SECTION B

TECHNICAL REPORT

PROPAGATION OF MAHSEERS IN HIMALAYAN WATER OF NEPAL

Life History of Mahseer and Ecological Requirements

January 1, to June 30, 1987

INNOVATIVE SCIENTIFIC PROGRAM (ISRP)
PROJECT NO (3E - 30)

Interim Report

By
Tej Kumar Shrestha Ph.D. F.L.S. (London)
Principal Investigator/Associate Professor
Department of Zoology
Tribhuvan University
Kathmandu, Nepal

In Collaboration With:

Tribhuvan University
Kathmandu, Nepal and
University of Arkansas and
US Fish and Wildlife Service

Endorsement by

Department of Wildlife Conservation
Principal Private Secretariat
Royal Palace Kathmandu (NEPAL)

Funded by US Agency for International Development,
Washington, D.C.

Ecological Aspects of Life History of the Golden Mahseer Tor Putitora (Hamilton) in the Rivers and Creeks of Nepal

By

Tej Kumar Shrestha
Department of Zoology
Tribhuvan University
Kirtipur Campus
Kathmandu, Nepal

Abstract

The early development of the golden mahseer Tor putitora Hamilton,was examined from an ecological perspective. Mahseer eggs are small (3.5 mm diameter) demersal and adhesive. Hatching occurs normally but the larval period is intervened by a brief post-hatching latency period. Hatchings are photonegative and geopositive and are transformed into small semi-transparent sac-fries and drift downstream shallow water nurseries. The larger swim up fry begin feeding directly on river diatoms, algae and minute aquatic insects and they complete four monthly cycle in the nursery beds of creeks and hill-streams. Soon after fries put on their weight change into fingerling and juvenile fish they show tendency to migrate downstream feeding zones. The close correlation between the developmental pattern of mahseer and environmental factors are interpreted. Heavy mortality of sac-fry, larvae, and swim up fry and jumping fry were recorded in field hatchery during bright sunny days than in overcast humid days. Under controlled condition of the reverside field hatchery it was practically possible to reduce mortality rate. Prospects of mahseer propagation and development of cool water reacreational fisheries management in Nepal are highlighted and management suggestions are given.

Introduction

Mahseers are superior game fish which also are useful for the development of cold water in reservoir fisheries. Few fishes of Himalayan waters illustrate better human taste than Himalayan Mahseers. Their excellent fighting properties plus good public image provide a background for expanding cool water fisheries. Mahseer fishery is steeply declining in Nepalese waters because of pollution and environmental factor such as barrier effects of dams, intensity of harmful fishing such as (dynamitting rock-striking stream poisoning) and wanton distruction of brood fish while migrating upstream for spawning. As the fish exercises great selectivity of spawning substrata the eyed,eggs and fries of this fish have to pass through a critical cycle of life-history as hatching period, prolonged semiqueiscent sac-fry stage and negative phototrophic behaviour of hatchlings,, their mortality is excessive. (40%) Human interference and water uses and pollution of streams can not be fully prevented. The fish therefore needs to be artificially propagated and fingerlings stocked into natural waters for the conservation of the species. Alternatively, pools of mahseer rich river should be declared as fish sanctuary so as to enhance natural breeding of the brood fish stock. To ensure intensive and extensive management, and safeguard early life history stages there should be compulsory provision of fish ladders in every dam and reservoir site to provide by-pass facilities for the migratory masheer.

Development and life history of fishes have been studied by a host of biologists in the past. Prominent among them are Harrington)1976), Yamamoto (1967), Paine and Balon (1984). Some important contribution has been made by a few Indian and Nepalese workers. Khan (1926), studied breeding bahit of (Tor tor) as well as copper masheer Acrossocheilus hexagonolepis. Ahamed (1948) described the spawning habits of mahseer (Lissocheilus hexagonolepis) of Assam. Alukhuni (1956) described the development maturity of Cirrhina reba and Labeo bata. Dabid (053) dealt with binomics some fishes of North India and Kashmir. He gave an admirable account of eggs, larvae and early life history early stage of Mahanadi mahseer (B. (Tor) mosal mahanadicus). Das (1953) observed gonad condition and breeding season in some fishes of North India. Das and Rampal (1968) made some contribution on life history of mosquito fish Gambusia affinis. Kulkarni (1970) gave an account of spawning habits, eggs and early development of Decan Mahseer, Tor Khudree (Sykes). Desai (1972) gave notes on early larval stages of Tor putitora. Chaturvedi (1976) studied spawning biology of Tor tor. Shrestha (1980) studied life history of hill-stream trout Schizothrax plagiostomus. Shrestha (1983) studied artificial spawning of the mahseer Tor putitora. There is no systematic record of any work on the ecological aspects of life history of mahseer living in running waters of Nepal. In this paper, I present my finding on the life history of mahseer so as to advance our knowledge about ecological requirement of the deminishing species.

