Preserving a Critical Fishery Resource in Inle Lake, Myanmar for Sustainable Fisheries and Food Security

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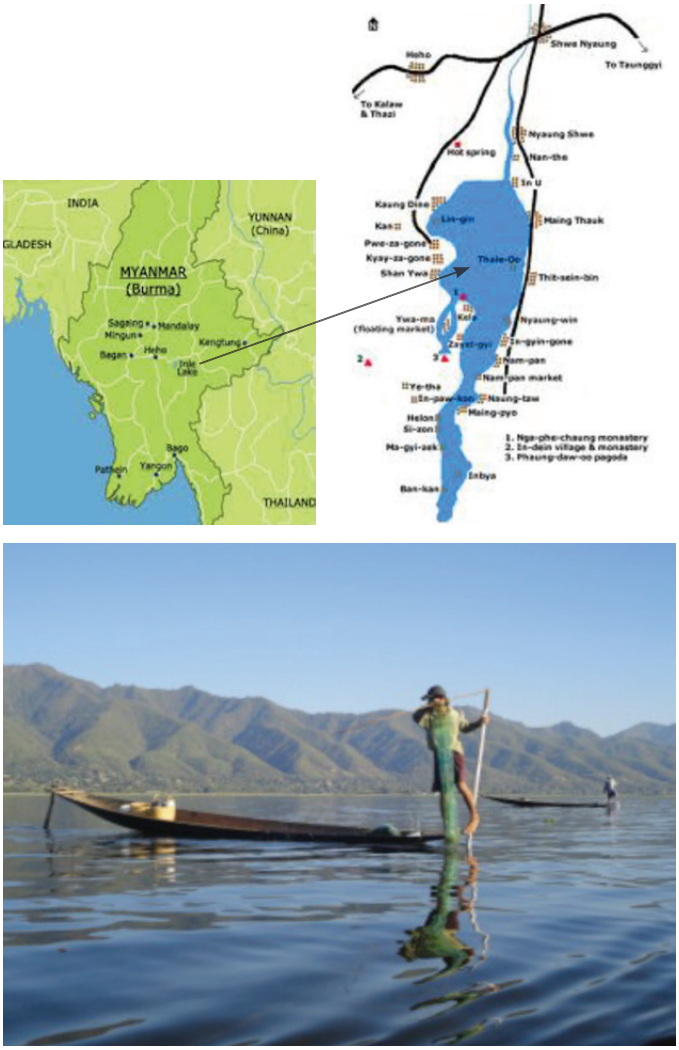
Inle carp (*Cyprinus intha*) is a bottom dweller species of carps which is endemic in Lake Inle of Myanmar. This species of carp is being driven to near extinction due to overfishing and environmental degradation of its natural habitat. Lake Inle is the second largest natural inland water body in Myanmar. Situated in Shan State in the northeastern part of the country, Lake Inle has an area of about 116 km^2 and sits in a tropical monsoonal area with diverse species of flora and fauna. Recently, the Lake has suffered environmental degradation due to deforestation and agro-chemical pollution, a situation that affects not only the Inle carp that inhabits the Lake due to its degrading water quality but also the Intha fishers who depend on Lake Inle and Inle carp fisheries for their livelihoods.

Inle carp (*Cyprinus intha*) is a Cyprinid fish commonly found in Lake Inle and an endemic species in Myanmar. In 2011, the IUCN Red List declared the Inle carp as endangered as it had been impacted by the introduction of some *Cyprinus* species in the Lake. *C. intha* inhabits the shallow zone of the Lake, especially in areas with dense submerged vegetation and muddy with high organic bottom. Spawning of this species usually takes place in waters with temperature ranging from 24°C to 26°C, between November and March.

