JOURNAL OF THE INLAND FISHERIES SOCIETY OF INDIA THE INLAND FISHERIES SOCIETY OF INDIA C/O ICAR -CENTRAL INLAND FISHERIES RESEARCH INSTITUTE BARRACKPORE KOLKATA -700 120 WEST BENGA...

Bimal Prasanna Mohanty
Indian Council of Agricultural Research

ISSN 0379-3435

Journal of the Inland Fisheries Society of India

Volume 50 Number 2 December 2018

JIFSI Golden Jubilee Volume

ABSTRACTED BY

Indian Science Abstracts
Indian Fisheries Abstracts
Chemical Abstracts Services (USA)
CABI Abstracts (U.K.)
ICI (Indian Citation Index)

Published by : The Secretary, Inland Fisheries Society of India, Barrackpore, Kolkata - 700 120, West Bengal

JOURNAL OF THE
INLAND FISHERIES SOCIETY OF INDIA

Volume 50 | Number 2 | December 2018

JIFSI Golden Jubilee Volume

JIFSI is now online, please visit
http://epubs.icar.org.in/ejournal/index.php/JIFSI

http://ifsi.org.in

NAAS RATING 4.54

THE INLAND FISHERIES SOCIETY OF INDIA
C/O ICAR-CENTRAL INLAND FISHERIES RESEARCH INSTITUTE
BARRACKPORE KOLKATA - 700 120 WEST BENGAL INDIA

PUBLICATION OF INLAND FISHERIES SOCIETY OF INDIA

1. **Coldwater Fisheries of India**
   By V. G. Jhingran and K. L. Sehgal

2. **An Approach to Coastal Zone Management and Planning in West Bengal**
   By A. G. Jhingran and P. K. Chakraborty

3. **Contributions to the Fisheries of Inland Openwater System of India, Part-I**
   Edited by A. G. Jhingran, V. K. Unnithan and A. Ghosh

4. **Contributions to the Fisheries of Inland Openwater System of India, Part-II**
   Edited by M. K. Das and P. K. Chakraborty

5. **Index to Vol. I-X, Journal of IFSI**
   Prepared by M. K. Stanley and S. C. Patil

6. **Fish and Prawn Disease in India - Diagnosis and Control**
   By M. K. Das and R. K. Das

7. **Changing Perspectives of Inland Fisheries**
   Edited by K. K. Vass and M. Sinha

8. **Eco-friendly Management of Resource for Doubling Fish Production - Strategies for 21st Century**
   Edited by M. Sinha, Dhirendra Kumar and P. K. Katiha

9. **Fisheries Enhancement in Inland Waters - Challenges Ahead**
   Edited by V. V. Sugunan, G. K. Vinci, P. K. Katiha and M. K. Das

10. **River Fisheries in India - Issues and Current Status**
    Edited by K. K. Vass, K. Mitra, V. R. Suresh, P. K. Katiha and N. P. Srivastava

11. **Water Management in Fisheries and Aquaculture**
    Edited by K. K. Vass, N. Sarangi, K. Mitra, J. K. Jena, V. R. Suresh, N. P. Srivastava and
    P. K. Katiha

12. **Ecosystem Health and Fish for Tomorrow**
    Edited by Dr. M. K. Das, Mrs. G. K. Vinci, Dr. S. K. Manna, Dr. V. R. Suresh

13. **The 8th Indian Fisheries Forum Proceedings 2008**
    Edited by G. K. Vinci, S. K. Manna, V. R. Suresh, K. Mitra, N. P. Shrivastava, K. K. Vass and A. P. Sharma

14. **Public Private Partnerships in Aquaculture 2017**
    Edited by V. R. P. Sinha, P. Keshavanath, A. P. Sharma and B. P. Mohanty

J. Inland Fish. Soc. India, **50**(2), 2018

Registered with the Registrar of Newspaper
for India, No. R. N. 1837870

CONTENTS

EDITORIAL **01-02**

REVIEW PAPER

Rai Milan Bhowmick — Development of inland aquaculture in India, with special reference to hypophysation technology **03-32**

RESEARCH PAPERS

Preetha Panikkar, U. Amala , P.K. Jesna, Feroz Khan, M . Das, B.K . Chandish, R. Ballal, M.A Hassan — Black soldier fly (Hermetia illucens) pre-pupae meal as a fish meal replacement in diet for amur carp (*Cyprinus carpio*) **33-38**

A. K. Nath . B. M. Majhi — Studies on the seasonal abundance of the juveniles of *Tenualosa ilisha* from Hooghly River estuary of West Bengal, India **39-45**

Shilpa Sahoo . U. Acharya . J. P. Sahu — Effect of dietary probiotic supplement on growth performance and survival of *Labeo rohita* (Hamilton) fingerlings **46-51**

Manas Kumar Das · Srikanta Samanta · Keya Saha · Sanjoy Bhowmick P. K. Srivastava · S. Bandopadhyay — Effect of phenol and sulphide on the reproduction of sexually maturing riverine cat fish *Rita rita* (Hamilton) **52-57**

Monika Gupta . N. N. Pandey . V. K. Tiwari, Raghabendra Singh . Chandra Prakash . C. S. Chaturvedi — Optimization of stocking density for successful larval rearing of *Labeo dyocheilus* in coldwater conditions **58-62**

Hiramoni Das . Sudhir Kumar Das . Dibakar Bhakta — Effects of periodical starvation on growth and muscle composition in fingerlings of *Labeo bata* (Hamilton, 1822) **63-67**

B. K. Bhattacharjya . B. J. Saud . V. K. Verma D. Debnath . A. K. Yadav . Simanku Borah Hiron Pegu . U. K. Sarkar — Indigenous fishing method used for catching spiny eels (*Macrognathus* spp.) in floodplain wetlands of Assam, India **68-72**

Raju Baitha . S. K. Manna . V. R. Suresh K. Paniprasad . M. Naskar — Topographic distribution pattern of *Posthodiplostomum* sp.acercariae on body surface of cyprinid fishes of river Ganga **73-78**

Aparna Roy . Archana Sinha . Ranjan K. Manna . B.K Das . Sucheta Majumdar — Socio-cultural tradition of the Rabha tribes of North Bengal, India : in relation to fisheries aquatourism in floodplain wetlands as a potential alternative livelihood option for the fisherfolks - A case study of Deepor beel in Assam **79-83**

Shakti Ranjan Panigrahy . Dilip Vahoniya — Analysis of profitability of inland fish farming through ponds and tanks in Gujrat **84-88**

SHORT COMMUNICATIONS

Prasenjit Pal — The dynamics of fish seed production in West Bengal over the years **89-92**

Ganesh Chandra . B.K. Das . M.A. Hassan — CIFRI Cagegrow™ floating fish feed **93-94**

Meeting / Training Report — 1st Barrackpore Proteomics Workshop **95-96**

Concept Building and Basic Statistical Analysis **97-98**

19th World Congress of Food Science & Technology - IUFoST 2018 INDIA **99-100**

ICAR - Worldfish Collaborative Research Strategy Development and Theory of Change Workshop July 17-19, 2018 **101-102**

Awards — Awards/Honours/Recognition To IFSI Fellows/Life Members/ Office Bearers **103**

Obituary — Prof. V. R. Desai **105-106**

GUIDELINES FOR SUBMISSION OF PAPERS Inner Back Cover

Editorial

It is my pleasure to present before you readers the volume 50(2) issue of *The Journal of Inland Fisheries Society of India* (JIFSI). There are some new features added in this issue. We have started inclusion of review papers in this issue onwards; It would be authoritative reviews, both solicited and unsolicited, in any area within the scope of inland fisheries.

There are ten research papers in this issue; one paper has reported black soldier fly for fish meal replacement in carp feed. The second paper deals on seasonal abundance of hilsa juveniles in Hooghly estuary. A paper by Shilpa Sahoo and co-workers reports effect of dietary probiotic supplementation on growth performance and survival of carps. The other paper by M.K. Das and co-workers reports effect of phenol and sulphide on the reproduction of riverine catfish *Rita rita*. The paper by Monika Gupta and co-workers discuss optimization of stocking density on successful larval rearing of coldwater fish *Labeo dyocheilus.* Next paper reports impact of periodical starvation on growth and muscle composition of minor carp *Labeo bata*. B.K. Bhattacharya and co-workers report indigenous fishing methods used in floodplain wetlands of Assam. Raju Baitha and co-workers report topographic distribution patterns of the parasite Posthodiplostomum sp. on body surface of cyprinids. Next paper deals on socio-cultural tradition of the Rabha tribes of North-Bengal in relation to fisheries and livelihood. The other paper makes an analysis on profitable inland fish-farming through ponds and tanks in Gujrat. There are few short communication; one is on the dynamics of fish-seed production in West Bengal over the years and the other one is on commercialization aspect of CIFRI Cagergrow fish feed, developed by ICAR-CIFRI, Barrackpore.

There are few national and international training/workshop reports in this issue. ICAR-CIFRI, Barrackpore has developed expertise and drawn global attention for its pioneering research on fish proteomics; it has planned to conduct a workship series on fish proteomics and here there is a training report on the "First Barrackpore Proteomics Workshop" conducted recently. There is a training report on 'concept building and basic statistical analysis'. The 19th World Congress of Food Science and Technology (IUFoST-2018) was held in India for the first time in Mumbai from 23-27 Oct, 2018 with the focal theme on “25 billion meals a day by 2025 with Healthy, Nutritious, Safe and Diverse Foods”. In this program, there was a special session on fisheries and many scientists from ICAR including Scientists from Fisheries Science Division presented their research. A brief report on this program is included for information and also for bringing awareness on the importance of food science research going on globally. A joint meeting by WorldFish and ICAR (represented by 3 Fisheries Institute CIFA, CIFRI and CIFT) was organized at CIFA, Bhubaneswar under ICAR- window 3 program. It included one Workshop titled ‘TOC workshop’ with objective to plan work on three broad themes for the next five years.

Award/ Reward/ Recognition of IFSI Fellow/ Member section proudly records the Lifetime Achievement Awards awarded to the World Food Laureate Dr. M. V. Gupta, who was also formerly ADG, WorldFish; Senior Scientist at ICAR-CIFRI and was also a former Editor of JIFSI and to Dr. T. Mohapatra, Secretary-DARE and DG, ICAR. It also gracefully records the recognition to Dr. B. K. Das, President IFSI and Director-CIFRI by the National Academy of Agricultural Sciences (NAAS). This issue also records obituary of Prof. V. R. Desai, a renowned Scientist in the field of inland fisheries and a former Director of the ICAR-CIFRI, Barrackpore and a great patron of IFSI and JIFSI.

I take this platform once again to solicit authoritative reviews in any area of inland fisheries from Scientists, researchers and learned experts in the field of Inland Fisheries and related disciplines for the JIFSI Golden Jubilee Special Supplement.

Let Science progress.

Jai Bigyan!

Bimal Prasanna Mohanty

Dr. B. P. Mohanty
Editor-in-Chief, JIFSI

Development of Inland Aquaculture in India, with special reference to Hypophysation Technology

Rai Milan Bhowmick

Received: 20 November 2018 / Accepted: 21 November 2018

General Introduction

Fish husbandry has emerged as a major source of animal protein for the expanding human population in the world. Fish not only provides nutrition but also resists some diseases. In India population is in the increase. It is estimated that by 2020 AD population will reach at 1.4 billion (P.Kumar,2000) increasing the gap between the demand and supply of fish.Inland aquaculture which is a major contributor in fish production in inland sector is extended throughout the country even in the interior region of the rural sector. To reduce the gap between demand and supply the country has to rely on aquaculture which is indicating increasing trend in fish production.

Fish culture is an age old practice in China and Asian countries mainly. Hulse(1979) reported that Romans practiced cultivation of carps, mullets, turbots and eels in ponds and shell fishes in marine habitats. In spite of long history of fish culture commercial fish farming of fin fishes became established in Europe and in North America probably in 19th century (Hulse, 1979). In India, fish farming is traditionally practiced since ancient times. Culture system was developed by the fish farming community through age old experiences. The seed fishes (Dimpona) were collected from the natural source, the rivers and streams, where the cultivated major carps, catfishes and other fishes naturally reproduce during south west monsoon, during June-September when the rivers are in flood, every year (Hora, 1945, Qasim and Qayyum,1962, Natarajan and Jhingran, 1963). The farmers procured the seed fishes from the rivers by shooting nets to replenish their stock in the ponds/tanks, every year. Collection of fishseed thus made contains uneconomic, unwanted and predatory fishes. Since there is no dependable method of segregating the cultivated species from the mixed lot at that early stage, the farmers are left with no other alternative but to stock their ponds with mixed collection of seed fishes thus burdening the fishery with uneconomic species. Besides, the method of collection of seedfishes from the natural habitats involves efforts of collection, transport, often mortality during transport and above all uncertainty of availability of seedfishes of pure quality, in time.

Non availabity of seedfishes of quick growing fishes, was major impediment in practicing aquaculture in ponds ,tanks, impoundments and in other water bodies in captivity. Many fish species including Indian carps, cat fishes, and brackish water fishes are generally reluctant to spawn in ponds, tanks, impoundments in confinement, although these fishes attain penultimate stage of sexual maturity in that environment. This problem was solved by the scientists of Argentina (Houssay,1931) and of Brazil (Ihering , M. and Azevedo , P.de, 1934), for the first time in the world. This pioneering achievement was a turning point in the history of fish seed production under controlled conditions by hormone treatment opening avenues for extension of aquaculture where it was nonexistent before, leading to increase fish production and to produce hybrids with cultural qualities.

R. M. Bhowmick (✉)
Ex-Senior Advisor, FAO/UNDP
Ex-Principal Scientist, ICAR-CIFRI, Barrackpore
BL-15, Sector-2, Salt Lake, Kolkata-700091
e-mail: raimilanbhowmick@gmail.com

Natural reproduction of major cultivated carps and stages of gondal maturity

Successful reproduction is an essential factor for species survival and in most animals breeding period is adjusted in time so that they are suitable for rearing of their offspring. Gonadal development (recrudescence) however, is a complicated physiological process requiring some time. These internal physiological functions prepare animals for spawning at the most appropriate time.

The Indian major carps, catla, rohu, mrigal, calbasu and other minor carps such as bata, fimbriatus, gonias, reba are the residents of the riverine habitat in the Indian sub- continent. These carps use day length along with other environmental factors as reliable signal for the timing of their gonadal recrudescence prior to the onset of monsoon. Maturation process of gonads of these carps which is controlled by the environmental factors and the endocrine system, commences after the resting phase, during winter (November to January). Day length and temperature begin to increase in February onwards.Along with the increasing temperature and day length, the process of gonadal maturation commences and continues during summer season when the temperature and day length is maximum (Author's observation). By April/ May, Indian carps attain gonadal maturity but the process of maturation is not yet completed. There are two major phases in gonadal development,each is governed by the endocrine system, but each has its own set of casual factors. Gametogenesis (Harvey and Hoar,1979) and gonadal growth constitute the first phase. Thesecond is much shorter phase, involves the completion of maturation of the gametes followed by ovulation and spermiation. Spawning behavior usually occurs shortly after the second phase.

In natural habitats, in rivers and in streams the second phase is completed during the south-west monsoon (June to September), when the rivers and the streams are flooded and the temperature comes down followed by natural spawning of the Indian carps (Hora, 1945; Qasim,S,Z and Qayyum, 1962; Natarajan and Jhingran,1963)). But in captivity in ponds and tanks these carps although attain maturity and reach penultimate stage of maturity do not complete the second phase and consequently there is no natural spawning in ponds and tanks.Dr. Swingle (1956) reported that there are some depressing factorspresent in the confined water bodies (ponds and tanks) which prevent final sexual maturation and spawning of fishes in captivity.

Vitellogenesis : Like most of the teleosts, the ovary of the Indian carpsis a hollow organ covered with a germinal epithelium. Internally many ovigerous folds project into the lumen of the ovary. Germinal epithelium also covers the ovigerous folds. Oocytes are generated from oogonia which are located within the germinal epithelium. The transformation of oogonia into oocytes is referred to as oogenesis. Oogonia multiply in the ovary bymitotic division and give rise to primary oocytes. These primary oocytesundergo the process of yolk accumulation or vitellogenesis(Harvey and Hoar,1979). Entire processof gonadal maturity passes through various stages. They are divided intoseven stages. The seven stages of maturity recognized, were in conformity with that of the scale given by the International Council of Exploration of Sea(Wood,1930.)

The seven stages of gonadal maturity in Indian major carps are as follows:

Stage 1: The ovary is very thin, thread-like, light pinkish in colour,occupying 1/3 of the body cavity. The developing oocytes under the microscope look small, roundish and transparent with a distinct nucleus inthe centre. (months - November to January).

Stage 2: Ovary increased slightly in size, thread like but occupying almost 1/2 of the body cavity in length. The developing oocytes have increased in diameter. The oocytes are still transparent with distinct nucleus in the centre under the microscope (months - November to early February).

Stage 3: The ovary has increased in size considerably, occupying about 3/4 of the body cavity. The developing oocytes under the microscopeare semi- transparent due to beginning of yolk formation but the nucleus is still visible. The oocytes are slightly granular in shape with increased diameter.

Stage 4: The ovary is occupying almost the entire body cavity and size of the ovary is increased enormously. The eggs are opaque under the microscope due to deposition of yolk and so the nucleus is not visible.

Now they are completely granular in shape (April to May). They are visible in naked eyes.

Stage 5: The ovary is occupying the entire body cavity. Under the microscope no nucleus is visible. The center of the eggs is still opaque while the margin is turning transparent (April to June). They are granular and are visible in naked eyes. The ovigerous folds are clearly visible and the size and weight of the ovary is enormously increased.

Stage 6: This is the spawning stage, when the eggs are looking translucent under the microscope, with yolk mass congregated in the center.They are soft and attained maximum size due to hydration (June toSeptember). Spawning of these carps take place in the natural habitats dueto the conducive factors and triggering of gonadotrophic hormone sstimulated by the environmental stimuli during monsoon months, June to September.

Stage 7: In the natural habitats this stage is the spent stage. After spawning the ovary is like an empty sac, wrinkled, blood shot and amber in colour. But in captivity, in ponds and in tanks, these carps are not ableto spawn and the ovary is gradually absorbed in the system which is termed as resorption stage or atresia (September to October) (Bhowmick,R.M,1969).

Stages of gonadal maturity in males

In males of the Indian major carps all the seven stages of gonadal maturityare not so pronounced and discernable under the microscope, they areclassified into four stages such as 1st. Immature, 2nd. Maturing, 3rd. Mature,4th. Spent or resorbed. All the four stages are as follows :-

1st stage Immature: The gonad is very small and thread like structure occupying 1/3 or less of the body cavity in length. The structure appeared hard in texture and under the microscope it looks like ordinary tissue whitish pink in colour.

2nd Maturing: The gonad is increased in size both in length and in width occupying 1/2 or more of the body cavity in length. The tissue does not look so hard as in case of immature gonad. The structure of the testis appears soft, tubular whitish pink in colour. Spermatids are visible underthe microscope in macerated tissue of the testis. Formation of loops has begun. No milt was observed.

3rd Mature: The gonad further increased in size both in length andvolume, occupying almost entire body cavity in length. The testis tubularin shape, having loops and is very soft to touch. Milt, whitish in colour,comes out with little pressure.

4th Spent or resorbed: The gonad is shrunken and blood shot. No milt as such comes out with little pressure. In the natural habitats, in rivers and in streams the male spawners release its sperms in the water for fertilization of the eggs and thus get spent but in captivity in ponds and in tanks they are not able to shed their sex products and thus gradually get resorbed in the body (Bhowmick,R.M,1969).

Sexual dimorphism

The Indian carps, especially the major carps are heterosexual. Sex differentiation is possible when they are ripe. A ripe female is easily distinguished from its fully distended and soft abdomen with a slightly swollen reddish vent. Pectoral fins of the female fish are smooth to touch while theyare rough in the case of male fish. (Chaudhuri,1959a). The pectoral fins during the breeding season is greater than or equal to anal fins in the males while in females the former is smaller than the latter. It is found that the pectoral fins in matured males of the majority of the Indian carps is slightly bigger and when extended reached 8th and 9th lateral line scale in *L. rohita* and *C. catla* where as in gravid females it reaches only 6th and 7th lateral line scale. In case of *C.mrigala*, pectoral fins when extended reaches 9th and 10th lateral line scale where as in matured females, the pectoral fins are very smooth and reaches8th and 9th lateral line scales. In ripe males of all the species of Indian carps,milt ooze out when gentle pressure in applied at the abdomen

First maturity (age and size): The Indian major carps normally attain sexual maturity in the second year of life. *C. mrigala*, however was found to mature earlier. *L. calbasu* was found to retain its maturity for a longer period in ponds. *C.catla* normally matures on 2 plus years of life. Unlike other Indian carps catla has a tendency to grow visceral fat and to mature late. Males of all of the major carps were found to mature early and loose its functional maturity earlier than the female in captivity (Author's observation).

Spawning migration and spawning:

During south west monsoon, the rivers and the streams are flooded inundating vast adjoining riparian land creating a conducive environment for spawning of the carps. Ripe male and female spawners take a short migratory journey from the deep water areas of the rivers to the newly inundated shallow region, suitable for spawning. An access to the suitable spawning ground is most important for successful breeding. In nature, like majority of the teleosts, Indian carps demonstrate some sort of sex play. Normally female spawners are chased by the males.The female swims faster splashing water and releasing its eggs. The male spawners follow the female and release its milt fertilizing the eggs. The act of releasing eggs andmilt is synchronized for fertilization of eggs in water, culminating in spawning.

Spawning frequency:

Carps are known to breed once a year as a specific habit, during monsoon months. Qasim and Qayyum, (1962) studied spawning frequency of Indian major carps and inferred that the carps have the specific habit of spawning only once in a year during monsoon months, June to September,when the rivers are in flood . Their studies were based on measurements of ova contained in the ovary during spawning season, in monsoon. They observed that the ovary of the spawners contained immature , maturing and mature ova which were represented in histogram, species wise and month wise and concluded that the mature ova which are large, free and translucent are only ovulated culminating in spawning , in monsoon when the rivers are in spate making a conducive environmental conditions for spawning. The maturing ova which will be mature, are destined to be released in a single spawning act next year spawning season. .

Environmental factor influencing reproduction in fishes

Besides, endocrine control the environment plays significant role in this phenomenon and it appears out of all the environmental factors, light (photo-period), temperature, rainfall, flooding and salinity play decisive role in reproduction of fishes.

Light (photo-period) and Temperature: Significant research work hasbeen done on the influence of photo-period on the fishes. It was reported that changes in day length are important in regulating sexual cycling in the stickleback family, *Gastrostidae* (Craig Bennett, 1931). There are two groups of fishes , one group is used to breed in retarding temperature such as mullets, and the other group in increasing temperature such as Asiatic carps.

Mugil cephalus was successfully spawned by hypophysationin winter months when the day length was minimum and the temperature was low in India. (Chaudhuri et al., 1977) It was reported that the combination of retarded photo period (6L/18D) and constant temperature of 21°C was the most effectivefor the completion of vitellogenesis of oocytes to functional maturity in *M. cephalus* during refractory period (Kuo et al., 1974a). In tropical areas near the equatorday length is approximately 12 hours throughout the year and annual temperature fluctuations are very little. India is however, characterised bydistinct seasons - winter, spring, summer and rainy months. Day lengthvaries from about 10 hrs. to about 14 hrs. in winter and summer respectivelyand accordingly temperature ranges between 0° to 45° C in some places(Northern India). In eastern India temperature fluctuates between 8°C to 40° C mainly with little variation here and there. Investigations in Indiashow that the vast majority of the seasonally breeding fishes, the activityof gonads regulated by length of the day. The role of light (photo- period) in maturation and spawning has been demonstrated experimentally in carps and in catfishes (Sundararaj and Vasal,1973).

Cirrhinus reba, a minor carp, was observed to attain early maturitywhen subjected to artificial photoperiod longer than the natural day lengtheven in winter months. When the temperature ranged between 18° C to 20° C, spawning condition of this species could be maintained up to November by providing enhanced artificial light hours (Verghese, 1968). Successful spawning of silver carp (*H. molitrix*) under controlled temperature and light was reported. (Alikunhi et al. ,1980) The Indian carps and many other monsoon breeding species also, pass through short photoperiod or decreasing day length and low temperature regime during winter months (Author's observation) followed by increasing photo period and increasing temperature regimeduring summer months which appear to activate neuroendocrine centers which regulate reproductive cycle stimulating gonadal maturation and spawning in monsoon months. This process of gonadal maturity of the fishes living in the rivers and in the ponds/tanks continues in the increasing day length and attains full maturity when the photo period is more than 12 hours (Author's observation). This phenomenon ensures gonadal enlargement of the spawners prior to onset of monsoon rain flooding the rivers, which stimulate through the endogenous endocrine system and induce natural spawning in carps, cat fishes and majority of the fishes live in the riverine habitats in India. In ponds/ tanks the major carps do not attain full maturity.From the investigations carried out it is evident that the temperature plays a dominant role in sexual cycling of fishes. It was reported that the Indian major carps, stimulated by the environmental stimulation, spawn only when the water temperature is within the optimum range (Hora, 1945). It was reported that there were critical temperature above and below which fish would not reproduce (Pickford and Atz, 1957). It was reported that hormone treated Indian major carps normally spawnedat water temperature between 24-31°C (Chaudhury, 1963) An interesting observation atJaunpur, Uttar Pradesh, was made when pituitary hormone treated *L. rohita* spawned at higher temperature of 38 °C with normal range of fertilization (Bhowmick et al. 1968). It appears that Indian major carps may spawn at a wide range of temperature having an optimum range.

From the foregoing, it is evident that the photoperiod and the temperature play major role in combination with the endogenous endocrine system in regulating the reproductive cycles in fishes. It was also observed that there were two groups of fishes, one group maturing during increasing temperature and day length (Asiatic Carps) and the other in decreasing photo regime and temperature (e.g. mullets). Near the equator, as in SriLanka, the Indian major carps matured and spawned almost throughout the year. (Bhowmick, et al. 1986) They normally spawn once a year during south west monsoon months, June to September, in India.

Salinity

Salinity plays a crucial role in maturation, ovulation and spawning in certain euryhaline and migratory fishes of economic importance. There are long distance migrants such as Indian shad, (*T. ilisha*) and Atlantic Pacific salmons, grow and attain penultimate stage of maturity in the sea and migrate to the rivers for final gonadal maturity and spawning, are knownas ana dromous fish while the catadromous eels (Anguilla spp.) migrate from fresh water habitats and take a long journey to reach deep sea for spawning. Hilsa spawns in the riverine habitats and the young ones return to the sea. The cycle of migration repeats itself every year. *Anguilla* spp. onthe other hand, breed in the sea and return to the fresh water for growth.The maturing specimens of *M. cephalus* and *C. chanos* in the fresh waterand the low saline zone and migrate to the sea for final maturation andspawning. It has been observed that the *M. cephalus* migrates from the Chilka Lake to the sea during winter months for spawning, (Jhingran,V.G. , 1958), (Chaudhuri et al., 1977).

Rainfall and flood

Rainfall and accumulated rain water play a key role in triggering final maturation, ovulation and spawning not only in carps but also in majorityof the warm water fishes. It has been reported that the failure of monsoon leads to shortage of seed fishes in the natural habitats. Inadequate rainfall was found to adversely affect spawning of carps, reared in ponds, eventhough hypophysation helps to some extent bypass the environmental variables. (Sneed, K.E. and H.P. Clemens,1959). It has been observed that when the monsoon is delayed spawningof fishes in nature is delayed. In the northern India monsoon arrives late,not earlier than July every year, and accordingly induced breeding operation is also delayed because the spawners reach to the optimum gonadal maturation after receiving some monsoon showers (Author's observation, 1964). It was also suggested flooded condition of rivers due to rain and the optimum temperature were responsible for spawning of carps. Better spawning and fertilization of Indian and Chinese carps in captivity, by hypophysation were achieved during rainy days with low conducive temperature at Kaushalyaganj and at Cuttack ResearchCentre, Orissa (Author's field experience). Evidences have been produced which showed there was close relationship between flooding and spawning in Indian carps.

From the above consensus it seems to be that fresh rain water and flooded conditions are the primary factors to act as the triggering mechanisms for final gonadal maturation and spawning in warm water fishes. The question now arises as to howchanges in the environment control reproductive physiological processes in teleost fishes. Considerableevidence is now available which shows that the endocrine system serves as link between the environment and gonadal function. More specifically the hypothalamus - hypophyseal neuroendocrine axis is of ultimate importance in mediating the effects of environmental variations on sexual cycling of fishes (Harvey and Hoar, 1979).

Hypophysation

Pituitary / Hypophysis

Voluminous work has been on the record of pituitary of teleosts , in different countries of the world(Pickford and Atz, 1957). In India, work on pituitary is in initial stage. Sporadic attempts have been made to study the pituitary of cultivated fishes. Some detailed studies, however were made on the morphology and histology of *Labeo rohita* (Ham.) and *Cirrhinus mrigala* in the University of Burdwan, West Bengal (Moitra and Sarkar 1976). Studies also were carried out onpituitary of major carps in the Pond Culture, Research Substation, Cuttack,Orissa (Sen,1972).

Locationand structure of Pituitary:Pituitary gland of Indian major carps, *L. rohita*, *C. mrigala*, *C. catla*, *L.calbasu* and of other fishes, is a small, pear shaped soft body, whitish in colour. The gland is situated ventrally to the brain behind the optic chiasma in a bony concavity known as sella turcica, on the floor of the cranium.The pituitary is connected to the brain by a stalk called infundibulum. In many teleosts and also in carps the gland is incapsulated by a thin membrane called durameter. Glands having distinct stalk are classified under leptobasic as in Indian carps and without distinct stalk under platybasic as in some catfishes. In some fishes the glands are deeply embedded in a well developed sella turcica as in common carps, *Cyprinus carpio*, while in some other fishes distinct sella turcica may be wanting as in *Pangasius pangasius* (Author's observation).

The pituitaryis the most important of all endocrine glands and is known to secrete a large number of hormones which control various physiological and reproductive functions in vertebrates and also in fishes. Of these, the gonadotrophic hormones-Follicle stimulating hormone (FSH) and luteinizing hormone (LH) play decisive role in maturation of gonads and stimulate ovulation in female andspermiation in males-culminating in spawning in fishes.

Morphology

Morphology of pituitary of carps is divided into glandular portion, adeno hypophysis and a nervous portion, the neurohypophysis as in other teleosts. The glandular portion is divided into anterior glandular region -the rostral pars distalis (RPD), the middle glandular region - the parsintermedia (PI). The roastral pars distalis occupies the antero - dorsal portion of the gland. The proximal pars distalis lies in the middle while the pars intermedia is located ventrally to the other two regions forming the apex of the gland. The rostral pars distalis is the smallest portion while the proximal pars distalis comprises the largest portion of the gland and is separated by the neurohypophysis into two parts. It occupied the entire central region of the gland. The pars intermedia occupying a large portion,comprising the postero- ventral half of the gland is separated from the proximal pars distalis by means of a notch in Indian carps. (Moitra and Sarkar,1976) A neurally derived component, the neurohypophysis connects theglandular portion - the adenohypophysis to the base of the brain and is composed largely of the axonal fibres of the neurons whose cell bodies are located in the hypothalamus. This nervous tissue interdigitates extensively with the adenohypophysis, particularly in the pars intermedia. But in theIndian major carps, the branches of the neurohypophysis ramify into all the three lobes of the gland (Moitra and Sarkar, 1976).

Pituitary and its Functions

Gonadotrophic hormones: It has been possible to obtain a number of hormones from the anterior lobe of the pituitary. Some of them, obtained in pure form, have been thoroughly investigated with regard to their chemical nature and physiological activities. Gonadotrophic hormones are elaborated in the basophil cells of the anterior lobe of the pituitary. Two gonadotrophic hormones, FSH (Follicle stimulating hormone) and LH(Leuteinizing hormone) have been thoroughly studied, (the former stimulates the growth and maturation of the follicles in female animals, while in male animals it stimulates the formation of sperms, the latter stimulatesinterstitial elements of the ovaries and formation of the corpus luteum,while in males it stimulates the development of Leydigs cells in the testes,as well as the secretion of male sex hormones in higher animals). In fishes these gonadotrophic hormones have been identified with similar functionsof stimulating growth and maturation of gonads, ovulation and spermiation,in female and male respectively, culminating in spawning. It has been experimentally found out that the injection of the pituitary extract stimulatesmaturity in immature fishes. This finding underlies practical usefulness inthe field of pisciculture and this idea was successfully applied for producing seed fishes by injection of pituitary extract in captive fishes (N. Gerbilskyin The Text book of Physiology (ed.) by Bykov, K.M. 1953).Voluminous work in this field of endocrine control of reproduction infishes is on record. Pituitary gonadotropins have been purified in some teleosts. But there are differences of opinions regarding existence of one or two gonadotropins. Two types of gonadotropins were observed in salmon,eel and goldfish. On the other hand, one type of gonadotropic cells have been observed in cat fishes and common carp. It was opined that theteleost pituitary gland elaborates only one gonadotropin. However available data, on this subject are conflicting. It was remarked that the nature of the fish gonadotropin was still not resolved, the data for a single factor seemed to be accumulating steadily. (Donaldson,1973). On the other hand it was also opined that the synergic actions between the two gonadotropins account for better results.

Reviewed literatures (Harvey and Hoar,1979; Schereck,1974)in this field revealed that there were considerable evidences which showed that endocrine system of fishes serves as a link between the environment and reproductive functions. More especially the hypothalamus -hypophyseal neuro endocrine axis is of ultimate importance in mediating the effect of environmental variations on sexual cycling. Diagram below demonstrated the major links in physiologic chain of eventsof mature gametes culminating in spawning.

From the studies and from many experiments carried out on Indian carps and other cultivated fishes, it is evident that various physiological events culminating in spawning depend to a large extent on the environmental stimuli.

Environmental stimuli

↓

Brain

↓

Neural Connection

↓

Hypothalamus

↓

Releasing Hormones

↓

Pituitary

↓

Gonadotropic Hormones

↓

Gonad

↓

Sex Hormones

↓

Maturation and release of Gametes

Source: Harvey and Hoar, 1979. (IDRC)

Endocrine control of reproduction in fishes with reference to indian carps

Hypothalmic neurons whose axons link make up the neurohypophysis which are of specialized type referred to as neurosecretary cells. These cells respond to the electric signal from the brain with a release of chemical messenger at the axon terminal, thus bridging the gap between the nervous and hormonal information. Our main interest however, is with the neurons of the nucleus preopticus (NPO) Hormone produced by the NPO neurons are released largely into blood channels running between neurophypophysis and adenohypophysis. Endocrine cells of the adenohypophysis are to beinnervated directly by neuro secretary axons and the chemical messenger released at this junction is termed as Releasing Hormone (RH).