Materials and Methods

The mahseer (Tor putitora) inhabits ice-cold running waters of creeks hill-streams, rivers of Nepal. It principally breeds in autumn breeding run ensuses in August and lasts for about two months (September and October). During spawning run the gravid male and female fish can easily be netted at night of of Trisuli river. (Particularly in feeder streams such as Malekhu Khola, "adi Khola) Up to 16,000 to 30,000 eggs are stripped from a mature female. Similarly 1-5 ml. of spermatic fluid could be stripped from each male. The ripe eggs from gravid fish are fertilized by mixing with spermatic fluid (milt from one or more male in a clean and dry container, followed after two minutes by repeated ringing in water. The hydration of fertilized egg with water (water hardening) causes elevation of the egg membrane which iscompleted with loss of stickiness in 15 minutes. Experiments were conducted by collecting broad mahseer from Malekhu Khola, Kolku Khola, Sindhurae Khola, Khaharae Khola and TRisuli river.

The size of the male brood ranged 75 to 104 centimeters and female 80 to 120 cms. Their weight ranged from 5 to 18 kg. The brood fish was fed with

Table 1

Developmental stages of Golden Mahseer Embryos and Larva corresponding Morphological Characteristics

Developmental Stages	Embryological Events
1.	Fertilization to early blastodisc formation
2.	Blastodisc extends half the distance to the equator: no neural plate evident
3.	Blastodisc envelops one-third of the yolk: neural plate is visible
4.	Embryo encircles half of the yolk: optic vesicles are apparent
5.	Embryo encircles three-quarters of the yolk: melanophores first appear: red blood cells are first evident
6.	Eye pigment is first apparent: pectoral fin buds are easily recognizable
7.	Eye pigment darker; dorsal melanophores arranged in rows, lateral melanophores now evident; dorsal and anal fin folds present
8.	Melanophores present on dorsal gut surface.
9.	Embryo completely encircles yolk; a few melanophores appearing on head
10.	Many stellate melanophores on each side of head, three rows on dorsal body surface
11.	Two rows of melanophores on each side of head three rows on dorsal body surface
12.	Mouth visible, caudal fin fold becoming lobate
13.	Melanophores present on opercle area
14.	Lower jaw grow over with or slightly protruding beyond upper jaw; hatching occurs during this state.
15.	Swim bladder develops after four days of hatchings. Hatchlings are photonegative geopositive
16.	Hatchling changes to sac fry which has black dot at the base of caudal fin a recognisation mark for fry of mahseer
17.	Sac fry changes into the swimp up fry after 8 to 10 days after the absorption of yolk sac
18.	Swim up fry changes into jumping fry after 15 to 18 days. They show tendency to jump out of the holdng tray.
19.	Jumping fry changes into full fledged fry after 25-30 days. In this stage they are to be transported in holding cloth tank suspended in pond water
20.	Fry changes into the fingerlings after three month to a year

fed with a mixture of flour, rice, barn, oil cake, brood fish are conditioned in cloth tank or happa as described by Shrestha (1986).

Each batch of eggs are fertilizer by dry and wet methods were transferred to hatching trays and small portable trays (30 x 10 x 5 cms) set in river water. Each battery of tray contained 300 to 500 stripped eggs. Sample of the eggs were drawn from each incubation tray or happa and were scanned under steroscopic microscope. The morphometric changes of the fish embryo through different hours and days were noted down and sketched properly. Few developing eggs were taken out and treated with 5% acetic acid. This technique facilitated proper sketching. For the histo-cytological studies developing eggs were fixed in Bouins, Hollands and Zenker fixatives. Embryos were stained with Alcian blue, cleared with trypsin and then stained with alizarine red.

The eggs of live fish are fertilized with the milt of male fish died about 5 hours earlier. Similarly, milt of live male fish is used to fertilize the eggs of dead which had died about 3 hours earlier. In both cases 50% of the eggs found to have been fertilized. The physico-chemical characteristic during the period of observation were: temperature 22° to 33°C; pH 6.5 to 7.0; oxygen concentration 4 to 19 ppm; turbidity 120 to 240 cms. (Table a and b)

OBSERVATION

Embryonic phase:

The mahseer's eggs are spherical and demersal and lithopelagophil. In river bed they are attached to submerged stones, gravel and sand. (Fig.) The eggs are transluscent and lemon yellow in colour when just fertilized. They swell up uniformly in five to 10 to 30 minutes and become semi-transparent. The fully swollen eggs have fairly large perivitelline space. The diameter of the internal kernal of egg range 0.85 mm from 1.8 mm and that of outer shell ranges from 2.5 mm to 3.05 mm.

Cleavage (Activation to organogenesis):

About an hours after fertilization, a crecentric, narrow blastodisc appears over the yolk mass. The first cleavage occurs after one hour of the fertilization. The second cleavage takes place immediately and this makes the embryo 8 celled stage. The third cleavage occurs after two and half hours. Asynchrony becomes evident by third cleavage. Horizontal cleavages occurs after fourth cleavage, producing irregular morula.

Differentiation of the embryo (Organogenesis to hatching and adoption to branchial respiration and pelagic phase):

The blastoderm cells begin to spread over the yolk mass, about the third of which covered in another eight hours. The yolk plug stage is reached at about four hours and thirty minutes of the fertilization. The yolk is completely invaginated by the blastoderm cells in next twelve hours and the embryonic rudiment is formed as marginal, narrow, thickened band.

