etc.) are based on 100 or so species (Prescott-Allen and Prescott-Allen, 1990).

It is instructive to look at the introductions of tilapia into the region in context with other introductions of inland fishes. Beverton (1992) examined several threats to aquatic species, e.g. overfishing, habitat loss, alien species, and disruption of waterflows. He evaluated the records in Welcomme (1988) on 1 354 piscine introductions in inland waters throughout the world and reported that:

- 22 percent disappeared without a trace (considered to be an underestimate due to non-reporting of failed introductions)
- 51 percent had little or no effect on the ecosystem(s), or depended on regular stocking for continued presence, ;
- 17 percent established self-sustaining populations, either with beneficial or neutral effects;
- 7 percent had harmful effects that could obviously be discerned; and
- 3 percent rapidly increased and then declined, either through natural means or deliberate eradication.

The overall conclusion from Beverton's analysis was that the major threats to inland fishes were habitat deterioration and changes in waterflows. The majority of introduced species have proved either "non-viable or ecologically neutral". However, some general colonisers and powerful predators (e.g. Nile perch) seriously harmed the native fish fauna. It was also shown that negative effects could manifest 50 to 100 years after the introduction as in the case of the accidental spread of the sea-lamprey (*Petromyzon marinus*) in the Laurentian Great Lakes of North America. However, as Beverton (1992; page 139) points out, "... it is usual for two or more ... threats to operate together; ... the result may be more dangerous than the sum of their independent effects."



Tilapia cages in Lake Maninjau, West Sumatra

Species of tilapia, especially Nile tilapia, have become domesticated and genetically altered to increase production. This has also raised concerns over their interaction with native con-specifics or close relatives. For example tilapia genetically altered and moved around Africa would inter-breed with native varieties thus contaminate native gene pools or they may even enter fish farming facilities and compromise selective breeding programmes. Similarly salmon and trout that have been introduced or stocked into the Pacific Northwest of North America may interbreed with native salmonids and reduce the fitness of those populations. What is needed is to keep a careful track of events when and if newly developed strains of tilapias are introduced into the natural ranges of distribution, and try to minimize the risks of uncontrolled breeding, for example by using all male fish.

Freshwater fish are considered to be one of the most threatened groups of vertebrates used by humans (Bruton, 1995; Moyle and Leidy, 1992). In general, alien piscine introductions are cited as a major contributing factor leading to the threatened and endangered status of indigenous species (Moyle and Leidy, 1992).

The balance of currently available evidence in the Asia and the Pacific suggests that, as far as we are aware, tilapias have had no major negative impact on biodiversity per se. Welcomme and Vidthayanon (1999) examined the impacts of alien species in the lower Mekong Basin and found no direct evidence of environmental harm arising from tilapias. However, in some instances it may be too early to judge negative impacts. Therefore, there is a need for vigilance. With increasing emphasis on biodiversity issues (see for example Holdgate, 1996; Maclean and Jones 1995; Beveridge *et al.*, 1994), it is understandable that there are schools of thoughts emerging and indeed gaining momentum, expressing the view for a shift in emphasis of culturing aliens (i.e. the tilapias) to indigenous species (Jensen, 1999; Bakos, 1997; Bartley, in press). This may not be the complete solution to the hypothetical problem of tilapias impacting biodiversity with time.

Tilapias are already present in most of the major watersheds in the region and it will be difficult to remove them completely from natural and quasi-natural water

bodies in which they are already established. Previous attempts to eradicate established alien fish species (e.g. common carp in Australia) provide compelling evidence of the inherent difficulties that are encountered in such an exercise (Roberts and Tilzey, 1997). The analysis of Beverton (1992) on introductions concluded that only rarely has an unwanted alien been eradicated once it has become established. Evidence has been presented that tilapias are established in the Asia and the Pacific as well as in the Americas and will continue to contribute to the world's animal protein supplies, as well as have significant societal impacts in developing countries. It will be difficult, if not impossible, to eradicate them.

In the context of increasing but often unsubstantiated views on tilapia impacts on biodiversity, a pragmatic strategy would be to prevent the spread of tilapias to environmentally sensitive areas, or areas with productive inland fisheries. Such a strategy should go in parallel with prevention of further deterioration of the immediate environments and their catchments. A good example is the Great Lake, also known as the Tonle Sap, in Cambodia with its unique hydrology and a very rich and diverse piscine fauna. To date, tilapias have not been reported to inhabit this lake. The fishers in fishing communes around this lake increased from 0.36 to 1.20 million, and catches surged from 125 000 to 235 000 tonnes, a 1.9 fold increase from 1940 to 1995–1996, with an overall 44 percent decrease in catch per fishing commune inhabitant (Sverdrup-Jensen, 2002). In this productive system tilapia are not needed and should be prevented from becoming established. If the Tonle Sap becomes more degraded and overfished tilapia may find an opportunity to invade as there are tilapia farms in the floodplain of the lake. More often than not, aliens get established in undesired waters when the environment is degraded and its diversity and complexity are reduced as a consequence (Maclean and Jones, 1995; Moyle and Leidy, 1992).

Pillay (1977) expressed the view that haphazard introduction of species between nations, watersheds and continents, for all intents and purposes, is over and future introductions will be more considered from an ecological viewpoint. Unfortunately, it is common knowledge that currently many introductions and transfers of fish, crustaceans and newly developed strains are still being made. The general concerns on introductions led to the development of guidelines for introductions (ICES 1994; Turner 1988), and culminated in the development of codes of conduct for responsible fisheries (FAO 1995). Alien species in general and tilapia specifically have played and will continue to play a role in fishery development in developing countries in Asia and the Pacific. The task at hand is to ensure that this important group of fish is used responsibly and that native biodiversity is conserved in the process.