The gonadotrophins, Follicle stimulating hormone (FSH) and Leuteinizing hormone (LH) through the mediators initiate the process of maturation of gonads due to the influence of environmental stimuli (temperature and photo-period). Steady rise of gonadotrophins which complete the maturation of gonads in increasing temperature and photo period during April/May, the fishes spawn during monsoon months from June to September when the rivers are in flood due to rainfall. But in confined waters the maturation process of carps, rohu, catla, mrigal, calbasu and other medium sized and small sized carps is not completed probably due to the presence of some depressing factors preventing spawning, in the confined water (Swingle, 1956).

Concept and History of Hypophysation Technology

Scientists were carrying out research and field experiments in many countries to breed the cultivated fishes which are reluctant to breed in confined water bodies like ponds, tanks and in impoundment under controlled conditions. In an experiment , investigators implanted pituitary in a immature mice which attained precocious sexual maturity and in another experiment hypophyseal extract injection was administered in a immature animal which attained precocious gonadal maturity indicating that the pituitary hormones have a role to play in accelerating gonadal maturity in fishes (Bykov, 1953).

Following the same principle, Houssay, (1931) of Argentina administered pituitary extract to induce gonadal maturity and spawning in a native fish precipitating spawning which was a turning point of hypophysation technology in fish seed production for aquaculture as mentioned earlier. Brazilian scientists (Cardoso, 1934; Ihering , 1937) further developed the technology for field use under local conditions. The technology being essentially similar, many countries around the world adopted it. Russian scientists (Gerbilskii,1938; Kazanskii,1939) used hypophysation technology to induce spawning in anadromous Sturgeons. In U.S.A. success in inducing spawning by injecting pituitary extract in native fishes, was achieved in 1939, and in 1940 (Hasler et al., 1939, Hasler et al., 1940). Fujita et al. (1946) successfully precipitated spawning in loach by administering pituitary hormones, to produce seed fishes under controlled conditions, in Japan. Subsequent to these successful application of hypophysation, many countries adopted the technology of injecting pituitary hormones to induce spawning in their native fishes under controlled conditions to produce seedfishes for aquaculture. In China which has a long history of fish culture used hypophysation technology to produce fish seed of the quick growing carps silver carp (*Hypophthalmichthys molitrix*, grass carp (*Ctenopharyngodon idella*), and bighead carp (*A. nobilis*), for aquaculture. At present, with the availability of synthetic hormones LH-RH analogue and other ovulating agents, Chinese carps are induced to breed by using LH-RH analogue in combination with Human Chorionic Gonadotropins. In Malaysia, Chen et al.(1969) used Synohorin, a preparation of H.C.G. in combination with a low dose of common carp pituitary to induce spawning in silver carp, grass carp and bighead carp.

In India, Khan (1938) attempted to induce spawning in *Cirrhinus mrigala* (Ham), for the first time by administering injection of mammalian pituitary extract. The recipient fishes released ovarian eggs indicating positive action of pituitary hormones. Subsequently during fifties induced breeding with pituitary extract injection in carp minnow Esomus danricus and in catfish, Pseudotropius atherinoides was successfully achieved (Chaudhuri, 1955, 1956). Ramaswamy and Sundararaj (1956, 1957)administered pituitary hormones and repeated success of spawning was achieved in H. fossilis.

Outstanding and epoch making success in hypophysation of Indian major carps,*Catla catla*, *Labeo rohita*, *Cirrhinus mrigala* was achieved in 1957 (Chaudhuri and Alikunhi, 1957). This achievement has not only opened dependable source of pure quality fish seed of cultivated fishes but also paved the way for production of hybrids for aquaculture.

Standardisation of hypophysation technology for field use under prevailing environmental conditions in India

Experiments on standardization of technology suitable for local conditions for production of fish seed, during sixties, were undertaken in the Killa Fish Farm under the Pond Culture Substation, Cuttack, Odisha. Many experiments were carried out on hypophysation to standardize it for field use under local conditions. It was prerequisite to determine the doses first of all to induce successful spawning in recipient fishes. At initial stage of experiments on hypophysation, part of a pituitary gland such as one fourth, half, three fourth and whole gland after maceration were used to induce spawning in fishes. Doses were determined on the basis of estimation which gave varied results. But these experiments indicated that there was relationship between the weight in kg of recipient fishes and the required pituitary in mg to induce spawning. This idea was useful to determine the correct doses. So it was decided to take weight of individual pituitary gland in chemical balance in milligram and determine the doses of required pituitary according to the weight of the recipient fish. Accordingly doses could be mentioned as mg of pituitary gland per kg body weight of the recipient fish. Once the dose is decided total quantity of pituitary required according to the weight of the recipient fishes , is taken out. As for instance the total weight of the recipient fishes is 10 kg and the decided doses is 8mg per kg so the total quantity of pituitary required is 10 x8 =80 mg. (Chaudhuri, Bhowmick, and Pal (1960), Chaudhuri (1960), Chaudhuri (1963).

This 80 mg of pituitary gland is macerated in measured quantity of distilled water in a homogenizer to get the required hormones in the solution. The macerated pituitary is then centrifuged in a electrical machine or in a hand centrifuge to remove tissue particles which get deposited at the bottom of the tube. The supernatant fluid is taken which contains required hormones for injection. Thus, after carrying out number of field experiments the relationship between weight of pituitary and the recipient fishes was found and the method of determination of doses is resolved. This technique now is used through out the Indian Sub continent and also abroad. Experiments were continued to find out minimum and maximum effective dose range to induce spawning in Indian major carps during sixties, at Pond Culture Research Sub -station, Cuttack.

Determination of doses however, depends mainly on the extent of ripeness of gonad of the recipient fishes and the prevailing environmental and climatic conditions (rain, water temperature). It was observed that when the recipient fishes are nearer to spawning stage, a very low dose may be sufficient to induce spawning but when the fishes are resorbing, comparative higher dose is required for induction.

Many experiments were carried out during sixties, on the Indian major carps to find out the minimum effective dose under different environmental conditions and was found out that the minimum 5mg of pituitary is required to precipitate spawning in female spawners of major carps. Dose range, however, was 5mg to 8 mg, at the initial stage and it was increased to 12mg per kg body weight of the recipient females . The minimum and maximum doses especially for female fish as mentioned earlier is dependent on the extent of gonadal maturity and climatic conditions. Accordingly maximum dose maybe decreased or increased to some extent. Male spawners required less of hormone, 2mg to 3mg/ kg body weight of recipient fishes may be sufficient to induce them(Chaudhuri et al.,1960). The female brood fishes are given two split doses at an interval of six hours. Similarly technique of administration of injection of pituitary extract in the muscular region above the lateral line, near the caudal peduncle, avoiding vital organs was found to be appropriate place for injection. Graduated Hypodermic Syringe, 2ml and needles of different size (26-19 nos.) for small and big fishes respectively, were used effectively. Spawning environment, and for incubation and hatching, hapa (breeding hapa and hatching hapa) were used. Breeding hapa was stitched of close mesh cloth and the hatching hapa is consisted of two hapa, outer hapa and inner hapa . The outer hapa is stitched of close mesh cloth and the inner one is stitched of mosquito netting, which is fitted inside the outer hapa. Breeding hapa are of different dimensions,the smallest one is of 6x3x3 feet, and the biggest one is of12x6x6 feet in size, for small and big fishes respectively. The hatching hapa and the breeding hapa,all are rectangular in shape. Right size and dimension of hapa were designed after repeated field experiments (Chaudhuri et al.1960; Chaudhuri, 1960; Chaudhuri,1963). The female are given two split doses at a interval of about 6 hours. Similarly technique of administration of inter muscular injection in the muscular region above the lateral line,near the caudal peduncle, avoiding vital organs was standardized. Breeding environment: Breeding hapa (close meshed cloth enclosure) of rectangular shape and of different dimension ranging from 6x3x3 feet to 12x6x6 feet , for smaller and bigger spawners respectively was designed. Incubation and hatching technique were standardized using double hatching hapa, outer hapa of close meshed cloth, measuring 6x3 x3 feet and the inner hapa of 5x2.5x2.5 feet, fitted inside the outer hapa. Inner hapa is stitched out of mosquito netting so that the hatchlings can pass through into the outer hapa.

Egg shell and dead eggs are left behind in the inner hapa which is removed and when all the eggs are hatched out and hatchlings escaped to the outer hapa. Larvae are left undisturbed in the outer hapa till the 3rd day after hatching. By that time yolk almost gets absorbed and the young ones start feeding. They are collected and measured with a 15 to 20 ml perforated cup so that number of (3 days old) could be estimated. After measuring volumetrically they are stocked in nursery ponds.

Technology of hypophysation:

Hypophysation technology involves several steps such as collection pituitary gland, nutrition and care of brood stock, selection of brood fishes, determination of doses, preparation of extract of pituitary gland, administration of injections, spawning environment, spawning and hatchery operations.

Techniques of collection, preservation, processing and storage of fish pituitary glands

The successful hypophysation of cultivated fishes in early thirties to produce quality fish seed, in captivity has brought a revolution in the field of aquaculture. (Houssy,1931) It is now a routine practice in several countries to breed fish by pituitary gland extract injection. Pituitary gland is a pre-requisite essential in induced breeding of fishes. Methods of collection, processing and storage of pituitary glands are described here below:

In India, glands are collected without removing the head from the fish.With the help of a knife the roof of the cranium is chopped off exposing the brain. The brain is removed exposing the gland which is under a membrane in the bony depression. By removing the membrane the gland is collected. But in large scale collection from the markets glands are collected from the fish heads those are already cut off by the retailers. Inthis case, the fish is cut in such a way so that the posterior part of the brain case is cut exposing the region of the brain. Through the opening thus made it is easy to remove the gland by lifting and pushing the brain backward or by pulling out the entire brain material. The adoption of this method is now a routine practice in India. As for instance in Sealdah market (Kolkata, West Bengal) fish head is removed in such a way that the posterior region is exposed, exposing the brain of the fish. The gland is collected through the posterior region. To facilitate collection a light is used. (author's field experience).

In India, successful results have been obtained with pituitary glands collected from freshly killed fishes or fishes preserved in ice for 5-7 days,and it is now a regular practice to collect large quantities of glands from fishes preserved in ice for a few days (Central Inland FisheriesResearch Sub station,Cuttack).

Maturity of donors

Major carps are the main source of pituitary glands in India and large quantities are collected from fish markets. Since these carps spawn with the commencement of monsoon, in the month of June, July, they are available in ripe conditions in the market during pre-monsoon months and it is at this period that pituitary collections are made in the market (Author's practical experience). In fish farms also pituitaries are collected from mature or maturing fishes.

Pituitary gland of Induced- bred fishes

In India, it has been observed that pituitary glands from induced bred fish,collected immediately after spawning are potent and can be used effectively.At the Central Inland Fisheries Research Station, Cuttack/Dhauli where hundreds of specimens of Indian and Chinese carps are induced to breed annually, it is a routine practice to collect pituitary glands from induced bred fishes which are to be killed. This practice has a considerable importance because in farms where hypophysation work is taken up in a large scale, the glands of the induced-bred fishes can also be utilized economically.

This observation is quite significant because in induced breeding operations, usually a question is raised regarding the role of endogenous and exogenous pituitary glands. Since glands collected from induced- bredfishes have given satisfactory results in spawning, it is possible to assume that the main role is played by the exogenous pituitary glands.

Preservation of Fish Pituitary Glands in alcohol/acetone Immediately after collection pituitary glands are preserved either in absolute alcohol or acetone so as to defatten and dehydrate the glands. The gonadotrophic hormones in the pituitary glands are soluble in water but insoluble in absolute alcohol or in acetone. In India, pituitary glands, immediately after collection are preserved inabsolute alcohol. Twenty four hours later the alcohol is replaced with fresh absolute alcohol and is stored in the refrigerator. Fresh pituitaries are however, more potent than the preserved ones.

Nutrition and care of brood fishes

Major carps

The success of hypophysation of cultivated fishes depends on the optimum gonadal maturity of the brood stock. To ensure gonadal maturity nutritive food, containing protein, carbohydrate, minerals and vitamins are to be provided and the rearing pond is to be prepared suitably with proper care and some management measures are also to be undertaken.

Nutritional requirement: Studies on the nutritional requirement of Indian carps using purified, fortified with minerals and vitamins indicated that the gross protein and carbohydrate requirement for carp fry and fingerlings varied from 36% to 45% and 26% to 28% respectively. Further studies on major carps revealed that protein requirement for *L.rohita*, *C.catla* and *C.mrigala* varied roughly between 40 to 47%. Another study indicated the optimum requirement of carbohydrate, varied from 22to 26%, lipids 4 to 6%, vitamin B Complex, 0.1%, vitamin C 600mg/kg and vitamin A 2000-4000 µg/kg of diets (Source: CIFA, Bhubaneswar).

Rearing of brood stock

Major carps and other medium size carps are reared in perennial undrainable ponds in India. Rain is the source of water in those ponds. The size of rearing ponds for brood fishes vary from small to large, from 0.3 to 1.0 ha in area , depending on the availability. Depth of water may vary from 1.5to 2.0 m

Pre Stocking Management measures

Aquaculture on the scientific lines demands certain measures to be adopted before commencement of culture operations, to maximize production in ponds or in tanks. Pre-stocking management measures for composite fishculture, polyculture include control of weeds, eradication of predatory and weed fishes and fertilization of ponds/tanks. Various steps have been described for preparation of ponds before planting seed fishes.

Aquatic weeds and its control

The presence of excess of weeds in ponds/tanks takes away the nutrients turning the water bodies less productive and shelters weed fishes, create sproblems of netting operations and restricts the diffusion of sunlight,adversely affecting ecological balance.

The nature and types of common Aquatic Weeds Infestations

Three types of weeds are mainly encountered in the fishery waters -floating, submerged and rooted emergent. Water hyacinth (*Eichhornia* sp),water lettuce (*Pistia* sp.), *Wolffia* sp., *Lemna* sp., *Azolla* sp., *Ipomea* spp., *Jussiaea* sp.,*Vallisneria* sp., *Salvinia* sp. are commonly found weeds.

Amongst the submerged weeds- *Hydrilla* sp., *Najas* sp., *Ceratophyllum* sp., *Potomogeton* sp., *Vallisnerea* sp., *Ottelia* sp., *Chara* sp. and *Utricularia* sp. are common. Emergent rooted weeds are water lilies (*Nymphaea* sp.), Lotus (*Nelumbo* sp.) and *Nymphoides* sp.

Algal Bloom

Occurrence of algal bloom in fishery waters is often more dangerous and persistent than other vegetations and causes sometimes mass mortality of fishes in ponds. The algal bloom of *Microcystis* sp. and *Anabaena* sp. often form sperennial bloom in highly fertile and organically polluted ponds causing sudden mortality of fish population due to depletion of oxygen.

Control methods of weeds

Manual removal of weeds by using mechanical devices such as winces etc. is effective.

Chemical

There are several chemical weedicides available in the market of which 2,4-D paraquat sold as Gramoxone 40', sodium arsinite, dichlobeniol,simazine and ammonia are the most important. 2,4-D which is a hormone weedicides

(2,4-Dichlorophenoxy acetic acid) are the cheapest and have been known to be effective against the most obnoxious weed, water hyacinth(Eichhornia sp.).
The following doses are found to be effectively used in controlling water hyacinth
100 gm plant weight - 10 mg of 2,4-D
100 gm - 500 gm - 20 mg of 2,4-D
500 gm - 30 mg of 2,4-D

Pistia sp.
Another floating weed which is much lighter can be effectively controlled by Gramoxone 40' @ 0.2 kg/ha.

Similarly Salvania found to occur in water bodies in India in heavy infestation may be treated with gramoxone 40'. Pistia sp. can also be controlled by spraying 1%-1.5 % aquaous ammonia.

The submerged weeds can be controlled by sodium arsenite at 4-6ppm very effectively but it is dangerously poisonous to human beings,cattle and also to fish food organisms thus adversely affecting fish production.

Ammonia has been used effectively in controlling submerged weeds. About 225 kg of ammonia may be required to clear submerged weeds in 1 ha water area of 1.5 m depth. Simazine @ 5 ppm and Gramoxone @2 ppm are also effectively used in controlling the submerged weeds. However,ammonia has been reported to be the cheapest of all the chemicals with some added advantage.

Biological Control

Grass carp has been found to be most effective agent in controlling some of the submerged aquatic weeds like *Hydrilla* sp., and *Najas* sp.. While grass carps consume aquatic weeds, by feeding on them, rapidly grows contributing to the fish production. Grass carp can consume 50% of its body weight in a day. Its weed consuming capacity, however depends on the type of weed available and water temperature. 300-400 fishes of about 400-600 gm, in weight may be required to clean 1 ha. *Hydrilla* sp. infestation in one month approximately.

Control of algal bloom

Controlling of algal bloom is neither possible by biological nor by manual methods. Bloom of *Microcystis* sp. and *Anabaena* sp., blue green algae, are effectively controlled by application of chemical weedicide like simazine @ 0.6-1.0ppm of Tafazin 50' 6 kg-10 kg, Simazine may be required for 1 ha water area.

Copper sulphate is another chemical very effective at 1 ppm against algal bloom. Ramchandran (1969)

Predatory and weed fishes and their control

The commonly occurring predatory and weed fishes in ponds/tanks are *Wallago attu*, *Channa marulius*, *C. punctatus*, *C.striatus*, *Notopterus* sp., Heteropneustes fossilis, *Clarias batrachus*, *Amblypharyngodon mola*, Esomus danricus, *Puntius sarana*, *Ompok* sp., *Glossogobius giuris*. Predatory fishes are harmful to the fishery water not because they compete for food and space with the cultivated species but also directly prey on the latter.

Majority of the predatory and weed fishes multiply in ponds/tanks and are active competitors for food and space with the cultivated ones. The biggest and the most dangerous are the murrel group *C. marulius* , *C. striatus* and the fresh water shark , *W. attu* and other cat fishes. Their presence in the fishery waters very often may cause total loss of fish population. It is imperative that such predators are eradicated before stocking.

Methods of eradication

The simplest methods to eradicate the predators and weed fishes either bycomplete draining or by dewatering of the pond. However, predatory fish population can be completely and satisfactorily eradicated by applying proper fish toxicants. Although there are several fish toxicants available of both plant and chemical origin the former are preferable. Among the plant poisons Derris root powder, (Rotenone 5%) and oil cake of mahua plant (*Bassia latifolia*) are most important.

Derris root powder (Rotenone 5%) in most effective in eradicating predatory as well as weed fishes @ 6 to 10 ppm. Snails , tadpoles and insects are also affected by rotenone treatment and are easily eradicated.Mahua oilcake (4% to 6% saponin) is another fish toxicant which is very effective in eradication of predatory and other unwanted fishes. It has another added advantage. While mahua oil cake as a toxicant kills fishes and other organisms, it helps producing fish food organisms as a fertilizer in ponds/tanks. However, mahua oilcake is effective at a very higher doses such as 200-250 ppm.

Fertilization of Pond

The object of pond fertilization is to supply certain essential nutrients which stimulate the growth of natural fish food organisms in pond. Organic fertilizers such as cow-dung is extensively used in fish ponds in the Indiansub-continent. Inorganic fertilizers which have limited use in ponds are not dealt here. The study of pond (Saha, 1976) bottom soils is a necessary pre-requisite for determining the doses in fertilizing a pond.

Liming of Pond

The importance of liming pond is well known. In addition to supplying the essential nutrient-calcium, lime possesses unique properties, viz. it corrects soil and water acidity, establishes a strong pH buffer system, speedsup decomposition of organic matter, acts as disinfectant. It tunes up the pond ecosystem for better response from added fertilizers.

For liming in ponds, ground lime stone ($CaCO_3$), slaked lime ($CaOH_2$)and quick lime (CaO) are used, the last two being corrosive should not be applied where fishes are present in pond. The necessary doses to be applied may be decided on soil reaction. At pH range of 6.5 - 7.0 (near neutral) 200kg/ha may be required (Saha, 1976).

Fertilization with organic manures

In order to enrich the pond water with sufficient food reserve in the formof microscopic fish food organisms, fishery waters have to be manured.The most suitable and easily available manure is cow-dung. This is regarded as complete fertilizer because of presence of all the three major importantnutrients viz. -N.P. and K. In addition, this contains organic carbon, trace elements, micro organisms and growth regulating substance, vitamin like in nature.

About 15 days prior to stocking, the manure can be broadcasted along the marginal waters at the rate of 10,000 kg/ha. However, better results are obtained when the manure is applied in installments. This will lead to the growth of various types of planktonic organisms which will reach a peak production by about the tenth day. However proper care has to be taken in the use of organic manure like cowdung so that there is no depletion of oxygen due to its application.

Stocking of potential broodfish

Potential brood fishes are collected from various sources and released inthe pond after the winter season is almost over. Normally during Januaryand February when the temperature gradually rises the potential broodfishes of 1-4 kg in weight and of 2-4 years old are stocked normally at therate of 1500 kg/ha.

Post stocking Management

Supplementary feeding

In addition to the natural nutritive fish food organisms available in the pond, supplementary feeding with oil cake and rice bran is provided. The quantity of supplementary feed is applied at the rate of 1- 2% of the bodyweight of the fishes stocked. The ratio oil cake and the bran is 1:1. The feed mixture is made into dough by soaking in water and dough is placed in the feeding trays fixed below the surface of water. There are may be four trays fixed in the four corners of the pond. The feed mixture is also broad castin the water. Provision of supplementary feed ensure necessary nutrition.The feed is provided daily in the morning. It may also be provided twice daily in the morning and in the evening.

Sometimes, due to application of organic manure and supplementaryfeeding there may be growth of bloom of algae in the pond. In such cases,the feeding should be suspended temporarily. The brood stock may be checked once in a month for growth, maturity and health and accordingly manuring and feeding schedule may be adjusted. Care should be taken to see that the brood fishes do not grow undesirable fat.The Indian carps, attain gonadal maturity along with the increasing temperature and photo-period. The fishes which are stocked at the end January-February will normally attain sexual maturity by April-May. During the south- west monsoon (June to September) due to accumulation of rain water in the ponds, the gonadal maturity of the fishes further accelerates when these are taken up for induced breeding operations.

Selection of spawners

Success of induced breeding largely depends on selection of spawners of right maturity. Indian carps mature during pre-monsoon months, April -June both in ponds and in natural habitats. In captivity, in ponds they reach penultimate stage of maturity only (IV - V stage) and exhibit sexual dimorphism by which sexes are distinguished as stated earlier. Proper care is taken to select the spawners. In all the species of carps such as *L. rohita*, *L. calbasu*, *L. gonius*, *L. bata*, *C. catla*, *C. mrigala*, *C. reba*, *L. fimbriatus*, a fully ripe male freely oozes milt when the abdomen is gently pressed, are selected. Milt is milky white in colour in all the specimens of the carps.Pectoral fins in mature males have a relatively rough dorsal surface in contrast to a very smooth surface of the corresponding appendage in females. This difference can be found out just by feeling the surface by finger tips. However, this sex identifying features disappear after the breeding season. The fins of both the male and females are smooth to touch after the breeding season. The female spawners can be recognized by the comparatively larger bulging abdomen and selected by feeling the softness of the abdomen. Those having bulging rounded and soft abdomen with slightly swollen and reddish genital opening are selected for induced breeding. This method of identifying and selecting spawners served auseful purpose because the spawners can be sexed easily and quickly by inserting the hand inside the net bag in water with minimum handling. (Chaudhuri,1960).

Females for final selection are kept up side down in water side by side, to compare distension of abdomen, roundness and softness in the different specimens, comparatively better ones in respect of distension of abdomen and softness to touch are selected (Author's observation). Selection of catla spawners, however sometimes poses a problem because of thickness of the abdomen due to accumulation of fat. Its abdomen having eggs is not as soft and round as in the other Indian carps. In doubtful cases only a catheter may be used to draw egg samples and examine the stage of maturity. The sample of eggs may be examined under microscope to ascertain the position of the nuclei of individual ova. A peripheral location of nucleiis an indication of readiness for spawning. If, however the nuclei are located in the centre of the ova, such a spawner may be discarded for the experiment. However, catla female spawners are selected by morphological character as in rohu, mrigal and used for hypophysation.Use of catheter is not required normally.

Weighing of spawners by Spring balance to determine doses

Determination of dosage

Determination of optimum dosage of pituitary extract depends mainly on the extent of ripeness of the gonad of the recipients and the prevailing environmental and climatic conditions (rain and water temperature) during the experiment. When the recipient is nearer to the spawning stage, a verylow dose may be sufficient to induce spawning but when they are resorbing, a comparatively higher dose is required for induction. A female recipient requires more hormones than the male. The females are given two split doses. Dosages are determined on the basis of weight of the recipient. A preliminary dose of 2-3 mg per kg body weight and after an interval of 6hours a second dose of 5-12 mg per kg body weight administered to the female. A dose of 2-3 mg per kg body weight is injected to the males at the time of second injection to the female.

However, the dosage differs from species to species. In case of Catfishes,such as *P. Pangasius*, *C. batrachus*, *H. fossils*, *O. bimaculatus*, *Ompok* spp. the doses are different than that of carps. Doses also depend in the ovulating agent used for induction. However, homogeneous pituitary gland appears to be more potent than heterogenous pituitary gland.

Maceration of Pituitary

Once the proper dosage isdetermined, the quantity of glands required for injecting the recipients are calculated according to theweight of the fish. The requisite quantity of gland is then taken out and macerated in a homogenizer in a little distilled water (measured). The homogenized gland extract is then diluted to known volume. The dilution is generally made at the rate of 0.2ml per kg body weight of the recipient fish. The homogenized extract isthen centrifuged to remove the tissue particles which settle down at the bottom of the tube. The supernatant fluid contains the hormones.

Administration of injection

In general practice intramuscular injection of pituitary extract is administered in the region of the caudal peduncle, a little above the lateral line. The needle is inserted under the scale, at first parallel to the body of the fish and the needle is pierced in the muscle at an angle of about 30°. A hypodermic syringe of 2 ml capacity graduated to 0.1 ml divisions usually is used for administration of injection. The size of the needle depends on the size of the recipient fish. B.D needle no. 19/20 is used for bigger fishes and no. 22/26 is used for smaller fishes. While injecting the spawner are kept inside a hand net and placed in a cushion.Female carps are treated with the preliminary dose @ 2 - 3 mg and released inside a breeding hapa. Second dose of 5 -12 mg/kg is administered to the female after an interval of 6 hrs. when the males are also injected@2 - 3 mg and the set (usually 2 males: 1female) is released inside breeding hapa. For each set separate hapa is used.

Spawning Environment

Conducive spawning environment is important for successful result. At initial stage, during fifties-sixties Hapa only was used for breeding carps and other fishes. Breeding hapa is rectangular cloth- enclosure stitched out of close meshed netting having an opening on one side through which brood fishes are introduced and taken out. The opening can be securely tied after introduction of spawners so as to prevent their escape.Breeding hapa is fixed to bamboo poles in the marginal water of ponds.

They may be fixed in any suitable water bodies such as reservoirs, canals,lakes, tanks and rivers and also in cement cistern. However, breeding hapa should be fixed in water -sheds devoid of common carps and tilapia.After eighties scenario has changed. Many places, hapa has been replaced with concrete circular breeding tank with running water facilities yielding better results. Over 900 hatcheries with overhead water tank providing running water facilities are working in India. However, marginal farmers are still using breeding hapa for their seed requirements. For small fishes (*H. fossilis*, *C. magur*, A. *testudineus*) aquarium of suitable size may also be used as breeding environment. Rain and accumulated rainwater are conducive for spawning. Lower temperature (24° C - 31° C) promotes better results in both spawning and hatching (Chaudhuri,1960, 1968).

Spawning

Spawning of carps take place naturally inside the hapa or in cistern or breeding tank. Spawning usually takes place within 3 -6 hrs. after the second injection. Before spawningoccurs the recipient fishes demonstrate some sort of sex play.Normally the female is chased by the male. The female spawner swims faster. This sex play continues forsome time. The female swims splashing water and releasing eggs and the males follow the female releasing its milt. The act of releasing eggs and milt is synchronized culminating in fertilization. (Author"s field observations). After fertilization development process continues inside the hapa. After water hardening developing eggs are removed for incubation and hatching.

Tables showing details of experiments of hypophysation on Indian major carps, *C. catla*, *L. rohita* and *C. mrigala*.

Incubation and Hatchery operation

Major carp eggs which are not adhesive, but semi- buoyant, swell up gradually to 3.5 to 5.5 mm in dia. after spawning. Eggs are removed from the hapa when these are properly water hardened after 3 -4 hours. Eggs are collected from the hapa with 1 litre mug and put in the bucket. Egg samples are collected before hand and put in enamel tray with water for counting. Total quantity of eggs laid is estimated from the volume of eggs measured with 1 litre mug and percentage of fertilization is scored from the egg sample (numbers of viable and dead eggs per ml). Viable eggs are transparent. Dead eggs are opaque to naked eye. The ratio of viable eggs (good eggs) to dead eggs is the percentage of fertilization. Thus from, the percentage of fertilization total number of viable eggs are found out. And from the total number of viable eggs number of spawn expected is estimated.

Eggs are distributed for hatching in the hapa hatchery fixed in stagnant ponds or in a indoor Glass

Table I *Catla catla*

Year/Month	1971 Jun-Aug	1970 Jun-Jul	1975 Jul-Aug	1972-77 Jun-Jul-Aug
Female Weight/Age	1.3 to 5.0kg 4yr.	8.0(Av. wt.)	2-4 yrs.	2.5-7.6 kg.
No. of Female	38	6	15	6 (Albino female)
Assessment of gonadal state	Bulging, round, soft abdomen	Bulging, round, soft abdomen	Bulging, round, soft abdomen	Bulging, round, soft abdomen
Hormone used and its origin	Pituitary gland extract	Carp pituitary	Salmon pituitary gonadotropin (SG.-G-100)(IDRC)	Carp pituitary
Doses female mg/kg 1-2	2-3 mg (1) 8-15 mg(2)	1.5 mg(1) 7.5-9.0mg(2)	2-3 mg (1) 11-13 mg(2)	2-3 mg (1) 10-18 mg (1)
Method of administration	Intramuscular	Intramuscular	Intramuscular	Intramuscular
Time and frequency	6 to 7 hrs.	6 hrs.	6 hrs.	6 hrs.
Latent period	4 to 7 hrs.	----	----	----
Fertilization%	14 to 73 natural spawning (in hapa)	Av. 55% natural (in hapa)	Natural spawning (in hapa)	57% natural (in hapa)
Incubation and hatching	Cloth hapa and Jar hatchery	Cloth hapa	Cloth hapa/Jar hatchery	Cloth hapa/ Jar hatchery
Temperature ^oC	28 to 33^0C	26 to 29 ^0C	28-33 ^0C	29-32 ^0C
Result	96% spawned, 3.46 million spawn obtained	80% spawned, 0.6 million spawn obtained	67% spawned, 0.61 million spawn obtained	83% spawned, 0.7 million spawn obtained (albino)
Remarks	Males injected @ 2-3 mg/kg	Males injected @ 2-3 mg/kg	Males injected @ 2-3 mg/kg	Albino males wt. 2.0 to 5.15 kg @ 2-3 mg/kg
Reference	Bhowmick et.al. (1978)	Bombay, (1971)	Chaudhuri et.al. (1977)	Bhowmick et.al. (1978)

Table II *Labeo rohita*

Year/Month	1970 Jun-Aug	1968 August	1968 August	July	1975 Jul-Aug	1972-75 Jun-Aug	1972-75 Jun-Aug
Female wt. in kg/age	1.4kg (Av.)	0.9 to 1.1	0.9 to 1.1	2-4 yrs.	2-4 yrs.	0.8 to 2.0 kg	0.8 to 2.0 kg
No. of Female	289	7	12	7	29	10	19
Assessment of gonadal maturity	Bulging, round, soft abdomen	Bulging, round, soft abdomen	Bulging, round, soft abdomen	Bulging, round, soft abdomen	Bulging, round, soft abdomen	Bulging, round, soft abdomen	Bulging, round, soft abdomen
Hormone used and its origin	Carp Pituitary gland. Market collection	Synahorin (mainly HCG)	Carp Pituitary + Synahorin	Tachysarus PG-Marine catfish	Salmon gon-adotropin SG-8-100 (IDRC)	Freshwater catfishes 4 genera	Clomiphene citrate with and without pituitary
Doses female mg/kg 1-2	2-3 (1) 5-8 (2)	5 RU (1) 45 RU (2)	2-8mg (1) 25 RU (2)	Total mg/kg males @ 15 mg (1) 30 mg (2)	2-3 (1) 3-11 (2)	2-3 (1) 12-14 (2)	10-200 mg/kg clomiphene alone; also with 4-5 mg/kg pituitary
Method of administration	Intramuscular	Intramuscular	Intramuscular	Intramuscular	Intramuscular	Intramuscular	Intramuscular
Time and frequency	6 hrs.	6 hrs.	6 hrs.	6 hrs.	6 hrs.	6 hrs.	6 hrs.
Spawning	Natural	Negative	Natural	Natural	Natural	Natural	Negative
Fertilization%	84%	----	----	----	----	----	----
Incubation and hatching	Cloth hapa in ponds	----	Cloth hapa in ponds	Cloth hapa in ponds	Cloth hapa in ponds/jar hatchery	Cloth hapa in ponds/jar hatchery	----

Table III *Cirrhinus mrigala*

Year/Month	1970 Jun- Jul	1975 Jul-Aug.	1975 July
Female Wt. /kg/age	1.25	1.25 to 2.0	1-3 yrs.
No. of Females	42	4	4
Assessment of gonadal maturity	Bulging, round, soft abdomen	Bulging, round, soft abdomen	Bulging, round, soft abdomen
Hormone used and its origin	Carp pituitary	Salmon gonadotropin SG-G -100 (IDRC)	Taonysurus sp., pituitary gland marine cat fish
Doses-Female 1-2	0.5-0.75 (1)3.5-5.0 (2) mg/kg	2 to 3 (1)6 to 8(2)mg/kg	20 mg/kg to 30 mg/kg
Method of administration	Intramuscular	Intramuscular	Intramuscular
Time of frequency	6 hrs.	6 hrs.	---
Fertilization%	70% natural	Natural	Natural
Incubation and hatching	Cloth hapa	Cloth hapa / Indoor hatchery	Cloth hapa
Temperature ^{0}C	26-29	28-33	25-27
Result	97%3.2 million spawn	100%0.29 million	50%
Remarks	Male 2mg/kg	Male2-3mg/kg	---
Reference	Bombay (1971)	Chaudhuri et.al.(1977)	Varghese et.al. (1975)

Jar hatchery with running water. The hapa hatchery consists of series of hatching hapa which are fixed to bamboo poles in marginal water in ponds. Hatching hapa consists of two pieces of separate hapa, one fitted inside the other, both are rectangular in shape without any cover. The inner hapa which is smaller than the outer hapa, is stitched of round mesh mosquito netting through which larvae escape to the outer hapa. Outer hapa is stitched with a very close meshed cloth or nylon netting, which prevents escape of larvae from the hapa. Depending on the percentage of fertilization about 75000 to 1 lakh eggs are uniformly spread in the stretched bottom of the inner hapa. The eggs usually hatch out in 15 to 18 hours after fertilization, at a temperature of 27° C to 31°C. The period of incubation however may vary according to water temperature. After hatching larvae escape to the outer hapa, egg shell and dead eggs are left behind in the inner hapa which is removed and all the eggs are hatched out and hatchlings escape to the outer hapa. Larvae are left undisturbed in the outer hapa till the 3rd day after hatching. By that time yolk almost gets absorbed and the young ones start feeding. They are collected and measured with a 15 to 20 ml perforated cup so that number of spawn (3 days old) could be estimated. After measuring volumetrically they are stocked in nursery ponds, which are prepared and kept ready to receive them. However the hatching hapa fixed in pond is subjected to field hazards which are beyond control under field condition. To solve this problem of field hazards and to reap maximum benefit of induced fish breeding an indoor hatchery with running water facilities, was designed for carps and installed at the Central Research Substation, Cuttack, for the first time in 1970. This indoor hatchery eliminates field hazards and ensures higher survival of fish seed.