Sensitive Stage: *SENSITIVE STAGE*

Mahseer eggs become progressively fragile during a period extending from 24 hours. The embryo starts elongation when it is 36 hours old. It measures about 0.80 x 0.55 mm. In that next 48 hours the cephalic and caudal region of the embryo becomes faintly discernible. At this stage notochord has formed and two myotomes have differentiated. After 52 hours the cephalic and caudal ends of the embryo become further differentiated and are easily distinguishable from one another. In the mean time, two more myotomes get added up and egg envelope start breaking. The embryo wriggles out from the egg shell as miniature hatchlings. They show little movement due to the hidrance provided by yolk sac.

Larval Development (Finfold phase of larval development to endogenous feeding):

Eyed Stage Larva, beginning to hatch (3 days):

The prolarva or hatchling is long and slender. As term implies it has closely set eye and lens. A large number of star shaped melanophores occur along dorsal line. Mouth is not still discernible. The area occupied by the embryo on the yolk is three fourth of the entire area. A rudiment of dorsal fin fold becomes more clear. Pro-larva now possessess thirty myotomes and measures about 5 to 7 mm in length. The larve shows twitching movement inside the egg capsule.

Larva or sac fry (6 days):

The larva is small, slender and almost transparent. Generally it is devoid of mouth. The optic vesicle assumes now oval shape. The embryonic fin fold extends up to two third of the body. The vistage of the anus is situated far back and the post-anal length is about one fourth of the total length. There are 30-38 myotomes of which 25 are pre-anal in position. The yolk sac is broad which tapers anteriorly towards, the vent. The larva lies quiscent on the yolk and occasionally moves about for sometimes. The rupture of the eggs membrane takes place due to the force exerted by jerky movement of the tail which lies below the abdomen. The larva escapes out of egg membrane. Its movement is said by the lashing movement of the tail. Out of fifty eggs watched

fourty of them came out normally without any difficulty but 10 of them had large yolk sac lying entangled in the egg membrane. The yolk sac caused hidrance for movement, process and large mortality occurred during hatching. The yolk sac obsorption time is variable which varies from 2 to 3 days depending upon the environmental temperature and physico-chemical property of the water. In the Trisuli and Tadi river time is variable. It takes place within 3 days in September and 4 days in October. The delay in obsorption is witnessed to take 6 days. It is clear that warm environment of Trisuli influences quicker hatching.

Early fin fold Larva (6 to 10 days old):

Larva at this stage bears a complete fin fold. The dorsal fin fold broadens at the level slightly posterior to the vent, indicating the formation of the dorsal fin. A similar broadening of the ventral fin fold, posterior to the vent marks the position of the anal fin. In the meantime, the tip of the notochord gets slightly turned up. In the caudal fin the traces hypurals and fin rays are seen clearly developed. The mouth of the larva now acquires terminal position and becomes more prominent. The larva now becomes dark coloured and internal structure is no longer visible. Now rudiments of the scales at head region are also clearly seen. Larva now measures 10 mm.

Fin fold larva (10 days old):

The cephalic end of the larva becomes more prominent. About 6-8 myotomes are seen to have been differentiated. The pectoral fins become flap like and the larva swims about by jerky movement in the water. In the mean time optic vesicle gradually acquire spherical shape. The unpigmented heads that decurved over a relatively large bulbous yolk sac. The dorsal fin fold is continuous with with ventral fin folds. In the larva melanophores appear in all parts of the body. The melanophore at head now number 12-15. Eyes become fully pigeminated. The yolk sac becomes partly absorbed, and then ceratotrachia appears in the caudal fin. Larva now measures 15 mm.

Juvenile Development (Transformation of Larva to adult fish)

Free Swimming fry (15 days old)

In this stage yolk sac is totally absorbed. Mouth becomes well developed and larva starts feeding ctivity. The alimentary canal becomes straight. A large number of melanophores appears on the integument They increase in size and number as well. The posterior concretion of the optic vesicle gets doubled in comparison to the size of the anterior one. The larval fin fold is continuous. The internal structure of the larva such as swim bladder and gills are clearly visible due to the transparency. The larva at this stage is 21.7 mm long.

Swim up fry (17 to 20 days old)

The paired fin of the larva is greatly elongated. The larval dorsal and ventral fin assumes nearly adult form and structure. The pectoral fins and supporting rays are also well-formed. The caudal fin bears 12 to 17 rays and becomes slightly forked. The larval fin fold completely disappears at this stage. The anal and ventral fin fold are broken into separate parts, and later possesses 9 to 10 rays. The body of the larva is heavily shot with melanophores. A characteristic black dot appears at the base of the caudal fin. The whole body of the larva is now covered over by minute scales. At this stage fry measures 28 mm.