The inland waters of Myanmar include natural inland and seasonal water bodies as well as freshwater fishponds that are being tapped for fisheries, which has been playing a vital role in the cultural and socio-economic advancement of the country. These natural inland water bodies include riverine and estuarine systems, such as the Ayeyarwady (also known as Irrawaddy) measuring about 2,150 km long, Chindwin (844 km), Sittaung (503 km), and Thanlwin

Inle carp, *Cyprinus intha* (below) and common carp (above)



Clockwise: Map of Myanmar showing Lake Inle, and intha fishers' technique of rowing boats in Lake Inle with a unique motion that has become a symbol of the local intha tribe

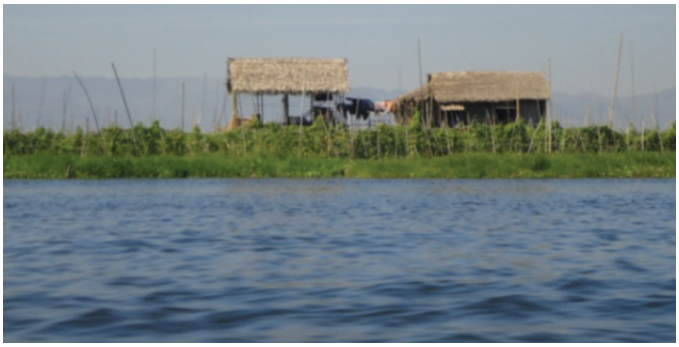
(2,400 km long) Rivers (Welcomme, 1985); and lakes such as Lake Inya, Lake Kandawgi, Lake Indawgi, and Lake Inle, among others.

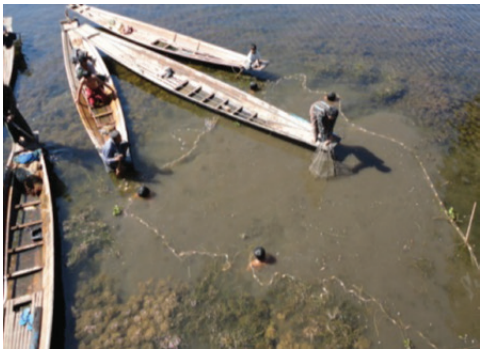
A highland water body, Lake Inle is the second largest lake in Myanmar with a surface area of about 116 km^2 and an altitude of 880 m, with average water depth of about 2 m. Flanked by high mountains, the Lake is host to a number of endemic aquatic species including more than 20 species of snails and nine species of fish that are not found elsewhere in the world. The people of Lake Inle, called *inthas*, use small boats for transportation and fishing with a unique style of propelling by standing on the stern of the boat on one leg and the other leg secured on a single oar as they balance the boat while fishing or traversing the Lake's still

waters. This technique enables rowers to see and elude floating vegetations on the Lake including floating gardens that are anchored in the Lake's bottom with bamboo poles, as well as see the lakeshores beyond the reeds and other growing vegetations.

On Lake Inle, the *inthas* have a unique practice of raising tomatoes and squash as well as growing cut flowers. Known as floating gardens, these are long strips of floating structures formed by tying together tangled water hyacinth, weeds and reeds that accumulate on the shores of the Lake, and secured at the bed of the lake using long bamboo poles. A form of hydroponic agriculture, the floating gardens primarily produce tomatoes which the *inthas* sell in local markets. Moreover, the *inthas* are also famous for weaving fabrics utilizing lotus and water hyacinth fibers believed to be fine, luxurious and silky. As major alternative livelihoods for intha fishers, these also serve as their means of maximizing the resources of Lake Inle. Moreover, the *inthas* also build their houses above the lake waters on stilts possibly exacerbating the pollution and siltation of the Lake.

During the past decades, Lake Inle has been going through severe environmental degradation brought about by siltation and pollution. Siddle *et al*. (2007) cited that between 1886 and 1948, the Lake had shrunk by 15% while its open water surface area had been reduced by 32% between 1935 and 2000. One of the major causes of the decreasing area and surface water is deforestation in the mountains flanking the Lake as well as along the banks, and agricultural encroachment and the practice of shifting cultivation on the lakeshores (Su and Jassby, 2000). Within the Lake, cultivation of tomatoes and to certain extent squash and cut flowers in floating gardens which the *inthas* have been practicing for a long time (Siddle *et al*., 2007) has impacted the water quality of the Lake due to excessive use of agro-chemicals (Akaishi *et al*., 2006).





