FINAL REPORT

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PROPAGATION OF MAHSEERS IN HIMALAYAN WATERS OF NEPAL

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EXECUTIVE SUMMARY

Mahseers are superior mountain river game fish of international importance. They are known to occur in all Indo-Gangetic drainage system. All Ganges rivers emerge from the lofty Himalaya of Nepal and drain in Nepal, India, Bangladesh creating opportunities for development of fisheries. During recent decades in India and Bangladesh mahseer habitats have been disrupted by high dams and a few wild population of mahseer remains in these countries. In Nepal there are still some habitats of mahseer, where migratory spawners return year after year for spawning. Therefore, it was thought highly desirable to undertake investigation on the propagation of Mahseer in Nepal. The project has developed methodology and technology for artificial breeding, rearing and transporting of mahseer which is cornerstone for successful propagation in lakes and reservoirs of Nepal. It has taken the adult mahseer or brood stock returning to creek every year as starting point for producing mahseer. Great emphasis has been placed for release tagged mahseer in new habitats of lakes, reservoirs and pond and study their success in new environment. The project has become a model to Asian countries which provided impetus for more research and development. This project has clearly demonstrated that hatchery produced young fish can be successfully stocked in lakes and reservoirs of Nepal, where angling pressure is high and natural reproduction is often inadequate to maintain desirable sport fisheries. The fry of mahseer is of high demand in India and Bangladesh. In these countries, hatchery bred fries can be exported in future. Therefore, mahseer will become a tangible source of national income in future. The scientific data and information derived from Mahseer Ecology Project (MEP) have already been shared with scientists of Nepal, India, Bangladesh and Bhutan. Publication of mahseer research papers by the investigator has made rapid dissemination of mahseer breeding technology beyond the frontier of Nepal.

INTRODUCTION

In recent years, various investigators have given considerable attention to the propagation of seriously endangered mahseer in the Himalayan waters (Badola and Singh 1984, Shrestha 1986, 1988, 1990, Nautial and Lal 1988, Das 1990). They have been prompted by several considerations among them are: (i) loss of natural habitat and endangering breeding population; (ii) overfishing in natural waters and pollution and destruction spawning ground and broodfish; (iii) scarcity of healthy broodfish for artificial breeding by hormone injection; (iv) recognition by cold water fish culturists of a need for propagating mahseer in lakes and reservoirs to boost recreational fisheries; and (v) the realization that the mahseer may be ranched so that wild population be built in natural waters.

In developed countries particularly in the United States, methods have been developed for successful propagation of fish (McFarland 1960, Collins and Hulsey 1964, Anderson 1968, Webster, Trandhl and Leonard 1978, and Mauri, Andrews and Miller 1979).

As a contribution to this problem, studies were initiated in 1985 on the propagation of the mahseer, *Tor putitora*. Although experiments are still in progress enough data have been obtained to warrant the publication of the result during the four year period, i.e., 1985 to 1989.

A few accounts of induced breeding of the species of mahseer have been published (Tripathi 1978, Kulkarni and Ogale 1986). Methods for artificial propagation have yet to be described in detail (Shrestha 1985). This is the first attempt in Nepal at large scale breeding and propagation of the mahseer species in the ponds, lakes and reservoirs of Nepal.

RESEARCH OBJECTIVES

The mahseer, once a vital species in sport and commercial fisheries of mountain river was extirpated from the major river system of Nepal as a result of combined stresses of habitat loss because of intense fishing and pollution. His Majesty Government of Nepal realized restoration of the mahseer population to be of high priority and included in the development plan. In India and Bangladesh the fish has already entered in endangered list. Recognizing this important fact Mahseer Ecology Project was initiated to this endeavor to save the fish from extinction.

The specific objective of the Mahseer Ecology Project in order of priority are:

(i) Spawning Triggers

(ii) Hormonal Induction

(iii) Spawning Substrate

These are listed as follows:

(i) Determine the habitat conditions and requirements necessary for spawning, fertilization and survival of the young (spawning triggers).

(ii) Determine the effects of eco-physiological factors (temperature, rainfall, turbidity and hormones) on maturation, fecundity and spawning of mahseers (hormonal induction of spawning).

(iii) Determine whether these reproductive requirement can be incorporated into design and construction of the impoundment, supplied artificially, or whether propagation in a hatchery is required (spawning substrate).

Mahseer Ecology Project [MEP] addresses important problem of habitat restoration and propagation of rare and endangered mahseer stock. A series of experiments were conducted on spawning triggers, hormonal induction and rearing. This study has provided sound data base on maturation and spawning, critical phase of life history and provided mitigation measures for saving mahseer resource from impairment and loss because of construction of dam and other water related development.

MEP has made a significant progress in perfecting technique of tagging. These small tags offered advantage over traditional fish marking techniques because they allow scientists identify accurately to them in the field throughout their life span. The project has also been successful to bring conservation awareness among the public by developing audio-visual material and presenting conservation issues. The education materials such as book, poster, radio and television program prepared by P.I. has impressed large audience of the public.

I have developed a very meaningful contact for exchange of research results with scientists in Bhutan, Bangladesh and India particularly Dr. H. R. Singh, Dr. Nautial of Garhwal University, Dr. C. V. Kulkarni, Tata Electric Company, India I have also established special contacts with Dr. Mohammad Ali Azadi, University of Chittong, Bangladesh, Professor S.M. Das, Mahseer Ecology Project, Kumaun University and Dr. Desai, Senior Fishery Scientist, Central Fishing Research Institute, India. Dr. S. M. Das highly appreciated my studies on spawning migration, migratory behavior and spawning triggers of mahseer which hitherto remained a new area of research in the Asian-subcontinent.

Mahseer research has been endorsed and supported by Department of Wildlife Conservation, Royal Palace, Kathmandu, Nepal. Authorities of Royal Palace provided me an opportunity to examine brood fish stocked in Royal Mahseer Farm. Ministry of Agriculture, His Majesty's Government of Nepal provided me housing and other field facilities for the project at Gadkhar fish farm (Fig 1). Besides these Nepal Television, Radio Nepal and National News Agencies such as the Gorkhapatra and the Rising Nepal cooperated PI for wider publicity of the project.