ADULT FISH DEVELOPMENT

Jumping fry (20 to 30 days):

The fry at this stage measures 25 to 40 mm. It shows jumping tendency from the holding tray in which it is reared. So it is highly desirable to transfer the jumping fries from tray to a rearing cloth tank (happa) suspended in the pond water. Jumping fries holding tank need regular supervision, and feeding once in a day. Boiled chicken egg, particularly yolk emulsified in water is used with a great advantage. A jumping fry has all characters developed in swim up fry. Its differ on in size and shape.

Fingerlings (Two months to a year):

Jumping fries gradually transform into fingerlings during the span a year. A fully formed fingerlings measures 60 to 90 mm in length. This stage is marked by changes in the shape of head, body and tail. The head becomes more conical and body become roundish with the increase of girth. Tail also become deeply forked. Mintute silvery larval scale changes into large scales dashed with golden yellows, brown and blue scales. The fingerling is photopositive and rheopositive. They show tendency to migrate down river. (Table 1 and 2)

Discussion

Regarding the life histories of mahseers, there is no account excepting the early development of *Acrossocheilus hexagonolepis* (Ahmad 1948), *Tor tor* (Desai 1973), *Tor Khudree* (Kulkarni 1970). Kulkarni (1970) gave diagnotic feature of mahseer larve which help to distinguish them from the larvae of other fishes. He noted caudal spot in all larvae but failed to notice in sac fry below 10mm size. In the larvae of *Tor putitora* also such caudal spot is noticed in all larvae beyond 8mm size.

In common with many cyprinids the sac fry of the *Tor putitora* also contains copious amount of yolk to tide over the unfavourable situation. The yolk sac provides hidrance for brisk movement of larvae therefore they lead a quiescent life. This is one of critical stage in the life history at this time when developing eggs become infected with fungus and bacteria. The sac fry can tolerate low level of dissolved oxygen contained in flood water (4ppm). The flood water is rich is haematite particle and silty red clay which act as antiseptic. The developing egg of *Tor putitora* also undergo pre-hatching latency for a brief period as reported by Harrington (1947) in *Fundulus*. This is an adaptation to the pelagic nature of the egg so that developing embryo hatch out in a suitable environment. At this stage cold shock or treatment of ice or lunar eclipse delay the morphogenesis or hatching process even kills the embryo.

The study of the life history of the mahseer lends active support to the theory of "Saltatory Ontogeny" (Paine and Balon 1984) which postulates that development proceeds as a sequence of intervals of relative steps (Stasis), separated by rapid jumps (Switches) to new form and function. (Thresolds). It appears that these thresholds are ecologically important to the unstable life in mountain stream when they mark changes in the organism to environment relationship.

Management Suggestion

Golden mahseer has intriguing prospect for the development of cold water fisheries. There is a wide scope for propagation of mahseer in reservoirs. Constant supply of fertilized fish seed can be made from the riverside hatchery. Production of the seed any fry by artificial and induced breeding has been carried out by Shrestha (1986). The mahseer is suitable for culture in association with Nepalese hill barbel or catlae (*Acrossocheilus hexagnolepis*) and snow trout (*Schizothorax plagiostomus*) Artificial feeding of mahseer fry can be done by extract of boiled egg (yolk) strewing rice barn on the surface of the rearing pond or cloth lanic (Dhappa).

Nepalese mahseer is of unquestionable utility for stocking in highraltitude lakes. In the ice-cold water mass recreational fishery of the mahseer and its allied species can be developed. Fishing mahseer in midland natural and man made lakes such as Fewa, Begnas and Indrasarovar (Kulaekhani) will be of great touristic attraction. The field observations of the author have indicated that to obtain ripe male and female in breeding state is not difficult during August. The stripped egg can be fertilized with little effort (Shrestha 1990b). And transportation of the developing eggs is feasible over a long distance. Although mortality occurs during transportation which is of low percentage, the yolk sac fry of the mahseer possesses copious quantity of the yolk which facilitates the growing fish larva to tide over food shortage. The larva is known to feed well only after 10-15 days depending upon the environmental condition to which they are reared. Larvae can be reared in earthen pots. Mahseer larvae can be transported by keeping in earthen pot half filled with water or by using oxygen packed polythene bag.

Table a

Physical and chemical data of Creek water at Spawning den of mahseer at Gadkar Creek around and at the time of spawning 1986.

Parameters	
Water level (m)	1.2 to 3.5 m
Current velocity (m/sec)	0.50 to 4 m/sec.
Air temperature (°C)	30 - 33°C
Water surface Temperature (°C)	31° to 32°
Dissolved oxygen	4 to 10
Turbidity	pH 6-8
Specific conductivity (mohs)	450-550
Barometric Pressure	945 mm - 958 mm

Table b

Size of Mahseer Brood Collected from Trisuli and Tadi River Confluence Site at Devighat