Floating garden *(above)* and *inthas* fishing in Lake Inle using the traditional gear Inle saung *(below)*

Fisheries Production of Myanmar

Inland fisheries that include capture fisheries and freshwater aquaculture are very important for food security and economy of Myanmar. As shown in **Table 1**, the country has seen much progress in terms of inland fisheries development with inland capture fisheries accounting for an annual average of 26% and freshwater aquaculture by about 19% of the country's total fisheries production from all sectors during the five-year period from 2007 to 2011. Moreover, the country contributed 44% to the total inland capture fisheries of Southeast Asia in 2011, 13% to the region's total production from freshwater aquaculture in the same year, and its total production from all sectors contributed about 12% to the region's total fisheries production. The main species produced from inland capture fisheries (SEAFDEC, 2013) is freshwater gobies although the species were not identified, mostly captured from rivers (83%) and other inland water bodies (17%). For freshwater aquaculture, the most important species is *Labeo rohita*

Table 1. Five-Year Fisheries Production of Myanmar (in metric tons (MT))

Myanmar Production:	2007	2008	2009	2010	2011
Inland Capture Fisheries	**717,640**	**814,740**	**899,430**	**1,002,430**	**1,163,159**
Freshwater Aquaculture	556,354	605,552	670,773	772,396	761,697
Total Fisheries Production	2,808,037	3,147,605	3,491,103	3,901,979	4,149,799
Southeast Asian Production:					
Inland Capture Fisheries	**2,008,301**	**2,329,524**	**2,397,273**	**2,377,253**	**2,641,094**
Total Freshwater Aquaculture	3,292,292	4,345,762	4,739,861	3,097,970	6,071,294
Total Fisheries Production	25,302,870	27,207,826	28,917,096	31,438,435	33,487,689

Sources: *Fishery Statistical Bulletin of Southeast Asia (SEAFDEC, 2010a, 2010b, 2011, 2012, 2013)*

(rohu) accounting for about 70% of the total production from freshwater aquaculture in 2011 (SEAFDEC, 2013) followed by *Catla catla*, tilapia, mrigal carp (*Cirrhinus mrigala*), grass carp (*Ctenopharyngodon idella*), bighead carp, *Pangasius* spp., and others contributing the remaining 30%. Inle carp (*Cyprinus intha*, Annadale 1918), which is endemic to Lake Inle, is a staple of the local diet of the *inthas*. Reported to be endangered and is now in the IUCN Red List Category, this native species has been affected by overfishing, as well as increased sedimentation and euthrophication from expanding agriculture activities in and around the shores of the Lake. In addition, this species may have also been impacted by competition and hybridization of the common carp *Cyprinus carpio*, recently introduced in the Lake (Vidthayanon, 2013).

Intha fishers depend on Lake Inle for their livelihood using several types of fishing gear such as set gill net, hook and line, Inle *saung* and fish trap. Although the main fish species caught by gill net are tilapia, featherbacks and snakeheads, some local species including the Inle carp (*Cyprinus intha*) are also caught resulting in the depletion of their stocks year by year. Meanwhile, the most important species for freshwater aquaculture are major carps including the Indian carps, namely: rohu (*Labeo rohita*), *Catla catla*, and *Cirrhinus mrigala*.