METHODS

For the study of natural spawning and behaviour, both direct sensing and remote-sensing methods were used. Direct sensing of the mahseer habitat and behaviour was made by unaided yes. Spawners were dazzled with light of petromax to study spawning performance. The flourscent tube lamps were also used as light source in remote and inaccessible places. Occasionally, underwater torch lights were used to observe spawning activity and pick-up the freshly deposited spawn or fertilized eggs. Plankton nets of various sizes were used to collect the spawn. The physio-chemical feature of the spawning ground were recorded in sites (Table 1 and 2). Remote sensing of the habitat was done by binoculars and camera fitted with the telephotolenses and video recordings. The shape and size of the spawning ground and other physical characteristics were recorded. Freshly-deposited eggs were removed from the spawning beds, and successfully incubated in hatchery eggs trays. Both early and advanced fries were reared in trays and cloth bags for suspending in pond water. For stocking purposes, fries of different stages were transported to different places.

For artificial breeding, the live fishes were collected from the spawning creeks by using gill nets and trammel nets. They were acclimatized sexwise in separate plastic pools or cloth bags suspended in river water. The conditioned fishes in the plastic pools were fed with soybean and rice barn in proportion 1:1. Experiments were made by injecting extracts of pituitary from carp, the dosage is 4 glands per kg. body weight of fish. They spawned after 18.00 hours with only one intramuscular injection. Artificial fertilization was done by stripping the male and female brood fish by using conventional wet and dry methods.

Early fries produced as a result of artificial breeding were reared in incubation trays. The advanced fries were reared in cloth bags or happa suspended in pond water. Progressive development stages of fries were monitored for three years (1986-1989) and life table were constructed. Traicaine methylsulphonate MS-22 was used as anesthetics to tranquilize adult fish. Hauling the mahseer by truck and jeep was also tried. Mahseers were tagged 15 Sept. 1986 to 16 Sept. 1987. Most of the tagged fish were captured by gill nets and all were tagged with Floy tags.

To study the survival of mahseer in new habitats, experimental releases were made in Trisuli reservoir, Kulekhani reservoir (Indrasarovar). About 1044 semi-adult fish were released in Trisuli and Tadi river confluence sites. Among them 580 fishes were recovered after a year.

RESULTS

(a) Natural Spawning and Physical Feature of Spawning Site

Gadkhar creek is located in Chokedovan, near His Majesty's Government fish farm (Fig. 2). The creek gets flooded during early May and is down to a trickle during February to March. It consists of gravel, pebbles, cobble with boulders. There is a wide confluence site where the creek enters the Tadi river. Three beds A,B,C were identified on the creek. Bed A, consisting of pebbles less

than 10cm in diameter is the cleanest place among the three. Bed B, consists of rocks 45-90cm in diameter and Bed C consists of rocks 50 to more than 80cm in diameter. Water quality of the spawning ground is given in Table 1 and 2.

At midnight, mature mahseers came to the confluence a few at a time, they gathered from a group consisting of 10-30 in number. While swimming together in a group, several males would actively pursue the females, nuzzling and biting. After midnight, during the full moon period, courtship behaviour was intensified and suddenly the mahseers swam rapidly in shallow zones of the creek near the bank, where they vigorously flopped and trembled. Eggs and sperms were released at this moment and fertilization took place. The fertilized eggs came to lie on the surface of the pebbles, adhering firmly to stones pebbles. At an interval of two hours, ejection of eggs and sperms were again noticeable because the water of the outgoing current turned milky. The majority of eggs 2.5-3.5mm in diameter were washed away gradually by the current and the number of eggs adhered in situ was very small. The hydro-biological condition in relation to the spawner movement is given in Table 1.

Observation of the mahseer spawning activity commenced in September 1987. The periods of spawning observed were from August to September 1986. As evident from the Table 1, there is a strong correlation between spawning day and weather conditions. During the breeding season (September-October), spawning took place every evening on billowy and/or stormy days with heavy rainfall. The commencement of spawning behaviour also seems to have a strong relation with the hours of high flood in the parent river and medium flood in the feeder creek. Spawning took place at mid-night to early dawn. By a combination of meteorological data, it was seen that there was a significant relationship between the hours of onset of spawning and weather of the day (high rainfall and low barometric pressure), spawners selected rocks, stones, pebble, gravel, sand, logs debris as spawning substrata (Table 1). Spawning was not noticed among algae, among discarded plastic bags that had drifted to the creek bank. During the spawning season, observation were made during daytime in the creek for the detection of spawning.

Spawning of mahseer was initially observed on five consecutive evenings, September 2 to October 5 (fullmoon Sept. 2 to Oct. 15). Its occurrence was noted in relation to flood conditions. Spawning began 26 minutes after heavy flooding. The time of first spawning occurred after midnight of September 15, when there was a full moon. On November 15, no spawning was seen. During this period, there was no moon; flood intensity was too low and water was relatively clear (Table 1).

Mass spawning during and after the flood showed that the flood water level may provide a mechanism whereby fertilized eggs are transported to the river bank to find suitable shallow nursery habitat for fertilized eggs to settle and develop into fry (Fig. 3).

High temperature accelerated hatching time which was noticed in this study when eggs wee reared in incubation trays and aquaria, but caused decrease in oxygen content. This situation was rectified in aquarium by supplying fresh river

water and maintaining aeration. Laboratory observation revealed that continuous supply of freshwater, proper aeration, right start food, regular removal of dead eggs and waste material are the best ways and means for reducing mortality and shortening time of hatching. Mahseer sac-fry undergoes latency for a period of two days until yolk is fully absorbed; this phase was considered to be very suitable for long distance transfer (Figs. 4, 5).

(b) Collection of Naturally Spawned Egg Fry from Spawning Ground

The mahseer seed collection net (3 to 7m long) devised for this purpose was conical or funnel shaped, made of coarse cloth to allow easy filtering water. The tapering end, fitted with a ring 9 to 12 inches in diameter was made of reeds. A small pocket net, 0.5m long and 2.5cm deep that looked like a monk's hood was attached to the tapering end. The mouth of the net was often enhanced by adding two wings at the mouth (Fig. 6).

The net was stretched in shallow water bends of the creek where the flow is gentle, 1.2 to 2.5m/sec. It was tied to poles with the mouth facing the current. the hind portion of the net would drift in the direction of the current and was tied in this position to the poles just below the surface. The upper edge of the mouth of the net and the upper edge of the tail piece would be just above the water. The spawn and fry thus collected acclimatized separately in happa (cloth bags)(Fig. 8) and they were reared to fingerling stage. Fully grown fingerling is released later in adult fish ponds of Gadkhar fish farm for successful growth. Both hatchery bred and naturally spawned fries were transplanted to different water bodies.