S. No.	Sex	Total Length cm	Standard Length cm	Girth cm	Weight kg.	Sex Characters
1	Male	18	25	7	0.40	Virgin male becoming mature.
2	Male	41	34	20	1.80	- do - - do -
3	Male	48	45	22	2.40	- do - - do -
4	Male	73	62	33	1.80	Adult male in second spawning run. milt oozing.
5	Male	75	65	39	2.40	- do - - do -
6	Male	103	103	52	10.00	Adult with defined rough tubercles on the snout. milt oozing.
7	Female	34	29	15	0.26	Immatue virgin female.
8	Female	36	32	16	0.60	Immatue virgin.
9	Female	75	65	39	14.00	Mature abdomen obtuse scratches in the abdomen to constant rubbing at the gravel bed of spawning den.
10	Female	80	72	40	6.50	- do - - do -
11	Female	82	80	39	4.00	- do - - do -
12	Female	104	96	51	10.00	- do - - do -

Cleavage Horizontal Views

a. First cleavage; b. Second cleavage.
c. Third cleavage; d. Morula;
e. High morula; f. Flat morula

ph. Periblast

Epiboly and Organogenesis

a. Germ ring and embryonic shield, horizontal view.
b. Epiboly
c. Neural plate formation
d. Dorsal view
e. Side view

av. auditory vesicle, es. embryonic shield; Gr. germ ring.
Kv. Kuffer's vesicle, m. melanophore
np. neural plate.

Scale 1.5 mm

Table 2

Chronological Events in the Life Cycle of the Golden Mahseer

Time after Fertilization	Stage of Development	Size mm
0 Minutes	Fertilized egg	3.05
10 Minutes	of water Hardened egg	3.55
30 Minutes	(Clevage) 1 cell embryo embryonic area (mm)	0.80
60 "	2 cells	0.94
90 "	4 cells	0.98
2 hours	8 "	1.00
4 hours 15 minutes	16 "	1.50
6 hours 25 minutes	32 "	1.55
8 hours 35 minutes	64 "	1.60
2 hours 10 minutes	Early morula stage	2.00
18 hours	Blastula stage, forming blastocoel	2.50
24 "	Yolk invasion; half complete	3.00
30 "	Yolk plug state,	3.50
35 "	Early indication of Cshaped embryo	3.80
40 "	Pro-lara neural groove and somites apparent	5.80
48 "	11 somites, optic vesicles are visible	7.80
55 "	19 somites, tail is movable, watch-spring like embryo	9.00
55-60 hours	Newly hatched hatchlings with yolk Sac	10.00
120 "	Yolk sac hatching optic and auditory vesicles apparent. Pigment occurs around the yolk	12.00
7 days	Quiescenthatchlings or early Sai fry distinct pigments around the yolk, heart is observable	14.5
10 "	Free swimming sac fry eye pigments visible, heart started to work	15.5
15 "	Early fry barbles, mouth and digstive tract are forming, tail membrane expanded	16.00
18 "	Mouth developed, barbels elongated	18.00
20 "	Swim up fry with yolk sac is fairly well obsorbed, palatine teeth fully developed, barbels elongating, the fin are forming	21.00
22 "	The lower parts of the body are deeply pigmented, tail membrane is slightly concave	24.00
25 "	Fin rays of tail membrane are gradually appearing, first dorsal fin and anal fin forming	28.00
30 "	The jumping fry are fully developed and resemble the adult	30.00
3 months two a year	Fingerlings	50.00

Table 1

Water quality of Mahseer spawning ground, Tadi River

Temperature	30^0 C
Color	Brown
Visibility (m)	0.38
Compensation depth	0.85
pH	7.8
Oxygen ppm	19.5
Dissolved solids (mg/l)	160.5
Hardness	48.0
Specific conductance	584.0 mohs
Chloride mg/l	15.5
Sulphate mg/l	12.5
Calcium	28.0
Magnesium	3.0
Iron	0.18

Table 2

Distribution of Copper Mahseer Spawn in spawnig ground of Tadi River

Spot No.	Nature of substratum	Number of attached eggs
1.	Rocks and stones	156
2.	Rubble	139
3.	Gravel	378
4.	Fine sand and silt	105
5.	Logs and debris	65

Table 3

Fertilized eggs or spawn of Copper Mahseer from Gadkhar creek, (Khaharae Khola)

Months	Number of egg trail (average)	Fertilized egg dia (mm)
January	–	–
February	–	–
March	–	–
April	15	2.68
May	18	2.59
June	20	2.18
July	25	2.70
August	50	2.65
September	160	2.79
October	15	2.60
November	–	–

Cleavage Horizontal Views

a. First cleavage; b. Second cleavage.
c. Third cleavage; d. Morula;
e. High morula; f. Flat morula

pb. Periblast

Epiboly and Organogenesis

a. Germ ring and embryonic shield, horizontal view.
b. Epiboly
c. Neural plate formation
d. Dorsal view
e. Side view

av. auditory vesicle, es. embryonic shield; Gr. germ ring.
Kv. Kuffer's vesicle, m. melanophore
np. neural plate.