Some introduced species of common carp (*Cyprinus carpio*), Chinese grass carp (*Ctenopharyngodon idella*) and silver carp (*Hypophthalmichthys molitix*) are also being cultured in freshwater environments of the country. Fish seed production is one of the most important aspects in the country's freshwater aquaculture since fish farmers have been using fish seeds that are mostly collected from natural sources (Myo, 2013). An age-old practice in the country, collecting fish seeds from the wild limits the availability of pure fish seeds since the collected seeds generally comprise mixed stocks together with both

desirable and undesirable fish species, and separating the desirable seeds from the mixed stock is a gigantic task. In order to overcome these problems, induced breeding of desired species especially the endangered species, has been promoted in the country not only to supply the demands of the freshwater aquaculture industry but also to conserve endangered aquatic species by enhancing their stocks, especially in Lake Inle for sustainable fisheries and food security of the local people, the *inthas*.

Breeding and Culture of the Inle Carp

Okamoto (2012) reviewed the capacity of *intha* fishers to adapt and cope with the current deteriorating Inle carp resources in Lake Inle of Myanmar. Based on the framework developed by Agrawal (2008) which classifies possible adaptation and coping strategies into mobility, storage, diversity, community pooling, and market change, Okamoto (2012) cited that *intha* fishers may not be able to adopt mobility because of the decreasing catch of Inle carp from the Lake while storage is also not feasible since the *inthas* do no process the fish as these are sold fresh in the market. Although diversification which includes culturing the fish among others could be an option, stability of fish culture should be ensured in order that this could provide supplementary incomes for the *inthas*, while the issues and constraints in the culture of Inle carp should also be addressed. Another option to sustain the Inle carp resources is by controlling the fishing periods but this could be difficult to enforce as *intha* fishers continue to fish throughout the year in order to survive. Similarly, community pooling and market change would not be possible options considering the present local economy in the Lake's fishing communities.

In an attempt to promote the breeding and culture of Inle carp for the conservation of this important resource and for providing alternative livelihoods to intha fishers, Myo (2013) conducted a case study on the development of seed production techniques for Inle carp which could be disseminated to grow-out fish farmers in Myanmar. Such study was initiated with the main goal of preserving a critical fishery resource in Myanmar's Lake Inle, *i.e.* the Inle carp *Cyprinus intha*, for sustainable fisheries and food security of the local people.

Seed Production of Inle Carp

Currently, the seed production technique for Inle carp being promoted in the country follows the hypophysation method or the practice of injecting crude fish pituitary extracts into breeders. Since the 1970s, fish breeding by pituitary gland extraction has been considered an effective and dependable way of obtaining pure seeds of cultivable

fishes and is a simple practice that can be adopted by most fish famers in Myanmar. Since the common carp, *Cyprinus carpio* is a perennial breeder and its mature individuals could be obtained almost all year round for collection of pituitary glands, this carp species has therefore been used for pituitary gland extractions. The most suitable time for collecting pituitary glands of common carps is during May to July, when majority of carps attain advanced stages of maturity. If the collected pituitary glands are not meant for immediate use these must be preserved to prevent immediate enzymatic action by using absolute alcohol or acetone and freezing. Preservation of fish pituitary glands in absolute alcohol is most preferred because this makes seed production technique through hypophysation method easily transferrable to fish farmers in rural communities of Myanmar. Through this breeding technique, seeds of fish species required by local fish farmers could be made available for their culture operations, as in the case of the Inle carp for food security and poverty alleviation in fisheries communities along Lake Inle.

Generally, Myanmar could be considered as a carp country, where carps alone contribute 85% of the country's total production from aquaculture. In fact, the successful induced breeding of major carps through hypophysation technique was achieved in Myanmar in early 1960s (Fishery Statistics of Myanmar, 2009-2010). Thereafter, several inducing agents have replaced the fish pituitary glands extractions for induced breeding, especially those that allow fishes to reproduce for long-lasting periods on their own through their seasonal or continuous reproductive cycle. Nevertheless, various methods of induced breeding of carps are being extensively adopted in the country, to adequately supply the fish seed requirements of many fish farmers who had been dependent earlier on natural fish seeds collected from the wild, the quantity of which has already been severely decreasing through the years.