(c) Artificial Spawning

Experiments were made during 1986-1989 by injecting extracts of pituitary from carp. The dosage being 4 glands per kg body weight of the fish. The pituitary extracts were injected at a time (with 0.3% saline water as carrier) in male and female breeders. They spawned after 18.00 hours with only one intramuscular injection. No death was caused by higher dosage.

Artificial fertilization by stripping the male and female breeders was done by both conventional dry and wet methods, brood fish ranging from 80 to 160cm weighing 2500 to 3800gms. The dry methods was far more successful than the wet one.

The larvae obtained by induced breeding as well as artificial stripping process resulted in 80,000 fry. They were reared in incubation trays and aquaria for a fortnight. About 40 percent mortality was recorded. Dead fries were immediately preserved for development and life history studies and live ones were reared in the Gadkhar fish ponds to adult-hood for three years (Table 3). Various stages such as sac-fry, swimup fry, fingerlings were transferred from the Gadkhar farm to Balaju fish pond, Gokarna fish ponds and Indrasarover of Kulekhani and survival of young fish in new habitat was monitored.

In the history of embryonic development of *T. putitora*, characteristic latency period was noticed in which the sac-fries became quite inactive and

showed only feeble motion and concentrated in dark corners of the incubator. This lasted about 8 to 12hrs. Hatching period appeared to be dependent on temperature. High temperature 32 to 34°C accelerated hatching process. In the present experiment in *T. putitora*, hatching occurred when oxygen concentration was 8 to 15ppm. The result showed that warm, overcast rainy days triggered spawning in *T. putitora*. Hot and sunny days were noted to be harmful for survival of hatchlings.

(d) Transfer of Hatchery Breed Fry

During 1986 studies, it was found that 4-8 days old sac fry could be handed safely and transported to long distances. On 21 September of the year, 10,000 sac-fry (volumetric measurement, 150 fry per cubic centimeter) were carried in light truck at the rate of 12,000 per can at a distance of 76 kilometers without significant loss. This successful operation was repeated again on September 15, 1987; at this time 50,000 fry were moved at the same distance. Each of these trips required about three and half hours to complete, and the water was not changed enroute. The sac-fry, not advanced enough for free swimming, settled to the bottom when placed in can and remained in that position during the transit (Figs. 4,5). The sac-fry were raised to fingerling stage in the happa or cloth bags suspended in pond water (Fig. 8).

Some transfers of advanced fry (free swimming 60 days) were made from Gadkhar Fish Ponds to ponds at Balaju. These fries were collected by fry net from incubators and transported in fish cans. A total of 22,000 fry of this age was transported by truck in 10 galleon cans for a distance of 70kms without significant loss. It is concluded from these results that advanced fry can survive from handling and transportation of over long distances (Fig. 7).

(e) Stocking of Advanced Fry

There is little information on the relationship between the rate of stocking and the age of stocked fry. Equally useful information on the rate of survival and rate of growth is lacking. Two ponds at Gadkhar Fish Ponds were used for stocking 60 days old fry in 1986. During September 1987, all ponds were drained. The liberated fish were removed and representative samples collected and recorded. In 360 days of the growing season, an average length of 25cm and weight 135gm was attained (Table 3).

The two ponds in Gadkhar were also stocked with 30 days old fry which gave much lower rate of survival than those stocked with 360 days old fry. In 360 days of the growing season, an average length of 18-22 cm and weight 120-130gm was attained.

Tagging of Mahseers

To study migration and dispersion of mahseer, 1044 fully grown mahseers and 2500 young mahseer were tagged (Fig. 11). Thirty percent of adults and 10 percent of young mahseers were captured. the young fishes were often captured 5 to 10km near released site,but adult fishes were captured 70 to 200km downstream of the released site.

This showed clearly that adult tagged fishes moved to warmer water feeding zone slowly to grow and mature further. The younger fish kept themselves in feeding zones downstream. The release site of parent stream got dry as soon as normal flood withdrawn. Most of them kept at lower reaches where sufficient water volume occurs to tide over dry spells. In any case, the mahseers are very mobile. Although this has been previously noted, long distance movement is usually thought to be spawning migration. It is now established that mahseer need fast and relatively warm rainfed water of creek for spawning so they migrate to headwater stream like Trisuli and Tadi for spawning. Soon after spawning is over, exhausted spawner move downstream as flood water in creek starts receding and they reach slow water downstreams reaches of the Narayani river. they repeat such migratory cycle year after year. The spawning and feeding areas are geographically separated between mountains an often range over great distances. Mahseers tags were located at different points of Trisuli, Tadi and Narayani rivers. The return of tags was made by volunteer fisherman (with Mahseer T-shirt award). Most of the tags were returned during the spawning season of fish. Tagging is still in progress; details are still to be worked out.

Transfer of Adults

Adult mahseer frequently experienced heavy mortality during hauling, which is to some extent counteracted when salt was added to the transport water and in some species, by adding anesthetic to transport water. The present study was conducted to determine methods, concentration, and kinds of anesthetics appropriate for use in hauling water for the successful transport of mahseer for as a long as 10 hours. Mean total lengths and weights of adult 20 males were 50-60cm and weight 8 to 10kg (Fig. 2) and fingerlings 18 to 20cm and weight 45 to 50 grams.

Anesthetic such as Tricaine Methanesulfonate (MS-222) was used as an experimental drug. The anesthetized fish were subjected immediately to a series of tests to evaluate these anesthetics at various concentrations and a stocking density of 2 fish/10l of water. In pilot tests of higher stocking densities of 4 to 6 fish/10l of water, all fish died. Fish were also held without anesthetic (control) in transport water containing either salt (.05%) or common salt (10%). The tests were made in double-lined plastic bags held in boxes (Figs. 9,10). Air was forced out by deflating the bags to water level; oxygen was then added and the bags were sealed and covered. Boxes were then left unattended for 10 hours. Bags were opened and fish behaviour evaluated by the criteria described by McFarland (1960), with modifications. Fish were acclimatized to 21-28°C and then released together in troughs for observation 10 hours later to evaluate their behaviour after anesthesia.