Scale 1.5 mm

Events in the Life History of Mahseer

January-May	Active feeding in large rivers.
June-August	Spawning migration from river to hill-stream.
August-September	Spawning migration from hill-stream to adjoining creeks.
SEPTEMBER	Spawning broadcast at suitable spawning dens. Stream to creek nocturnal migration for fractional spawning.
October	Kelt migrate downstream.
October-November	Appearance of hatchling and early fry on the river banks. Adult spawners migrates downstream.
November-December	Photonegative swim up fry show negative rheotaxis.
December-January	Photopositive active; early fingerling with positive rheotaxis.
January-February	Fingerlings put on weight metamorphosed into adult fish. They drift towards pools to fend themselves.
February-March	Fingerling join parents in the down river stretches.
March-May	Parr schooling with adults, able to fend themselves and avoid fisherman's nets.
June-August	Virgin fish join parents for up-stream migration to reach parental creek where they are born.

REFERENCE

Ahmad, N. 1944. On the spawning and early stages in the development of the Carp Labeo gonius (Ham), with hint to distinguish eggs, embryos and larvae of Labio gonius Cirrhina mrigala and Wallagonia attu. Proc. Nat. Inst. Sci. 10 (3): 343 - 353.

Ahmad, N. 1948. On the spawning habits and development of cooper mahseer Barbus (Lissocheilus hexagonolepis, McClelland). Proc. Indian Acad. Sci. 38: 11-20.

Alikunhi, K.H. 1956. Observations on the fecundity, larval development and early growth of Labeo bata (Hamilton). Indian Fish, 3 (1): 156-174.

Chaturvedi, S.K. 1976. Spawning biology of Tor tor (Ham). J. Bom. Nat. Hist. Soc. 74 (1): 65-72.

Das, S.M. 1959. Eggs, larvae and early life history of cat fishes of Lucknow. Proc. First All India Congress of Zoology, Part II: 30-38.

Das, S.M. and C. Rampal 1968. The life history of the mosquito fish Cambusia affinis holborkii the mosquito fish of Kashmir. Kashmir Science, 1: (1-2): 37-43.

David, R. 1953. Notes on the bionmics a early stages of Mahanadi Mahseer. J. Asiat. Soc. Sci. 19 (2): 197-297.

Desai, V.R. 1972. Studies on early larval stages of Tor putitora (Ham) from Narvada river. J. Zool. Soc. India. 24 (1): 47-51.

Harrington, R.W.J.R. 1959. Delayed hatching in stranded eggs of marsh killifish Fundulus confluentus Ecology. 40: 430-437.

Khan, H. 1926. Spawning of carps and their spawning grounds in Punjab. J. Bomb. Nat. Sci. 43 (3): 416-427.

Kulkarni, L. 1970. Spawning habits, eggs early development of Decan Mahseer Tor Khudree (Sykes). J. Bomb. Nat. Hist. Soc. 67 (3): 510-521.

Paine, M.D. and E.K. Balon, 1984. Early development of the rainbow darter, Ethosoma caeruleum, according to the theory of saltatory ontogeny. Environmental Biology of fishes. Vol. II. 4: 277-299.

Shrestha, T.K. 1979. Life history of the hill stream trout Schizothorax plagiostomus (Heckel). J. Inst. Sc. 2 (1): 209-222.

Shrestha, T.K. 1986. Spawning ecology and behaviour of the Himalayan Mahseer (Tor Putitora) Hamilton. Journal of Asian Fishery Society in Press.

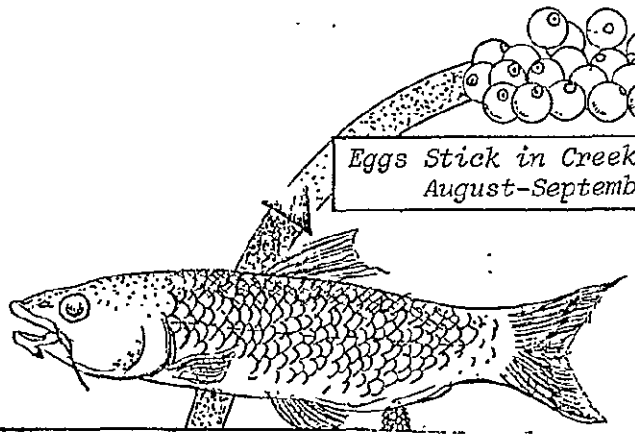
Shrestha, T.K. 1986. Artificial spawning of the Himalayan mahseer Tor putitora (Ham). A monograph. Department of Zoology, Tribhuvan University, Kathmandu, Nepal.

Shrestha, T.K. 1986. Induced spawning of mahseer Tor putitora (Hamilton) by pituitary hormone stimulation. Mimeographed. USAID. Kathmandu.

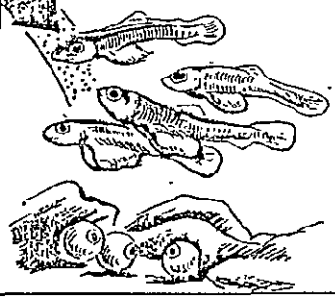
Wourms, J.P. 1972. The development biology of annual fishes II. Naturally occurring dispersion and segregation of blastomers during the development of annual fish eggs. J. Expt. Zool. 182: 169-200.

Yamamoto, T. and P. Medaka 1967. In methods in developmental biology N. Wessels (ed.) Thomas Y. Crowell Co. New York. 101-111.