Glass Jar Indoor Hatchery

It consists of 1) Water supply 2) Breeding Tank,3) Incubation and hatching jars , 4) Spawnery. Cement tanks are used for breeding the spawners and they also serve as spawn collecting tank, the spawnery, after the spawning operation is over. Four sets of spawners can be bred and two millions of eggs can be hatched in the hatchery in a single operation. The Cuttack hatchery consists of 40 jars with a capacity to accommodate 2.0 millions of eggs @ 50,000 eggs in each jar (6.36 litre) for hatching at a time. The two spawneries can accommodate 1.0 million spawn in each.

Hypophysation of Chinese carps, *H. molitrix* (Silver carp), *C. idellus* (Grass Carp)

The Chinese grass carp and silver carp were first transplanted to India in 1959, at the Central Inland Fisheries Research Sub-station, Cuttack, Orissa. Gift consignment of fry of silver carp and grass carp were obtained from Japan (Tone river) and from Hong Kong (originally from China) respectively.

Both the species attained gonadal maturity within two years, in ponds, at Cuttack. Although they attain gonadal maturity in ponds but do not spawn in such an environment, in captivity. They are not released in the open water bodies in India. So the seed of silver carp and grass carp required for aquaculture are produced by hypophysation only.

They were first induced bred (3 yrs. old), by hypophysation in 1962 at Cuttack, India. (Alikunhi et al., 1963). The Silver carp and Grass carp available in the country now have originated through hypophysation only from Cuttack Research Station.

Technology of hypophysation of Chinese carps, silver carp, and grass carp is essentially same as described for Indian major carps. However, still there are some differences in technique for Chinese carps. These carps require a little higher doses than that of Indian carps and normally these carps do not breed inside the breeding hapa. Artificial fecundation is adopted in case of Chinese carps by stripping for breeding.

Hatching Operation

Hatching operations are similar as that of Indian carps. In case of silver and grass carp, eggs are allowed to swell, after stripping in the tray. Fully swelled eggs are next released inside breeding hapa for water hardening, which are collected after about 4-6 hrs for hatching. Hatching operations are carried out both in hapa hatchery fixed in pond and in glass jar indoor hatchery with running water for higher survival and production. Hatching takes place within 18-20 hrs after fertilization. Larvae of grass carp and silver carp hatch out about 3 hrs. earlier in the indoor hatchery with running water. On third day yolk is absorbed, the fry are collected and stocked in the nursery ponds.

Breeding of *Cyprinus carpio* (Common Carp)

Common carp is one of the important food fishes cultivated internationally. It breeds naturally in ponds but percentage of fertilization and survival of fry is poor in wild spawning. For obtaining high survival and production of fry, these fishes are bred under controlled conditions. No hormone treatment is needed. Breeding technique of common carp has been developed at the Central Inland Fisheries Research sub-station, Cuttack. Pond Breeding Live fishes

Live fishes *Anabas Testudineus* (Koi) is a small and medium size fishes. They are cultivated in ponds. These fishes grow and mature and spawn in that environment.

Anabas testudineus (Koi) is an endangered species. It is necessary to employ induced breeding technology for recovery of the species. A project on induced breeding of Anabas, was undertaken in sewage fed water in East Calcutta in the year 2007. (Ghosh and Bowmick, 2007).

Potential brood fishes of *Anabas* were procured from the local market and released in sewage fed pond for rearing. In addition to available natural food, they were supplied with supplementary feed.

When they attained gonadal maturity they were netted to select the potential spawners.

Two sets (one set- one female and two males) were selected for breeding experiment. Success of induced breeding largely depends on the proper selection of spawners. They are selected on the basis of distension and softness of the abdomen. Before final selection female spawners may be kept side by side for comparing distension and softness. The best ones are selected. Males oozing milt on gentle pressure on the abdomen are selected. Milt of *A. testudineus* is whitish in colour and thick is consistency.

Doses :

Doses vary with the ripeness of gonad of the spawners. Doses also change with the various inducing agents used for spawning. When the recipients are nearer to spawning stage very little dose may be sufficient but when the recipients are in resorbing stage higher dose is necessary.Dose of pituitary for *A. testudineus* varies from 15 mg/kg body weight of female 30 mg/ kg. But in this experiment ovaprim, a synthetic hormone, was used. Doses of ovaprim vary from 0.4 to 0.9 ml/kg for female recipients. For male spawners half of the dose is sufficient to induce.0.5 ml of ovaprim /kg/body wt. of female and half of the dose was used for males in these experiments. Two sets of experiments were carried out. Intra-muscular injection with Insulin syringe having small needle was administered in the caudal peduncle region, a little above the lateral line. The hormone is to be injected slowly. Only one dose of injection is to be administered for each of the spawners.One set was released in Hapa fixed in pond and the other set was released in an aquarium. Both the sets spawned completely within 10-12 hrs. of injection yielding 21000 eggs having 98% fertilization at 31.5 ^{o}C. temperature.

Hatching/Rearing

Eggs are tiny in size, golden in colour and free floating in nature. Eggs were incubated at 28 ^{o}C to 31.0 ^{o}C temperature. These eggs hatched within 11-12 hrs. of spawning in four aquaria having 100% hatching. The

Table IV Induced Breeding technique
Hypophthalmichthys molitrix

Year/Month	1961-62 Jun-Jul	1964 Jul-Aug	1970 Jun-Jul	1979-80 Jul-Aug
Female Wt. in kg/age	2.6 to 6.5	1.3 to 6.0	5.8 Av. Wt.	1.0-3.0
No. of Female	15	45	16	13
Assessment of gonadal maturity	Bulging, round, soft abdomen	Bulging, round, soft abdomen, Swollen, pinkish vent	Bulging, round, soft abdomen, Swollen, pinkish vent	Bulging, round, soft abdomen,
Hormone used and its origin.	*L. rohitaC.mrigalaH. MolitrixC.idellus*	*L. rohitaC.mrigalaH. molitrix*	Carp pituitaries	Carp pituitary
Doses in mg/kg 1-2	3 to 7 mg/kg in 1 to 3 doses	8 to 11 mg/kg in 1 to 3 doses	1.5 to 2.5 mg/kg (1) 8.0 to 8.5 mg/kg (2)	2.0 - 4.0 mg/kg (1) 8.0 -12.0 mg/kg(2)
Method of administration	Intramuscular	Intramuscular	Intramuscular	Intramuscular
Time of frequency	3- 12 hrs	6- 8 hrs	6 hrs	6 hrs
Latent period	5-6.5 hrs	5 to 8 hrs	----	----
Fertilization%	65%, stripped dry	Stripped dry	Stripped dry over 50%	25-91% Stripped dry
Incubation on hatching	Cloth hapa in ponds	Cloth hapa in ponds	Cloth hapa in ponds	Cloth hapa in ponds
Temperature °C	28.2 - 34.9	27 - 32.3	26-29	26-30
Result and spawn obtained in million	0.55	0.30	0.58	61.5% fry obtained
Remarks	First success in India	Male @ 2-4 mg/kg	Work done in Tripura	Male @ 2-4 mg/kg
Reference	Alikunhi et al. (1963b)	Chaudhuri et al. (1966)	Bombay, 1971	Bhowmick et al. (1980) (MS)

Table Induced Breeding technique
Ctenopharyngodon idellus

Year/Month	1961-62 Jun-Jul	1964 Jun-Jul-Aug	1966	Jul-Aug	1979-80 Jul-Aug
Female Wt. in kg/Age	4.8 to 6.5 3years	1.35 to 3.35 kg	0.9 to 1.35	----	1.0 - 5.75kg
Assessment of gonadal maturity	Ripe female and oozing males, soft bulging abdomen in females	Bulging, round abdomen with swollen pinkish vent, female	Bulging, round abdomen, catheter used for selection	Bulging, round abdomen, catheter used for selection	Bulging, round & soft abdomen
Hormone used and its origin	Pituitary gland of *L.rohita* *C. idellus* *H. molitrix*	Pituitary gland of *L.rohita* *C. idellus* *H. molitrix*	*L.rohita*	Homoplastic, Heteroplastic pituitary	Carp pituitary
Doses female mg/kg 1-2	9 to 15 mg in 2-3 injections in 0.3 saline solution	10 to 12 mg in 2-3 doses in 0.3% saline solution	9 to 12 mg/kg in 2-3 doses	(1) 3-5 mg/kg (2) 7-10 mg/kg	(1)2.0-4.0 mg/kg (2)10.0-12.0 mg/kg
Method of administration	Intramuscular	Intramuscular	Intramuscular	Intramuscular	Intramuscular
Time frequency	Late evening	3-7 hrs.	3-6 hrs.	----	6 hrs.
Latent period	7-8 hrs.	6-7 hrs.	5-9 hrs.	5-6 hrs.	6 hrs.
Fertilization%	Stripped 30-37% (dry)	Stripped(dry) 3 female natural spawning in hapa	Naturally spawned in inside hapa	Stripped dry 15-80%	50-80%
Incubation and hatching	Cloth hapa in ponds	Cloth hapa in ponds	Cloth hapa in ponds	Cloth hapa in ponds	Cloth hapa in ponds
Temperature °C	28.2-34.9	28.9-32.2	28.9-31.2	28.0-31.0	26.0-30.0
Result and spawned obtained	2 of 6 responded fry obtained	8 of 28 sets responded 0.24 million	100%- 1 partial spawning, Fry obtained	0.55 million	55.5% fry obtained
Remarks	First success in India	Males received more than 1 injections @ 1-4 mg/kg	Males @ 2-4 mg/kg	Combined with synahorin (25 RU) ineffective	Males 2-3 mg/kg
References	Alikunhi et al. (1963a)	Chaudhuri et al., (1966)	Chaudhuri et al. (1967)	Singh et al., (1970)	Bhowmick et al. (1980), MS

newly hatched larva with big yolk mass are found floating on water surface. The yolk mass was absorbed within three days. 10,000 spawn was produced. Feeding was a critical problem after the absorption of yolk. They were fed with zoo plankton freshly collected from the farm-pond. The bigger form of plankton was eliminated by repeated sieving through progressively smaller mesh strainer. By this method problem of feeding at critical stage was solved. Brine shrimps, Artemia was also used as feed along with zoo planktons at later stage and subsequently discontinued. Differential growth among fry was observed. A tendency of cannibalistic habit among bigger fry was recorded. Physico-chemical parameter of water was monitored.

After rearing for 22 days 2444 nos. of fingerlings of average size of 0.22gm.were produced and released in sewage fed pond (250m^2), for rearing to marketable size fish of this species.

This is a first attempt to raise marketable size *Anabas testudineus*, a threatened species, using induced breeding technology, for aquaculture in sewage-fed pond.

Heteropneustes fossilis

Two sets of H. fossilis reared in cistern for growth and gonadal maturity were selected as spawners. They were selected on the basis of distension, roundness and softness of the abdomen, during breeding season, mainly during monsoon. They were released in the hapa fitted in a tank inside the carp-hatchery with running water. The tank was fitted with 24 hrs. shower creating artificial rain. Both the sets spawned in the hapa fitted in a tank. No pituitary or other hormone was used to induce spawning. (Bhowmick,1976)

Hatching

Fertilized eggs of *H. fossilis* are adhesive, dimersal and spherical in form. The yolk is green or brown in colour without oil globule. Diameter of fertilized egg varied from 1.4 to 1.6mm.

The spent spawners were removed from the hapa and the eggs were allowed to incubate and hatch in the hapa fitted with shower for 24 hrs. Hatching of eggs took place in the hapa. Hatchlings are tiny. They remain in the hapa for about 3 days and the yolk is absorbed when they start feeding. Larvae were then collected from the hapa and released in cistern for rearing.

H. fossilis are also induced bred with pituitary injection. Induced bred *H. fossilis* with homoplastic pituitary @ 0.5 mg to 1.5 mg. Investigator also used heteroplastic gland (carp pituitary) to induce spawning successfully. Successful spawning of *H. fossilis* was obtained by injecting mammalian hormone (DOCA) and with Human Chorionic Gonadotropin (H.C.G.) in recipients weighing 60 to 80 gm. Four crops of eggs were obtained from the same H. fossilis specimen in 4 months under artificial light.

Breeding of brackish water species

Seed of brackish water fishes like mullets, *Mugil Cephalus*, *L. macrolepis*, *L.tade*, *L. parsia*, *L. corsula*, *chanos chanos*, *Lates calcarifer*, Polynemus, *E. suratensis* (pearl spot) are obtained from the natural sources. Traditional practice of fish culture in brackish water involves allowing the seed of various species to enter the enclosure, by the feeder channel during the high - tide, where number of each species and their composition are not known. Seed production of these species stated above could not be done so far by hypophysation.

Hypophysation of *M. cephalus*

During October to January, the spawners of *M. cephalus* migrate from the Chilka Lake to the sea for spawning. The female spawner accompanied with 3-4 males are observed from the shore in the waves, to migrate, from the lake. Males are smaller in size than the female, when mature they ooze whitish milt on little pressure in the abdomen. Enroute to the spawning ground these spawners are intercepted in the coastal waters, near the lake mouth and caught in large number by the fishermen using dragnet, locally called *Chhatajal*. The fishes on their spawning migration are usually chased by dolphins and sometimes by sharks and other predators and driven towards the shore. The fishermen at that time swiftly cast their net in the ankle deep water and catch them. The spawners are selected and transported to camp laboratory by a jeep, in a plastic pool with sea water. Placed at the back of the jeep spawners are examined, and released in hapa fixed in plastic tank (50 ton) filled with sea water near the shore, at Puri. Water was pumped in from the sea (filtered) to fill plastic tank.

Doses :

Effective doses varied from 2 glands (donor - one male and one female *M. cephalus* to 8 numbers of glands per spawner inducing ovulation in *M. cephalus*. The time taken for the injected female to become ready for ovulation usually varied from $4^1/_2$ to 12 hrs after the last injection at a temperature 16 °C to 27.5 °C. Due to pituitary injection abdomen of the recipient spawners get distended considerably and dilation of the genital opening occurs remarkably. They do not spawn in the hapa naturally, but they are to strip to get the eggs. As they are ready to ovulate, very little pressure is required to get the eggs. Injected males are ready to ooze milt which are used for fertilization. Percentage of fertilization in general was poor. It varied from 5 to 50 %. Like Indian major carp, method of two injections was followed. Embryonic and larval development was studied.

In Taiwan and in Hawaii successful induced breeding of *M. cephalus* producing fry of the species is a regular practice for aquaculture.

Larval Rearing :

Fish Farming Cycle comprises fish seed production by hypophysation under controlled conditions or procurement from the natural sources; rearing of larvae to fry followed by productions of fingerlings, culminating in production of table size fish. Larval rearing is old as fish culture in India. Age old traditional practices of fry rearing developed by the farmers through experiences are being gradually replaced by the technology developed by the research institutes on scientific line.

The technique of three tier system 1) rearing of three days old spawn in nursery pond, 2) rearing of fry to fingerling 3) rearing of fingerling to adult or marketable size, evolved by the Central Inland Fisheries Research sub-station Cuttack, is practiced more or less throughout the country. The technique of rearing of larvae is essentially same for all species of carps. As such species-wise rearing of larvae is not shown.

The fish food organisms grow naturally in ponds, tanks, rivers and in other water bodies. These organisms grow due to interaction of sunlight, the prime source of energy, temperature, soluble minerals (nutrients) in the water and soil nutrients. Application of fertilizers in culture ponds play significantly to produce fish food organism, the food chain for production of fish mainly includes mineral nutrients, microscopic organisms of plant origin and microscopic organisms of animal origin and other macroscopic organism present in the water bodies. Consumption of these organisms by the fish leads to growth and production.

The principal constituents of fish food organism occur in the water bodies mainly come under the following groups:
1. Zoo Plankton 2. Insects 3. Misc. 4. Phyto-Plankton 5. Plant matter. detritus etc.

1. Zoo Plankton:

Rotifers : Rotifers are minute organism measuring 1.5 to 2.0 mm. They are free floating and short lived ranging from 2-3 weeks but can exist in prodigious quantity. Rotifers form a very important fish food for fry, fingerlings and for adult fish. These are mainly represented by Brachinous and Keratella which constitute important fish food in ponds, tanks and other water bodies.

Crustaceans : Among the crustaceans , copepods and cladocerans form the principal food items for plankton feeding fishes.

Copepods: These are small in size -rarely larger than 5 mm in length. Various developing stages (nauplii, eggs) and the adult copepods form the food of the fry, fingerlings and adult fishes. Cyclops diaptomus, are the prominent form, occurs in the culture ponds.

Cladocerans: These are mainly represented by three genera, Bosmina, Daphnia and Moina. Developing stages of Bosmina and Moina constitute major bulk of the food item for larvae, fry and fingerlings of carps and other cultivated fishes.
Periphytic plankton constitutes food for some bottom living fishes in the culture water bodies.

Other Crustaceans: Ostracods, Amphipods, Stomatopods also occur and form food items for the fishes and the higher Crustacians which are in abundance in the water bodies of which shrimps, small prawns constitute a source of nourishment especially for carnivorous fishes.

Insects: Insects occur in the pond in abundance. Larvae of insects are fed upon mainly by plankton feeding fishes and the adult insects are preferred by the carnivorous fishes cultured in ponds. Chironomids (diptera) and their larvae form one of the principal sources of food of fishes,except plankton feeding fishes, all other fishes feed Chironomids which form predominate source of their nourishment. Besides, Chironomids water beetles also occur in the ponds in good number. Normally these insects are not appreciated by the fishes. But the larvae and nymphs are eaten often by the fishes in early stage.

Miscellaneous (Animal Origin) : This item of fish food of animal origin consists of worms, gastropods, bivalve, polychaetes, protozocens and others.

Phytoplankton: This item of fish food organisms is represented by different types of algae, (unicellular, multi-cellular) diatom and decaying plant matter, detritus etc.

Algae: Among the algae Cyanophyceae and Chlorophyceae are dominant groups. Cyanophyceae is represented by Microcystis, Oscillatoria, Spirolina, Anabaena, Nostoc while the Chlorophyceae is represented mainly by Chlorella, Spirogyra, Oedogonium. Bacilloriophyceae (Diatom) consists mainly of Cosmorium, Synedra, Nitzchia, Navicula and Surirella which constitute food for fishes in low abundance.

Aquatic plant matters, detritus and mud are also found in gut contents of many bottom living fishes.

Source: **Central Fisheries Research Substation, Cuttack.**

Development of synthetic ovulating and spawning agents:

During last decades several ovulating agents (Synthetic, Mammalian, Chemical) were manufactured by different countries, through research and experiments.

Some of the synthetic hormones which are found to induce ovulation and spawning in various fish species are delineated in the following:

Ovaprim :

Ovaprim is one of the wonder drugs in the field of induced fish breeding with a great possibility. It is synthetically manufactured by M/S Syndel Laboratory, Canada. It is marketed in India by Agridate Farm Care, Glaxo, India.

Preliminary experiments conducted in the college of Fisheries, Mangalore, (1988), demonstrated positive results in carps. Subsequently this drug was used to induce spawning in Indian major carps and some minor carps and Chinese carps in nine states of the country. All the states reported successful spawning in all the species tried.

Ovaprim successfully used in other fish species also, such as *Ompok pabda*, *Anabas testudineus*, *Heteropneutes fossilis* and *Wallago attu*.

Doses :

The doses administered varied from 0.1 ml to 0.6 ml/kg depending on the state of gonadal maturity, species and the prevailing environment.

Advantages over pituitary hormone and other hormones.

- It is available in liquid form in phials ready to use.
- One injection of Ovaprim is sufficient to induce breeding in males and females.
- Injections are given to males and females at the same time.
- Ovaprim can be kept at room temperature without losing its potency.
- Dose is low in comparison with other hormones.
- Costly equipments are dispensed with, and technicality is avoided.

Ovaprim is comparatively costly and is yet to reach the farmers in the rural India, where pituitary hormone is mainly used to produce seed fish species. Some farmers culture *Cyprinus carpio* in separate ponds as a source of pituitary.

LHRH-analogue: (Luteinising Hormone Releasing Hormone):

LHRH-a is another drug which has a great potential in seed production of cultivated fishes. In India, Sundararaj and Goswami conducted fish breeding experiments in the recent past with this super active analogue (Hoe; Hoechst pharmaceutical Ltd., West Germany) to induce spawning in different fish species with success. This ovulating agent can be successfully used to precipitate spawning in Indian major carps and in Chinese carps.

In main land china, this drug is used to induce spawning in the indigenous Chinese carps to produce seed fishes. Often priming dose of Pimozide or Pituitary (2 mg/kg) is used along with LHRH-A.

Brackish water fish, *Lates calcarifer* was induced by injecting this hormone successfully to spawn (Doses- Female: @60-70micro milligram/kg, Males @ 30-35 micro milligram /kg)

WOVA-FH (Synthetic gonadotropin Releasing Hormone Analogue):

Product of Biotadt Agri. science Wockhard, Mumbai: - This synthetic gonadotrophic hormone is found to induce successful spawning in *Anabas testudineus*, with encouraging results.

Doses :Recommended doses for cat fishes 0.2 to 0.4 and for *A. testudineus* 0.2 to 0.6.

Ovatide:

Ovatide is an another synthetic hormone is found to induce ovulation and spawning with an encouraging result in *Pangasius pangasius*.

HCG (Human Chorionic Gonadotropin):

HCG is produced in the chorial tissue of the placenta and excreted with urine of a pregnant woman. The hormone excreted from the urine is like luteinizing hormone in action. So HCG is extracted and used as a ovulating and spawning agent in fish species in many countries.

HCG in combination with fish pituitary @ 4 mg of pituitary gland + 1 mg of HCG, was found to precipitate spawning in major carp (*L. rohita*) in about 40% experiments.

Synahorin:

Synahorin was obtained from Japan. It is mainly a preparation of HCG, which has been in use in Japan and Taiwan for production of seed-fishes of Chinese carps. The author conducted several experiments on *L. rohita* with synahorin during 1968-70, and the results were compared with that of crude HCG prepared in the laboratory. It was observed that the synahorin alone not able to induce any spawning in L. rohita. However, synahorin in combination with pituitary (25 Ru + 4mg. of PG) precipitated successfull spawning in L. rohita thus it was confirmed that HCG alone is ineffective in inducing spawning in *Labeo rohita*.

Sumarch (HCG):

Sumach in another crude preparation of HCG, manufactured by the Infar (India) Ltd. Calcutta. This preparation is gaining popularity in recent days among the farmers mainly in West Bengal. Reports on the efficacy of the preparation from various corners, from farmers and from the scientists, indicate that sumach is effective in inducing spawning in silver carp. However Sumach, in combination with pituitary, was found to precipitate successfull spawning in other cultivated carps also. Report also revealed that when sumach was injected alone to Indian major carps, the results were variable.

It has been reported that periodical injections of HCG augment gonadal development in cultivated carps. Author conducted experiment to enhance gonadal maturity in rohu and catla by injecting them weekly with HCG @ 0.5 mg. / kg. prepared in the laboratory. Final examination of the test fishes after 25 injections revealed that treated ones showed remarkable development of gonad (three fold) in comparison with that of control.

From the foregoing paragraphs the following conclusions may be drawn:-

1) HCG is effective in inducing spawning in Silver Carps. *M. cephalas*

2) HCG in combination with pituitary gland is also effective in precipitating spawning in Indian and Chinese carps.

3) HCG alone is not able to induce any spawning in Indian major carps.

4) Periodical injection of HCG enhanced gonadal maturity in cultivated carps.

Chomiphene Citrate (Chemical origin):

Chomiphene is tried to induce spawning in *Labeo rohita* at a different doses which yielded negative results. Pandey, N., Stacey and Hoar, S.S. (1973) induced ovulation in gold fish with this drug. Gold fish is a free spawning species in captive condition where as Indian

The table below shows the result of survey conducted in the villages

Nos. of Panchayats	Nos. of Farm Families	Total culturable water area (ha)	Actual area under culture (ha)	Avg. yield in Kg
4	178	69.92	14.3	294.1

major carp *L. rohita* is non free spawner in captive condition in ponds.

SG-G 100 Partially Purified Salmon Gonadotropin:

This salmon gonadotropin (SG-G-100) received from Canada through the International Development Research Centre (IDRC) and was tried by the author in various species in Indian major carps. The results indicated that this hormone is effective in inducing successful spawning in Indian carps at a minimum dose of 5 mg/kg for female.

Extension, Training in Aquaculture

FAO Global Consultation meet on Aquaculture Extension in 1989, in general agreement stated that extension 'is a central mechanism' in the rural livelihood development process through agriculture and allied food farming activities both in terms of technology transfer and human capital development.

Aqaculture is one of the most important food farming technologies which is developed through research and field practice and extended it throughout the country. But utility of this technology is proved its worth when it is transferred to the users, for adoption. Here, comes the role of extension.

Many organizations, ICAR institutions, Research institutions are engaged in extension service which appears to be inadequate for the country in general and rural sector in particular.

Extension and Training

With the increased developments of fish culture in the inland sector and the standardization of the technologies, the service of extension, is essential especially in the rural sector.

Establishment of Krishi Vigyan Kendra (KVK) and Trainers' Training Centre (TTC)
Considering all these developments and the potential of fish culture especially in the rural sectors, Indian Council of Agricultural Research established Krishi Vigyan Kendra (KVK) Trainers' Training Centre (TTC) at Kausalyaganga, Puri District, Orissa.

Krishi Vigyan Kendra

Objectives

The objectives of the Krishi Vigyan Kendra, are to impart training through work experiences and field practices in scientific fish culture, hence it is concerned with the technical literacy, the acquisition of which does not require the ability to read and write. The ultimate objective is the economic upliftment of the poor village farmers and the weaker section of the society through fish culture, knowhow of the technologies, to the farming community, is to be disseminated.

Implementation of the programme of extension and training

Demonstrations, meetings, extension methods, seminars and discussions were held with the participation of the village farmers and other villagers, panchayat leaders, block development officers. The farmers were persuaded and motivated to adopt technologies which are remunerative.

Survey and selection

Survey in the villages for selection of farmers, farming families and the water bodies suitable for fish culture carried out. It was observed that the villagers were endowed with large number of freshwater ponds. The smaller ponds were owned by the marginal farmers and the large ones by the gram panchayats.

Direct Transfer of Aquaculture Technology to the Adopted Farmers (Bhowmick et al; 1980)

Out of the villages surveyed Nakhur Patna (I) Nakhur Patna (II) Nakhur Patna and Gobardhan Pur-I, Gobardhan Pur-II, Ekohalia, Suabarei and Pratapsasan and the ponds owned by them for transfer of various technologies, were selected at the first instance. The farmers carried out culture operations with the practical guidance of the staff of the KVK centre in their own pond.

Nakhur Patna I: Pond having water area of 0.5 - 0.7 ha is mainly used for domestic purposes. Technologies of rearing of brood fishes of carps and breeding of common carps were transferred to the farming family by actual operation of the technologies in their pond with the guidance of the centre.

The culture continued for 10 months when the fishes attained the gonadal maturity, they were harvested and sold to the market. The sale proceeds were handed over to the farmers.

Breeding of Common carp

The farmers with the guidance of the staff members of the KVK Centre, carried out breeding operation of common carp. Common carp breeds naturally in the ponds but percentage of survival is poor, in ponds. To obtain higher survival, controlled breeding technique was undertaken. No pituitary hormone injection was needed to induce them to spawn.

Harvest of brood fishes and the spawn of common carps produced were sold in the market making a profit of Rs. 12,859/ - by the farmers for the first time (1979 - 1980).

Technology of nursery pond management

Nakhur Patna II: Pond area measures 0.08 ha owned by the farming family. The pond was not used for fish culture before. Technology of nursery pond management was carried out by actual operation of the technique in the farmer's pond.

Harvesting: Fry were harvested after2 weeks of rearing in the nursery pond, when they attain a growth of 25 - 30 mm. (about 1"). Survival rate usually 60 - 70% under scientific methods. In this case the fry harvested were sold in the market making a profit of Rs. 2, 723/- by the farmers.

Nakhur Patna III: The pond size measures 0.75 ha. The technology of composite fish culture of various species f carps was carried out in this pond owned by the farmers.

Harvesting: They were harvested by the farmers and marketed. The sale proceeds were handed over to the farming families as their income. Income of Rs. 3,368/- was made from this culture operation during nine months of rearing.

Nakhur Patna IV: Under the off campus training programme, a special training in aquaculture and in seed production by hypophysation were organized for 44 landless farmer families, adopted by the KVK centre. These landless farmers belong to the weaker section of the society. The pond size was abour 1.0 ha in water area, and was more suitable for composite fish culture. The farmers harvested 2,526 kg of fish from the pond, bringing the rate of production of 3,368 g/ha/yr. The total income made through the sale of the harvest was Rs. 25,266 in nine months from the pond which was remained unused.

Gobardhanpur - I: The size of the pond was 0.04 ha in the area. The technique of rearing of fry to fingerling (100 - 150 mm) was carried out in the pond by actual operation by the farmers under the guidance of the centre (KVK).

The pond was stocked at densities varying 60,000 to 3,00,000 fry/ha. But normally 60,000 to 1,00,000 fry are stocked in the farmer's ponds.

Rearing continued for three months when the fry attained a size of 100 -150 mm. Survival rate varied from 50 - 70% depending on the nature of management. At this stage the fingerlings were harvested. The harvest was sold and made a profit of Rs. 20,500/- by the farmers.

Gobardhanpur - II: The size of the pond measured 0.04 ha. Composite fish culture of six species of carps as stated earlier was carried out by actual operation of the technology of composite fish culture. The farmers harvested the marketable fishes and sold making an income of Rs. 20,000/- in 12 months period.

Ekohalia: Farmer's pond measured 0.2 ha in water area. Composite fish culture of six carp species was adopted by actual operation of the technology of composite fish culture. The culture continued for 12 months. The harvest was sold and made a profit of Rs. 17,390/- in 12 months by the farmers. The farmers are now confident to repeat the culture operation by themselves in their ponds.

Suabarei: The pond owned by the farmers, measured 0.012 ha in water area. The technology of fry to fingerling rearing was carried out by actual operation of the technique in the pond. Rearing of fry continued for 3 months when the fry attained the size of 100 - 150 mm, fingerlings were harvested by the farmers for marketing. In this case, profit of Rs. 5,655/- was made by the farmers. The field practice would help them to repeat the culture operation by themselves.

Pratapsasan:

The pond measured 0.1 ha in water area. Technology of composite fish culture of six species was carried out by actual operation of the technique. The culture continued for 10 months when the fishes attained marketable size, they were harvested by the farmers and sold, making a profit of Rs. 24,000/- in ten months. The farmers are now confident to repeat the culture operation themselves.

Seed Production by Hypophysation of Indian carps and Chinese carps during 1979 -1980

Spawn production

About 48.0 lakhs of spawn of Chinese carps and Indian carps were produced by hypophysation with the active participation of the farmers during 1979 -1980.under the guidance of the staff of the KVK centre. The spawn produced was handed over to the farmers.

Training imparted to the farmers and trainers and extension officers on myriad aspects of Aquaculture Number of farmers trained

During 1977 - 1081, KVK centre trained 292 fish farmers in different aspects of fresh water aquaculture. Now the farmers themselves adopted the technologies and continuing culture of fishes in their ponds as their gainful occupation, located in the respective villages.

The programme of transfer of technologies of aquaculture is continued in other villages by the KVK centre. The various technologies of aquaculture were transferred to hundreds of grassroot level poor farmers in the interior villages, extending aquaculture in rural sector, which will go long way in fulfilling the mandate of the KVK centre and enhancing fish production.

Training imparted to trainers and extension officers

The table below shows number of trainers and extension officers in Orissa, Department of Fisheries and Private Agencies.

Important Points of Benefits Emerging from the Foregoing Studies

From the foregoing aquaculture activities performed in the rural sector involving participating poor farmers, the following points of importance emerged:

1)Transfer of Technologies of aquaculture: The poor farming community leads their livelihood below subsistence level, depending so long on the agriculture. To achieve this objective, farmers were adopted, trained and motivated through massive extension methods to adopt scientific aquaculture as their occupation. At the beginning the farmers were hesitant to hand-over their ponds to the Govt. organization, but ultimately they understood that the modern aquaculture is a lucrative enterprise and adopted the technologies of aquaculture in their ponds. The response gradually increased after observing the neighbours making profit from aquaculture. The

Duration of	Nos. of Trainees			Sponsoring
Training	Male	Female	Total	Authority
6 months	9	Nil	9	Dept. of Fisheries, Govt. of Orissa
6 months	6	Nil	6	Dept. of Fisheries, Govt. of Orissa
3 months	7	Nil	7	Dept. of Fisheries, Govt. of Orissa
6 months	25	2	27	Dept. of Fisheries, Govt. of Orissa
5 months	27	2	29	Dept. of Fisheries, Govt. of Orissa
10 months	18	1	19	Dept. of Fisheries, Govt. of Orissa
3 months	1	Nil	1	Principal of College, Ganjam
20 days	3	Nil	3	Lutheran World Service
10 months	18	2	20	Dept. of Fisheries, Govt. of Orissa
20 days	8	Nil	8	Lutheran World Service

technologies were transferred and knowhow disseminated to the clientele.