Hauling Mahseer by Truck

Three additional tests were conducted to determine the best method for hauling the mahseer by truck. Anesthetized fish were put into a rectangular tank containing 5000l of water with anesthetic and salt. Oxygen (3-5l/min) was added through a porous pipe. Fish were hauled in the tank for 10 hours, then removed to a holding trough for a 10 hours observation period (Table 4).

Concentrations of MS-222 were tested at 5mg/l increase up to 35mg/l. fish did not survive at the 1mg/l concentration, but did at the higher concentration up to 15m/l

exhibited loss of equilibrium; those exposed to 20-25mg/l were lightly anesthetized and those exposed to 30-35mg/l exhibited deep anesthesia. All fish quickly revived during tempering. Water quality was better at higher levels of MS-222. The deep anesthesia at 30-35mg/l indicated that lethal concentrations were approached.

Hauling Mahseer by Jeep

For making a field evaluation MS-222 (25mg/l) transport to Kathmandu is made by jeep. Two fish were put into each bag containing water (25°C; 10% salinity), anesthetic, 0.5mg/l. Bags were inflated with Oxygen and ice was added to the Styrofoam boxes. Seventeen boxes of fish with MS-222 were brought to Kathmandu. Fish were acclimatized by floating the bags in a pond at the Balaju fish pond following the trip (Fig. 11). Water temperature in the bag was about 18°C, whereas in the pond it was 16°C. All fish survived and appeared in good condition when released in the pond. After one month, two mortalities were noted.

The effectiveness of MS-222 in different species of fish is variable in the American experiments on the threadfin shad (*Dorosoma petencse*) and gizzard shad (*D. copedianum*). They were hauled successfully in 22mg/l of MS-222 (Collins and Hulsey 1964, Anderson 1968), whereas the American Shad (*Alosa sapidissima*) were intolerant of a 10mg/l dose of MS-222 (Murai *et al.* 1979).

Further studies may show that stocking densities in both bags and tanks could be increased. Results of my present tests, however, confirm hat every effort should be made to reduce stress and scale loss during the handling and transport of mahseer (Table 4).

Adult mahseers were put in the big earthen pots filled with water. Natural red clay collected from river bank is rich in haematite 200 gram in 40 liter of water were put. Common salt concentration must be maintained to 0.5 percent. Three changes of water were made during the transit, each change after a one-hour interval and fresh red soil and salt is added at each interval. The atmospheric oxygen dissolved in water was found sufficient for the hand carried fish. Splashing effect of water provided good aeration while carrying the fish in earthen pots. This method is useful at places where manpower is cheap and access by road is poor.

The present work demonstrates the possibility of augmenting depleted stocks of mahseer in the tail waters of dams and reservoirs of Nepal to rebuild the population decline owing to the barrier effects of dams, oversilting and habitat loss. Only the fingerling of mahseer is recommended for transplanting and restocking by using anesthetics and therapeutic oxygen inflated bags. It has been possible to release mahseer over a long distance (more than 180kms) from the Trisuli to the Kulekhani reservoir.

IMPACT, RELEVANCE TECHNOLOGY TRANSFER

To study contribution of artificial breeding or hatchery program marking methods were developed. The marking method use paints or tag to mark young and adult fish. The marking method is considered reliable method following homing and migration of the mahseer and may be widely used to study behavior, including growth and reproduction. Fin-clipping is another popular method and is mainly used for accessing

improved techniques of release. Both of methods used in MEP to determine appropriate time, place and method of releasing fry and examine feeding condition prior to the releases.

The propagation of mahseer required periodic handling of fish and transportation between sites. These operations, though of short duration, were potentially critical because such effort stressed or traumatized fish. Efforts were made to develop safe techniques for handling and transportation of fish which could increase overall success of hatchery release programs.

PROJECT ACTIVITY

Besides regular field and laboratory work, the project has been successful in the dissemination of research result among scientists in different countries. The following are the list of the meeting attended.

Date	**List of the Meeting Attended Title of the Paper**	**Organizer**
10-15 April 1986	Spawning Ecology and Behavior of Himalayan Mahseer *Tor putitora* (Ham.)	First Asian Fisheries Form, Asian Fishery Society, Philippines
15-18 Dec.1986	Breeding of the Copper Mahseer *Acrossocheilus hexagonolepis* by Hormone Stimulation	National Seminar on Fish and their Environment Kangri University, Hardwar, India
01-05 Dec. 1987	Field and Laboratory Technique for Breeding Golden Mahseer *Tor putitora* (Ham.)	National Seminar on Recent Trends in Fish Biology, Magadh University, Bodh Gaya, India
15 Dec. 1988	Mahseer Hatchery Techniques: Progress Report	US A.I.D., Kathmandu
20-22 March 1988	Impact of Water Use Development Projects on River Wildlife	National Seminar on Perspective in Aquatic Ecology, Nepal
23-25 Oct. 1989	Chronology of Early Development and Life History of Mahseer in the Intergravel Environment of The Himalayan Stream	National Symposium on Advances in Limnology and Conservation of Endangered Fish Species Garhwal University, Srinagar, Garhwal, U.P. India

17-20 Jan. 1990	Status, Biology and Conservation of Mahseer in Nepal	Fresh Water Biological Association of India, Bhagalpur University India
17-22 April 1990	Lunar Periodicity and Spawning Performance of the Golden Mahseer *Tor putitrora* (Ham.)	Tokyo University, Japan Paper presented in Absentia
10-14 June 1990	Status of Coldwater Aquaculture in Himalayan Water of Nepal	World Aquaculture 90 Halifax, Canada Paper presented in absentia
16-20 July 1990	Rare Fishes of Himalayan Water	University of Lancaster United Kingdom of Britain
14-10 April 1991	Conservation of Fish Germplasm in the Himalayan Waters of Nepal	World Fisheries Congress Athens, Greece Paper has been accepted
6-10 August 1991	Propagation of Mahseer in Himalayan Waters of Nepal	Network meeting of BOSTID National Research Council held in Manila, Philippines

Major Publication

The following are the important publications from the project.

1986 Artificial Himalayan Mahseer Spawning, Department of Zoology, Tribhuvan University, Kirtipur Campus, Kathmandu, Nepal, pp. 1-25.

1986 Spawning Ecology and Behavior of Mahseer *Tor putitora* (Ham.) in the Himalayan Waters of Nepal, pp. 689-692, J. L. Maclean, L. B. Dizon and L. V. Hoslilos [eds.], the First Asian Fisheries Forum, Asian Fisheries Society, Manila, Philippines.