LIFE CYCLE OF THE GOLDEN MAHSEER

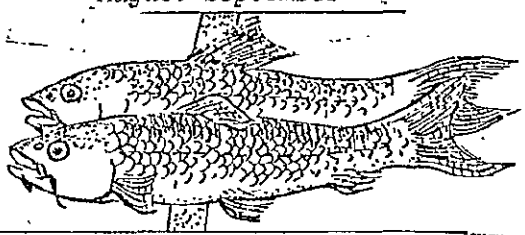


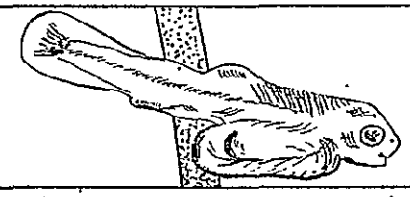
Eggs Stick in Creek Gravel
August-September



h Making Spawing Broad Cast in the Home Creek
August-September

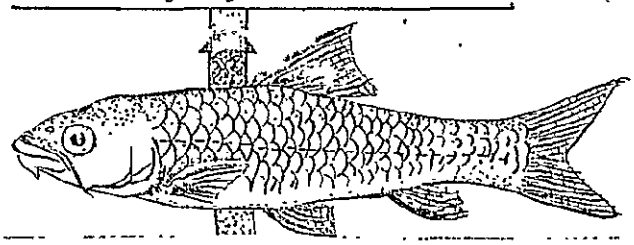
Hatchlings

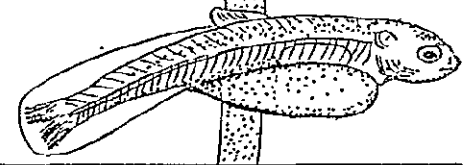




ule and Female Select Spawing Beds in Creek
July-August

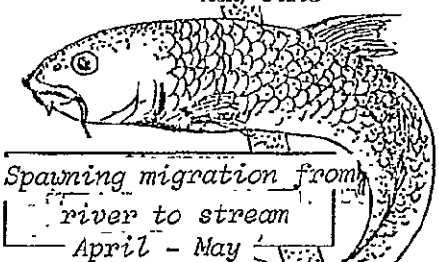
Sac-Fry in Creek Gravel
September-October

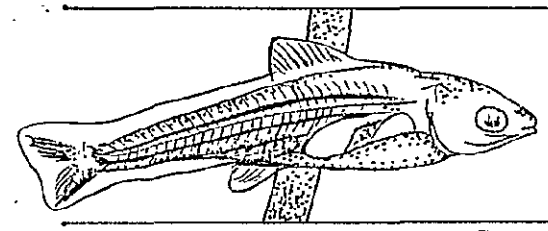




Adult Migration from River to Confluence Site
of Stream and Creek
May-June

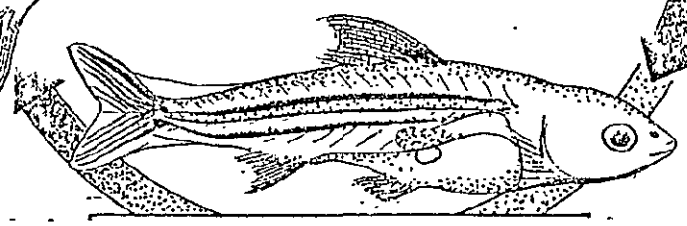
Alvin Migration to Nursery Pools
November-December