2) Manpower Development: The practical field practices and participation of the farmers in the actual culture of fishes in their ponds enabled them to pursue the aquaculture enterprise for long term benefit and sustainability opening employment opportunity in the rural sector.
3) Production level: Direct involvement of the farmers in aquaculture activities following scientific and proven technology of seed production and composite fish culture, enabled to increase level of production in their ponds, having hitherto low production.
4) Improvement of quality of life: The scientific aquaculture adopted by the farmers, yielding increased production and generating higher income and profit having long term economical benefits, enabled to improve their quality of livelihood.
5)The training imparted to the farmers and to the trainers, extension officers, state fisheries officers of private agencies helped to increase the fish production. Work was carried out by following the scientific technologies developed by the Pond Culture Research Substation of the Central Inland Fisheries Institute, Barrackpore, ICAR.

Advances of Aquaculture in Inland Sector:

1.Pre-monsoon maturation and spawning of major carps: The major carps (catla, rohu, mrigal) have a specific habit of spawning during monsoon (June to September) naturally in the riverine habitat once in a year, when the rivers are in flooded condition. In captivity, in ponds and tanks major carps are induced to spawn by hormone treatment during monsoon months only. A technique has been developed to induce maturation and spawning of major carps during pre-monsoon months in April/May by hypophysation.

In China (Shanghai) Chinese carps are induced to spawn 2-3 months ahead of spawning season.

2. Multiple spawning of major carps: Available literatures on spawning of major carps, contain no record of spawning more than once in the same spawning season. A technology has been developed by applied research on hypophysation to induce spawning in major carps (rohu, catla, mrigal) twice in the same season during 1970-71, thus doubling production of spawn for the first time in the Indian sub-continent.

Following this success, the tehnology of multiple spawning has been further developed achieving success of spawning of catla for four times in the same season obtaining four crops of spawn, by hypophysation, during pre-monsoon and monsoon months. This outstanding achievement of multiple spawning not only contributes increasing fish seed production but also saves use of brood fishes.

3. Manufacture of Synthetic hormone: Research in the field of induced breeding resulted in manufacture of number of effective ovulating agents synthetically prepared. Ovulating agents are ovaprim, Wova-FH, LH-RHa, ovatide, HCG and Salmon gonadotropin partially purified. Out of all these ovulating agents, ovaprim is found to be more effective in many cultivated fishes with added advantages over pituitary hormone.

4. Application of induced breeding technology on new cultivable species: A number of new fish species of fresh water and of brackish water origin, have been successfully induced bred by pituitary and by synthetic hormones producing seed fishes for aquaculture.

5. Establishment of Indoor Hatchery: Installation of indoor hatcheries with running water facilities and flow through hatcheries (sub-Himalayan Region) in the country would go long way in enhancing production of seed fishes of cultivated fishes for expanding aquaculture in the country.
6. Construction of new commercial fish farms: Construction of new commercial fish farms by the business houses turning aquaculture as an industry.
7. Cage Culture: Cage culture has been introduced in many states in India for culture of important fish species; even it has extended to the coal-field to utilize the pits with accumulated water (Ranchi, Bihar). *P. pangasius* is cultured in the cages to adult size and marketed to Punjab, Haryana and to the hotels as fillets. P. pangasius enjoys consumers' preference because it has less of spine. Red tilapia also are cultured in cages, besides other fishes thus contributing in the aquaculture production.
8. Pen Culture: Pen may be fitted in different types of still water bodies, such as, reservoir, big impoundment, in ponds, tanks, wet land (beel, tal, boar, maun) derelict

water bodies and lakes for rearing, seed fishes and often used for raising table fishes in the absence of adequate pond space.

9. Ranching: Ranching of fingerlings in the depleated water bodies plays very important role in reviving and rehabilitating the threatened species. Induced breeding and artificial fecundation to produce fingerlings mainly of threatened species play a significant role in this respect.

10. Pens are successfully used for raising seed fishes and table fishes almost in all states in general and particularly in Assam, Bihar, West Bengal. In Sri Lanka under intensive rearing system seed fishes of Chinese carps and Indian major carps raised in millions in pens, in the absence of adequate pond space. PVC pools (50 ton) were also used and millions of seed fishes were raised from 6 pools. Fish food organism required for rearing of seed fishes were cultured in separate pool (50 ton) fixed nearby.

Acknowledgement

I express my appreciation to the Director, ICAR-CIFRI, Barrackpore, for inviting me to this write up on hypophysation (induced breeding) and aquaculture particularly in Indian context on which I have dedicated my whole working life. I also appreciate Dr. B. P. Mohanty's earnest interest in publishing it. Appreciations are also due tomy son, Dr. Sanjay Bhowmick, PhD and son-in-law Dr. Mrinal K. Ghosh, PhD, for their efforts in helping me with the draft preparation.

References

Alikunhi KH, Sukumaran KK Parameswaran, Banerjee SC(1964) Preliminary observations on commercial breeding of Indian carps under controlled temperature in Cuttack laboratory. Central Inland FisheriesResearch Institute, Barrackpore, West Bengal, Bullettin No. 3

Alikunhi KH, Sebastian KJ, Sukumaran KK, Nair V, Vincent TJ (1971) Induced spawning of grey mullet (Mugil macrolepis) and observations on rearing hatchlings to fingerlings stage. Workshop on Induced breeding of carps, Central Institute of Fisheries Education, Bombay.Working paper, 33: P.2

Alikunhi KH, Sukumaran KK, Parameswaran S, 1963 a Induced spawning of the Chinese carps, *Ctenopharyngodon idella* (Cd) and *Hypophthalmichthys molitrix* (Cd) in the ponds at Cuttack, India. *Curr. Sci.* 32: 103 - 126

Ayyappan S (1997) Brochure on aquaculture production. Central Institute of Freshwater Aquaculture, Kausalyaganga, Bhubaneswar, Orissa

Ayyappan S (2000) Potentials for development of fresh water Aquaculture in India. In Souvenir, Fifth Indian Fisheries Forum. 81-85

Bhattacharya SK (2003) Effects of pimozide and LH. RH analogue on induction of ovulation in some teleosts. *J.Inland Fish.Soc.India*, 38(1): 94-97

Bhowmick RM, Sen PR, Bagchi MM (1968) Observation on induced spawning of Indian major carps under certain environmental conditions of Gujartal Farm, Uttar Pradesh, India. *Sym. Comp. Endocrinol, Benaras University*

Bhowmick RM, SK Mukhapadhyaya (1968) Experiments on Inducing early maturity in carps by frequent injections of Human Chorionic Gonadotropin (M.S.)

Bhowmick RM (1969) Rearing of breeders , sexing and segregation of cultivated fishes. FAO/UNDP. Seminar (India). FRI/IBCF/19

Bhowmick RM (1971) Working paper on Induced breeding of carps- "Workshop" on Induced Breeding of carps. Central Institute of Fisheries Education, Bombay, India

Bhowmick RM, Bagchi MM (1971) A note on the preservation of sperms of carps. *J. Inland Fish Soc*. India III: 119-120

Bhowmick RM, GV Kotwal (1973) Simplified technique of induced breeding of major carp. *J. Inland Fish. Soc.* India. V:PP 218-22

Bhowmick RM (1976) Glass jar hatchery for carps- *Indian J.Fish.* (Cochin), India.

Bhowmick RM (1976) Technique of induced breeding of Indian and exotic carps, hatching techniques and operational cost involved. In Bulletin "Fish Farmers' Development Agency Official Training in Composite Fish Culture and Fish Seed Production," ICAR, CIFRI, Barrackpore

Bhowmick RM, Kowtal GV, Jana RK, Gupta SD (1976) Large scale production of seed of *Catla catla* (Ham.) the quickest growing Indian major carp, by hypophysation. *J.Inland Fish Soc. India*. X: 52 -55

Bhowmick RM, Mukhapadhyaya SK (1976) On the viability of germ cells of major carps *Labeo rohita*. *Indian anim. Sci.* 47 (5): 289-291

Bhowmick RM (1977) "Lecture on the Fish Breeding in India", *University of Auburn*, Alabama, U.S.A.

Bhowmick RM, Kowtal GV, Jana RK, Gupta SD (1977) Experiments on second spawning of Indian major carps, in the same season by hypophysation. *Aquaculture* 12: 149-155

Bhowmick RM (1978) The use of 'Synohorin' to induce spawning in major carps - *Labeo rohita* (Hamilton). Proc. 66th. *Science Congress*, Hyderabad

Bhowmick RM (1979) Observations on the use of Human Chorionic Gonadotropin, prepared in the laboratory, in inducing spawning in major carps-*Labeo rohita* (Hamilton). Tech paper 16 presented at the symposium on '*Inland Aquaculture*, Barrackpore, CIFRI, ICAR

Bhowmick RM, Kowtal GV, Jana RK, Gupta SD (1979) Observations on the use of various hormones and clomiphene citrate in hypophysation of Indian major carps. Tech. Paper 14 presented at the *symposium on Inland Aquaculture*, Barrackpore, India

Bhowmick RM, SK Sarkar (1980) Experiments on the second maturity and spawning of the *Cirrhinus mrigala* (Ham.), in the same season by hypophysation. (MS)

Bhowmick RM (1980) A review of induced fin fish breeding in India. Workshop on induced Fin Fish Breeding , *Proc. International Development Research Centre, Canada and Ministry of National Development, Singapore*. (Page 1- 70)

Bhowmick RM, Rao KM, Sarkar SK, Dutta BR, Kumar K Radheyshyam (1980) Induced spawning of Chinese carps, *Ctenophryngodan idella* (C & V), H. molitrix (C & V) under certain environmental conditions at Kaushalyagang Farm, Orissa. (M.S.)

Bhowmick RM et al. (1980) Direct transfer of Aquaculture technologies, to the grassroot level farmars of the rural sector of the Puri dispur, Odisha (unpublished)

Bhow.mick RM (1982) Technique of hypophysation of Indian carps (in Sri Lanka). *J. Inland fish.*Vol - I : 47-53 printed in Sri Lanka

Bhowmick RM (1985) Terminal report on "Aquaculture Development and Training" in Sri Lanka. Project, 45 pages *(FAO/UNDP) SRL/79/ 023*. Draft report submitted to FAO

Bhowmick RM, KSB Tenakoon, LKSW Balasuriya (1986) Induced breeding experiments on major Indian carps, transplanted in Sri Lanka. *Seminar, Barrackpore,* CIFRI

Bhowmick RM, Kowtal GV, Ghosh SR, Jana RK, Gupta SD (1986) Observations on the acceptability of artificial feed by the Fry of Mugil cephalus (L). *Proc. Sym. Coastal Aquaculture,* 4 : 236-240

Bykov KM (1953) Text Book of Physiology (translated from *Russian*) Central Inland Capture Fisheries Research Institute, Barrackpore (ICAR). *1990 Research Highlights* Chaudhuri H, Alikunhi KH (1957) Observation on the spawning in Indian carps by hormone injection. *Curr. Sci*., 26(12) 381-382

Chaudhuri H (1960) Experiments on Induced spawning of Indian carps with pituitary Injections. *Indian Journal of Fisheries,* Vol.VII, No.1 (Page 20 -48)

Chaudhuri H (1963) Induced spawning of Indian carps. *Proc. Net. Inst. Sci.* India(b): 29(4): 478-87

Chaudhuri H (1968) Breeding and Selection of cultivated warm water fishes in Aisa and The Far-east, A. review *FAO Fish. Rep.* (44), 4: 30-66

Chaudhuri H, Bhowmick RM, Pal RN (1960) Observations on induced breeding of Indian major carps during 1960 at Cuttack. (Abstract). *Proc. 49th.Science Congress,* Calcutta, 1962

Chaudhuri H, Bhowmick RM, Kowtal GV, Jana RK, Gupta SD(1977) Efficacy of partially purified salmon gonadotrophic hormone (SG- G-100) in inducing spawning in Indian major carps. *J. Inland Fish Soc.,* India. IX: (162-164)

Chaudhuri H, Bhowmick RM, Kowtal GV, M M Bagchi, Jana RK, Gupta SD (1977) Experiments in Artificial propagation and larval Development of Mugil cephalus (L) in India. *J. Inland Fish. Soc.* Vol IX(Page 30-41)

Criag-Bennett A (1931) The reproductive cycle of the three-spined stickleback, Gasterosteus aculeatu's Linn. Phil. *Trans Roy. Soc. London,* Ser. B., 219: 197-279

Crim LW, Peter RE, Billard R (1976) Stimulation of gonadotropin secretion by intraventricular injection of hypothalamic extracts in the goldfish, Carassius auratus. *Gen. Comp. Endocrinol.,* (US), 30: 77-82

Director of Instruction (Fisheries) College of Fisheries, Mangalore. 1990. Ovaprim - A new Wonder drug for Successful fish breeding. *Fishing Chime* - S, 10(2)93

Donaldson EM (1973) Reproductive Endocrinology of fishes. *Amer. Zool*., 13: 909 - 927

Fujita T, Uno K, Yatsunagi K, Kobuta Z (1946) On the artificial taking of eggs of loach by injection of Pituitary Hormone. *Contr. Cent.Fish Stn. Jap.*, 44: 254-258

George John (2000) Expectations from R and D in Aquaculture. In. *Souvenir of the Fifth Indian Fisheries Forum*, P. 86-89

Gerbil'skii NL (1938) Expedition for the study of the Physiology of Spawning. *Rybonoe khoziaistvo* 18(10), 33-36

Gerbil'skii NL (1940) Seasonal changes of the gonadotropic potency of the Pituitary gland of the fishes. *C.R. Acad.Sci. Moscow* 28 PP 675-678

Ghosh KK (1976) Statistical projection of fresh water carp - seed demand and possible supply from riverine sources. In recent advances and prospects of different technologies of major carps seed production in India. (Group discussion) *Pune, India*.11p

Ghosh SD, Bhowmick RM (2007) Production of stocking material of climbing perch, *Anabas testudineus* (Bloch) by induced breeding in captivity, in sewage fed water, for conservation and aquaculture. *Abstract.* Submitted to *Inland Fisheries Society, Journal,* India

Gopakumar K (2000) Indian Fisheries, An overview - In: *Souvenir of the Fifth Indian Fisheries Forum*. P. 1 - 6

Goswami MM, Hazarika R, Saud BJ (2007) Induced spawning, Embryonic and Larval Development of Pangasius pangasius (Hamilton and Buchanan). *J Inland Fish. Soc.* India, 39 (2): 1 -9

Govt. of India (1966) Report of the Fish Seed Committee, *Ministry of Food and Agriculture,* New Delhi, p. 211

Gupta SD, Rath SC, Dasgupta S, Tripathi SD (1995) A first report on quadruped spawning of Catla catla (Ham). *Vet.archiv* 65, :143 - 148

Harrington JW (1959) Photoperiodism in fishes in relation to the annual sexual cycle in R.B. Withdraw (Editor). Photoperiodism and related phenomena in Plants and Animals. *Asso. Advancement of Science,* O.C. Washington P 651-667

Harvey BJ, Hoar S (1979) The Theory and Practice of Induced *Breeding in Fish. Ottawa, Ont, IDRC,* Canada. 48 p ill

Hasler AD, Meyer RK, Field HM (1939) Spawning induced prematurely in trout with the aid of pituitary glands of the carp. *Endocrinology* 25 (6) 978-981

Hora SL (1945) Symposium on the factors influencing the spawning of carps : Analysis of factors influencing the spawning of carps: *Proc. Nat. Inst. Sci. Ind.* 11 (3): 303-12

Houssay BA (1931) Action sexuelle de I' hypophyse Sur les poissons etles reptiles. *CR. Soc. Biol., Paris,*106, 377-378

Ihering M, Azevedo P de (1934) A curimata acudes nordestnos (Prochilodus argenteus) *Arch.Inst. Biol., S. Paulo,* 5, 143-84

Jhingran VG (1958) Observations on the seaward migration of *Mugil cephalus* (L) from the lake Chilka for breeding. *Curr. Sci.* 27: 181- 82

Jhingran VG (1976) Fish and Fisheries of India. *Hindusthan Publishing Corporation* (India), Delhi 954 pp

Jhingran VG, Pullin RSV (1985) A Hatchery Manual for the common carp, Chinese and Indian major carps - published by *Asian Development Bank*, Manila Philippines

Jun Wang Xi (1982) General Situation in Pond Fish Culture in China -Lecture in *a seminar on Pond/Tank Fish Culture,* sponsored by FAO/UNDP Project and Ministry of Fisheries, *Sri Lanka,* Udawalawe

Khan H (1938) Ovulation in fish (Effect of administrating of anterior lobe of mammalian pituitary gland) *Curr. Sci.,* 7 (5), 233-34

Kuo Ching-Ming, Shehadeh ZH, Nash Colin E (1973) Induced spawning of captive Grey Mullet (Mugil cephalus L). Female by injection of Human chorionic Gonadotropin (H.C.G.) Aquaculture, 1: 429-432

Kau Ching-Ming, Nash CE, Shehadeh ZH (1974a) The efforts of temperature and photo period on ovarian development in captive grey mullet (Mugil cephalus L) *Aquaculture,* 3: 25-43

Lakshmanan MAV (1976) Nursery and rearing pond management techniques. In the Farmers' Development Agency Officials', *Training in Composite Fish Culture and Fish Seed Production, CIFRI, Barrackpore* (ICAR)

Malhotra JC, Mehorta SM (1979) Observation on artificial propagation of *Hilsa ilisha* (Hamilton) of river Narmada and its culture in confined water. Tech paper -17. Preented at the *symposium in Inland Aquaculture*, Barrackpore, West Bengal , India

Moitra SK, Sarkar SK (1976) The morpho-histology of pituitary glands in two fresh water major carps of India, *Labeo rohita* (Ham.) and *Cirrhinus mrigala* (Ham). *Anat. Anz. Bd.* 130, S. 421-441

Pandey S, Hoar WS (1972) Induction of ovulation in goldfish by clomiphene citrate. *Can.J. Zool.* (Canada), 50, 1679-1680

Pickford GE, Atz JW (1957) The Physiology of the pituitary gland of fishes. *New York Zoological Society,* New York

Pillay TVR, Dill A (eds). (1979) Advances in Aquaculture. *Fishing News Book Ltd. Farmham, Surrey,* England

Qasim SZ, Qayyum (1962) Spawning frequency and breeding seasons of some fresh water fishes with special reference to those occurring in the plains of Northern India. *Indian J.Fish.* 8: 24-43

Radheyshyam, Sarangi N (2005) Breeding and egg incubation of *Notopterus chitala* (Hamilton) in captivity. *J. Inland Fish. Soc.* India 37(2): 8-14

Ramachandran V (1969) Weed Control is a must in *Fish Culture. Indian Farming* Vol. XIX(9) Page 5-77

Ramaswamy LS, Sundararaj BJ (1956) Inducing spawning in the Indian cat fish. *Science,* 123(326), 1080

Ramaswamy, LS Sundararaj (1957) Inducing spawning in the Indian cat fish. *Heteropneustes* with mammalian chorionic gonadotropin *Acta. Anat*., 32, 1222-24

Saha GN (1976) Fertilization of fish ponds; In the Farmer's composite culture and fish seed production; Development Agency *Officials Training; Central Inland Fisheries Research Institute,* Barrackpore (ICAR)

Sen PR (1972) Cytological studies of the pituitary gland of female *Labeo rohita* (Hamilton), during different stages of maturity. *J. Inland Fish. Soc.* India Vol - IV, 20-25

Sinha VRP (1979) Present status of composite fish culture in India. (ICAR) *CIFRI Souvenir.* Pp.43-48

Sukumaran KK (1969) Growth, Maturation and Fecundity Cultivated fishes *FAO/UNDP Regional Seminar* 'On *Induced Breeding of Cultivated Fishes. FRI/IBCF/5*

Sundararaj BI, Vasal S (1973) Photoperiodic regulation of Reproduction Cycle in the catfish *Heteropneustes fossilis* fossilis (Bloch) in R.O. Snow (Editor) *Endocrinology, Proc. Fourth Int. Cong. Ser.* 273. Excerpta Medica Amsterdam pp. 180-184

Swingle HS (1956) Arepressing factor controlling reproduction in fishes. *Proc. Pacif. Sci. Congr.* 3: 865-871

Verghese PU (1968) Preliminary experiments on the modification of the reproductive cycle of an Indian carp, *Cirrhinus reba* (Ham), by control light and temperature. *Proc. Indo-Pacific. Fish. Coun.*, 13: 171-184

Wood H (1930) Scottish herring shoals prespawnmg and spawning movements, *Scotland Fish Bd.Sci. Invest,* 1: 1-71

Woynarovich E (1969) Technique of hypophysation of induced breeding of cultivated fishes Calcutta, Cuttack, Bombay *FAO/UNDP*

JIFSI 2018 50 (2): 33-38 **RESEARCH PAPER**

Black Soldier Fly (*Hermetia illucens*) pre-pupae meal as a fish meal replacement in diet for amur carp (*Cyprinus carpio*)

Preetha Panikkar · Amala, U · Jesna P.K · M. Feroz Khan · B. K Das · Chandish. R. Ballal · M.A. Hassan ·

Received: 29 October 2018 / Accepted: 15 December 2018

Abstract A feeding trial was conducted to evaluate the potential of complete and partial replacement of fish meal (FM) with Black Soldier Fly (*Hermetia illucens*) pre-pupae meal (BSFM) incorporated feed for Amur carp (*Cyprinus carpio*). Four different types of feed prepared with 0, 30, 70 and 100 % replacement of fish meal with sun dried BSF pre-pupae were provided. The fishes were fed the diets twice per day at a daily feeding rate of 10 % of biomass over a period of 90 days. Percentage weight gain, specific growth rate (SGR), survival, feed conversion ratio (FCR) and feed efficiency ratio (FER) were estimated to analyse the growth performance of the experimental animal. There were no significant differences (P≤0.05) in growth performance among fishes fed different diets with up to 70% fish meal replacement. However, fish fed diet with 100% replacement of fish meal had significantly lower growth with significantly lowest (P≤0.05) average final weight (8.750[a]± 0.127), mean weight gain (6.560[a]±0.140), percentage weight gain (299[a]± 5.66) and specific growth rate (1.540[a]±0.018). Lowest FCR (2.18[a]±0.08) was recorded in fishes fed diet with 0% fish meal replacement which was statistically different (P≤0.05) from the treatment with 70% fish meal replacement. The results of the study indicate that up to 70% fish meal can be replaced with BSFM without affecting growth and survival of Amur carp fingerlings.

P. Panikkar (✉) Amala U · P.K. Jesna · M Feroz Khan · B.K Das · Chandish. R. Ballal · Hassan M.A ·
Regional Centre of ICAR-Central Inland Fisheries Research Institute, Bangalore,
ICAR-National Bureau of Agricultural Insect Resources,Bangalore
2ICAR-Central Inland Fisheries Research Institute, Barrackpore
e-mail: preetha23@gmail.com

Keywords *Cyprinus carpio*, Black Soldier Fly, *Hermetia illucens*, Growth, Amur carp

Introduction

Freshwater fish culture is done using supplementary high protein feeds, and intensive aquaculture production of carnivorous fish species need high quality fish meal. However, increased demand for aquaculture feeds has led to rapid price increases for these commodities (FAO, 2016). Of the world's total fish production 76% was used for fishmeal and fish oil in 2014, the rest being made use for purposes including as raw material for direct feeding in aquaculture (FAO, 2016). Fish meal is made from whole pelagic fish and is generally sold as a powder used mostly in food for poultry, pigs and farmed fish (Windsor, 2001). Hence, fish meal based supplemental feeding practices in aquaculture is a threat to the conservation of wild fish population. To overcome these impediments, considerable research is being undertaken to reduce the dependency of aquafeed manufacturers on fishmeal and fish oil (Glencross et al., 2007). The major challenge for aquaculture is to find an alternate sustainable supply of protein source from terrestrial animal and plant feedstuffs for aquafeed production (Naylor et al., 2000; Tacon et al., 2011).

Insects represent a noteworthy food and feed source rich in high quality protein as well as other beneficial nutrients. With the ever increasing demand and price of fishmeal as an ingredient in aquaculture feed, alternate protein sources for complete or partial replacement of fishmeal using insects could be a viable option. Different insects have been tested as animal protein source in food or as feed ingredient for aquaculture like Mealworm (*Tenebrio molitor*) (Gasco et al., 2014), Silkworm pupae (Hong et al., 2015, Kurbanov et al., 2015), Black soldier fly (*Hermetia illucens*) (Stamer et al., 2014), House fly (*Musca domestica*) (St-Hilaire et al., 2007) earthworm and maggot meal (Djissou et al., 2016). Larvae and prepupae of Black Soldier Fly (BSF) has been included in diets for evaluating the feasibility as a feed ingredient in various fishes like *Oncorhynchus mykiss* (Sealey et al., 2011, Stamer et al., 2014, Renna et al., 2017), *Psetta maxima* (Kroeckel et al., 2012), *Tachysurus fulvidraco* (Zhang et al., 2014) and *Salmo salar* (Lock et al., 2015).

Larvae has been identified as one of the most potential components as fish feed. The rearing of BSF offers the additional benefit of organic wastes utilization (Diener et al., 2009) and provides a potential solution for safe manure management (Yu and Chen, 2009). The BSF larvae are nutritionally very rich. It is reported that the BSF larvae on dry-matter basis contain 40-45% protein, 30-35% fat, 11-15% ash, 4.8-5.1% calcium, and 0.6% phosphorous, as well as a range of amino acids and minerals (Yu and Chen, 2009). Several authors have successfully fed BSF larvae to different fish like rainbow trout, catfish and tilapia (St-Hilaire et al., 2007, Bondari and Sheppard, 1987 and Yu and Chen, 2009).The BSF larvae can be reared easily on a wide range of substratum like chicken/pig/cattle manure, kitchen waste, fruit and vegetable waste etc. Interestingly the composition of the substratum will change the body composition of fly prepupae. BSF does not act as a vector of disease and since it doesn't have active mouth parts that may not be coming to contact with human (Sheppard, 1983). Moreover ecofriendly and sustainable culture of this insect is also possible (Shakil Rana et al., 2015).

To further characterizing the feasibility of BSF larvae as an ingredient in fish feed, feeding trials were carried out to evaluate the feed efficiency and the growth performance of Amur carp (*Cyprinus carpio*) fed on three different diets of BSF pre-pupae with a control excluding BSF pre-pupae. The Amur carp has been chosen for this study because the fish is hardy, seeds are easily available,easy to rear, readily accept pellet feed locally available and is suitable for enclosure culture.

Table1 The name of the ingredients and their amount in percentage used in theformulated feed

Ingredients	Feed 1	Feed 2	Feed 3	Feed 4
Fish Meal	0	10.5%	4.5%	15%
BSF meal	15%	4.5%	10.5%	0
GNOC	41%	42%	47.5%	40%
Rice Bran	44%	43%	37.5%	45%
Maida	5 % of diet	5 % of diet	5 % of total	5 % of diet
Veg Oil	3 % of diet	3 % of diet	3 % of diet	3 % of diet
Vit Min Premix	0.1 % of diet	0.1 % of diet	0.1 % of diet	0.1 % of diet

Materials and methods

Production of Black Soldier fly prepupae

The rearing of black soldier fly, *Hermetia illucens* was done in the experimental farm of ICAR - National Bureau of Agricultural Insect Resources (NBAIR) Yelahanka campus (77°34'E; 13°54'N). A mixture of different vegetable and fruit wastes were collected from the local markets for rearing the BSF prepupae. Five kilograms of vegetable and fruit wastes were taken in a rearing plastic rearing boxes and covered with black coloured muslin cloth to prevent breeding of unwanted flies in the rearing substrate. About hundred numbers of one day old BSF larvae were collected using a camel hair brush and inoculated over the rearing substrate. The substrate was monitored on daily basis for the feeding of the larvae till pupation.

After completion of the larval stage, the prepupae were manually harvested from each substrate. The harvested prepupae washed thoroughly to remove any debris and was killed by keeping in the refrigerator for a day. After one day, the prepupae were taken out and sun dried for a period of seven days. The dried prepupae were used for diet preparation.

Fish rearing with BSF pre-pupae incorporated diet

Amur carp fry were reared with different inclusion level of BSF prepupae meal incorporated diets. A control diet was prepared replacing BSF meal with fish meal. The experimental animals were procured from Fisheries Research and Information Centre (FRIC), University of Agricultural Sciences, Bangalore. Four different types of diets prepared with 0 (T4), 30 (T3), 70 (T2) and 100 %(T1) replacement of fish meal with sun dried BSF

Table 2 Proximate composition of BSF prepupae on dry matter basis

Feed	Moisture (%)	Crude protein (%)	Crude lipid (%)	Ash (%)	Carbohydrate (%)	Digestible energy (Kcal/ 100g)
BSF prepupae	12.93	32.53	22.1	21.56	23.81	424.26

pre-pupae. Pearson's technique was followed to prepare BSF based fish diet and fishmeal diet (Table 1).

Black soldier fly prepupae was dried and then ground to fine powder form before incorporating in the diet. The control diet was prepared with fish meal, rice bran, groundnut oilcake, and vitamin-mineral premix. Dry pellets were prepared by mixing the ingredients using an extruded pellet machine and sun dried. The proximate composition of formulated feed is shown in Table 1.

Fishes of average weight (2.18±0.05g) and length (4.12±0.04cm) were stocked at the rate of 150no./m^3 based on completely randomized design. Fishes were fed at the rate of 10% of body weight per day. The daily ration was divided into two equal halves and offered two times a day (08.30 and 16.00 hours). The feeding trial was conducted for a period of 90 days. Water exchange was carried out once in two weeks to ensure the water quality parameters to be in optimum range for fish growth.

Growth monitoring and water quality measurement

The fish sampling was carried out biweekly. Total length and weight of individual fish were recorded using a wooden scale and an electronic compact balance. The amount of feed was adjusted according to the fish biomass in each rearing tank.

Growth parameters such as percentage weight gain, specific growth rate, food conversion ratio, feed efficiency ratio and protein efficiency ratio were estimated by recording the weight of individual experimental animal. The animals were starved overnight prior to recording body weight. The growth performance indices were calculated using the following formula:

Weight gain (g) = mean initial body weight (g) - mean final body weight (g)

Specific growth rate (SGR) = 100 x (ln final body weight (g) - ln initial body weight (g))/days of trial

Food conversion ratio (FCR) = dry feed intake (g) /wet weight gain (g)

Feed efficiency ratio (FER) = wet weight gain (g)/ dry feed intake (g)

The water quality parameters such as temperature, dissolved oxygen and pH were measured weekly by using a hand held EZ-DO meter and pH checker.

Biochemical Analysis of BSF prepupae

Analysis of diet and fish was done to estimate the proximate composition following standard methods of AOAC (1995). Moisture, Crude Protein (CP), Ether Extract (EE), Ash, Total Carbohydrates and Digestible energy value (DE) were estimated for BSF prepupae. Proximate composition of BSF prepupae was performed by the standard methods of AOAC (1995). Samples were dried to a constant weight at 105 °C to determine moisture content. Ash was determined by incineration at 550 °C, crude lipid by soxhlet extraction using a Soxtec system 1046 (Tecator AB, Hoganas, Sweden), and crude protein by Kjeldahl method (N 9 6.25) after acid digestion. The digestible energy value of diet was calculated on the basis of standard physiological values (Halver, 1976) as per following formula:

Digestible energy (Kcal/ 100g) = Protein (%) x 4 + Lipid(%) x 9 + Carbohydrate (%) x 4.

Statistical analysis

The data were analysed by one-way Analysis of Variance (ANOVA) test using Duncan's Multiple Range Test (Duncan, 1955) to compare the means at 95 % confidence level (P ≤0.05). Statistical package SPSS 16 version was used for analysis of all data pertaining to growth performance and proximate body composition of the fish.

Results

Proximate composition of BSF prepupae is presented in Table 2. The crude protein contained in BSF prepupae was estimated to be 32.53%. The performance of formulated diets on the growth of Amur carp fry was satisfactory in all treatments and recorded a good survival rate of fishes which ranged from 77% (T1) to 90% (T2). The lowest average final weight (8.750a± 0.127), mean weight gain (6.560a±0.140), percentage

Table 3 Growth parameters of amur carp fed with experimental diet for 90 days culture period

Growth parameters	Treatments			
	T1	T2	T3	T4
Initial wt (g)	2.18 ±0.06	2.19±0.04	2.20± 0.03	2.19±0.02
Final wt (g)	8.75[a]± 0.13	9.08[b]± 0.19	9.09[b] ±0.12	9.20[b] ± 0.11
Mean wt gain (g)	6.56[a]±0.14	6.90[b] ±0.17	6.91[b] ±0.18	7.02[b] ± 0.15
Percentage weight gain	298.17[a] ±5.66	315.07[b] ±3.74	314.09[b] ±6.20	320.55[b]±4.48
SGR	1.54[a]±0.02	1.59[b] ±0.01	1.59[b] ±0.01	1.60[b] ±0.01
FCR	2.68[c]± 0.06	2.45[ab]±0.03	2.33[ab]±0.04	2.18[a]±0.08
FER	0.36[c]±0.01	0.49[ab]±0.01	0.54[ab]±0.02	0.58[a]±0.02
Survival rate (%)	77.52±2.66	87.62±3.06	88.53±2.09	90.32±2.03

The mean values in the same row with different superscript vary significantly at 95% confidence level.

weight gain (299[a]± 5.66) and specific growth rate (1.540[a]±0.018) found in T1 after 90 days of rearing the fish, showed significantly lower (P≤0.05) growth rate compared to other treatments (Table.3).On the other hand, final average weight gain, mean weight gain, percentage weight gain, FCR, and FCE, of treatment T2, T3 and T4 were significantly (P < 0-05) higher than 100% BSF (T1) , that means up to 70% fish meal can be replaced with BSF without affecting the fish production.

Feed conversion ratio of T1 (2.68[c]± 0.058) was significantly higher (P≤0.05) compared to fishes fed with 100% fish meal diet (T4, 2.18[a]±0.082). Whereas the difference was not statistically different among other treatments. FER also showed a similar pattern to that of FCR, with significantly higher values (P≤ 0.05) in fishes fed with fish meal diet (0.58[a]±0.024) and lowest in T1 (0.36[c]±0.007).