1987 On Induced Spawning of Mahseer *Tor putitora* (Ham) by Pitutary Hormone Stimulation, Bulletin of Zoological Society of Nepal, pp. 3-4.

1988 Impact of Water Use Development Projects on Fish and River Wildlife, National Seminar on Perspective of Aquatic Biology, Papyrus Publishing House, New Delhi.

1989 Breeding of Copper Mahseer *Acrossocheilus hexagonolipis* by Hormone Stimulation, Himalayan Journal of Environment and Zoology, India, Vol. 3, 1989, pp. 22-27.

1990 Status, Biology and Conservation of Mahseer in Nepal, Journal of Fresh Water Biological Association in India.

1990 Behavior of Golden Mahseer *Tor putitora* (Ham), Journal of Fresh Water Biological Association in India, 2(3):209-219

1990 Rare Fishes of Himalayan Waters, Journal of Fish Biology, Academic Press, London.

1990 Life of Mahseer in Mountain River of Nepal: A Monograph [in process of publication].

Awarding Published Results

Royal Nepal Academy of Science and Technology, on behalf of Third World Academy of Science, Tristae, Italy, recognized PI research and awarded TWAS Award to P.I. in 1988. The citation of the award committee is quoted as follows:

> for his contribution in the field of expanding knowledge about wildlife of Nepal, confirming reliable method of propagation of mahseer and preparing inventory of Gangetic Dolphin.

Fishery Society of British Isles, at International Symposium on Rare Fish awarded cash award to PI with following citation in the year 1990.

> he participated with a significant contribution and received Fisheries Society Award for the best poster paper at symposium.

Joe Dillard, President of American Fishery Society presented Sturgeon Tie Pin to Dr. Shrestha, for his important work on endangered Mahseer at the International Rare Fish Symposium, held in University of Lancaster, U.K.

PROJECT PRODUCTIVITY AND INNOVATIVE ASPECTS

Mahseer project was started with following innovative ideas:

(i) That Mahseers grow to maturity in impoundment, but do not breed there. To discover this fact, the field work was carried out to determine the environment of mahseer reproduction.

(ii) That Mahseer has special habitat requirements. It is found mahseer have demanding spawning habitat requirements. If these habitat requirements are incorporated into impoundments they will grow to maturity and breed there.

(iii) That Mahseer has special spawning triggers. I discovered unique spawning triggers in mahseers. These include maturity of brood fish, water level (water quality and quantity) water surface, temperature, intergravel water flow, gravel

size, depth water, velocity, oxygen content etc. For example, I found water velocity, must be fast enough to stimulate a visual trigger. The visual trigger is always sight specific. I discovered that female mahseer is highly specific in selection of spawning ground. Gravel must be uniform in size, just large enough to cradle eggs, provide good flow of oxygenated water. Intergravel water that filter through gravel must be fast enough to remove silt. Unfortunately in existing impoundment of Nepal these characteristics are never met.

The pond raised mahseer was found to develop viable eggs and milt which are not released in ponds. The silt laden bottom of the pond does not elicit site specific visual trigger enough to release the eggs. I have been successful to conduct in induced breeding experiment which demonstrates clearly the possibility of augmenting depleted population of mahseer using carp pituitary as inducer. I have transported hatchery bred oxygen packed fry to the impoundments of Kathmandu.

Mahseer fingerlings so transported have been very much successful to grow into large fish by exploiting themselves food shelter and other resource of new environment.

I have discovered migratory runs of mahseer. I tagged juvenile mahseer to study the growth and reproductive parameter and construct life table of mahseer, such an innovation is much needed for management in nature and captivity.

FUTURE WORK

A number of studies on the reproduction of the warm water fish has been done in Asia. The information about reproduction, development and propagation is meagre indeed. To fill this gap, Mahseer Ecology Project (MEP) information on both basic and applied subjects are being accumulated. This included studies on spawning ecology, behavior, embryological development, ecological attributes of fry fingerling, transporting success in new habitat MEP has appreciably contributed the above research needs and improvement of present mahseer propagation program. In future more indepth studies on spawning, homing behavior, river ascent and changes in stock size and population dynamics will be needed. It is hoped that studies on these line future will elucidate present problems and find a means to increase stock size through high recruitment and assured production.

In Nepal nearly all rivers have been blocked by dams. There is no provision of fish ladder and spawning channel. I have been aware of enormous work being done on tail water fishery management in United States and Canada during my visits. Upon my return to Nepal, I began to think about feasibility and desirability of a spawning channel in different area displaced by dam. I proposed for need and opportunity for creation of mahseer runs. My idea has been welcomed by officials in Nepal and received active support from them. My new proposal entitled "Ranching Mahseer in Himalayan Waters of Nepal" is approved by U.S. Agency for International Development, Washington D.C. for study. I thank USAID for kind consideration.

TABLE 1 Observations on the Spawning of Mahseer in Gadkhar Creek

Date	Weather	Temp-erature (°C)	Interstream Migratory Movement	Downstream Movement	Spawning Dens	Spawning Assembly	Lunar Cycle
8/19/86	Sun and clouds. Rain for whole day. Barometric pressure 385.	25	Vigorous movement started around 1 a.m. at creek confluence and upstream in creek. Preliminary courtship acts and false spawning in the shallows.	Spawners moved downstream at 1 a.m. Fifty (38 males, 12 females) captured in gill net across confluence.	Gravel, sand bar, intergravel shallow water current speed to 0.5 m/sec. Temp. 31°C.	Possibly 3 males, 1 female. Low turbidity, gravel beds clearly visible.	Two days before full moon.
9/2/86	Cloudy, heavy rain (for about 6 hr.) and wind. Sky relatively clear at night. Full moon visible. Barometric pressure 360.	28	Mass movement of mahseer at about 12 p.m. Spawners travelled 100 meters upstream from confluence site. Male chased the female, brief courtship took place. Spermatic fluid released over the eggs deposited in the gravel. Creek water at certain spots appeared milky.	Spawners moved downstream at 5 p.m. Six females, six males were captured in gill nets.	Gravel, sandbar, intergravel water with depth 0.5 to 1 m. Current velocity 0.5 to 2 m/sec. Temp 32°C.	Possibly 53 males, 18 females. High turbidity, gravel beds not visible.	Full moon first day.
10/5/86	Cloudy, drizzling with wind. Full moon. Barometric pressure 380.	28.5	Movement of mahseer at the creek. Jumping, courtship and spawning.	Spawners moved downstream. Two females, two males captured in gill nets. All had running eggs or sperm.	Edge of deep pool, with mixed stones, pebbles and gravel. Depth and current velocity as above. Temp. 35°C.	About 500 spawners congregated, peak spawning period reached. Gravel bed clearly visible, turbidity low.	Full moon.
11/15/86	Cloudy, drizzling. New moon. Barometric pressure 456.	25.5	Usual spawning movement followed by courtship action. No eggs or sperm released. False spawning occurred.	Spent spawners moved downstream. Twenty females and sixty males captured in gill net. All were in spent condition.	Spawners very active. No ovulation or sperm observed. Temp 28°C.	Number of spawners decreasing steeply. Few late spawners still present.	New moon.