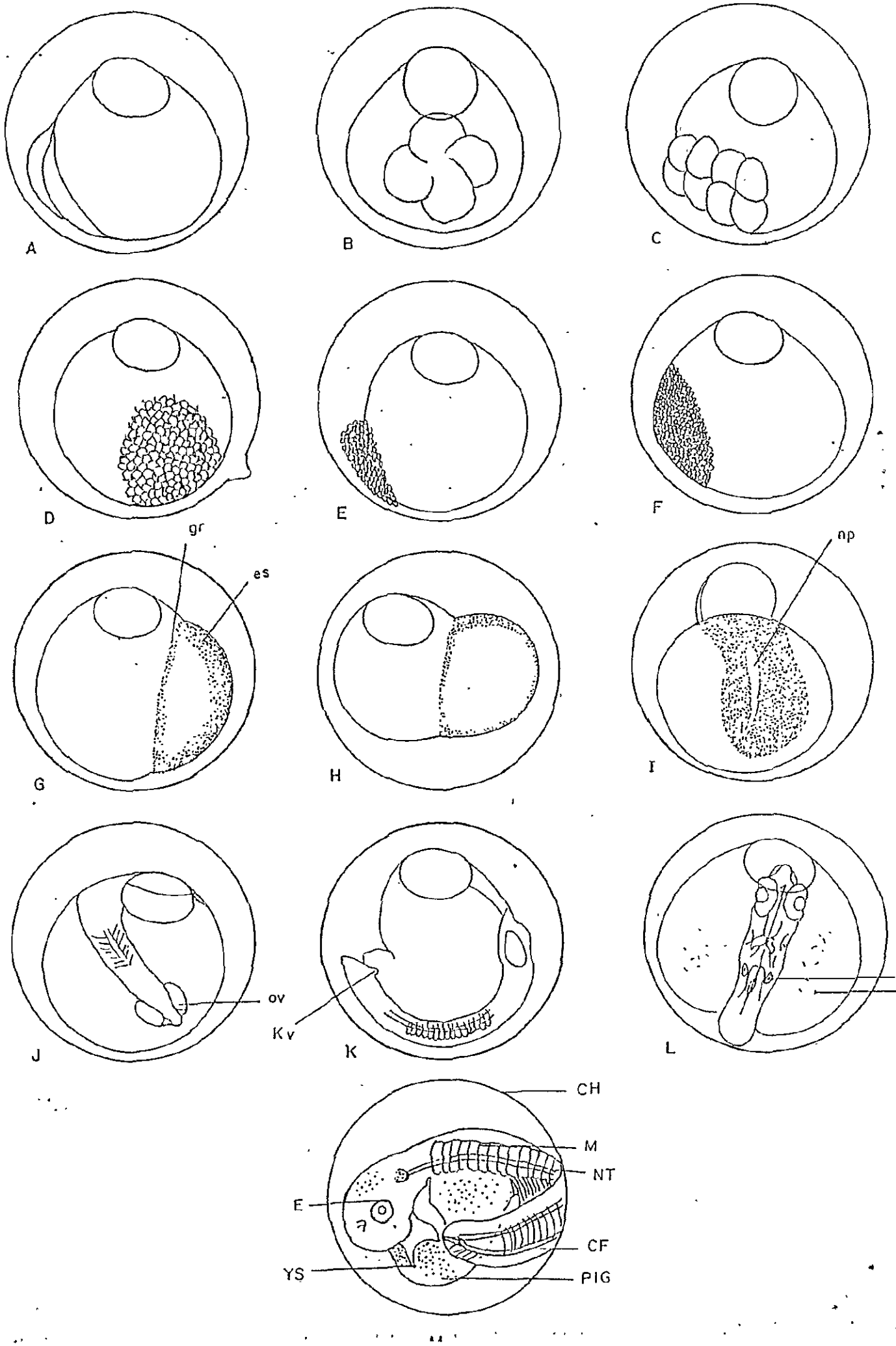


Spawning migration from
river to stream
April - May

Juvenile Parr Migrate Down Stream
January-April



Smolts Migrate to Pools to Feed an Grow to Maturity
1 to 3 Years


A
B
C
D
E
F
gr
es
G
H
np
I
ov
J
Kv
K
L
CH
M
NT
E
CF
YS
PIG

REFERENCE

Ahmad, N. 1944. On the spawning and early stages in the development of the Carp Labeo gonius (Ham), with hint to distinguish eggs, embryos and larvae of Labio gonius Cirrhina mrigala and Wallagonia attu. Proc. Nat. Inst. Sci. 10 (3): 343 - 353.

Ahmad, N. 1948. On the spawning habits and development of cooper mahseer Barbus (Lissocheilus hexagonolepis, McCelland). Proc. Indian Acad. Sci. 38: 11-20.

Alikunhi, K.H. 1956. Observations on the fecundity, larval development and early growth of Labeo bata (Hamilton). Indian Fish, 3 (1): 156-174.

Chaturvedi, S.K. 1976. Spawning biology of Tor tor (Ham). J. Bom. Nat. Hist. Soc. 74 (1): 65-72.

Das, S.M. 1959. Eggs, larvae and early life history of cat fishes of Lucknow. Proc. First All India Congress of Zoology, Part II: 30-38.

Das, S.M. and C. Rampal 1968. The life history of the mosquito fish Gambusia affinis holborkii the mosquito fish of Kashmir. Kashmir Science, 1: (1-2): 37-43.

David, R. 1953. Notes on the bionmics a early stages of Mahanadi Mahseer. J. Asiat. Soc. Sci. 19 (2): 197-297.

Desai, V.R. 1972. Studies on early larval stages of Tor putitora (Ham) from Narvada river. J. Zool. Soc. India. 24 (1): 47-51.

Harrington, R.W.J.R. 1959. Delayed hatching in stranded eggs of marsh killifish Fundulus confluentus Ecology. 40: 430-437.

Khan, H. 1926. Spawning of carps and their spawning grounds in Punjab. J. Bomb. Nat. Sci. 43 (3): 416-427.

Kulkarni, L. 1970. Spawning habits, eggs early development of Decan Mahseer Tor Khudree (Sykes). J. Bomb. Nat. Hist. Soc. 67 (3): 510-521.

Paine, M.D. and E.K. Balon, 1984. Early development of the rainbow darter, Ethosoma caeruleum, according to the theory of saltatory ontogeny. Environmental Biology of fishes. Vol. II. 4: 277-299.

Shrestha, T.K. 1979. Life history of the hill stream trout Schizothorax plagiostomus (Heckel). J. Inst. Sc. 2 (1): 209-222.