There was no significant mortality during the trial and the survival rate ranged from 77 to 90%. The range of average temperature, dissolved oxygen and pH of the rearing tank water were 28±0.32 °C, 5.4±0.6ppm and 8.1±0.3 respectively during the study period.

Discussion

Common carp (*Cyprinus carpio*) is considered to be one of the oldest domesticated species for aquaculture (Balon, 2006). The fish being omnivorous show high tendency to consume benthic organisms, such as water insects, larvae of insects, worms, molluscs and zooplankton (Peteri, 2006). In the present study, the fishes fed with diet by complete replacement of fishmeal by BSFN should significantly lowest growth and highest FCR values when compared to other diets. For optimal growth fish require a minimum level of protein which has a balanced level of essential amino acids. This can easily be achieved by using fishmeal as the main protein source. The study on common carp by Mohapatra and Patra (2014) showed that fish fed diet with 20% fish meal dietary inclusion performed excellently well compared to other treatments.

Zhou et al., (2018) tried 100% replacement of fish meal with the Black soldier fly larvae meal in *Cyprinus carpio var. Jian*, and reported that the growth of fish was not different from the other inclusion indicating that 100% BSFLM can be included in diets of Jian carp without unfavourable effects on growth. However, in other fishes, the result was not appreciable with 100% BSF inclusion in the diet. The growth of channel catfish and blue tilapia was strongly suppressed by feeding with 100% of black soldier fly larvae (Bondari & Sheppard, 1987). The 60 g/kg dietary inclusion of BSF prepupae in channel catfish (Newton et al., 2005), 150 g/kg (St-Hilaire et al., 2007) and 180-360 g/kg (Sealey et al., 2011); inclusion of BSF prepupae in rainbow trout 50-250 g/kg inclusion of BSF prepupae in Atlantic salmon (Lock et al, 2015) had shown a similar weight gain to that of fish fed fish meal. These results comply with our study where up to 70% of fish meal replacement with BSFM rendered no adverse effect on growth performance of amur carp. Whereas at 100% fishmeal replacement reduced growth was recorded in Amur carp. Similar results were obtained when higher inclusion levels (120-300 g/kg) reduced fish growth significantly in channel catfish, rainbow trout and turbot (Kroeckel et al., 2012; Newton et al., 2005; St-Hilaire, Sheppard et al., 2007), and more than 330 g/kg inclusion lev of BSFM would significantly decrease the palatability of the diet, protein digestibility, feed intake and growth performance in turbot (Kroeckel et al., 2012). Higher chitin levels of black soldier fly larvae or prepupae were reported to affect digestibility of diets and the growth of fish. The nutritional benefits of using combinations of various animal ingredients. Replacement of 75-100% fishmeal by maggot meal for the culture of groupes (Millamena, 2002) and cuneate drum (Guo et al., 2007) resulted in reduced growth and feed utilization in *Clarias gariepinus* as reported by Adewolu et al.,2010. Poor growth of fish has been attributed to the presence of high content of chitin in maggot meal which might be difficult for fish to digest (Emre et al., 2003). Combining two or more animal protein sources can improve fish performance as compared to single protein source

(Phonekhampheng, 2008). This is probably due to a more favourable essential amino acid balance. Our study also showed an optimum growth increment in fishes fed a combination of two different animal protein sources.

This study clearly demonstrates the potential of BSFM to replace up to 70% of the FM in diets for *C. carpio* fingerlings without affecting growth performance and feed utilization. Thus, feed costs can be substantially reduced and profit increased. This feed can be effectively used for the cage culture of these fishes. Apart from the economic benefits, agricultural and other organic wastes which would otherwise be a nuisance to the environment can now be recycled into an acceptable source of protein for developing fish feeds.

References

Adewolu MA, Ikenweiwe NB, Mulero SM (2010) Evaluation of an animal protein mixture as a replacement for fishmeal in practical diets for fingerlings of *Clarias gariepinus* (Burchell, 1822). The Israeli Journal of Aquaculture - Bamidgeh, 62(4):237-244

AOAC, 1995. Official Methods of Analysis of AOAC International, Vol. 1, 16thedn. (ed. Cunniff, P. A.). AOAC International, Arlington, USA

Bondari K, Sheppard DC (1987) Soldier fly, Hermetia illucens L., larvae as feed for channel catfish, *Ictalurus punctatus* (Rafinesque), and blue tilapia, *Oreochromis aureus* (Steindachner). Aquaculture and Fisheries Management, 18:209-220

Diener S, Zurbruegg C, Tockner K (2009) Conversion of organic material by black soldier fly larvae: establishing optimal feeding rates. Waste Management and Research, 27(6):603-610

Djissou Arnauld, Ochiai Akito, Koshio Shunsuke, Fiogbe Emile (2017) Effect of total replacement of fishmeal by earthworm and Azolla filiculoides meals in the diets of Nile tilapia *Oreochromis niloticus* (Linnaeus, 1758) reared in concrete tanks. Indian Journal of Fisheries, 64(1):31

Duncan, DB (1955) Multiple range and multiple F tests. Biometrics, 11:1-42

Emre Y, Sevgili H, Diler I (2003) Turkish Journal of Fisheries and aquatic sciences, 3:81-85

FAO, 2016. The State of World Fisheries and Aquaculture. FAO- I5798EN/2/01.17. Pp 16

Gasco L, Belforti M, Rotolo L, Lussiana C, Parisi G, Terova G, Roncarati A, Gai F (2014) Mealworm (Tenebrio molitor) as a potential ingredient in practical diets for rainbow trout (*Oncorhynchus mykiss*). In: Abstract book of the international conference 'Insects to feed the world', 14-17 May 2014, Ede, the Netherlands, pp. 69

Glencross B, Booth M, Allan GL (2007) A feed is only as good as its ingredients - A review of ingredient evaluation for aquaculture feeds. Aquaculture Nutrition, 13(1):17 - 34

Guo J, Wang Y, Bureau DP (2007) Inclusion of rendered animal ingredients as fish meal substitutes in practical diets for cuneate drum, *Nibea miichthioides*. Aquaculture Nutrition, 13:18-87

Halver JE (1976) The nutritional requirements of cultivated warm water and cold water fish species. Paper no. 31. FAO Technical Conference on Aquaculture, Kyoto, 26 may to 2 June, Pp.9

Hong Ji, Jian-Lu Zhang, Ji-Qin Huang, Xiao-Fei Cheng, Chao Liu (2015) Effect of replacement of dietary fish meal with silkworm pupae meal on growth performance, body composition, intestinal protease activity and health status in juvenile Jian carp (*Cyprinus carpio* var. Jian). Aquaculture Research, 46(5):Pp. 1209-1221

Kroeckel S, Harjes AGE, Roth I, Katz H, Wuertz S, Susenbeth A, Schulz C (2012) When a turbot catches a fly: evaluation of a pre-pupae meal of the black soldier fly (*Hermetia illucens*) as fish meal substitute - Growth performance and chitin degradation in juvenile turbot (*Psetta maxima*). Aquaculture and Fisheries Management, 364:345-352

Lock E, Arsiwalla T, Waagbo R (2015) Insect larvae meal as an alternative source of nutrients in the diet of Atlantic salmon (*Salmo salar*) postsmolt. Aquaculture Nutrition, 22:1202-1213

Mohapatra SB, Patra AK (2014) Growth response of common carp (*Cyprinus carpio*) to different feed ingredients incorporate diets. Advances in Applied Science Research, 5(1):169-173

Naylor RL, Goldburg RJ, Primavera JH, Kautsky N, Beveridge MC, Clay J, Folke C, Lubchenco J, Mooney H, Troell M (2000) Effect of aquaculture on world fish supplies. Nature, 405(6790):1017-1024

Newton GL, Sheppard DC, Watson DW, Burtle GJ, Dove CR,Tomberlin JK, Thelen EE (2005) The black soldier fly, *Hermetia illucens*, as a manure management/resource recovery tool. In: Symposium on the State of the Science of Animal Manure and Waste Management, San Antonio, TX, USA

Millamena OM (2002) Replacement of fish meal by animal by-product meals in a practical diet for grow-out culture of grouper *Epinephelus coioides*. Aquaculture, 204: 75-84

Phonekhampheng O (2008) On-Farm Feed Resources for Catfish (*Clarias gariepinus*) Production in Laos: Evaluation of Some Local Feed Resources. Ph.D. thesis, Swedish University of Agricultural Sciences, Uppsala. 65 pp

Renna M, Schiavone A, Gai F, Dabbou S, Lussiana C, Malfatto V, Prearo M, Capucchio MT, Biasato I, Biasibetti E, De Marco M, Brugiapaglia A, Zoccarato I, Gasco L (2017) Evaluation of the suitability of a partially defatted black soldier fly (*Hermetia illucens* L.) larvae meal as ingredient for rainbow trout (*Oncorhynchus mykiss* Walbaum) diets. Journal of Animal Science and Biotechnology, 8:57

Sealey WM, Gaylord TG, Barrows FT, Tomberlin JK, McGuire MA, Ross C, St-Hilaire S (2011) Sensory analysis of rainbow trout, *Oncorhynchus mykiss*, fed enriched black soldier fly prepupae, *Hermetia illucens*. Journal of the World Aquaculture Society, 42:34-45

Shakil Rana KM, MA Salam, Shaharior Hashem, Md. Ariful Islam (2015) Development of Black Soldier Fly Larvae Production Technique as an Alternate Fish Feed.

International Journal of Research in Fisheries and Aquaculture, 5(1):41-47

Sheppard DC (1983) House fly, Musca domestica, and Lesser Fly, *Fannia canicularis*, control using the Black Soldier Fly, *Hermetia illucens*, in manure management systems for caged laying hens. Environmental Entomology, 12(5):1439-1442

Stamer A, Wesselss S, Neidigk R, Hoerstgen-Schwark G (2014) Black Soldier Fly (*Hermetia illucens*) larvae-meal as an example for a new feed ingredients' class in aquaculture diets. In: Proceedings of the 4th ISOFAR Scientific Conference. 'Building Organic Bridges', at the Organic World Congress 2014, 13-15 Oct., Istanbul, Turkey (eprint ID 24223) edited by Rahmann G & Aksoy U. Pp 1043-1046

St-Hilaire S, Sheppard C, Tomberlin JK, Irving S, Newton L, McGuire MA, Mosley EE, Hardy RW, Sealey W (2007) Fly Prepupae as a Feedstuff for Rainbow Trout, *Oncorhynchus mykiss*. Journal of the World Aquaculture Society, 38:59-67

Tacon AGJ, Hasan MR, Metian M (2011) Demand and Supply of feed ingredients for farmed fish and crustaceans: Trends and Prospects. Technical Paper No 564, Food and Agriculture Organization of the United Nations, Rome, Italy

Windsor ML (2001) Torry Research Station, Torry Advisory Note No. 49. FAO Corporate Document Depository. www.fao.org/wairdocs/tan/x5926e/x5926e01.htm

Yu G-H, Chen Y-H (2009) Research progression on the larvae and prepupae of black soldier fly *Hermetia illucens* used as animal feedstuff. Chinese Bulletin of Entomology, 46(1):41-45

Zhang J, Zheng L, Jin P, Zhang D, Yu Z (2014) Fishmeal substituted by production of chicken manure conversion with microorganisms and black soldier fly. In: Abstract book of the international conference Insects to feed the world, 14-17 May 2014, Ede, the Netherlands, pp. 14-17

Zhou JS, Liu SS, Ji H, Yu HB (2018) Effect of replacing dietary fish meal with black soldier fly larvae meal on growth and fatty acid composition of Jian carp (*Cyprinus carpio* var. Jian). Aquaculture Nutrition, 24:424-433

Studies on the seasonal abundance of the juveniles of *Tenualosa ilisha* from Hooghly River estuary of West Bengal, India

Ashim Kumar Nath · Bhuban Mohan Majhi

Received: 19 October 2018 / Accepted: 15 December 2018

Abstract The Hooghly-estuarine system harbours important commercial fishes including hilsa, *Tenualosa ilisha*. Exploitation of hilsa juveniles through fixed bag net and small meshed gill net indicates that they are available in maximum quantity in station 2-Bagbazar region. Pre monsoonal (March-June) catch found in maximum amount than post monsoon (November - February) in all the studied three stations viz. Raichak, Bagbazar and Serampore. Juvenile is noticed throughout the year in station 3-Serampore area. Bag net catch was found maximum in comparison to small meshed gill net in Serampore region. Rainfall, tidal amplitude and salinity has found no effect on their abundance of Hilsa juveniles. Study indicates they are likely to remain there for some time and after attaining 16 cm move deeper region of water.

Keywords Hooghly-estuary, *Tenualosa ilisha*, Juveniles, Bag Net, Gill Net

Introduction

The Hooghly-estuarine system, on the Indian coast of Bay of Bengal, is one of the largest and most productive estuaries in the country (Jhingran and Ghosh, 1978). It is located in West Bengal between latitude 21° 31' and 23° 30' and longitude space between 87° 45' and 88° 45' E and is the largest among the estuaries of the Indian coast supporting a large scale of fishery. Hilsa ascends the freshwater stretch of rivers from inshore areas of the sea mainly for spawning purposes (Hora, 1940; Hora and Nair, 1940; Pillay, 1958, De, 1986, Bhaumik and Sharma, 2011, Bhaumik, 2013) and after attaining a suitable size of about 100 mm starts their downstream migration towards coastal region (Nath and Banerjee, 2013). Ahsan et al. (2014) stated that juveniles remain in rivers/estuaries till they reach a length of 15 - 16 cm which is believed to be attained in five months.They need saline environment for growth and attaining sexual maturity. Occurrence of juvenile offers evidence of a likely spawning season and spawning ground (Ahsan et al. 2014).Availability of hilsa juveniles in a long stretch of the Hooghly estuary indicates that the stocks still prefer to spawn in this region (De, 1986; De and Sinha, 1997; De, 2001; Bhaumik, 2010; Bhaumik and Sharma, 2012). Besides hilsa, young ones and juveniles of other fish species inhabit for feeding purposes in this region (Mitra et al., 1988). Large scale changes in the estuarine ecosystem consequent to the commissioning of the Farakka Barrage have resulted in the greater extension of freshwater zones sea wards. As the yield of hilsa is decreasing day by day in the Hooghly estuary (Ahsan et al., 2014; Bhaumik, 2015 b), monitoring of the month wise abundance of hilsa juveniles with size frequency throughout the year is required. In the aforesaid context, the objective of the present study is to assess the present scenario of month wise availability of the hilsa juveniles with size frequency using bag net and small meshed gill net in a particular stretch of Hooghly-estuary with a conservational approach.

A. K. Nath(✉) B. M. Majhi ·
Fisheries and Aquaculture Research Unit, Department of Zoology, Sidho Kanho Birsha University, Purulia, West Bengal
e-mail: nathasim@yahoo.com

Table 1 Length, weight of Hilsa juvenile at Station 1- Raichak

	Pre monsoon				Monsoon				Post monsoon			
Bag Net	March	April	`May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb
L (cm)	7 - 12	6 - 9	5 - 8	3 - 7.5	-	-	-	-	-	4 - 9	-	3 - 12
Wt (g)	8 - 45	8 - 45	8 - 30	8 - 50	-	-	-	-	-	10 - 40	-	10 - 50

Length, weight of Hilsa juvenile at Station 2 -Bagbazar

	Pre monsoon				Monsoon				Post monsoon			
Bag Net	March	April	`May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb
L (cm)	3.5 - 10	3.5 - 7	3 - 8	3 - 5	-	-	-	-	2.5 - 7.5	3 - 8.5	3 - 7	3 - 12
Wt (g)	10 - 50	12 - 45	8 - 40	10 - 50	-	-	-	-	8 - 9	8 - 12	10 - 30	10 - 30

Length, weight of Hilsa juvenile at Station 3-Serampore

	Pre monsoon				Monsoon				Post monsoon			
Bag Net	March	April	`May	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb
L (cm)	9.5 - 12	10 - 11	7.5 - 15	9 - 11	-	8 - 9	-	4 - 15	4.5 - 5.5	5 - 11	5 - 6	7 - 13
Wt (g)	8 - 26	12 - 18	4 - 56	10 - 15	-	6 - 7	-	2 - 32	3 - 5	2.5 - 4	2.5 - 4	4 - 12
Gill Net												
L (cm)	9 - 13	10 - 11	9 - 13	11 - 14.5	-	-	-	-	-	-	-	-
Wt (g)	10 - 31	10 - 30	10 - 30	13 - 38	-	-	-	-	-	-	-	-

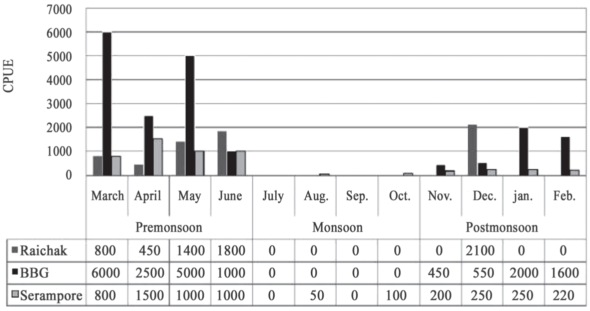
Materials and methods

Along 80 km stretch of the Hooghly estuary, three (3) sampling centres were selected for the purpose of investigations namely station 1-Raichak (South 24 Parganas 22° 12.411//North / 0880 07.399//East), station 2 -Bagbazar (Kolkata 220 36.124//North / 0880 21.685// East) and station 3- Serampore (Hooghly22045.251// North / 0880 21.059//East) of West Bengal. These zones are considered as gradient-transition zone where tidal activities take place. Observations made during all the months of 2015-16 and 2016-17. The whole year is divided into pre monsoon (March - June), monsoon (July - October) and post monsoon ((November - February) period. Observations were made on the catches made by the fishermen at the fishing spots using fixed Bag net (local name - Behundijal) and small mesh sized (40 - 50 mm) gill net. In this gill net juveniles and hilsa up to 200 g are being caught. Fixed bag net is a long bag net with a wide mouth and end made of small meshed netting for operation in tidal areas. Bag nets are being operated in all the above three stations during full moon and new moon period for 5 - 6 days. In a day 4 times (2 times in low tide and 2 times in high tide) in 24 hrs nets are operated. Duration of this net operation is 2 hrs. Gill net is made of monofilament. The net as well as boat drifts along with the water current for gilling hilsa.

Small mesh sized gill nets are usually operated in station no. 3 i.e. Serampore area for catch of the juveniles. During the study period the stations were visited at regular intervals of 15 days and the catch per unit effort (CPUE) data of consecutive three days of new moon and full moon periods were calculated. Water parameters like temperature (°C), dissolved oxygen (DO), pH, alkalinity, hardness, salinity, phosphate etc. were measured following the standard methods (APHA 2012). Tidal amplitude and rainfall data were also recorded (data provided by CSSRI, ICAR, Canning and Meteorological Office, Kolkata, West Bengal). These data help to understand if there is any relation between the availability of Hilsa juveniles and these parameters.

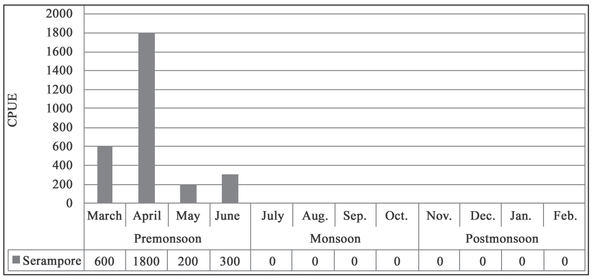
Results and discussion

Monthly abundance (CPUE) of hilsa juveniles for each station is given in Fig 1 and 2. Most of the catches ranged from 2.5 cm to 16 cm (Table 1). Upto 16 cm size range are considered here as juveniles in the present study as they are caught in the fixed bag net as well as small mesh sized gill net. Studied seasons indicate immature forms found throughout the year with a peak period from December to June. Pre-monsoonal catch was found higher in all the studied regions with a peak in station 2- Bagbazar region. Post-monsoonal catch was found higher in Bagbazar and Serampore region (Fig 1). Study indicates that juveniles are found almost throughout the year in this fluvial estuary zone especially in Bagbazar region. In the monsoonal period when the water level increases, fishermen do not operate Bag net in the Raichak and Bagbazar region as



	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	jan.	Feb.
	Premonsoon				Monsoon				Postmonsoon			
Raichak	800	450	1400	1800	0	0	0	0	0	2100	0	0
BBG	6000	2500	5000	1000	0	0	0	0	450	550	2000	1600
Serampore	800	1500	1000	1000	0	50	0	100	200	250	250	220

Fig. 1 Comparison of efficacy of Fixed Bag Net at different stations (BBG = Bagbazar) (CPUE in g)



	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.
	Premonsoon				Monsoon				Postmonsoon			
Serampore	600	1800	200	300	0	0	0	0	0	0	0	0

Fig. 2 Comparison of efficacy of small meshed gill net in different season at Station 3 - Serampore area (CPUE in g)

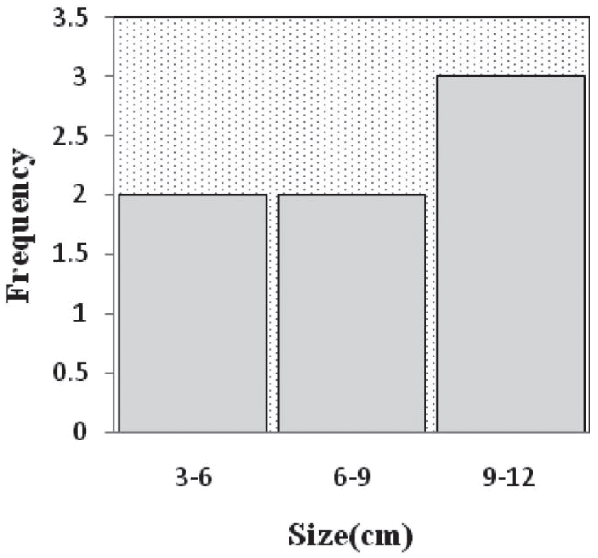


Fig. 3 Frequency of size range (cm) of Juvenile fish at Station 1-Raichak

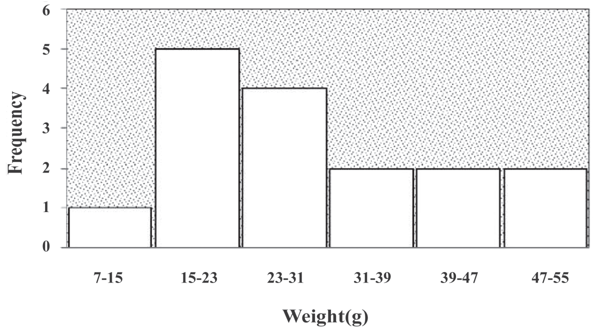


Fig. 4 Frequency of weight range (g) of Juvenile fish at Station 1-Raichak

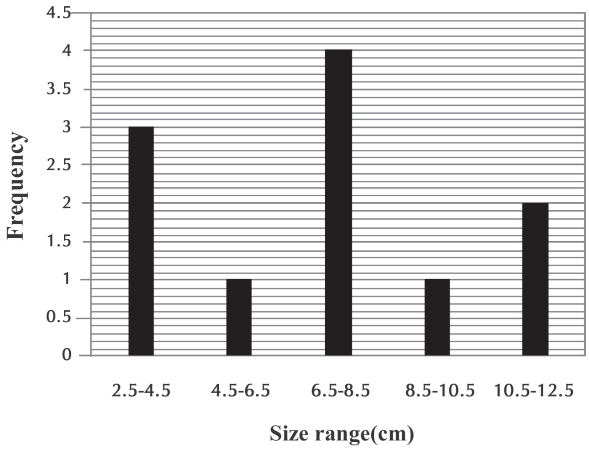


Fig. 5 Frequency of size range (cm) of Juvenile fish at Station 2 - Bagbazar area

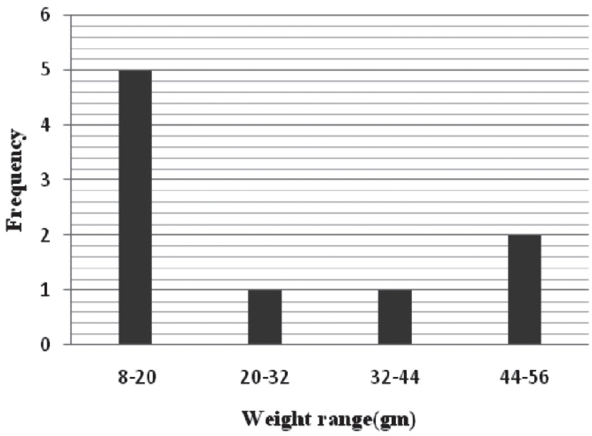


Fig. 6 Frequency of weight range (g) of Juvenile fish at Station 2 - Bagbazar area

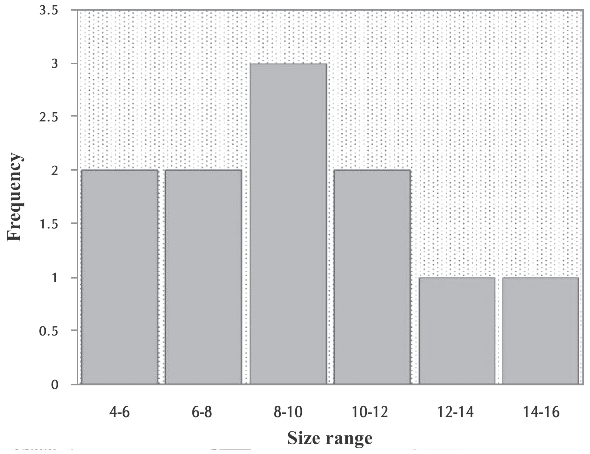


Fig. 7 Frequency of size range (cm) of Juvenile fish at Station 3 -Serampore area

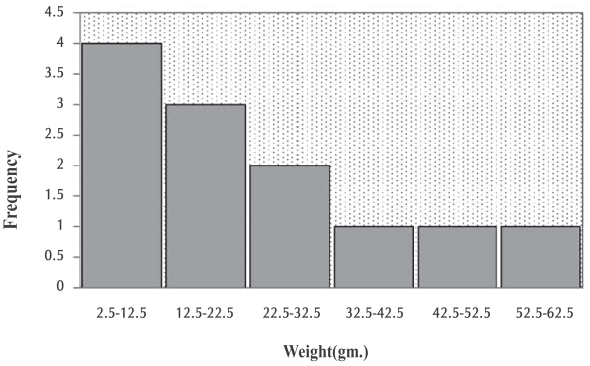


Fig. 8 Frequency of weight range (g) of Juvenile fish at Station 3-Serampore area

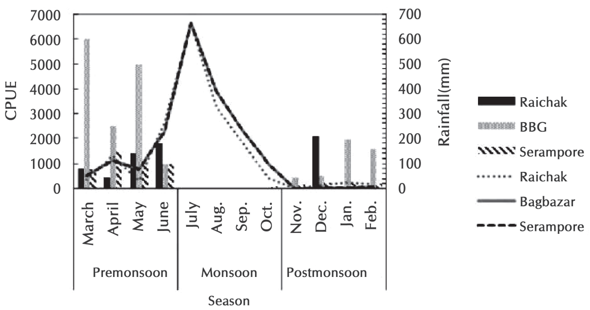


Fig. 9 Relation between Catch per unit effort (CPUE) and rainfall (mm.) throughout the study period at different season

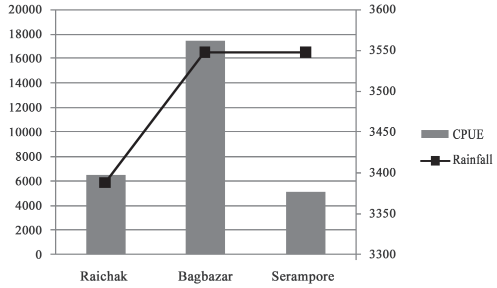


Fig. 10 Total juvenile catch with total rainfall at the different station 2015-2017 (CPUE in g; Rainfall in mm)

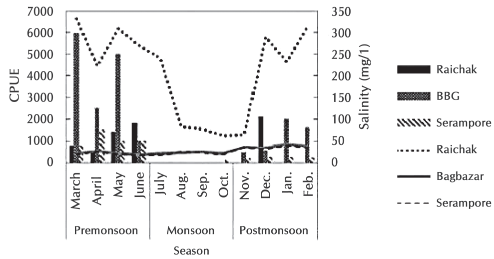


Fig. 11 Relation between Catch per unit effort (CPUE) and salinity(mg/l) throughout the study period at different season (BBG-Bagbazar).

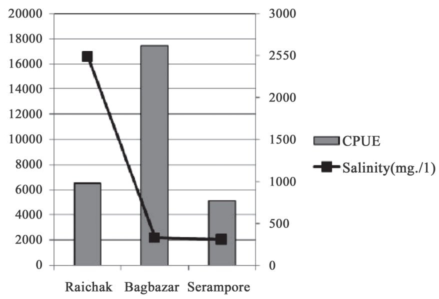


Fig.12 Relation between Total catch and total salinity (mg/l) at different station during study period 2015-2017

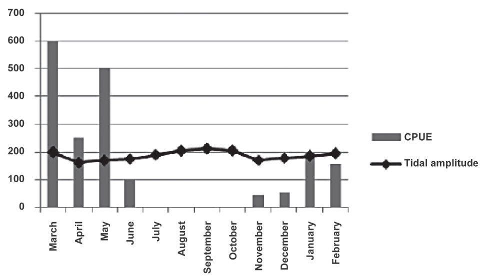


Fig. 13 Relation between month wise catch and tidal amplitude (in inches) at Station 2 - Bagbazar area during the study period 2015-2017

Table 2 Physico - chemical parameters (Av. value for two years) of the studied area

Parameters	Station 1 (Raichak)	Station 2 (Bagbazar)	Station 3 (Serampore)
Dissolved oxygen (mg/l)	7.9	7.6	7.6
Temperature (°C)	30.00	29.8	29.6
Water pH	7.6	7.7	7.6
Salinity (mg/l)	208.3	25.8	25.3
Hardness (mg/l)	232	121	100.6
Alkalinity (mg/l)	281.3	161.7	152.3
Phosphate (mg/l)	0.31	0.16	0.20

they are nearer to the coastal zone. Less operation also noticed in Serampore region. In this area small mesh sized gill net catch records hilsa juveniles during pre monsoon period (Fig 2). Results indicate that juveniles are used to inhabit in the upper part of the fluvial estuary where tidal ingression is less and the juveniles are produced from the adult fishes found in that region. CPUE data shows highest catch in Bagbazar region (Table 1) during pre monsoon period followed by post monsoon period which differs from the view of Hora and Nair (1940) who stated jatka or juveniles is said to occur in greater quantity towards the end of the February - March and latter half of March. Presence of juveniles below 8 cm in the catches of Bag net can be attributed to the fact that the Bag nets are efficient which cover the middle of the river. According to Pillay and Rosa (1963), all the riverine and estuarine stocks of hilsa appear to breed in the upper reaches. The juveniles appear to inhabit the surface waters but later stages move in deeper zones as well (Bhaumik and Sharma, 2011; Bhaumik, 2013; Ahsan et al., 2014).

In the Raichak region juvenile fish size ranged from 3 - 12 cm with a peak of 9 - 12 cm with a weight range of 7 - 55 g showing peak of 15 - 23 cm (Fig 3 and 4). In the Bagbazar region it ranged from 2.5 - 12.5 cm with a peak of 6.5 to 8.5 cm having a weight range of 8 - 56 g (Fig 5 and 6). The peak of weight at Bagbazar is 8 - 20 g. In the Serampore region juvenile fish length ranged from 4 - 16 cm with a peak of 8 - 10 cm catched in Bag net with a peak of weight range 2.5 - 12.5 g (Fig 7 and 8). In this region gill net juvenile catch size ranged from 9 - 14.5 cm with a peak from 9 - 12.5 cm. Results throw some light on the location of the breeding grounds of the hilsa which must be conserved. It is observed that at Raichak and Bagbazar maximum length (12cm) found in February and at Serampore area maximum length of 15 cm found during May and October. Noticeable maximum length also found during December, March, April, June. Authors (Raja, 1985; Mazid and Islam, 1991; Bhaumik and Sharma, 2011, Bhaumik, 2012) pointed out that the jatka remain around the nursery grounds for about 5 - 6 months and attain a maximum size of 15 - 16 cm and with a dominant size of 10 -12 cm (Rahman and Halder, 1998, Bhaumik, 2015 a). Present observation reports up to 15 cm catch in Bag net in the Hooghly river. It differs from the observation of Hossain (1975) who reported that when larvae reach 12 cm they disappear from the river. Gradually the jatka acquire the ability to tolerate saline water and move downstream to the estuary. There they spend their young life stages in brackish water. The young after some days move to the offshore for feeding and adult size is achieved. According to Ahsan et al.(2014), larvae and juveniles of hilsa make their way downstream to the sea during a period of five to six months. They also pointed out that in about 6 - 10 weeks, fry grows to about 12 - 20 cm and mentioned that in Hooghly-Bhagirathi estuary, fish start downstream migration after attaining 8 - 10 cm which commences from February and continues to June.

Hilsa juveniles are found in maximum amount in Bagbazar region followed by Serampore and Raichak region. Bagbazar zone is the freshwater zone with the high tidal current. At Raichak salinity is noticed in some parts of the year. Results indicate that the juveniles prefer the freshwater zone with high tidal current which supports the work of Hora and Nair (1940) where they mentioned that jatka (juveniles) prefers the part of the river channel with the stronger current. An ideal nursery ground of hilsa should have shallow water depth, high aquatic vegetation specially submerged algae for food, devoid of strong current, riverine freshwater.

In Serampore area hilsa juveniles are caught by Bag nets and gill nets. CPUE results in Bag net depicted sizes ranged from 800 to 1500g whereas in gill nets depicted 200 to 1800g. Monsoonal CPUE in Behundi nets depicted between 50 and 100g since Bag nets were not properly operated due to high water table during monsoon period. In Bagbazar region pre monsoonal CPUE ranged from 1000 to 6000g whereas during monsoon Behundi nets were not operated and during the post - monsoon period CPUE ranged from 450g to 2000g.

In the Raichak region in pre-monsoon period CPUE ranged from 450g to 1800g in Behundi net. In the monsoon period Bag nets are not operated due to operation of gill net for catching the adult fish and also due to the high water table. In the post-monsoonal period CPUE ranged from 250g to 2100g.