TABLE 2 Physical and Chemical Parameters of the Trisuli River Water (1986)

Month	Mean Current Velocity m/sec	Discharge Mean cu m/sec	Temp. (0°C) Mean	Depth (m) Average	Color	Odor	Tur-bidity (cm)	pH	Dis-solved O_2 (ppm)	Free CO_2 (ppm)	Total Alka-linity	Specific Conduct-ivity
January	0.6	60.00	10.0	2.5	Clear green	Fishy	180	7.6	18	28.0	160	61
February	0.5	46.00	14.0	2.0	Clear green	Fishy, methane	150	7.8	16	20.0	160	52
March	0.5	43.00	16.0	2.5	Unstable green	Methane	130	7.8	15	18.0	185	55
April	1.2	85.00	18.0	2.8	Silty brown	Fishy, methane	30	7.9	15	16.0	186	65
May	1.5	103.00	18.0	3.0	Silty brown	Strong, methane	20	7.4	10	18.0	192	76
June	3.0	440.00	24.0	4.0	Red silty brown	Methane	8	6.5	12	12.0	194	130
July	2.7	1080.00	25.0	6.0	Reddish silty brown	Weak methane	4	7.6	9	14.0	195	115
August	2.9	1226.00	26.0	6.5	Red brown, silty	Weak methane	5	7.8	8	4.0	245	128
September	3.0	870.00	27.0	4.0	Red silty brown	Fishy, methane	13	7.9	10	10.5	250	70
October	1.3	375.00	15.0	3.0	Dark green	Fishy, methane	19	7.4	12	15.2	310	62
November	0.8	164.00	12.0	2.5	Clear green	Fishy	85	7.5	18	20.0	320	65
December	0.7	61.00	9.0	2.0	Clear green	Fishy	100	7.6	20	30.0	340	60

TABLE 3 Biometric Data on Stages of the Mahseer during a Three-Year Period

Life History Stage	Time	Weight (gm)	Length (mm)
Egg or spawn	0 hrs	0.15	3.5
Fertilized egg	30 minutes	0.18	4.5
Hatchlings	55 hours	0.20	8.0
Sac fry	72 hours	0.25	12.0
Swim-up fry	110 hours	0.45	20.0
Jumping fry	180 hours	0.50	30.0
Fingerlings	3 months	1.90	80.0
Young fish	6 months	5.00	150.0
Young fish	1 year	135.00	221.0
Adolescent fish	1.5 years	450.00	250.0
Maturing fish	2 years	2,000.00	600.0
Mature fish	2.5 years	3,500.00	800.0
Spawning fish	3 years	5,000.00	900.9

TABLE 4 Classification of the Behavioral Changes of Mahseer under Anesthesia

Stage	Anesthesia Classification	Fish Behavior
0	Normal or natural	Highly excited, frantic reaction to external stimuli when caught from riverine habitat
1	Drugged	Decreased reaction to external stimuli, but swimming ability retained
2	Loss of equilibrium	Able to stay afloat, but unable to maintain body equilibrium
3	Light anesthesia	Total loss of swimming power, but able to move on the bottom (with tail movement)
4	Deep anesthesia	No movement on bottom, gill movement greatly reduced
5	Death	Gill movement ceased, fish float belly upwards