Cyprinus intha inhabits in the shallow zone of Lake Inle, and spawning usually takes place in waters with temperature that range from 24°C to 26°C between November and March (Myo, 2013). Results of the study of Aye (2007) on the Gonadosomatic Index (GSI) of *C. intha* from November 2006 to April 2007 showed that the highest GSI value was between November 2006 and January 2007, while the lowest GSI value was attained during December 2006 and March 2007. According to Smith (2004), peaks of GSI value occur prior to spawning (pre-spawning) and spawning is evidenced by sharp decline in GSI value.

For oviparous fishes, the extruded eggs could be demersal (on the bottom) or pelagic (above the bottom, and often at or near the surface). Eggs produced by demersal egg spawners are heavier than the surrounding water and develop on the bottom or attached to the substrate or float loosely on the bottom. Being demersal in nature, eggs of *C. intha* have been observed at the roots of water hyacinth or float loosely at the bottom. The embryonic development of *C. intha* is divided into six periods: zygote, cleavage, blastula, gastrula, segmentation, and pharyngula and hatching period (Myo, 2013). Hatching occurs 71-72 hours after spawning, and the newly hatched larva is 5.21 ± 0.04 mm in length surrounding the yolk sac. According to Kimmel *et al*. (1995), Stroban *et al*. (1992, 1995) and Steven *et al*. (1996, 1998) cited in Nica *et al*. (2012), carp embryonic development is more or less similar in nature.

In the case study of Myo (2013), the larvae reached the fry stage after 8 days of hatching. After four weeks, the fry increased in length to 18-23 mm, with distinct dorsal, anal, ventral and pectoral fin and the body entirely covered by scales and appeared similar to an adult. The result also implies that hatching and larval development occurred in water temperatures of 24°C-26°C, which correspond to the normal water temperature in Lake Inle. These findings were the same as Ghosh *et al*. (2012) where Koi carp eggs would hatch after 72-73 hours at water temperatures of 26°C-28°C. Kuo *et al*. (1973) and Liao (1975) also reported that the incubation period of carp eggs and larval development would depend largely on water quality parameters such as salinity and temperature.

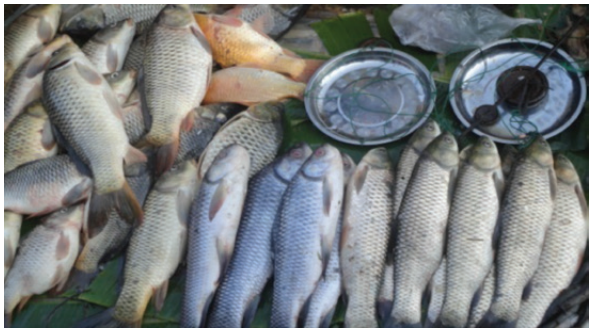
Culture of Inle Carp in Freshwater Ponds

Fish cultured in freshwater ponds in Myanmar generally comprises the common carps, Indian carps and Chinese carps. These species are characterized by their fast growth and with good adaptability in confined waters. Aquaculture, not only in commercial-scale but also in small-scale is an important protein source for rural communities in the country. Freshwater aquaculture in Myanmar started in 1954 using introduced species such as tilapia, gouramy and common carps. Many attempts had been made to culture Inle carp, *Cyprinus intha* in fishponds near the Lake Inle to preserve this endemic species which has been declared as endangered. Nevertheless, sustainable aquaculture of Inle carp should start with good seed production technique so that fish farmers would not have to rely on seeds from the Lake (Myo, 2013). In this aspect, the technique of producing the seeds in hapa nets was promoted as this is easy to transfer to fish farmers including fish seed producers. In the case study, Myo (2013) also promoted the polyculture of Inle carp with other carp species considering that this species is bottom dweller and thus, surface and column feeders could be cultured at the same time. Specifically, since freshwater ponds usually produce variety of food organisms in different layers of the water,

stocking various species that have complementary feeding habits or that feed in different zones could therefore, be done in a polyculture system to efficiently utilize space and available food and increase total fish production. In the global scenario, cyprinids such as *Labeo rohita*, *Catla catla* and *Cyprinus carpio* are the main species popularly polycultured since *Catla catla* is a surface feeder, *Labeo rohita* is a column feeder, and *Cyprinus carpio* is a bottom feeder fish.