Availability results indicate that juveniles are found throughout the year in Serampore region as well as in the Bagbazar region. In the Bagbazar region it seems they are also present throughout the year but they are not caught due to non-operation of bag net during monsoon period due to high water level. In Serampore region sporadic operation of bag net noticed during monsoon period. In Serampore area siltation problem is more than Bagbazar region. Earlier observations (Nath and Banerjee, 2013) indicate that the adult hilsa fishes are found in the upper part of the Hooghly estuary throughout the year which suggests they may be the residential species in the freshwater zone. These juveniles might be produced from them. As a result juveniles are found throughout the year in station 3 i.e. Serampore region. Authors (Hora, 1938; Hora and Nair, 1940) also reported that some hilsa stocks remain permanently in freshwater stretch of rivers. Through collection of hilsa juveniles in the Hooghly estuary Bhanot (1973) confirmed that species bred throughout the year with peak activity in February - March, July - August and October - November.As the juveniles are found in the above studied region especially from Bagbazar to Serampore - these zones must be protected for the conservation of juveniles. It is necessary to preserve the natural stock of juvenile hilsa through legislation during the months of March - June (pre-monsoon period) and Nov - Feb (monsoon period) in Bagbazar to Serampore region to a great extent and at Raichak region during March to June and December. Hora and Nair (1940) also pointed out the fact that there is no need of artificial fecundation.

Physico-chemical parameters are found in the suitable amount (Table 2). Monthly rainfall and total rainfall with CPUE of hilsa juveniles does not show any significant relationship in controlling adult hilsa yield (Fig 10 and 11). Pati and Pati (1983) also reported a close relationship between total annual rainfall and landings of adult hilsa. Tidal amplitude also had no role in the abundance of juveniles seen at Bagbazar (Fig 13). Nath and Banerjee (2013) reported that tidal action had not played important role solely but along with rainfall it has an impact in adult hilsa yield. Present study reveals hilsa juveniles are found in the upper part of the Hooghly estuary irrespective of rainfall and tides. Results (Fig 11and 12) indicate that hilsa juveniles prefer low saline zones.

Illegal use of extremely small nets and the catch of the hilsa juveniles decreasing the stock of adult hilsa. Availability of hilsa juveniles in the studied zones indicates that these are the breeding/ spawning grounds of hilsa. According to Mitra et al., (1988), wanton destruction of these young ones entirely localised in the exploited region adversely affects the stocks of hilsa of the Hooghly estuary. It is therefore not desirable to catch the young ones before their downward migration to the sea.

Acknowledgement Authors are grateful to DST, Govt. of West Bengal for providing fund in Major Research Project (Memo No. 696 (Sanc.) /ST/P/S and T/ 5G-1/2004) to do the work.

References

American Public Health Association (APHA). 2012. Standard Methods for the Examination of Water and waste water 19th edition. Edited by AD Eaton, LS Clesceri and A. E. Greenberg. Pub. By American Public Health Association 1015 Fifteenth street, NW, Washington, DC20005

Ahsan DA, Niamul Naser M, Bhaumik Utpal, Hazra S, Bhattacharya SB (2014) Migration, spawning patterns and conservation of Hilsa shad (*Tenualosa ilisha*) in Bangladesh and India - Ecosystems for Life: A Bangladesh-India Initiative-Dialogue for sustainable management of trans-boundary water regimes in South Asia. IUCN, Academic Foundation, Total Pages 95

Bhanot KK (2013) Observations on the spawning of *Hilsa ilisha* (Ham.) in the Hooghly estuary. J. Of the Inland Fisheries Society, India 5: 50-54

Bhaumik Utpal (2010) Status of fishery of Indian Shad (*Tenualosa ilisha*) with reference to the Hooghly river system. In Souvenir, 21st All India Congress of Zoology and National Seminar on 'Biodiversity conservation with reference to fisheries management for food, livelihood and environment security' held at CIFRI, Barrackpore, Dec 21-23, p. 66-81

Bhaumik Utpal, Sharma AP (2011) The fishery of Indian Shad (*Tenualosa ilisha*) in the Bhagirathi-Hooghly river system. Fishing Chimes 31(8):21-27

Bhaumik Utpal (2012) Status space of space Hilsa spae fishery in India. In Hilsa: Status of fishery and potential for aquaculture. Eds. Wahab, Phillip and rahaman. World Fish centre, Bangladesh. P. 61-95

Bhaumik Utpal, Sharma AP (2012) Present status of hilsa in Hooghly-Bhagirathi river. In CIFRI Bulletin 179; 42 p

Bhaumik Utpal (2013) Decadal studies on Hilsa and its fishery in India - A review. J. Intercad. 17(2):377-405

Bhaumik Utpal (2015 a) space Perspectives of space reproductive biology and spawning behaviour of Indian shad (*Tenualosa ilisha*) - A Global review. Int. J. Curr. Res. Aca. Rev. 3(8): 229-241

Bhaumik Utpal (2015 b) Migration of Hilsa shad in the Indo-Pacific Region - A review.Int. J. Curr. Res. Aca. Rev. 3(11):139-155

De DK (1986) Studies on the food and feeding habit of Hilsa *Hilsa ilisha* (Hamilton) of the Hooghly estuarine system and some aspects of its biology. Ph.D. thesis. Calcutta University. 285 p

De DK, Sinha M (1997) Studies on the migration of hilsa, *Tenualosa ilisha* by tagging experiments. In National Seminar on changing perspective on Inland Fisheries. Organized by Inland Fisheries Society of India and CIFRI, Barrackpore, March 16-17

De DK (2001) An overview of biology of hilsa, *Tenualosa ilisha* (Hamilton) and its fishery in the Ganga-Hooghly drainage system. In. Proceedings of the International Terubok Conference, 11-12 Sep, Sarawak, Malaysia. 25-51p

Hora SL (1938) A preliminary notes on the spawning grounds and binomics of the so-called Indian shad *Hilsa ilisha* (Ham) in the river Ganges. Records of Indian Museum. 40:147-158

Hora (1940) Dams and the problems of migratory fishes. Current Science., 9:406-407

Hora SL, Nair KK (1940) Observations on the bionomics and fishery of the Indian shad *Hilsa ilisha* (Ham) in Bengal waters. Records of Indian Museum. 42:35-40

Hossain MM (1975) Studies on some aspects of biology of *Hilsa ilisha* (Ham.) of the river Padma. M.Sc. Thesis, The University of Dhaka, Bangladesh

Jhingran AG and Ghosh KK (1978) The Fisheries of the Ganga river system in the context of Indian Aquaculture. Aquaculture, 14:141-162

Mazid MA, Islam MS (1991) Hilsa Fishery Development and Management (in Bengali). A report published by Fisheries Research Institute, Mymenshing, Bangladesh, June, 1991

Mitra PM, Saigal BN, Karmakar HC (1988) Indiscriminate exploitation of young Hilsa from the upper fresh water stretches of the Hooghly estuary. Proc. Nat. Acad. Sci. India, sec B, 58 (1-4):349-358

Nath AK, Banerjee B (2013) Studies on the status of Hilsa catches in Hooghly-estuarine system of West Bengal, India. Fishing Chimes. 33 (9):46-51

Pati S, Pati DK (1983) The role of rainfall on the Hilsa fishery along the Orissa coast. Indian Journal of Fisheries, 29(1-2):234-240

Pillay TVR (1958) Biology of the Hilsa, *Hilsa ilisha* (Ham.) of the river Hooghly. Indian Journal of Fisheries, 5(2):201-257

Pillay SR, Rosa H (1963) Synopsis of biological data on hilsa, *Hilsa ilisha* (Ham.1822). FAO Fisheries synopsis: 25, 61 pp

Rahman AKA, Halder GC (1998) Assessment of current hilsa resources in Bangladesh. Proc. of BFRI/ACIAR/ CSIRO Workshop on Hilsa Fisheries research in Bangladesh. pp 20-27

Raja BTA (1985) A review of the biology and fisheries of *Hilsa ilisha* in the upper Bay of Bengal. Proceedings of the Marine Fisheries Resource Management, Bay of Bengal. Colombo, Sri Lanka. FAO/UNDP BOBP/WP/ 37:66pp

Effect of dietary probiotic supplement on growth performance and survival of *Labeo rohita* (hamilton) fingerlings

Shilpa Sahoo · U. Acharya · J. P. Sahu

Received: 29 August 2018 / Accepted: 12 November 2018

Abstract Feeding trials were conducted in triplicate for each treatment for a period of 10 months under laboratory conditions in FRP tanks to delineate the effect of dietary probiotic (Meracid) supplementation on growth and survival rate of *Labeo rohita* fingerlings at four different levels. The diets were prepared utilizing the locally available ingredients to which Meracid was added at the rate of 1.0 percent (T1); 1.5 percent (T2) and 2.0 percent (T3). Diet without Meracid incorporation served as control (T0). For each treatment 10 numbers of Labeo rohita fingerlings of uniform size and weight were stocked in 500 liters of FRP tanks. The growth in terms of weight gain (%) and increment in length was found to be highest in the treatment T2 followed by the treatment (T1& T3) respectively as compared to that of control (T0). Feeding frequency in all the variants was two times a day. The fishes were fed daily @ 3% of their body weight and decreased progressively with increasing body weight during the culture period. The specific growth rate, food conversion ratio, protein efficiency ratio and survival were observed to be the highest in case of the treatment T2 followed by T1. The highest survival percentage was observed in the treatment T2 and T1 as compared to treatment T3 and T0. The results thus obtained in the present investigation indicate that incorporation of Meracid as probiotic at the rate of 1.5% (T2) to the basal diet enhances the growth and survival of *Labeo rohita* fingerlings.

Shilpa Sahoo(✉) U. Acharya ·
P.G. Department of Biotechnology, Berhampur University, Bhanja Bihar, Berhampur - 760007, Odisha, India
J. P. Sahu
P.G. Department of Aquaculture, College of Fisheries (OUAT) Rangailunda, Berhampur - 760007, Odisha, India
e-mail: shilpasahoo1986@gmail.com

Key words *Labeo rohita*, probiotic, specific growth rate, survival rate.

Introduction

Aquaculture is now recognized as a vital and profitable enterprise worldwide. Which is now the fastest growing food producing sector and moving in new direction with the increasing in the intensification and commercialization of aquaculture production (Tran,et al., 2013). With the increasing intensification and commercialization of aquaculture production infectious diseases are a major problem causing heavy loss to the fish farming industry (Bondad - Reantaso, et al., 2005). It is widely demonstrated that the occurrence of diseases of fish farm is due to several factors concerned with the rearing methods, environmental conditions, quality feeds etc. In intensive aquaculture the use of antibiotics and chemotherapeutics for treatment and prophylaxis has been broadly criticized for its negative impact and research in interactions between growth immunity and development of eco-friendly alternatives to antibiotics that may keep fish healthy such as probiotics for treating diseases is enjoying attention in fish health and diseases management (Sahu, et al., 2007). A recent innovation in this aspect is the use of probiotics in aqua feed.

Probiotics are beneficial bacteria capable of repressing the growth of pathogenic organisms either through the production of inhibitory substances or by completion (Moriarty, 1998). Regular application of probiotics is done to maintain the desired population of beneficial bacteria and improve water quality. According to Fuller (1987) probiotics as a live microbial adjunct which has a beneficial effect on the host by modifying the host associated or ambient microbial community, by ensuring improved used of the feed or enhancing its nutritional value, by enhancing the host response towards diseases or by improving the quality of its ambient environment. The advantages of using probiotics in fish culture were recently reviewed by Nayak (2010) & Qi,et al., (2009). The use of probiotics as a dietary supplement in aquaculture of food fishes like rainbow trout, solmon and cod has shown promising results (Gatesoupe, 1994, 1997; Austin,et al., 1995; Robertson,et al., 2000). Hence probiotics can be used as an alternative to antibiotics and may arise as a promising area of research in the prevention of infectious disease in aquaculture system. The use of probiotics in Labeo rohita culture is well documented (by Kumar, et al., 2010; Mohapatra, et al., 2010; Sinha and Pandey, 2013).

Meracid (probiotic) a research product of Novous International manufactured and marketed by Biostat India Ltd., Mumbai. It is a proprietary blend of GEMS (Gut Environment Modifiers) designed to improve feed quality and optimized efficient nutrient uptake, effectively use less energy which results in higher growth rate. However, information with particular reference to Meracid on fishes is not available. Hence, the present experiment was designed with the objective to evaluate the effect of probiotic supplemented diet on growth performance and survivility of *Labeo rohita* fingerlings.

Materials and methods

Experimental Setup

The experiment was conducted for a period of 10 months (Aug. 2013 - May 2014) in FRP tanks in the wet laboratory of College of Fisheries, OUAT, Rangeilunda, Ganjam, Odisha. The experimental animal rohu (*Labeo rohita*) fingerlings were procured from Govt. Fish Seed Farm, Chatrapur. The test fish were first disinfected by placing 5 mg/l potassium permanganate solution and subsequently acclimatized for a period of 15 days in laboratory condition. The experiment was initiated with stocking at a density of 10 numbers per FRP tank containing 500 L bore well water. The laboratory was well ventilated so as to allow sufficient fresh air. Within the experimental period the fish were fed twice daily @ 3% of their body weight. The total feed was provided in two split doses, once during morning and evening hours. About 20% water was replenished with fresh bore well water daily in order to maintain hygienic condition of the culture tank. The experimental tanks were siphoned to remove left out feed and excreta daily. The water quality parameters of each experimental tank was analyzed.

Experimental group

The experiment was conducted in four distinct experimental groups, T0, T1, T2 and T3 in triplicates in twelve uniform sized FRP tanks of 500 L capacity each. Fishes were fed with experimental diet T0 i.e. basal diet containing no probiotic where as treatments T1, T2 and T3 contains basal diet incorporated with probiotic Meracid @ 1.0%, 1.5% and 2.0% per kg feed respectively.

Experimental diet

Four experimental diets were formulated containing 30% protein. The ingredients used for preparation of basal diet and experimental diets are enlisted in Table-1. The proximate composition was given in Table-2. The proximate composition of the test diets were analyzed following the standard procedure (AOAC, 1995).

Probiotics

Meracid a aquaculture feed probiotic was incorporated in basal diets at three different levels such as 1.0%, 1.5% and 2.0% to test its performance pertaining to growth performance and survivility. Meracid a proprietary blend of formic, propionic acids (free acids) not less than 50% with ammonium formate and ammonium propionate. It is a research product of Novus International.

Water quality parameters

Water samples were collected at 15 days interval from all the experimental FRP tanks and analyzed for temperature, pH, dissolved oxygen, free carbon-dioxide, total alkalinity, NH3, nitrite-nitrogen, nitrate- nitrogen following standard methods (APHA, 1985). The water temperature was recorded twice daily at 8 a.m. and 4.30 p.m. while other parameters were

Table 1 Percentage composition of different ingredients in the basal diet and experimental diets

Ingredients	Basal diet	Experimental diets		
	T0	T1	T2	T3
Fish meal	16	16	16	16
GNOC	16	16	16	16
Rice polish	54	53	52.5	52
Corn flour	2	8	8	8
Vitabest	8	2	2	2
Vitamin & mineral mixture	4	4	4	4
Probiotics- Meracid	Nil	1	1.5	2

Table 2 Proximate composition of ingredients used for preparation of experimental diet T0 Control (g per 1000 g diet)

Parameters	% on dry matter basis
Moisture	9.03
Crude protein	29.51
Crude fat (Ether extract)	8.34
Crude fibre	4.15
Total ash	13.33
Acid insoluble ash	3.16

analyzed for every 15 days interval till the end of the experiment by following standard methods (APHA-AWWA-WEF, 1998).

Growth parameters

Fish in culture tanks was collected, counted and weighed at two weeks intervals. Sampling was done of 15th day till 300th days to assess the weight gain by the experimental animals. The initial weight and final weight was used to calculate the following growth parameters.

Body weight gain= Finalweight-Initialweight
Daily weight gain= (Totalweight in g)/(No.of days)×100
Specificgrowthrate(SGR %) = (In(Finalweight)-In (Initialweight))/Numberofdays×100
Feedconversionratio(FCR) = (Dry feed fed in g)/(Net weight gain in g)
Protein efficiency ratio (PER) = (Net weight gain in g)/(Dry protein fed in g)
Survival rate (%)= (Total No.of fish survive)/(Total No.of fish stocked)×100

Statistical analysis

The relevant data thus gathered in the present investigation was subjected to analysis of variance (ANOVA) (Snedecor and Cochron; 1968) and completely randomized design (CRD) to find out significant difference between the treatments. Results are expressed as mean ± standard deviation. p values < 0.05 were considered as statistically insignificant.

Results and discussion

Water quality parameters

The values of three replicates of each treatment for water quality parameters during the experimental period treated with probiotic of the FRP culture tanks were found to be in the range of temperature (27.0 - 31.0 °C), pH (7.5 - 8.4), dissolved oxygen (4.7 - 7.5 mg l^{-1}), free carbon dioxide (Nil - 1.3 mg l^{-1}), total alkalinity (98.3 - 192.5 as $CaCo_3$) among dissolved nutrients nitrite-nitrogen (Nil - 0.50 mg l^{-1}), nitrate-nitrogen (0.21 - 0.5 mg l^{-1}), ammonia nitrogen (Nil - 0.06 mg l^{-1}). All the water quality parameters during the entire experimental period were found to be in the optimum range in probiotic treated FRP culture tanks than the control. (Boyd, 1982, Debnath, et al., 2007; Kumar, et al., 2010).

Growth parameters

The use of probiotic products as feed supplements has attracted considerable attention by feed manufacturer as a means of improving live stock performance. Several studies have been conducted to evaluate effects of probiotic on different fin fishes and shell fishes in commercial aquaculture. A large number of study have been conducted on Indian Major Carps like rohu *Labeo rohita* as it is one of the most demand and promising species in terms of growth and market value in aquaculture practices. However informations with particular reference to effect of meracid on fishes is not available.

In the present study the average increment in length (cm) and weight (g), specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER) and survivility of Labeo rohita fingerlings fed with different experimental diets were summarized in Table 3. Among the experimental fish the highest weight gain was recorded in treatment T2 (419.90 ±9.14 g) followed by treatments T1(349.80 ± 8.02 g) and T3 (347.90 ± 7.14 g). However the lowest weight (301.95 ± 7.21 g) being in control (T0). Final average weight gain recorded in T2 after 300 days of treatment was 425.00 ± 9.14 g whereas T1, T3 & T0 were 355.10 ± 8.21 g, 353.10 ± 7.23 g & 307.15 ± 7.52 g respectively. The highest increment

Table 3 Growth parameters of *L. rohita* fingerlings under different treatments during the experimental period August'13 - May'14 (mean ± SD)

Parameters	T-0	T-1	T-2	T-3
Initial length (cm)	6.4±0.02	6.4±0.02	6.5±0.03	6.5±0.02
Final length (cm)	22.7±0.13	28.1±0.12	31.2±0.15	26.2±0.28
Increment in length (cm)	16.30±0.12	21.50±0.13	24.74±0.14	19.60±0.28
Initial weight (g)	5.20±0.10	5.30±0.08	5.10±0.18	5.10±0.14
Final weight (g)	307.15 ±7.52	355.10±8.21	425.00±9.14	353.10±7.23
Growth Increment (g)	301.95±7.21a	349.80±8.02b	419.90±9.14c	347.90±7.14b
Daily weight gain (g)	1.0±0.02	1.16±0.01	1.39±0.03	1.15±0.01
SGR(%)	1.36±0.04a	1.40±0.06a	1.47±0.05b	1.41±0.04a
Survival (%)	90±1.75a	100±0.00b	100±0.00b	90±2.87a
FCR	3.0±0.12b	2.51±0.21a	2.65±0.19a	2.72±0.15a
PER	1.28±0.02 a	1.49±0.02bc	1.66±0.05cd	1.95±0.09 d

Values superscripts with different alphabets are significantly different.

in length was observe in T2 (24.74 ± 0.14 cm) followed by T1 (21.50 ± 0.13cm), T3 (19.60 ± 0.28cm) and lowest was found in T0 (16.30 ± 0.12cm). It clearly shows that the rohu fingerlings fed with probiotic incorporated diets grew faster than control. This is in agreement with the findings by different authors (Swain,et al., 1996; Murthy and Naik 2000; Ghosh,et al., 2002; Mohapatra,et al., 2010; Saini,et al., 2014). Singh,et al., 2014 also reported that the probiotic (problend) supplemented diet significantly increased the weight and length of catla and rohu fry. However Mohapatra,et al., (2011) studied the effect of supplementing dieatory multi species probiotic in the diet of *L. rohita* fingerlings and observed better growth response of fish fed with probiotic incorporated diets than those fed with diets without probiotic incorporation.

The values of SGR and PER was encouraging in the treatment groups than the control indicating improvement in utilization of the meracid supplemented diets by the test species *Labeo rohita* fingerlings. Bairagi,et al., (2004) fed rohu fingerlings with iso- nitrogenous protein and inoculated with fish intestinal bacteria *B. subtilis* and *B. circulans* to the experimental diet exhibited excellent growth response, feed conversion ratio, protein efficiency ratio and net protein utilization. In the present study FCR values observed were 3.0 ± 0.12 (T0), 2.51 ± 0.21 (T1), 2.65 ± 0.19 (T2) and 2.72 ± 0.15 (T3) respectively. Probiotics have been found to improve specific growth, PER, FCR in rohu fingerlings (Mohapatra,et al., 2012; Sinha and Pandey, 2013). The highest SGR was recorded in T2 (1.47 ± 0.05), T3 (1.41 ± 0.04), T1 (1.40 ± 0.06) and T0 (1.36 ± 0.04) respectively which decreased with increasing level of probiotic. Thus suggesting that the high concentration of probiotic supplemented in diets may not further promote the growth of *Labeo rohita* in this study. The overall survival percentage of rohu fingerlings were expressed 100% survivability in T2 (100 ± 0.00) followed by T1 (100 ± 0.00), T3 (90 ± 2.87) and T0 (90 ± 1.75) respectively. The results obtained are in conformity to the findings of (Singh, et al., 2014). According to Noh,et al., (1994) and Bogut,et al., (1998) observed different probiotics at different levels act differently to enhance the growth and nutrient utilization of various fish species. This in agreement with the results of the present study. Sreenivasulu,et al., (2018) reported that dietary supplementation of 'Eco-pro' probiotic resulted in better growth performance and feed utilization efficiency over the control diet fed fingerlings of rohu. The results of the present study are further supported by the work of Ghosh,et al., (2002) who on feeding rohu spawn with feed supplemented with an isolated fish intestinal probiotic, B. circulans observed direct effect on improvement in growth rate, weight gain and survivality.

Conclusion

It may be concluded that supplementation of meracid @ 1.5% in the basal diet improved growth, weight gain, SGR, FCR and PER in Labeo rohita fingerlings. As this is a preliminary study on the use of meracid in the culture of *Labeo rohita* fingerlings, the dose standardization and duration of application needs further research.

Acknowledgement

The authors are thankful to the HOD, P.G. Dept. of Zoology, Berhampur University, Bhanja Vihar and

Director, College of Fisheries, Rangeilunda, Berhampur, Odisha for providing laboratory and library facilities to carry out the present investigation.

References

Amarjit SL, Nanda S, Choudhury D, Das SS (2014): Effect of dietary probiotic supplement on growth and survival of Indian major carp seeds. AJAS9(2): 174-177

AOAC, 1995. Official methods of analysis of AOAC International. (16th Ed.) Arlington, VA, USA, Association of Analytical Communities

APHA, 1985. Standard methods for the examination of water and waste water. 16th ed. American Public Health Association, Washington, DC, 1268 pp

APHA-AWWA-WEF, 1998. Standard Methods for the Examination of Water and Wastewater, 20th edn pp, 413-426. American Public Health Association, American Water Works Association, Water Environment Federation, Washington DC

Austin B, Stuckey LF, Robertson PAW, Effendi I and Griffith DRW (1995) A probiotic strain of Vibrio alginolyticus effective in reducing diseases caused by Aeromonas salmonicida, Vibrio anguilarum and Vibrio ordalli.J. Fish Dis.,18:93-96

Bairagi A; Ghosh KS; Sen SK and Ray AK (2004) Evaluation of the nutritive value of Leucaena leucocephala leaf meal, inoculated with fish intestinal bacteria Bacillus subtilies and Bacillus circulans in formulated diets for rohu, *Labeo rohita* (Hamilton) fingerlings. Aquaculture Research, 35:436-446

Bogut I, Milakovic Z, Bukvic Z, Brkic S & Zimmer R (1998) Influence of probiotic Streptococcus faecium M74 on growth and content of intestinal micro-flora in carp *Cyprinus carpio*. Czech J. Anim.Sci.,43:231-235

Bondad Reantaso MG, Subasinghe RP, Arthur JR, Ogawa K, Chinabut S, Adlard R, Tan Z, Shariff M (2005) Disease and health management in Assian Aquaculture, Vet. Parasitol,132:249-272

BOYD CE, Water quality management for pond fish culture, 1982. Elsevier scientific publishing company, Amsterdam, Netherlands, 318

Debnath D, Pal AK, Sahu NP, Yengkokpam S, Baruah K, Choudhury D & Venkateshwarlu G (2007) Digestive enzymes and metabolic profile of *Labeo rohita* fingerlings fed diets with different crude protein levels. Comp Biochem Physiol B Biochem Mol Biol., 146:107-114

FAO, 2000. Fishery Statistics (Aquaculture production) Food and Agricultural Organization of the United Nations, Rome, 90/2:22-26, 26, 38, 114, 131

Fuller R (1987) A review: probiotics in man and animals. Journal of App. Bacteriology.,66:365-387

Gatesopupe FJ (1997) Siderophore production and probiotic effect of Vibrio sp. associated with turbot larvae, Scopthalmus maximus. Aquat. Living Res., 10:239-246

Gatesoupe FJ (1994) Lactic acid bacteria increase the resistance of turbot larvae, Scopthalmus maximus. Aquat. Living Res., 7:277-282

Gatesoupe FJ (1991) Bacillus sp A new tool against bacterial infection in turbot larvae, Scophthalmus maximus. Aquat. Living Res., 10:239-246

Ghosh K, Sen SK & Ray AK (2003) Supplementation of an isolated fish gut bacterium, Bacillus circulans, in formulated diets for rohu, *Labeo rohita*, fingerlings. Israeli J. Aquacult., 55:13-21

Ghosh K, Sen SK and Ray AK (2002) Growth and survival of Rohu, *Labeo rohita* (Hamilton) spawn fed diets supplemented with fish intestinal microflora. Acta. Icthol. Piscat., 32:83-92

Kumar V, Sahu NP, Pal AK, Kumar S, Sinha AK, Ranjan J & Baruah K (2010) Modulation of key enzymes of glycolysis, gluconeogenesis, amino acid catabolism, and TCA cycle of the tropical freshwater fish *Labeo rohita* fed gelatinized and nongelatinized starch diet. Fish Physiol. Biochem., 36:491-499

Mohapatra S, Chakraborty T, Prusty A, Das P, Paniprasad K and K Mohanta (2012) Use of different microbial probiotics in the diet of rohu, *Labeo rohita* fingerlings: effects on growth, nutrient digestibility and retention, digestive enzyme activities and intestinal microflora. Aquacult Nutr., 18:1-11

Mohapatra S, Sahu NP, Pal AK, Prusty AK, KumarV & Kumar S (2010) Haemato-immunology and histo-architectural changes in *Labeo rohita* fingerlings: effect of dietary aflatoxin and mould inhibitor. Fish Physiol. Biochem., doi: 10.1007/ s10695-010

Moriarity DJW (1998) Control of Luminous Vibriospecies in Penaeid aquaculture ponds. Aquaculture 164:351-358

Murthy HS and Naik ATR (2000) Effect of G-probiotic on growth, survival and carcass composition of Indian major carp, *Catla catla* fry. Mysore J Agric Sci., 34:78-82

Nayak SK (2010) Probiotics and immunity: a fish perspective. Fish and shell fish immunology, 29:1-2

Noh H, Han KI, Won TH & Choi YJ (1994) Effect of antibiotics, enzymes, yeast culture and probiotics on growth performance of Israeli carp. Kor. J. Anim. Sci., 36:480-486

Qizz, Zharg, XH, Boon, N. and Bossier P (2009) "Probiotics in aquaculture of China current state, problems and prospect" Aquaculture 290: 15-21

Robertson PAW, O' Dowd C, Burrells C, Williams P and Austin B (2000) Use of Carnobacterium sp. As probiotic for Atlantic salmon (*Salmo salar*) and rainbow trout (Oncorhynchus mykiss, Walbaum). Aquaculture, 185: 235-243

Sahu S, Das BK, Pradhan J, Mohapatra BC, Mishra BK, Sarangi N (2007) Effect of Magnifera indica Kernel as a feed addictive on immunity and resistance of Aeromonas hydrophylla in *Labeo rohita* fingerlings. Fish and shell fish immunology, 23:109-118

Saini VP, Ojha MC, Gupta MC, Nair P, Sharma A, Luhar V (2014) Effect of dietary probiotic on growth performance and disease resistance in *Labeo rohita* (Ham.) fingerlings. IJFAS1(6):07-11

Sinha A and Pandey PK (2013) Probiotic effect of a live bacterial isolate in nutrition of an Indian major carp, rohu (*Labeo rohita*). Indian J. Anin. Res, 47(6):509-514

Snedecor GW and Cochron GW (1968) Statistical methods. Oxford and IBH publishing company, Calcutta, W.B., India

Sreenivasulu P, Pemmineti NJ, Mohammed SA, Kothuru P (2018) Effect of water probiotic in water quality maintenance and growth of rohu (*Labeo rohita*) fingerlings. EJPMR, 5(1):280-286

Swain SK, Rangacharyulu PV, Sarkar S & Das KM (1996) Effect of a probiotic supplement on growth, nutrient utilization and carcass composition in mrigal fry. J. Aquac., 4:29-35

Tran NT, Pham MD, Kishio H (2013) Overview of the use of probiotics in aquaculture. IJRFA, 3(3), 89-97

Effect of phenol and sulphide on the reproduction of sexually maturing riverine cat fish *Rita rita* (Hamilton)

Manas Kumar Das · Srikanta Samanta · Keya Saha · Sanjoy Bhowmick
P. K. Srivastava · S. Bandopadhyay

Received: 09 February 2018 / Accepted: 12 December 2018
J. Inland Fish. Soc. India, **50** (2), 2018

Abstract Sexually maturing riverine cat fish *Rita rita* were treated with sub-lethal levels of phenol and sulphide for 30 days to identify their effects on the gonadosomatic index (GSI), hepatosomatic index (HSI), cholesterol levels in the ovary and liver, and plasma 17 β-estradiol levels. Both the contaminants significantly decreased the GSI, size of the oocytes and the plasma 17 β-estradiol levels. Whereas a significant increase in the HSI and the cholesterol levels of the ovary and liver was evident. The increase in the levels of ovarian and hepatic cholesterol and the decrease in plasma 17 β-estradiol and GSI indicate impaired steroidogenesis and ovarian maturation in the exposed fish.

Keywords Phenol, sulphide, reproduction, cholesterol, 17 β-estradiol, gonadosomatic index

Introduction

In recent time, pollution of the rivers from industrial discharges has increased significantly, impacting fish, an important protein food of the country. The adverse effects of the aquatic pollutants are manifested by frequent fish mortality, morbidity and decline of fish population in the rivers. In a polluted aquatic environment fish accumulate pollutants in their vital organs like liver, kidney and gonads and the deleterious effects are manifested on the growth and reproduction of fish(Mtra et al 2018, Samanta 2013). Fish being seasonal breeders, any change in the homeostasis of the steroid hormones by pollutants lead to disruption of the reproductive efficiency of the fish and consequent depletion in their population in the long run (Kime 1998). In the last two decades, information has been generated on the effects of various heavy metals, pesticides and industrial contaminants on the morphological and hormonal alterations in the gonads and blood of fish. Morphological dysfunction in oocyte development of fish due to arsenic, mercuric chloride, DDT, endosulfan, textile and vegetable mill effluents, phenol and sulphide from paper and jute mill effluents has been reported by several investigators (Ram and Sathyanesan 1983; Saxena and Bhatia 1983; Kulshrestha and Arora 1984; Shukla and Pandey 1984; Kumar and Mukherjee 1988; Rastogi and Kulshrestha 1990; Murugesan and Haniffa 1992; Mohanty et al. 2015). A number of researcher studied the effects of pollutants on steroidogenesis in fish (Shukla and Pandey 1985; Singh and Singh 1987a, 1987b; Mukherjee et al., 1991; Singh and Singh 1991, 1992; Choudhury et al., 1993; Singh et al., 1993). Phenol and sulphide contamination in riverine waters due to domestic sewage and industrial effluents of coal refineries, petrochemicals, pharmaceuticals, leather and pulp and paper mills are very common in India (Ying et al., 2002; Jansen et al., 2009; Sai Kiran et al., 2016). However, limited information is available on the effect of these common pollutants on the reproductive physiology of riverine fishes in India. The present study was

M.K. Das(✉) S. Samanta · K. Saha · S. Bhowmick · P. K. Srivastava · S. Bandopadhyay
ICAR - Central Inland Fisheries Research Institute, Barrackpore, Kolkata - 700120, India
e-mail: mkdas412@rediffmail.com

undertaken to evaluate the effects of sub-lethal toxicity of phenol and sulphide on the ovarian morphology and steroidogenesis in the riverine catfish *Rita rita* (Hamilton), an excellent reference fish for health assessment in Indian rivers.

Material and methods

Maturing *Rita rita* of average length and weight range (133-145 mm and 29-34 g) were collected in May, the breeding season of the fish from River Hooghly. The fishes were acclimatized in the laboratory for one month in fiberglass tanks (500 l) containing chlorine free tap water at a stocking density of 0.4 g/l with continuous aeration at 12 h light and 12 h darkness. The water quality conditions were pH (7.7-7.8), temperature (27-29 ^{O}C), alkalinity (136-160 mg l^{-1}) and hardness (170-190 mg l^{-1}). Water quality parameters were checked by the methods given in APHA (1995). Fish were fed *ad libitum* with tubifex worms. Water was changed daily and excretory products siphoned out. After acclimatization for 1 month, 180 healthy fishes were selected and were divided into 3 groups, each group consisted of 60 fishes. The doses of phenol and sulphide selected for exposure were sub-lethal at levels of 1/50th of LC_{50}.

Group1 - Control fishes were kept in fibreglass tanks @ 30 fish in 450 l of chlorine free tap water in duplicate.

Group 2- Fish were exposed to 1 mg l^{-1} of sulphide in two fibreglass tanks containing 30 fish in each tank. Required sulphide concentration was achieved by adding sodium sulphide (Purified reagent grade of Merck India Ltd.).