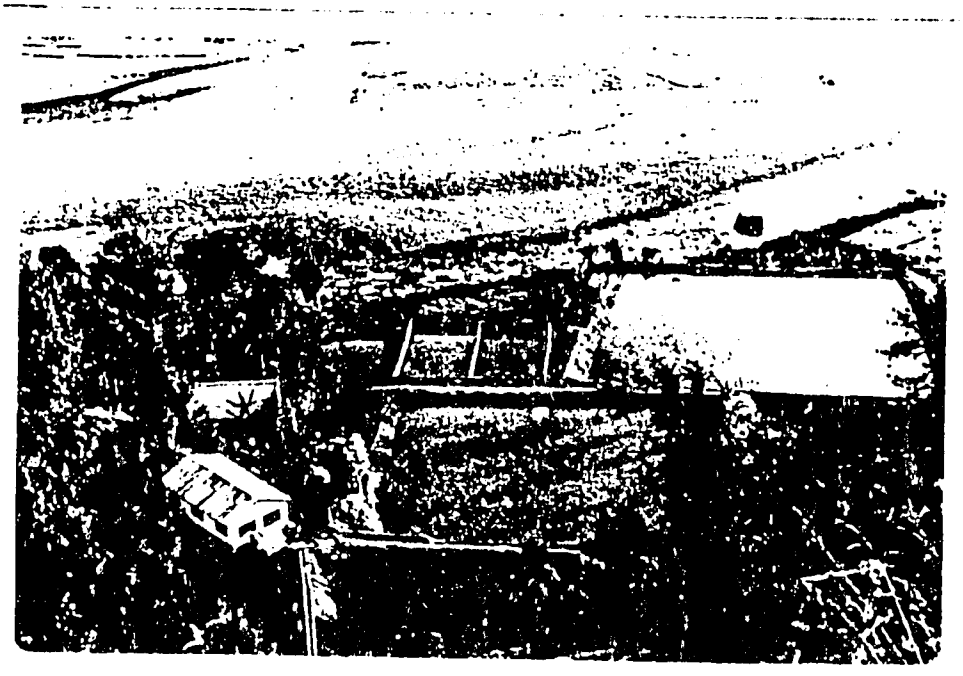

Fig. 1 Showing Gadkhar Creek and HMG Fish Farm Near the Creek

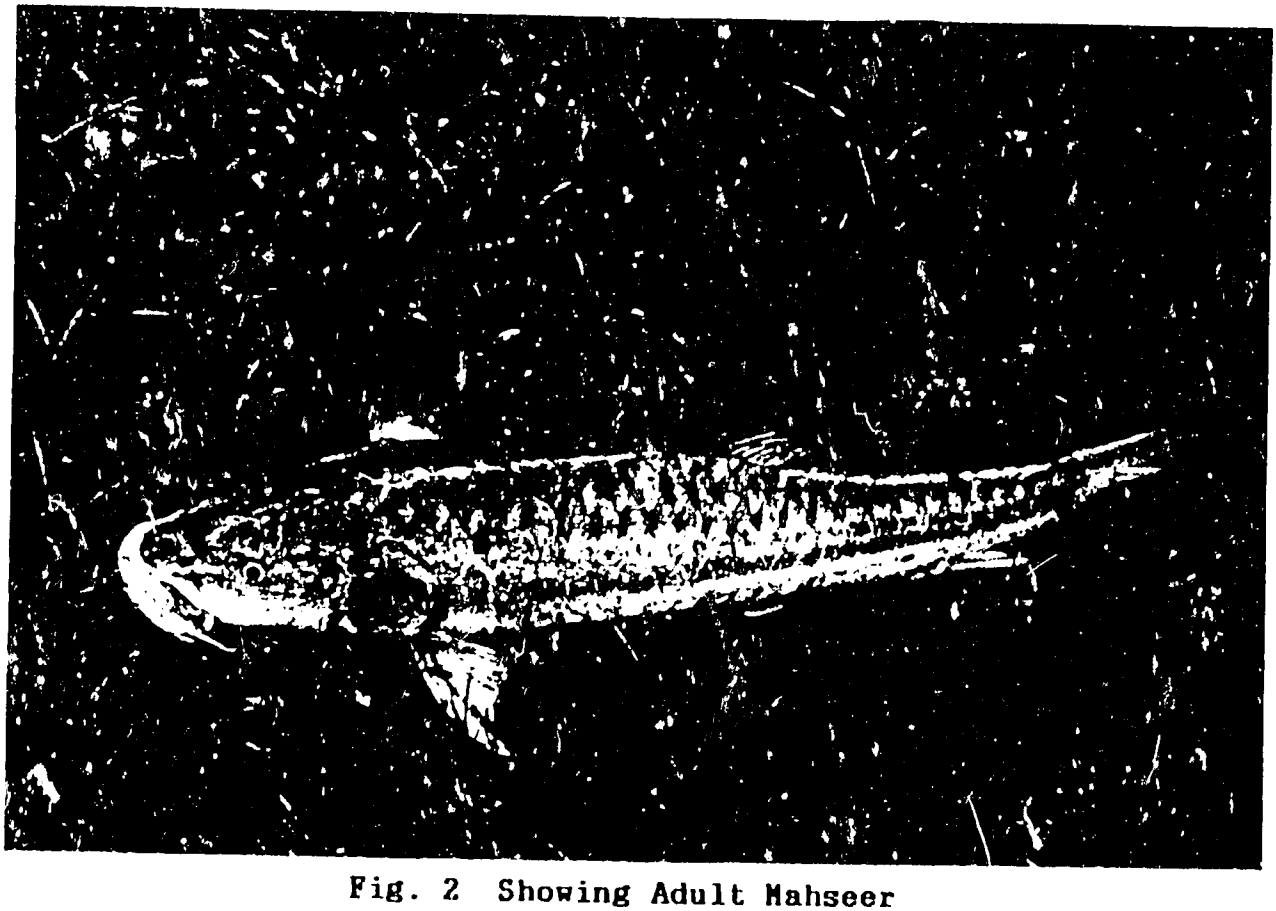

Fig. 2 Showing Adult Mahseer

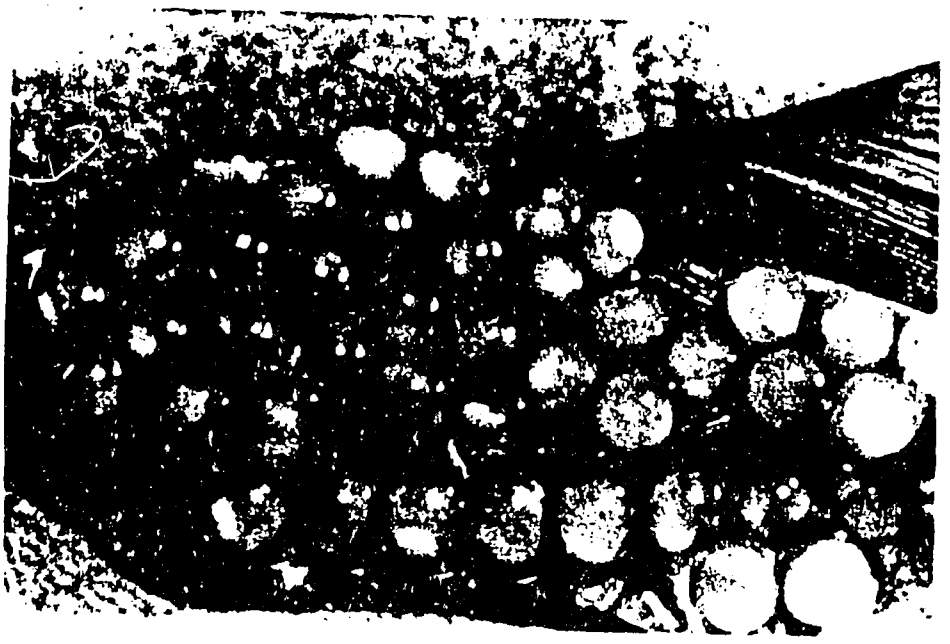

Fig. 3 Showing Fertilized Eggs of the Mahseer

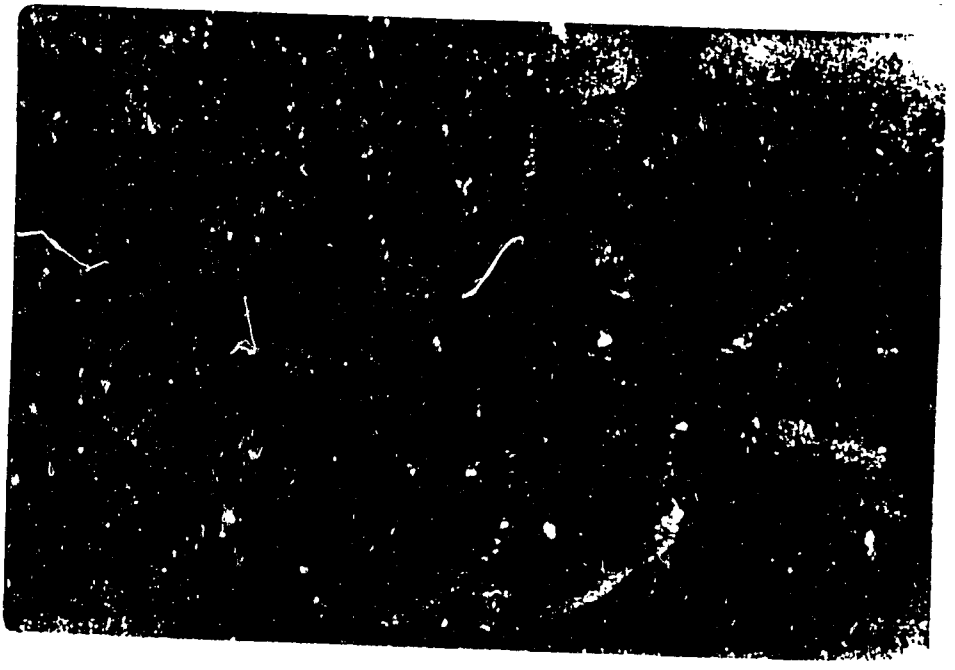

Fig. 4 Showing Early Sac-fry.

Fig. 5 Showing Advanced Sac-fry with Nearly Absorbed Yolk

Fig. 6 Showing Mahseer Spawn Collection Technique from Creek-beds

Fig. 7 Showing Six Months Old Fingerlings of Mahseer Ready for Transport