Issues, Concerns and Recommendations

During the last two decades, Inle carp, *Cyprinus intha* (Annandale 1918) has played an important role in supplying food fish to the local people inhabiting the lakeshores of Lake Inle in Nyaung Shwe Township in Southern Shan State of Myanmar. The high demand for Inle carp by the local people resulted in overfishing which eventually led to the gradual decline of the species in various parts of the Lake. Local fish farmers who are not much familiar with the culture of *C. intha*, had not attempted any culture operation in fishponds in view of their inadequate knowledge of breeding and feeding techniques, while seeds from the wild had also become very scarce. Although many researchers had attempted to develop seed production techniques for *C. intha*, these efforts have not been disseminated considerably to the local fish farmers. Therefore, in order to address insufficient data and information on this species including its culture potentials, concerned agencies should try to promote breeding techniques, including larval culture techniques, larval rearing, and so on. Furthermore, investigation on stocking density of fingerlings in fishponds and release of fish seeds for the purpose of conservation and sustainable fisheries of this important resource in Lake Inle, should also be promoted.



Based on the results of the experiments in ponds, Myo (2013) suggested that *C. intha* could be cultured in fishponds for both breeding and commercial purpose. Bagenal and Tesch (1971) cited in Sedagnat (2013) stated that the parameters of the fish, length and weight relationship are affected by a series of factors including season, habitat, gonad maturity, sex, diet, stomach fullness, health and preservation techniques. These aspects should also be considered during the conduct of R&D of this species. The concept of polyculture of fish is based on concept of total utilization of different trophic and spatial niches of a pond in order to obtain maximum fish production per unit area. Based on the case study, the suitable combination of the surface feeder *Catla catla* and the column feeder *Labeo rohita* could be stocked in a pond with the bottom feeder *Cyprinus intha* in a polyculture system.

The results of the case study (Myo, 2013) also revealed that the highest fish production was observed when organic fertilizer (cow manure) was used and supplementary feeds such as peanut oil cake, rice bran and maize flour were given along with fish meal, agreeing with the findings of Mahboob and Sheri (1997) that higher fish production was obtained when broiler droppings were used compared to the use of NPK fertilizer in culturing major species of carps. As recommended by Yadava and Garg (1992), using organic manure as fertilizer in ponds would provide economic benefits to fish farmers as it could reduce operations cost by 50% from using inorganic fertilizers and supplementary feeds. Since supplementary feeding is known to increase the carrying capacity of culture systems and can enhance fish production by several folds (Jhingran, 1995), concerned agencies should enhance its R&D activities on the use of locally-produced feeds using locally-available materials in order to reduce costs in fishpond operations. Polyculture of *C. intha* with other carp species should also be promoted with the practice of using organic fertilizers and supplementary feeds that are available and cheap in localities that surround Lake Inle.

Furthermore, the sustainable and intensified production of *Cyprinus intha* fingerlings should also be considered for culture-based fisheries, taking into account the fact that survival rate of fingerlings released to the wild could decline during the culture period, and consequently, most fish farmers could not provide adequate number of fingerlings for culture-based fisheries. In this regard, responsible seed production of *C. intha* should be promoted as an industry near the Lake Inle, while maintaining the

habitat of *C. intha* to be environment-friendly for the species to thrive successfully should be advocated. The need to re-stock the Lake with hatchery-produced *C. intha* should also be considered otherwise, Myanmar's natural assets in Lake Inle, the endemic Inle carp might completely disappear and eventually lead to the extinction of this important commodity in the Lake.

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