Group 3 - Fish were exposed to 3 mg l^{-1} of phenol in two fibreglass tanks containing 30 fish in each tank. Required concentration of phenol was achieved by adding phenol (analytical reagent grade of Merck India Ltd.) in chlorine free tap water.

Phenol was measured by visible spectrophotometric method and total sulphide was estimated by the iodometric method (APHA 1995). Water was changed regularly in control and experimental tanks and chemical solutions were added to maintain specific concentrations of the pollutants. Continuous aeration was given. Fish of both control and experimental tanks were fed *ad libitum* with tubifex worms but were fasted 24 h prior to their sampling.

Blood and Tissue sampling

R. rita fish samples from each group were sacrificed on 0, 7, 14, 21 and 30th day of the experiment. To obtain blood, *R. rita* were netted gently and rapidly anaesthetized using MS222 (ethyl m-amino-benzoate methane sulphonate) at the dose of 69 mg l^{-1} and the fishes were immobilized within 1 min. of application of the reagent (Das et al. 2002). Blood was collected by severing the caudal peduncle and pooled sample was processed further. Heparin was used as an anticoagulant @ 1 mg ml^{-1} of blood (Smitt and Hattingh 1980). Immediately after collection blood was centrifuged at 3000 rpm for 5 minute in cold. The plasma separated out was either used for analysis immediately or stored at -20ºC for later analysis. Sampling procedure of netting, anaesthesia and plasma storing was completed within 10 minute to avoid any changes in the cholesterol level due to handling and use of anesthesia (Tanck et al. 2000; Acharya et al. 2005). The liver and ovary cholesterol were assessed as per the procedures given by Wedmeyer and Yasutake (1977). 17β-Estradiol is the steroid hormone that regulates the development of vitellogenic oocytes in fish. Plasma 17β- Estradiol and cortisol were measured by a direct immunoenzymatic determination kit manufactured by Equipar srl via G. Ferrani, 21/N/21047, Saronno (Va), Italy using 96 well microlitre plate read technique by ELISA. After particular periods of exposure (0, 7, 14, 21, 30 days) the fishes were sacrificed and the liver and ovaries were collected for processing. Gonadosomatic index (GSI) and Hepatosomatic index (HSI) were calculated according to standard formula (Alam et al., 2015). The changes in the diameter of ovarian oocytes were recorded by measuring it in control and treated (phenol/sulphide) fishes.

Data obtained are presented as mean ± SE. Student 't' was used to compare mean value of parameters of treated fish with the control at respective periods (Senecdor and Cochran 1971). The probability level at $P< 0.05$, $P< 0.01$ were considered statistically significant.

Results

Exposure of *R. rita* to sub-lethal doses of phenol (3 mg l^{-1}) and sulphide (1 mg l^{-1}) for 30 days caused a gradual reduction in GSI compared to the control group (Fig. 1). In both treatments the GSI decreased significantly within 30 days of exposure compared to

Table 1 Changes in average diameter (in μm) of oocytes in phenol and sulphide exposed ovary with respect to control *Rita rita*

Exposure Time (Day)	Control		Phenol 3 mg l^{-1}		Sulphide 1 mg l^{-1}	
	Range	Mean ± S.E.	Range	Mean ± S.E.	Range	Mean ± S.E.
0	103.0 - 144.2	123.6 ± 6.4	103.0 - 144.2	124.6 ± 6.1	103.0 - 144.2	124.6 ± 6.1
7	103.0 - 154.5	120.0 ± 7.1	113.3 - 123.6	122.1 ± 1.7	118.5 - 133.9	127.7 ± 2.5
14	103.0 - 154.5	123.6 ± 8.0	103.0 - 122.5	118.0 ± 3.1**	113.3 - 144.2	129.8 ± 4.0
21	103.0 - 185.4	144.2 ± 10.8	93.7 - 113.3	109.0 ± 4.9*	103.0 - 144.2	119.0 ± 3.7
30	123.6 - 164.8	147.3 ± 7.5	82.4 - 123.0	101.0 ± 6.4**	82.4 - 144.2	112.0 ± 3.8*

*P<0.05; **P<0.01

control (P < 0.01). The HSI values of both phenol and sulphide-treated fish, on the other hand, increased significantly (P <0.05, <0.01) over a period of 30 days (Fig. 2). Significant decrease in the average diameter of oocytes was evident in the phenol (P<0.01) and sulphide exposed fish (P<0.05) compared to control (Table 1).

The ovary and liver cholesterol concentrations in both phenol and sulphide exposed fish increased significantly (P<0.01) during 30 days compared to control (Fig. 3 & 4). Whereas the plasma levels of the steroid hormone 17β- estradiol decreased significantly (P<0.01) during 30 days in both phenol and sulphide exposed fish (Fig.5). The plasma cortisol levels however showed an increase (P< 0.05) from its initial values in the sulphide treated fish (Fig. 6).

Discussion

It is evident that exposure to both phenol and sulphide at sub-lethal levels reduced the GSI of maturing female *Rita rita* within a duration of 30 days. Simultaneously the average diameter of the gonadal oocytes also decreased significantly resulting in increased interfollicular spaces. Similar decrease in the number and diameter of maturing oocytes was recorded in *Anabas testudineus* exposed to nonlethal concentrations of methyl parathion (Metacid-50), $CdCl_2$ and $HgCl_2$ for 90 days (Bandyopadhyay and Aditya 1998). The manifestation of the morphological damage indicated an impairment of the maturing oocytes in the C stage to incorporate yolk protein vitellogenin. The HSI on the contrary increased during the period indicating impairment of metabolic function of the liver of exposed fish. The observations are in agreement to that of Kumar and Mukherjee (1988), Mukherjee et al. (1991) where a similar response in the GSI and HSI of *Cyprinus carpio* exposed to sub-lethal concentrations of phenol and sulphide were recorded. Such ovarian dysfunction is indicative of liver malfunction and possible failure as opined by Kime (1998) due to depleted production of estradiol by ovarian follicle or a failure to incorporate vitellogenin produced by oocytes.

An increase in ovarian and liver cholesterol in both phenol and sulphide exposed fish compared to control indicate an impairment of vitellogenesis. A number of investigators described the role of cholesterol being a precursor for steroidogenesis (Jayshree and Srinivasachar 1979; Mukherjee et al.(1991) using [4-14C] cholesterol as tracer in *C. carpio* exposure to sub-lethal phenol and sulphide recorded an inhibitory effect on the conversion of radio-labelled cholesterol to steroidal products. Several earlier workers observed accumulation of ovarian cholesterol and reduced serum gonadotrophin levels in pesticide exposed fish suggesting impaired ovarian maturation (Kapur et al. 1978; Singh and Singh 1980, 1981; Ghosh et al. 1990). In the present experiment the accumulation of hepatic and ovarian cholesterol concomitant with the decrease of GSI and increase in HSI is suggestive of imbalance in gonadotropin control. This is evidenced by the significant decrease in the plasma 17β- estradiol levels in the pollutant exposed fish compared to control. Normally in female fish the plasma estradiol concentration increase during the vitellogenic phase of oocyte development and then decline as oocytes complete vitellogenesis. Estradiol plays a significant role to produce yolk protein, vitellogenin which is incorporated into developing oocytes thereby increasing gonadal weight during recrudescence. A number of studies have correlated a decreased GSI to low vitellogenin production as a response to the exposure to xenobiotics (Murphy et al., 2005; Arukwe and Goksoyr 1998). In the present experiment the plasma cortisol levels showed an increasing trend indicating a possible stress effect especially in the sulphide exposed fish. Stress as a factor to have an inhibitory effect on reproduction of fish probably acting via

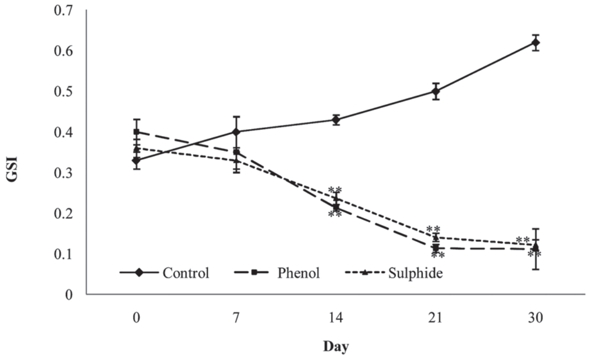


Fig. 1 Changes in the Gonadosomatic index of *Rita rita* exposed to 3 mg l^{-1} phenol and 1 mg l^{-1} sulphide, (Significant *$p<0.05$, **$p<0.01$)

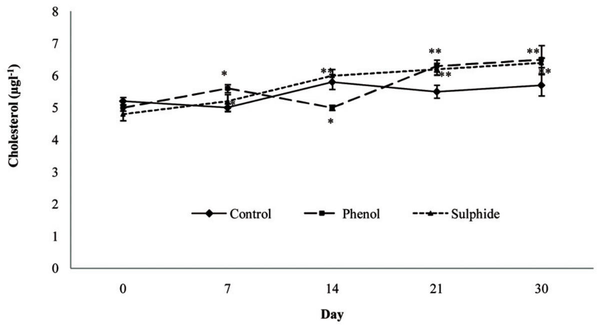


Fig. 4 Changes in liver cholesterol content of *Rita rita* exposed to 3 mg l^{-1} phenol and 1 mg l^{-1} sulphide. (Significant *$p<0.05$, **$p<0.01$)

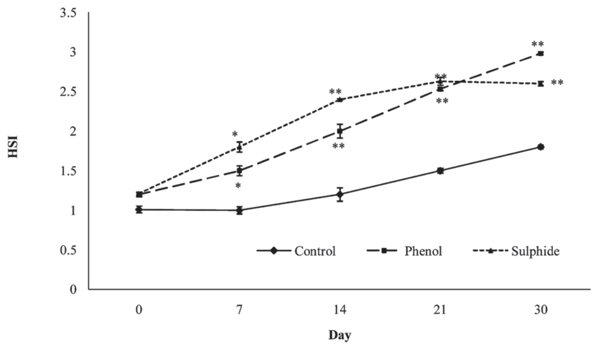


Fig. 2 Changes in the Hepatosomatic index of *Rita rita* exposed to 3 mg l^{-1} phenol and 1 mg l^{-1} sulphide. (Significant *$p<0.05$, **$p<0.01$)

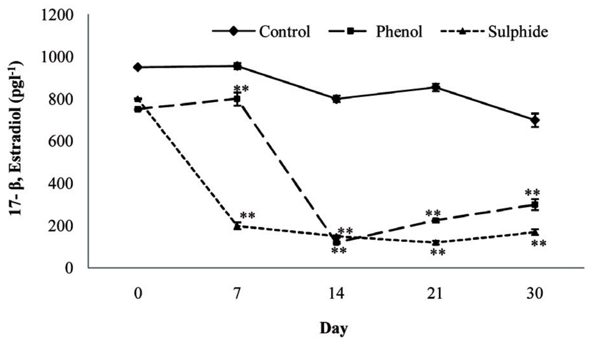


Fig. 5 Changes in plasma 17 β- Estradiol content of *Rita rita* exposed to 3 mg l^{-1} phenol and 1 mg l^{-1} sulphide. (Significant *$p<0.05$, **$p<0.01$).

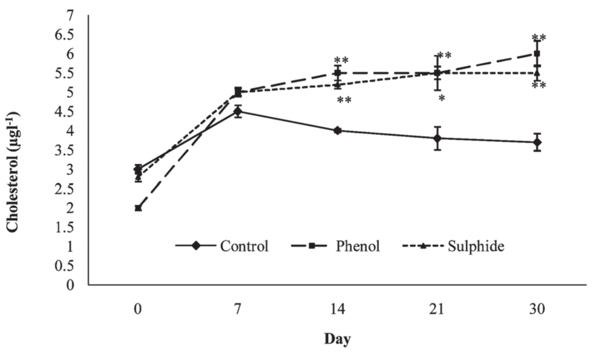


Fig. 3 Changes in the ovary cholesterol of *Rita rita* exposed to 3 mg l^{-1} phenol and 1 mg l^{-1} sulphide. (Significant *$p<0.05$, **$p<0.01$).

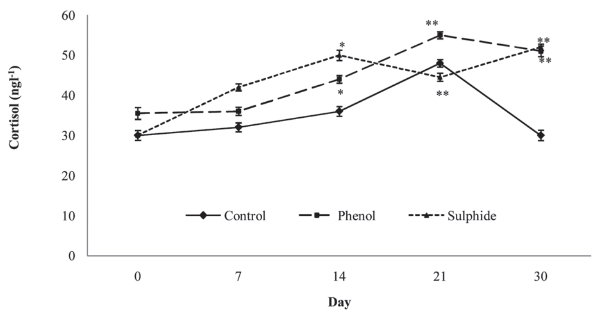


Fig. 6 Changes in plasma cortisol of *Rita rita* exposed to 3mg l^{-1} phenol and 1 mg l^{-1} sulphide. (Significant *$p<0.05$, **$p<0.01$)

adrenocorticotrophin (ACTH) or cortisol secreted by the internal glands of fish has been emphasized by several investigators (Kime et al. 1980; Campbell et al. 1992, 1994). Mediation of the pituitary and hypothalamic hormones in affecting gonadal functions of pesticide treated *Channa punctatus* have been clearly established by earlier investigators (Ghosh et al. 1990; Choudhury et al. 1993), but Kime (1998) cautioned that a comparative assessment of data obtained from the sub-lethal exposure to pollutants and depression of steroids with the results obtained from other forms of stress should be done. Bhattacharya (2000) is of the opinion that though cortisol is a major corticosteroid in many teleosts but there are few reports on its profile during steroidogenesis in fish under xenobiotic stress. The cortisol levels obtained in the present study do not indicate a significant change in the cortisol values creating stress and cannot be specifically correlated to gonadal impairment.

Conclusion It is concluded that apparently safe doses (1/50 LC_{50}) of phenol and sulphide in the aquatic ecosystem are potent endocrine disrupters and interferes with the reproductive competence of fish. The experiment also indicates that plasma 17β-estradiol can be a useful indicator for monitoring health of riverine fish population along with other bio-indicators of fish.

Acknowledgement The authors are thankful to the Director, ICAR-CIFRI, Barrackpore for research facilities and advice.

References

Acharya S, Dutta T, Das MK (2005) Effect of sublethal levels of nitrite on some blood parameters of juvenile *Labeo rohita* (Hamilton-Buchanan), Indian J Exp Biol 43:450-454

Alam A, Chadha NK, Chakraborty SK, Sawant PB, Kumar T and Sharma AP (2015) Maturation profile and fecundity of the exotic *Oreochromis nilotica* in the river Yamuna, India. J Environ Biol 36: 927-931

APHA (1995) Standard methods for the examination of water and wastewater. (American Public Health Association, American Water Works Association and Water Environment Federation. Washington DC)

Arukwe A and Goksoyr A (1998) Xenobiotics, xenoestrogens and reproduction disturbance in fish. Sarsia 83:225-241

Bandyopadhyay MP, Aditya AK (1998) Chemical Induced Changes in Percentage and Sizes of Diameter in the Ovarian Oocytes of *Anabas testudineus* (Bloch). J Freshwater Biol 10(1-2):75-82

Bhattacharya, S (2000) Signal transduction by xenobiotics in fish. Indian J Exp Biol 38:753-761

Campbell PM, Pottinger TG, Sumpter JP (1992) Stress reduces the quality of gametes produced by rainbow trout. Biol Reprod 47:1140-1151

Campbell PM, Pottinger TG, Sumpter JP (1994) Preliminary evidence that chronic confinement stress reduces the quality of gametes produced by brown and rainbow trout. Aquacult 120:151-169

Choudhury C, Ray AK, Bhattacharya S, Bhattacharya S (1993) Non-lethal concentrations of pesticide impair ovarian function in freshwater perch, *Anabas testudineus*. Env Biol Fishes 36:319-324

Das MK, Dutta T, Acharya S, Bhowmick S (2002) Sublethal temperature stress in juvenile *Labeo rohita* (Ham.-Buch.) and *Rita rita* (Ham.): Some physiological changes. Indian J Exp Biol 40:589-593

Ghosh P, Bhattacharya S, Bhattacharya S (1990) Impairment of the regulation of gonadal function in *Channa punctatus* by Metacid-50 and Carbaryl under laboratory and field conditions. Biomed Env Sci 3:106-112

Janssen AJ, Lens PN, Stams AJ, Plugge CM, Sorokin DY, Muyzer G, Dijkman H, Van Zessen E, Luimes P, Buisman CJ (2009) Application of bacteria involved in the biological sulfur cycle for paper mill effluent purification. Sci Total Environ 407:1333-1343

Jayshree R, Srinivasachar HR (1979) Hormonal control of testicular cholesterol levels in the catfish, *Clarias batrachus* (Linn.) - Siluroidea. Proc Indian Natt Sci Acad 45B(5):526-533

Kapur K, Kaur K, Toor HS (1978) The effect of Fenitrothion on reproduction of a teleost fish, *Cyprinus carpio* communis (Linn.): a biochemical study. Bull Env Contam Toxicol, 20:438-442

Kime DE (1998) Endocrine disruption in Fish. (Kluwer Academic Publishers) 395

Kime DE, Vinson GP, Mayor WP, Kilpatrick R (1980) Adrenal-gonad relationships, in general, comparative and clinical endrocrinology of the adrenal cortex. (Academic Press, London) 183

Kulshrestha SK, Arora N (1984) Impairment induced by sub-lethal doses of two pesticides in the ovaries of a freshwater teleost Channa striatus (Bloch). Toxicol Lett 20:93-98

Kumar V, Mukherjee D (1988) Phenol and sulfide induced changes in the ovary and liver of sexually maturing common carp, *Cyprinus carpio*. Aquatic Toxicol 13:53-60

Mitra T, Mahanty A, Ganguly S, Purohit GK, Mohanty S, Parida PK, Behera PR, Raman RK, Mohanty BP2018. Expression patterns of heat shock protein genes in *Rita rita* from natural riverine habitat as biomarker response against environmental pollution. Chemosphere; 211:535-546

Mohanty BP, Banerjee S, Sadhukhan P, Chaudhury AN, Goldar D, Bhattacharjee S, Bhowmick S, Manna SK, Samanta S (2015). Pathophysiological changes in Rohu (*Labeo rohita*, Hamilton) fingerlings following arsenic exposure. Nat Acad Sci Let 315 - 319

Mukherjee D, Bhattacharya S, Kumar V, Moitra J (1990) Biological significance of (14C)- phenol accumulation in different organs of a murrel *Channa punctatus*, and the common carp, *Cyprinus carpio*. Biomed Environ Sci 3:337-342

Mukherjee D, Guha D, Kumar D, Chakrabarty S (1991) Impairment of steroidogenesis and reproduction in sexually mature *Cyprinus carpio* by phenol and sulfide under laboratory conditions. Aquat Toxicol 21(1-2): 29-39

Murphy CA, Rose KA, Thomas P (2005) Modelling vitellogenesis in female fish exposed to environmental stressors: predicting the effects of endocrine disturbance due to exposure to a PCB mixture and cadmium. Reprod Toxicol 19:395-409

Murugesan AG, Haniffa MA (1992) Histopathological and histochemical changes in the oocytes of the air breathing fish Heteropneustes fossilizes (Bloach) exposed to textile mill effluent. Bull Environ Contam Toxicol 48:929-936

Ram RJ, Sathyanesan AG (1983) Effect of mercuric chloride on the reproductive cycle of the teleostan fish *Channa punctatus*. Bull Environ Contam Toxicol 30:24-27

Rastogi A, Kulshrestha SK (1990) Effect of sublethal doses of three pesticides on the ovary of a carp minnow *Rasbora daniconius*. Bull Environ Contam Toxicol 45:742-747

Samanta S (2013) Metal and pesticide pollution scenario in Ganga River system.Aquatic Ecosystem Health and Management.16 (4):454-464

Sai Kiran TJ, Bhaskar KJCS, Siva Reddy G (2016) Adsorption of phenolic compounds from industrial effluent by activated carbon. J Pharm Sci Res. 8(5):333-337

Saxena PK, Bhatia R (1983) Effect of vegetable oil factory effluent on ovarian recrudescence in the freshwater teleost *Channa punctatus* (Bl). Water Air Soil Poll 20:55-61

Senecdor GW, Cochran (1971) Statistical methods. (Iowa State University Press, Ames.) 593

Shukla JP, Pandey K (1984) Arsenic induced structural changes during the ovarian cycle of freshwater perch, *Colisa fasciatus* (Bloch and Schneider). Bull. Inst. Zool Acad Sinica, 23:69-74

Shukla JP, Pandey K (1985) Ovarian recrudesces in a freshwater teleost *Sarotherodon mossambicus* in DDT treatment and pattern of recoupment. J Environ Biol 6:195-204

Singh H, Singh TP (1980) Short term effect of two pesticides on lipid and cholesterol content of liver, ovary and blood serum during the pre-spawning phase in the freshwater teleost *Heteropneustes fossilis* (Bloch). Environ Poll (Series A) 2285-2290

Singh H, Singh TP (1981) Effect of parathion and aldrin on survival, ovarian 12 P uptake and gonadotropic potency in fresh water catfish *Heteropneustes fossilis* (Bloch). Endokrhinology 77:173 -178

Singh PB, Kime DE, Singh TP (1993) Modulatory actions of *Mystus gonadotropin* on β-BHC induced histological, cholesterol, and sex steroids levels in Heteropneustes fossilis. Ecotoxicol Environ Safety 25:141-153

Singh PB, Singh TP (1991) Impact of γ-BHC on sex steroid levels their modulation by ovine lutenising hormone releasing hormone and Mystus gonadotropin in the freshwater catfish *Heteropneustes fossilis*. Aquat Toxicol 21:93-102

Singh PB, Singh TP (1992) Impact of γ-BHC on lipid class levels and their modulation by reproductive hormones in the freshwater catfish, *Heteropneustes fossilis*. Bull Environ Contam Toxicol 48:23-30

Singh S, Singh TP (1987a) Evaluation of toxicity limit and sex hormone production in response to Cythion and BHC in the vittelogenic catfish *Clarius batrachus*. Environ Res 42:482-488

Singh S, Singh TP (1987b) Impact of Malathion and Hexachlorocyclohexane on plasma profiles of three sex hormones during different phases of the reproductive cycle in *Clarius batrachus*. Pesticide Biochem Physiol 27:301-308

Smit GL and Hattingh J (1980) Haematological assessment of generally used fresh water fish blood anticoagulants. J Fish Biol 17:337-341

Tanck MWT, Booms GHR, Eding EH, Bonga SEW, Momen J (2000) Cold shocks; a stressor for common carp. J Fish Biol 57:881 - 883

Wedemeyer GA, Yasutake WT (1977) Clinical methods for assessment of the effects of environmental stress on fish health. In: Technical papers of the U.S. Fish and wildlife services, (Eds. Wede-meyer GA & Yasutake WT), 1- 18

Ying G, Williams B, Kookana R (2002) Environmental fate of alkylphenols and alkylphenolethoxylates - a review. Environ Int 28(3):215-226

Optimization of stocking density for successful larval rearing of *Labeo dyocheilus* in coldwater condition

Monika Gupta · N. N. Pandey · V. K. Tiwari · Raghabendra Singh · Chandra Prakash · C. S. Chaturvedi

Received: 13 June 2018 / Accepted: 12 November 2018
J. Inland Fish. Soc. India, **50** (2), 2018

Abstract An attempt was taken to find out the optimum stocking density of the *Labeo dyocheilus* larvae for better recovery of fry in terms of survival and growth at different stocking densities i.e. 1, 2, 3, 4 larvae L^{-1} each with three replicates. Larvae were stocked in plastic tubs having average length of 4.3 ± 0.10 mm and weight of 0.007 ± 0.01 g. Growth performance of fish larvae was significantly affected by the stocking density and found maximum with lower socking density and minimum with higher stocking density. Optimum stocking density of *L. dyocheilus* for larval rearing was found 2 larvae L^{-1}. It may be advantageous to maintain healthy seed for the successful larval rearing for the mass seed production that could be used for wild stock augmentation in the natural resources and for aquaculture of this species in hills.

Keywords Stocking density, polylined tank, larval rearing, stock augmentation

Introduction

Labeo dyocheilus commonly known as Kali, are highly valued species that is widely distributed all along foot hill regions of Himalayan ranges of India, Pakistan, Bangladesh, Nepal, Myanmar and China (Talwar and Jhingran, 1991). In natural condition, this is an important species of fish biodiversity in the cold water resources but it occurrence and population is getting affected regularly due to anthropogenic activities and it has been categorized as threatened (Desai, 1994) and vulnerable (Dubey, 1994; Mahanta *et al*., 1994; Prasad, 1994). Hence, advanced sized seed is the prime requirement for the stock augmentation in natural water resources. On the other hand, *L. dyocheilus* can emerge as an important candidate species with regards to diversification of cold water aquaculture as well as mixed carp farming in mid altitudinal area, as this species has got high consumer preference and high selling price. For this purpose, seed of this species is basic requirement. Sarkar *et al*., 2001 succeed in breeding of this species in natural environment. Singh *et al*., 2008 observed normal ovarian development of *L. dyocheilus* under captivity in Tarai region of Uttarakhand, which indicates the possibility to breed the species under captivity. Possibility of breeding of this species in cold water condition under captivity was confirmed by Gupta *et al.,* 2013. Successful induced breeding (Pandey *et al.,* 2011 and Gupta, 2014) and incubation of eggs (Gupta *et al.,* 2013) of *L. dyocheilus* in cold water condition has been achieved. Still successful larval rearing of the species is the demand of time for the mass seed production there by stock augmentation in natural water body.

For successful larval rearing, stocking density is an important factor as it affects growth and survival, and

M. Gupta(✉) · N. N. Pandey · V. K. Tiwari · Raghavendra Singh · Chandra Prakash · C. S. Chaturvedi
ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata
ICAR-Directorate of Coldwater Fisheries Research, Bhimtal-263136, Nainital, Uttarakhand
ICAR-Central Institute of Fisheries Education, Mumbai-400061, Maharashtra
e-mail: monika_gupta22@yahoo.com

ultimately seed production. Variation in stocking density of fish may change growth and survival rate (Miao, 1992). Fish larvae have slow growing and low survival rate at high stocking density (Huang and Chiu, 1997). Therefore, it is necessary to predetermine and optimize stocking density to produce the healthy seed in mass quantity. The Positive or negative impact of stocking density on growth and survival have been assessed in many fishes (Sharma and Chakrabarti, 2003; Aminur *et al*., 2005; Biswas *et al*., 2006; Gholipour *et al*., 2007; Merino *et al*., 2007; Imanpoor *et al*., 2009; Sahoo *et al*., 2010; Ebrahimi *et al*., 2010; Khatune *et al*., 2012; Elaheh *et al*., 2013). Currently, information of optimum stocking density of larvae of *L. dyocheilus* for rearing is lacking.

Keeping the above facts in mind, the present study was undertaken to standardize the suitable stocking density of *L. dyocheilus* larvae in coldwater conditions. Survival of larvae and growth related data like length gain, weight gain, specific growth rate (SGR) and percent weight gain were studied to find out the optimum stocking density for successful larval rearing of this species in hill region.

Material and methods

The experiment was conducted at farm of ICAR-Directorate of Coldwater Fisheries Research, Bhimtal (29.3461° N, 79.5519° E, Altitude 1370 m msl). For the procurement of seed, fishes were induced to breed during first week of July as per the method described by Pandey *et al*., 2011 and Gupta, 2014. Total 20 larvae of *L. dyocheilus* were taken in triplicate after four days of hatching for taking the initial length and weight. The initial length of larvae was recorded under a compound microscope using an ocular micrometer to the nearest half millimeter and wet weight by using an electronic digital balance. For optimizing the stocking density during nursery phase, four days old spawn having average initial length and average initial weight 4.3 ± 0.10 mm and of 0.007 ± 0.01 g, respectively were stocked in plastic tubs having 100 l water holding capacity in four different stocking densities for a period of eight weeks from second week of July to first week of September. Four stocking densities 1, 2, 3 and 4 number L-1 were assigned as four treatments; S1, S2, S3 and S4, respectively. Triplicates were maintained for every treatment. During the experimentation period, spawns were provided with powdered conventional diet (mixture of rice bran and ground nut oil cake in the ratio of 1:1) twice daily at 07.00 and 17.00 hrs at 400% of total body weight of spawn for the first 3 weeks and 800% of body weight for the subsequent period of experimentation (Jena and Das, 2011). Left over feed and faecal matter was siphoned out daily.10% water was exchanged daily to maintain the water quality parameters in optimum range.

Sampling was done at every 7 days interval. Ten larvae were randomly collected from each tank to take the length and weight data to estimate the best growth and survival for optimizing stocking density.

The following formulae were used to determine the different growth parameters in each experiment.
1) Length gain of larvae (mm) = Average final length of larvae - average initial length of larvae.
2) Weight gain of larvae (g) = Average final weight of larvae - average initial weight of larvae.
3) Percent gain in length = Average final length of larvae - average initial length of larvae/ Average initial weight × 100
4) Percent gain in weight = Average final weight - average initial weight /Average initial weight × 100
5) Specific growth rate (SGR) = lnW2 - lnW1/ T2 - T1 × 100
Where,
W2 = Final live body weight (g) at time T2
W1 = Initial live body weight (g) at time T1
6) Survival rate = No. of larvae alive /Total number of stocked×100
During the experimental period following water quality parameters like temperature (^{o}C), pH, dissolved oxygen (ppm) and ammonia content of rearing water were also recorded weekly according to the method described by APHA (2005).

Microsoft Excel was used for statistical calculation and difference between the means was examined using one-way analysis of variance (ANOVA) and Duncan's multiple range test.

Result and discussion

Growth performance and survival of fish larvae of different stocking density are presented in the Table 1. The initial average length and weight of the larvae were

Table 1 Growth performance of *Labeo dyocheilus* larvae of different stocking density treatments (mean ± SD)

Treatment Parameter	S1	S2	S3	S4
Initial length (mm)	4.30±0.02a	4.30±0.02a	4.30±0.02a	4.30±0.02a
Final length (mm)	34.70±1.70a	33.40±2.10a	25.20±1.40b	22.10±1.20c
Length gain (mm)	30.4±1.1a	29.1±1.3a	20.9±1.1b	17.8±1.2c
Percent length gain	706.97±20.18a	676.74±17.83a	486.04±24.53ab	413.95±19.76b
Initial weight (g)	0.007±0.01a	0.007±0.01a	0.007±0.01a	0.007±0.01a
Final weight(g)	0.506±0.05a	0.481±0.03a	0.317±0.04b	0.172±0.03c
Weight gain(g)	0.499±0.01a	0.474±0.02a	0.310±0.01b	0.165±0.01c
Percent weight gain	7128.57±119.47a	6771.42±127.27a	4428.57±124.29b	2357.14±137.68c
Specific growth rate(% per day)	7.017±0.09a	6.934±0.07a	6.25±0.09ab	5.248±0.05b
Survival (%)	62±4.47a	61±5.29a	43±4.57b	34±6.41c

Values with different superscripts in a row are significantly different (one way ANOVA P < 0.05).

Table 2 Average value of water quality parameters in different stocking density treatments

Treatment Parameter	S1	S2	S3	S4
Water temperature (^{o}C)	23.10±0.49	23.10±0.49	23.10±0.48	23.15±0.50
pH	7.63±0.05	7.62±0.04	7.58±0.06	7.54±0.07
Dissolved Oxygen(mg L^{-1})	8.13±0.03	8.12±0.04	8.06±0.09	8.01±0.09
Free CO2 (mg L^{-1})	1.39±0.15	1.44±0.15	1.57±0.22	1.63±0.24
Alkalinity (mg L^{-1})	60.5±2.87	62.25±2.82	63.1±1.90	63.6±2.13
Ammonia -N (mg L^{-1})	0.031±0.006	0.031±0.006	0.033±0.007	0.035±0.009
Nitrite-N (mg L^{-1})	0.13±0.006	0.13±0.014	0.15±0.019	0.16±0.02
Nitrate-N (mg L^{-1})	0.133±0.008	0.141±0.01	0.150±0.007	0.152±0.007

4.30±0.02mm and 0.007±0.01 g respectively for all treatments. At the end of the experiment, the final average length of the larvae of treatment S1, S2, S3 and S4 were 34.70±1.70mm, 33.40±2., 25.20±1.4 and 22.10±1.20 mm while the final average weight were 0.506±0.05, 0.481±0.03, 0.317±0.04 and 0.172±0.03g respectively. The length gain and weight gain were found maximum (30.4±1.1mm, 0.499±0.01g) in treatment S1 followed by S2 (29.1±1.3 mm, 0.474±0.02g) and no significant difference was observed between these two treatments (P>0.05).

The length gain and weight gain in treatment S3 was 20.9±1.1 mm and 0.31±0.01 g while for S4 these parameters were recorded 17.8±1.2 mm and 0.165±0.01 g, respectively and a significant difference (P<0.05) was observed among treatment S2, S3 and S4. Minimum length gain and weight gain were observed in S4 which were significantly (P<0.05) lower than that of all other treatments. Similarly, the highest percent length gain and weight gain of the larvae was observed in treatment S1 which was not significantly (P>0.05) higher than those of S2 but a significant difference (P<0.05) was observed when compared with S3 and S4. After completion of the experiment, the highest specific growth rate found was 7.017±0.09% shown by the larvae of treatment S1 followed by S2 but statistically the difference was not significant (P>0.05). The specific growth rate of the larvae of S4 was significantly lower (P<0.05) than that of other treatments. There are no previous studies comparing the effects of *L. dyocheilus* larval density on its growth and survival. However, similar trends were also reported in decreasing growth of tilapia *Oreochromis niloticus* (Suresh and Lin, 1992); *Ictalurus punctatus* (Gatlin et al., 1986); *Clarias batrachus* (Sahoo et al., 2004) and *Horabagrus brachysoma* (Sahoo et al., 2010) with increasing stocking density. This observation indicated that growth performance of fish larvae was significantly affected by the stocking density and found maximum with lower stocking density and minimum with higher stocking density. Several studies have also demonstrated that increased stocking density has a negative effect on survival and growth (Huang and Chiu, 1997; Imsland et al., 2003; Irwin et al., 1999; Rowland et al., 2004; Schram et al., 2006; Rahman et al., 2008). This finding is supported by Yousif (2002), who reported that it is generally accepted principle, that increasing the number of fish will adversely affect the fish growth.