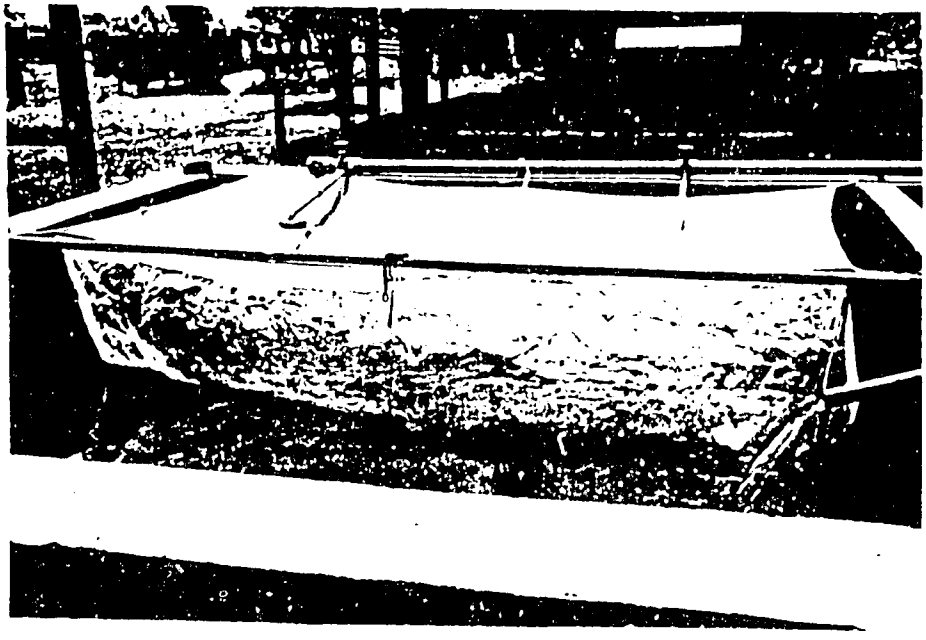

Fig. 8 Showing Happa or Cloth Bag Used in Rearing Fries and Fingerlings Mahseer

Fig. 9 Showing Consignment of Adult Mahseer Arrived in Balaju Fish Pond. First Oxygen Packed Bags were put in Pond Water to Cool Prior to Release in Pond

Fig. 10 Showing Adult Mahseer Transfer by Putting in Oxygen Packed Plastic Bags

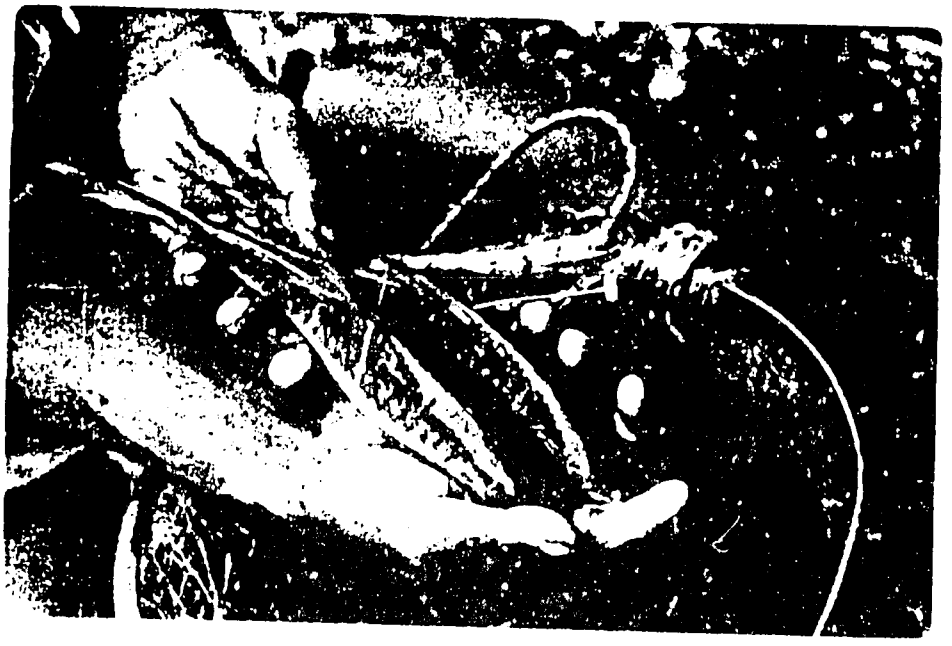

Fig. 11 Showing Young Mahseer Tagged with Floy Tag to Monitor Movement

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