Aksunger et al., 2007 explained that, higher stocking densities leads to increased stress and that resulting increase in energy requirements causing a reduction in growth rates. The survival rates in S1 S2, S3 and S4 were found 62±4.47%, 61±5.29% 43±4.57 and 34±6.41% respectively in which S_1 and S_2 were not significantly different (P>0.05), where as S_2, S_3 and S_4 were statistically different (P<0.05). Osofero et al., 2009 found out an inverse relationship between survival rate and stocking density. Our findings are also supported by Jamabo and Keremah, 2009 who reported that survival, mean body weight, mean total length, and specific growth rate were stocking dependent and found best in lower stocking density. Giant gourami (*Osphronemus goramy*) showed that potential density had no significant effect on the growth indices of fish (Ebrahimi et al., 2010). On the contrary, our finding does not supported Alhassan et al., 2012 who reported specific growth rate and survival rates were not affected by different stocking densities in rearing of *Oreochromis niloticus*. Osofero et al., 2009 who reported increase fish production with increased stocking density, attributed to good feed quality and favorable physico-chemical conditions.

The recorded water quality parameters (Table 2) in different stocking density treatments were not significantly affected by stocking density. All the water quality parameters in the experimental periods were found within tolerable level (APHA, 2005).

Conclusion

It can be concluded that growth and survival of fish larvae was found density dependent rather than environmental condition. Optimum stocking density for larval rearing of *L. dyocheilus* was found 2 larvae L^{-1}, it may be advantageous to maintain healthy seed for the successful larval rearing for the mass seed production and the wild stock augmentation in the natural resources.

Acknowledgements The authors are thankful to the Director, ICAR- Directorate of Coldwater Fisheries Research (ICAR-DCFR), Bhimtal, and Director, Central Institute of Fisheries Education, Mumbai for providing the opportunity to carry out this work along with their valuable guidance, useful suggestions and facilities during the research. Authors are immensely thankful to PCCF (WL), Department of forest, Govt. of Uttarakhand for permitting to catch the fishes for breeding. Authors are also thankful to ICAR, Govt. of India for providing research fellowship.

References

Alhassan EH, Emmanuel DA, Christian LA (2012) Effects of stocking density on the growth and survival of Oreochromis niloticus cultured in hapas in a concrete tank, African Journal of Agricultural Research 7(15), 2405-2411

Aminur R, Maziad RM, Rafiqur MA, Noor Khan MM, Hossain MA, Hossain MG (2005) Effect of stocking density on survival and growth of critically endangered mahseer, Tor putitora (Hamilton), in nursery ponds. Aquaculture 249, 275-284

APHA (2005) Standard methods for the examination of water and wastewater. 21st edn. American Public Health Association, Washington D.C.

Biswas JK, Sarkar D, Chakraborty P, Bhakta JN, Jana BB (2006) Density dependent ambient ammonium as the key factor for optimization of stocking density of common carp in small holding tanks. Aquaculture 261, 952-959

Desai VR (1994) Endangered, vulnerable and rare fishes of river system (western and central) of Madhya Pradesh. In:Threatened fishes of India. PV Dehadrai, P Das, SRVerma (Eds). Netcon Publication, India. 4,97-108

Dubey GP (1994) Endangered, vulnerable and rare fishes of west coast river system of India. In: Threatened fishes of India. PV Dehadrai, P Das, SR Verma (Eds.) Netcon Publication.India, 4, 77-95

Ebrahimi MH, Imanpoor MR, Adlo M (2010) Effects of stocking density on growth factors, survival and blood and tissue parameters, in Giant gourami (*Osphronemus goramy* (Lacepede, 1801). Journal of Fisheries 4(2), 97-106

Elaheh HNN, Imanpoor M, Taghizade V, Zadmajid V (2013) Effects of density stress, growth indices and survival rate of goldfish (*Carrasius auratus*), Global Veterinaria 10 (3), 365-371

Gholipour F, Allameh SK, Arani MM, Nasr M (2007) Effect of density on growth and feed conversion ratio in rainbow trout (*Oncorhynchus mykiss*). Research and Development Journal of Iran 70, 23-27

Gupta M (2014) Study on induced breeding and seed production of indigenous carp, *Labeo dyocheilus* (Mcclelland) in captivity under coldwater conditions. Ph.D.Thesis. Central Institute of Fisheries Education, Mumbai

Gupta M, Pandey NN, Singh R, Kumar P, Haldar RS, Ali S, Kumar S, Pandey A (2013) Effects of different tempertures on incubation period, hatching rate, survival and growth of *Labeo dyocheilus* larvae. J. Ecophysiol. Occup. Hlth. 1 & 2, 59-62

Gupta M, Pandey NN, Tiwari VK, Singh R, Prakash C, Chaturvedi CS (2013) Study of Gonadosomatic Index and fecundity of pond raised *Labeo dyocheilus* in cold water conditions. International Journal of Advance Research 1(7),137-140

Huang WB, Chiu TS (1997) Effects of stocking density on survival, growth, size variation and production of Tilpia fry. Aquac. Res. 28, 165-173

Imanpoor MR, Ahmadi AR, Kordjazi M (2009) Effects of stocking density on survival and growth indices of common carp (*Cyprinus carpio*). Iranian Scientific Fisheries Journal 18(3), 1-9

Imsland AK, Foss A, Conceicao LEC, Dinis MT, Delbare D, Schram E, Kamstra A, Rema P, White P (2003) A review of the culture potential of Solea solea and S. senegalensis. Reviews in Fish Biology and Fisheries 13, 379-407

Irwin S, Halloran JO, FitzGerald RO (1999) Stocking density, growth and growth variation in juvenile turbot (*Scophthalmus maximus*). Aquaculture 178, 77-88

Jamabo NA, Keremah RI (2009) Effects of stocking density on the growth and survival of the fingerlings of *Clarias gariepinus* (Burchell, 1822). Journal of Fisheries International 4,55-57

Khatune-Jannat M, Rahman MM, Abul Bashar MD, Nahid Hasan, MD, Ahamed,Yeamin, Hossain, MD (2012) Effects of stocking density on survival, growth and production of Thai Climbing Perch (*Anabas testudineus*) under fed ponds. Sains Malaysiana 41(10), 1205-1210

Mahanta PC, Kapoor D, Dayal R, Ponniah AG (1994) Prioritization of the Indian fish species for conservation. In:PV Dehadrai, P Das, SR Verma (Eds) Threatened Fishes of India. pp. 377-386. Proceedings of National Seminar on Endangered Fishes of India, Nature Conservators

Merino GE, Piedrahita RH, Conklinp DE (2007) The effect of fish stocking density on growth of California Halibut (Paralichthys californicus) juveniles, Aquaculture 265, 176-186

Miao S (1992) Growth and survival model of red tail shrimp (Penaeus penicillatus Alock) according to manipulating stocking density. Bull. Inst. Zool., Academia Sinica 31, 1-8

Osofero SA, Otubusin SO, Daramola JA (2009) Effect of stocking density on tilapia (*Oreochromis niloticus*, Linnaeus 1757) growth and survival in bamboo net cages trial. Afr. J. Biotechnolo. 8(7), 1322-1325

Pandey NN, Haldar RS, Ali S, Kumar P, Patiyal RS, Mahanta PC (2011) Induced spawning of Labeo dyocheilus in captivity under cold water condition. J. Inland fish Soc. India 43(2), 44-48

Prasad PS (1994) Status paper on endangered, vulnerable and rare species of Bihar. In PV Dehadrai, P Das, SR Verma (Eds.): pp 4, 25-29. Threatened fishes of India. Netcon Publication, India.

Rahman MM, Verdegem MCJ, Nagelkerke LAJ, Wahab MA, Milstein A, Verreth JAJ (2008) Effects of common carp *Cyprinus carpio* (L.) and feed addition in rohu *Labeo rohita* (Hamilton) ponds on nutrient partitioning among fish, plankton and benthos. Aquaculture Research 39, 85-95

Rowland SJ, Allan G, Hollis M, Pontifex T (2004) Production of silver perch (*Bidyanus bidyanus*) fingerlings at three stocking densities in cages and tanks. Aquaculture 229, 193-202.

Sahoo SK, Giri SS, Chandra S, Sahu AK (2010) Stocking density-dependent growth and survival of Asian sun cat fish, *Horabagrus brachysoma* (Gunther 1861) larvae. J. Appl. Ichthyol. 26, 609-611

Sarkar UK, Patiyal RS, Srivastava SM (2001) Successful induced spawning and hatching of hill stream carp, *L. dyocheilus* in Kosi river. Indian. J. Fish. 48(4), 413-416

Schram E, Heul JW, Kamstra A, Verdegem MCJ (2006) Stocking density dependent growth of dover sole (*Solea solea*). Aquaculture 252, 339-347

Sharma J, Chakrabarti R (2003) Role of stocking density on growth and survival of catla, *Catla catla* and Rohu, *Labeo rohita* larvae and water quality in a recirculating system. J. Appl. Aquacult. 14, 171-178

Singh A, Singh IJ, Ram RN, Kushwaha B (2008) Ovarian development in *Labeo dyocheilus* (McClelland) during active reproductive phase under captive and wild conditions. J. Evn. Bio. 29(2), 169-174

Suresh AV, Lin CK (1992) Effect of stocking density on water quality and production of red tilapia in a recirculated water system. Aquaculture Engineering 11, 1-22

Talwar PK, Jhingran AG (1991) Inland fishes of India and adjacent countries. Oxford and IBH Publishing Co., New Delhi, Bombay, Calcutta. 2, 207

Yousif OM (2002) The effects of stocking density, water exchange rate, feeding frequency and grading on size hierarchy development in juvenile Nile tilapia, *Oreochromis niloticus*. Emir. J. Agric. Sci. 14, 45-53

JIFSI 2018 50 (2): 63-67 **RESEARCH PAPER**

Effects of periodical starvation on growth and muscle composition in fingerlings of *Labeo bata* (Hamilton, 1822)

Hiramoni Das · Sudhir Kumar Das · Dibakar Bhakta ·

Received: 27 October 2017 / Accepted: 15 July 2018

Abstract A study was conducted to find out impact of periodical starvation on growth of fingerlings of *Labeo bata* (Hamilton, 1822) with four sets of experiments in triplicates for a period of 60 days. The treatments were designated as the control (fed every day), D_1 (one day starvation + 2 days feeding), D_2 (2 days starvation + 2 days feeding) and D_3 (3 days starvation + 2 days feeding). There was no significant difference in weight gain and specific growth rate (weight) between the treatment D_1 and control though feed consumption was considerably low. It indicated that one day of feed deprivation followed by two days of satiation feeding can compensate the growth in *Labeo bata*. However, such values were lower compared to control in treatment D_2 indicating partial compensation. The muscle composition did not exhibited significant difference in nutrient level between control and D_1 though it was significant in protein and lipid level in treatments D_2 and D_3. It indicated that one day of skipping the feeding with two days of subsequent satiation feeding in cyclic manner can reduce feed consumption substantially without compromising the growth in fingerlings of *Labeo bata*.

Keywords Growth compensation, starvation, *Labeo bata.*

Introduction

Compensatory growth is spurt in growth of fish occurring after some unfavourable condition like starvation, food restriction, adverse environmental condition etc. After starvation, some fish exhibit higher growth than continuously fed fish in order to catch-up the lost growth. It is influenced by several factors such as nature of feed restriction, diet composition, age, sex and stage of life cycle. It can be considered as a cost effective feeding strategy in order to reduce feed consumption and consequent pollution without hampering the growth significantly. Period of starvation and feed restriction also occurs naturally in fish due to environmental and seasonal changes as well as temporal and spatial patchiness of food availability (Killer et al., 2014).

Compensatory growth of fish is a rapid or faster growth than normal rate resulting from re-feeding after fasting or feed restriction. It has been reported in many fish species and it varies depending on fish species, fish size, water temperature, feed allowance, dietary nutrient composition, duration of feeding trial and feeding regime (Cho, 2011). Inappropriate feeding practices in aquaculture may lead to over feeding which results in feed wastes in pond water and consequently higher production cost and contamination of aquatic environment. However insufficient feeding lead to poor growth and high fish mortalities which make losses in the aquaculture business (Eroldogan et al., 2006). The feed costs in commercial aquaculture can be considerably reduced by adopting suitable feed management and husbandry strategies. Compensatory growth in fish is not only of theoretical interest but it has application in aquaculture (Hayward et al., 1997). It is of interest in aquaculture because of an understanding of its dynamics may allow to design an appropriate feeding schedule which can improve growth rates (Zhu et al., 2000). *Labeo bata* (Hamilton, 1822) is considered as an important candidate species in

H. Das · S. K. Das (✉) D. Bhakta ·
Department of Fisheries Resource Management, Faculty of Fishery Sciences, WBUAFS, Chakgaria, Kolkata-700 094, west bengal, India
e-mail: dibakarbhakta@gmail.com

aqua-farming in West Bengal, Assam, Odisha etc. due to high demand. Here, an attempt was made to study impact of intermittent feeding on growth and body composition of the fish.

Materials and methods

Preparation of experimental aquaria

The experiment was carried out in 12 clean glass aquaria of size 60 × 30 × 30 cm^3 each. They were filled with good quality tap water up to a depth of 20 cm. This depth was maintained throughout the experimental period. Half of the water in all aquaria along with excreta was removed by siphoning thrice in a week. Subsequently freshwater was filled to maintain the depth at 20 cm.

Stocking and rearing

The fingerlings of *Labeo bata* were collected from local fish seed farm. They were kept in two 500 litres rectangular tanks and fed a mixture of live Tubifex species and formulated diet for about two weeks prior to the experiment trial. Before onset of experiment, all the fishes were starved for one day. Ten numbers of uniform size fingerlings (Average length 72.61 mm and average weight 3.89 g) were kept in each aquarium. Fishes were fed under feed deprivation protocol and were designed as D_1, D_2 and D_3 respectively where fishes were starved for one day, two days and three days respectively and then fed at the rate of 5 percent body weight for a period of two subsequent days in each feeding cycle. Thus the corresponding feeding cycles were three days (one day starvation + 2 days feeding), four days (2 days starvation + 2 days feeding), and five days (3 days starvation + 2 days feeding) for treatments D_1, D_2 and D_3 respectively. Fishes in the control were fed every day @ 5% body weight. The experiment was carried out in triplicate for a period of 60 days.

Water quality parameters such as temperature, pH, alkalinity, hardness and dissolved oxygen contents of water in each treatment were monitored at weekly intervals following standard methods (APHA, 1995). A specific quantity of feed was given to fish in a Petri dish. After 3 hours of feeding, the left over feed was removed by siphoning. It was dried in the oven at 60° C for 8 hours and then kept in a polythene bags to estimate feed consumption.

Growth monitoring

Fish sampling was done at seven days interval to record their growth. Five numbers of fishes were caught randomly from each aquarium during sampling to record their length and weight. The adhering water was soaked in blotting paper before taking weight. Fishes were weighed in electronic balance to record the total weight in grams and their individual length was measured in millimetres.

Specific Growth Rate (SGR)

Specific Growth Rate= $(\ln W_2 - \ln W_1)/(t_2 - t_1) \times 100$
Where, W_1= Weight of fish at time t_1 and W2 = Weight of fish at time t_2
The calculated values give the average percentage increase in body weight per day during the experimental period.

Proximate composition of fish muscle

Proximate composition of body muscle of *Labeo bata* fingerlings was estimated both at the commencement and termination of the experiment. Muscle samples were collected from the trunk portion of the fishes avoiding bony parts. The muscle samples were dried in the hot air oven to obtain dry matter. The dried samples were analyzed for moisture, crude protein, crude fat and total ash following the standard procedure (AOAC, 1995). The caloric content was determined by multiplying the fat, protein and carbohydrate content with the energy factors 9.44, 5.64 and 4.11 respectively (NRC, 1993).

Statistical Analysis

Mean values of growth of fish for each treatment were calculated at regular intervals for their variation in length and wet weight. Differences between treatments were tested for significance using analysis of variance (ANOVA) technique. Mean values of nutrients in the fish muscle were tested for significance of difference with t-test.

Results and discussion

There was no mortality of fish in any of the treatments during the experimental period. The average temperature, dissolved oxygen level, pH and hardness

Table 1 Proportion of ingredients and proximate composition of formulated diet

Ingredients	Proportion in %
Fish meal	40
Wheat floor	10
Rice bran	17
Ground nut oil cake	30
Soyabean cake	2
Vitamin-mineral mixture	1
Proximate composition	**Nutrients in %**
Moisture	7.45
Crude protein	35.10
Crude fat	7.51
Total ash	9.84
Nitrogen free extract (NFE)	40.10
Energy value (kcal/g)	4.34

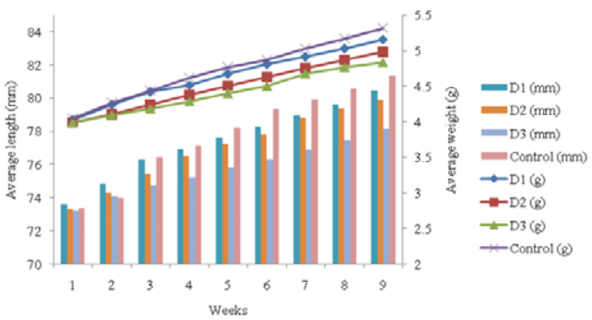


Fig. 1 Average length and weight of *Labeo bata* under feed deprivation

of water in various aquaria ranged from 16.33 to 23.33 °C, 4.41 to 6.50 mg l^{-1}, 7.08 to 7.48 and 543 to 682 mg $^{-1}$ respectively at weekly sampling during the period of investigation. Though temperature, oxygen and pH were under suitable range, relatively more hardness due to local conditions of water might have adversely affected the growth.

The average length and average weight of fingerlings of *Labeo bata* recorded in different treatments are depicted in Fig 1. The average length ranged from 81.34 mm in control to 78.17 mm in treatment D_3 and the average weight ranged from 5.32 g in control to 4.84 g in treatment D_3 during termination of the experiment. The specific growth rate (weight) ranged from 0.214 to 0.771 percent per day among different treatments and control group.

The total number of days of feeding with treatments D_1, D_2, D_3 and control were 40, 30, 24 and 60 days respectively. The feed consumed in treatments D_1, D_2 and D_3 were 74.92, 63.27 and 47.08 percent of control respectively. The variation in feed consumption might be due to duration of feeding and hyperphagia in fish. Though feed consumption was considerably lower in D_1 in comparison to control, there was no significance difference in weight gain in fish. However, the weight gain in treatment D_2 and D_3 was found to be significantly low.

Proximate composition of muscle of fish during beginning and termination of the experiment are presented in Table 2. It was observed that the nutrient contents such as crude protein and crude fat were increased while moisture and total ash contents were declined over initial values during termination of the experiment.

At the beginning of the experiment, there was no significant difference in average weight of fishes among different treatments of D_1, D_2, D_3 and control group. Fish of different treatments exhibited various rates of growth during the period of experiment. The weight gain of fish during termination of the experiment was 1.27g, 1.09g, 0.95g and 1.43g in the treatments D_1, D_2, D_3 and control respectively. Such low magnitude might be due to high hardness of water, weekly handling stress of fish and low temperature during winter period. It was found that growth of fish in the treatment D_1 was relatively faster in the 2 and 3 weeks of experiment which might be due to hyperphagia. The hyperphagy in treatments is indicated by the fact that feed consumed in treatments was proportionately more considering starvation period in D_1, D_2 and D_3 which being 74.92, 63.27 and 47.08 percent of control respectively versus 67% (40 days), 50% (30 days) and 33% (20 days) of control as days of feeding. Rubio et al. (2010) reported that hyperphagia of 51% was observed after two days of fasting and 79% after the second fasting period (9 days) on sea bass (*Dicentrarchus labrax*). Wang et al. (2000) reported that hybrid tilapia Oreochromis mossambicus showed CG response during re-feeding following a period of feed deprivation and observed that hyperphagia was responsible for increased growth rate. It is the main mechanism involved in the compensatory growth response, although increased food conversion efficiencies or behavioural adjustments might play a role (Ali et al., 2003). A significant difference was found in weight gain ($F_{3,\ 32}$=8.036, P< 0.05) and specific growth rate ($F_{3,\ 32}$=5.043, P, 0.05) in various treatments. It might be due to duration of feeding, feed consumption and environmental factors. Durairaja and Jawahar (2014) reported growth

Table 2 Proximate composition of fish muscle under feed deprivation set of experiment

	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	NFE
Initial	76.54 ± 1.24	14.49 ± 0.54	2.18 ± 0.57	2.48 ± 0.48	4.31
D1	75.18 ± 1.72	15.34 ± 0.58	2.72 ± 0.43	1.92 ± 0.62	4.84
D2	75.12 ± 1.90	14.48 ± 0.37	2.51 ± 0.52	2.04 ± 0.56	5.85
D3	76.26 ± 1.13	14.36 ± 0. 46	1.98 ± 0.46	1.62 ± 0.36	5.48
Control	75.24 ± 1.81	15.54 ± 0.54	2.78 ± 0.54	2.38 ± 0.54	4.06

compensation in *Clarias batrachus* with similar protocol. Full compensation was achieved during 3 week in the treatment D_1. Yengkokpam et al. (2008) also reported that *Labeo rohita* deprived of feed for one week matched with the control in two weeks and fish deprived of feed for 2 weeks matched in four weeks. In the case of treatment D_2, there was relatively high growth during 3 and 4 weeks and it might be due to hyperphagia in fish. In such case partial growth compensation was achieved during termination of the experiment. In the treatment D_3, there was relatively much slow growth indicating that fish could not catch up the growth to match with the control. Similar result was found by Kim and Lovell (1995), who reported that more extended feed deprivation, prohibited the channel catfish from attaining a final weight equal to control fish. In the present study, it was found that mean body weight of the fish of treatment D_1 was numerically lower than control but not different statistically. It indicated that one day of feed deprivation followed by two days of satiation feeding can compensate the growth in *Labeo bata.*

Limited attention was given on impact of feeding level on flesh quality and restrictive feeding has important role in flesh characteristics (Johnsen et al, 2011). There was significant difference ($P<0.05$) in protein level between treatments D_3 and D_2 compared to control, which can be attributed to utilization of protein for energy purposes due relatively more starvation. The ash content exhibited irregular trend of variation in different treatments during the termination of experiment. It is in concurrent with the results of El Sayed Ali et al. (2016) where protein and fat contents linearly declined in muscle depending on period of restriction in nile tilapia. Relatively less ash content in different treatments compared to control might be due to reduced structural growth for feed restriction.

It can be inferred from the present study that the feed deprivation protocols like the treatment D_1 can be tested in field conditions in order to reduce the cost of feed considerably without compromising the growth in the fingerlings of *Labeo bata*.

Acknowledgements

The first author would like to convey her deepest sense of gratitude to the Head of the department and the Dean, Faculty of Fishery Sciences, WBUAFS, Chakgaria, West Bengal for their timely support and showing keen interest throughout the study periods.

References

AOAC.1995. Official Methods of Analysis of AOAC International.Vol. I, 16th edition. AOAC International, Arlington,V.A. pp.1298

Cho SH (2011) Effect of dietary protein and lipid levels on compensatory growth of juvenile olive flounder (Paralichthys olivaceus) reared in suboptimal tempera ture. Journal of Animal Science, 24(3): 407-413

Durairaja R, Jawahar P (2014) Growth compensation in Asian catfish, *Clarias batrachus* (Linnaeus) following feed re striction and deprivation protocol. J. Exp. Zool. India, 17(2):443-450

El Sayed Ali T, Llorens SM, Monino AV, Cerda MJ, Vidal AT (2016) Effects of weekly feeding frequency and previous ration restriction on the compensatory growth and body composition of Nile tilapia fingerlings. The Egyptian Journal of Aquatic Research, 42(3):357-363

Eroldogan OT, Kumlu M, Kiris GA, Sezer B(2006) Compensatory growth response of *Sparus aurata* following different starvation and re-feeding protocols. Aquaculture Nutrition, 12: 203-210

Heyward RS, Noltie DB, Wang N (1997) Use of compensatory growth to double hybrid sunfish growth rates. Trans. Am. Fish. Soc., 126:316-322

Jiwyam W(2010) Growth and compensatory growth of juve nile *Pangasius bocourti* Sauvage, 1880 relation to ration. Aquaculture, 306:393-397

Johnsen CA, Hagen O, Adler M, Jonsson E, Kling P, Bickerdike R, Solberg C, Bjornsson BT, Bendiksen EA (2011) Effect of feed, feeding regime and growth rate on flesh quality, connective tissue and plasma hormones in farmed Atlantic salmon (Salmo salar L.). Aquaculture, 318: 343-354

Killer SS, Marras S, McKenzie DJ (2014) Fast growers sprint slower: effects of food deprivation and refeeding on sprint swimming performance in individual juvenile European sea bass. J. Exp. Biol., 217:859-865

Kim MK, Lovell RT (1995) Effect of restricted feeding regimes on compensatory weight gain and body tissue changes in channel catfish in ponds. Aquaculture, 4:285-293

NRC (National Research Council), 1993. Nutrient requirements of warm water fishes and shellfishes. National Academy Press, Washington, D.C., USA. pp. 102

Pang X, Fu SJ, Li XM, Zhang YG (2016) The effects of starvation and re-feeding on growth and swimming performance of juvenile black carp (*Mylopharyngodon piceus*). Fish Physiol. Biochem., DOI: 10.1007/s10695-016-0210-x

Pastoureaud A (1991) Influence of starvation at low temperature on utilization of energy reserves, appetite recovery and growth character in sea bass (*Dicentrarchus labrax*). Aquaculture, 99:167-178

Paul AJ, Paul JM, Smith RL (1995) Compensatory growth in Alaska yellow fin sole, (*Pleuronectes asper*), following food deprivation. J. Fish. Biol., 46:442-448

Rubio VC, Sanchez E, Cerda-Reverter JM(2010) Compensatory feeding in the sea bass after fasting and physical stress. Aquaculture Research, 298: 332-337

Wang Y, Cui Y, Yang Y, Cai F (2000) Compensatory growth in hybrid tilapia (*Orechromis mossambicus* × *O. niloticus*) reared in sea water. Aquaculture, 189:101-108

Zhu X, Cui Y, Ali M, Wootton RJ (2000) Comparison of compensatory growth responses of juvenile three-spined stickleback and minnow following similar food deprivation protocols. Journal of Fish Biology, 58: 1149-1165

Indigenous fishing method used for catching spiny eels (*Macrognathus* spp.) in floodplain wetlands of Assam, India

B. K. Bhattacharjya · B. J. Saud · V. K. Verma · D. Debnath
A. K. Yadav · Simanku Borah · Hiron Pegu · U. K. Sarkar

Received: 20 August 2018 / Accepted: 21 December 2018

Abstract The present paper describes ITK associated with a unique indigenous fishing method used to catch mud-dwelling spiny eels (*Macrognathus spp.*) in floodplain wetlands of Assam by Bhatiya community in Lower Assam (locally called Akra mara) as well as by the Mising tribe in Upper Assam (Germe-Kenane). Here the spiny eels are caught by piercing them with a swift swinging motion of a curved pointed barbless iron hook with a long bamboo handle. The specialized fishing method and the ITK associated with it were studied in 25 villages located around 12 floodplain wetlands (beel/ pitoni) of the study area. In this paper, we discussed how the two communities made effective use of the narrow visual field of the spiny eels through their traditional wisdom to catch these bottom dwelling fishes, which are otherwise difficult to catch.

Keywords Indigenous Technical Knowledge, Akra mara, Germe-Kenane, Bhatiya community, Mising tribe, *Macrognathus* spp., Floodplain wetland (beel), Assam

B. K. Bhattacharjya(✉) B. J. Saud · D. Debnath ·
A. K. Yadav · Simanku Borah ·
ICAR-Central Inland Fisheries Research Institute, Regional Centre, Housefeed Complex
e-mail: bkbhattacharjya@yahoo.com

Hiron Pegu
Office of the District Fishery Development Officer, Lakhimpur, Assam-787001

V. K. Verma · U. K. Sarkar
ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata-700120, West Bengal

Introduction

The north-eastern state of Assam (89° 42′ E to 96° E longitude and 24° 8 N to 28° 2 N latitude) has extensive areas under floodplain wetlands (commonly known as beels) covering 1,00,815 ha area (Anon, 1997). These wetlands support livelihood of thousands of fishers and provide nutritional security to riparian populace. People living around these wetlands have acquired indigenous knowledge about the fish species occurring in the wetlands, their abundance, seasonality of occurrence and behavioural patterns of different fish groups. These traditional knowledge systems have been applied for evolving specialized fishing methods as well as for constructing/ fabricating specialized fishing gear to catch certain fish species/ group over long period of time. Indigenous knowledge is that knowledge accumulated over generations of living in a particular environment. It is generally passed by word-of-mouth through generations, across time, space and communities and is not often recorded in writing. Most of the early studies on fishing methods and /or fishing gear in Brahmaputra valley of Assam mainly focused on the technical aspects from the fisheries perspectives (Yadav et al., 1981; Yadav and Choudhury, 1986). Attempts have also been made in recent years to document the ITKs associated with the diverse fishing practices prevalent in the northeastern region of India (Bhattacharjya et al., 2004; Dutta and Bhattacharjya, 2008 & 2009; Dutta and Dutta, 2013; Baruah et al., 2013; Saud et al., 2015). The present study shows that a particular traditional fishing technique/ method may be used by two different communities of a geographical region with or without modifications under different local names, which has been the case in Akra and Germe-Kenane. In the present paper we describing an indigenous fishing method practiced by the fishers belonging to Bhatiya community living around beels of Lower Assam as well as by those belonging to Mising tribe in Upper Assam to catch spiny eels (*Macrognathus* spp.).

Methodology

The present study was conducted in 12 floodplain wetlands (beel/ pitoni) located in three districts (Kamrup, Nalbari, Barpeta) of Lower Assam as well as two districts (Dhemaji and Lakhimpur) of Upper Assam during December 2014 to August 2016. In Lower Assam, the method was practiced by Bhatiyas whereas in Upper it was practiced by Mising tribe. A total of 12 field surveys were conducted in 25 fringe villages surrounding the wetlands of the five selected districts. Primary information on the fishing gear/ method was collected by participatory observation as well as through personal interviews with the fishers/villagers. A pre-structured interview schedule was developed for the study by incorporating queries to gather maximum possible information related to the ITKs associated with the fishing method. Key informants including active fisherfolk as well as village elders were interviewed during the process of data collection. A total of 19 and 16 fishers/ villagers from Bhatiya community and Mising tribe respectively were consulted through one to one interaction for detailed documentation of the fishing method and the associated ITK. Secondary information on gear was obtained from fishers as well as other villagers using focused group discussions (Townsley, 1993; Schonut and Kieveltiz, 1994). Sincere efforts were made to clarify the question by repetition to ensure and collect reliable data from the respondents. Prior informed consent (PIC) was obtained from the community leaders of both the communities (Bhatiya and Mising) of respective villages as per CBD guidelines in order to use and publish the recorded information on these indigenous fishing methods and ITK associated with it. Fishes caught using this fishing device was identified with the help of standard keys (Talwar and Jhingran, 1991).

Results

Akra (Fig. 1) and Germe-Kenane (Fig. 2) can be classified as grappling and wounding gear usually operated in selected floodplain wetlands (beel/pitoni) of Assam. We observed that both these fishing gear are almost similar in shape, mode of construction, construction material and operation. Akra is operated by Bhatiya community (an Islamic fishing community speaking Bengali) in Lower Assam while Germe-Kenane is operated by Mising tribe in Upper Assam (an ethnic Hindu tribe). These are basically curved pointed barbless iron hooks fitted onto a long and slender bamboo handle. In case of Akra, the bamboo handle is made from mature Bijuli variety (Bambusa pallida) of 2.5-4.0 cm diameter whereas in Germe- Kenane branches of mature bamboo of species Bambusa balcooa (locally known as bhaluka bah) is used (usually 2.5 cm diameter at the tip and 5 cm at the grip). The frontal part the iron rod is curved in the shape of a small sickle with a pointed tip prepared with the help of blacksmiths in both cases (Fig. 1&2). Smooth round iron rods were used for making the hooks in both the cases even though the rod used is thicker in Akra (6 mm diameter) than that in Germe- Kenane (4 mm diameter). The curved iron hook is fitted and secured into the slender bamboo handle by blacksmiths with the help of a metal ring in Akra and in Germe- Kenane it is fastened onto the bamboo handle with the help of used bicycle rubber tube. The total length of the Akra is about 1.8-2.0 m, of which the length of bamboo handle is 1.4-1.5 m. In case of Germe-Kenane the length of the iron rod ranges from 0.31-0.33 m and that of the bamboo handle ranges from 2.17-2.2 m. The total length of Germe-Kenane ranges from 2.3-2.4 m. The approximate diameter of the sickle-shaped iron hook ranges from 4-5 cm in both the gear. The shape of the iron hook slightly differed between the two gear. It was roughly C-shaped in Akra, whereas it was more curved in case of Germe Kenane (Fig. 1 & 2). The tip of the sickle shaped iron hook is made into a sharp point so that it can pierce through the skin of the fish.

Both these fishing gear are specialized in catching mainly the species of spiny eels occurring in floodplain wetlands of the study area viz., Macrognathus pancalus and *M. aral* (locally known as 'Tura', 'Turi') from muddy bottoms. However, other benthic fish species like *Nandus nandus*, *Heteropneustes fossilis* and *Clarius magur* also reportedly get pierced/ caught in the hook occasionally. During operation the fishers move the pointed hook from left to right and vice-versa in an oscillating manner pace along the bottom (Fig. 3 & 4) in waist deep waters to get the spiny eel pierced in

Fig. 1 Akra of Lower Assam

Fig. 2 Germe-Kenane of Upper Assam

Fig. 3 Bhatiya fishers operating Akra

Fig. 4 Mising fisher operating Germe-Kenane

Fig. 5 A haul of spiny eels caught with Akra

the pointed hook. Since there is no barb in the iron hook used in this gear, it does not need much effort to unhook the fish manually. Fishers of Bhatiya community simply dropped the fishes caught in the hook to the bamboo basket (locally called polo) placed in a triangular floating platform made up of banana stems (Fig. 5), which is tied to the waist of the fisher with a rope, whereas fishers of Mising tribe collected the catch in a bamboo basket (locally known as khaloi), tied to their waist with the help of a rope. The fishing hook along with its handle is prepared by the fishers themselves with the help of local blacksmiths and cost only ₹30-40 per gear. The fishers generally operated the fishing gear for 2-3 hours a day since it is a strenuous activity to move the gear along the muddy bottom in high speed. Fish catches ranging from 0.5 to 2 kg/ fisher were observed during fishing operations.

Discussion

Germe in Mising language refers to spiny eels, locally known as 'Tura' and Kenane refers to the fishing implement. The fishing method used by the two communities was found to be similar in construction and mode of operation with only slight variation in dimensions/construction of the gear used. The interviewed fishers from both communities informed that they learned of the technique from their forefathers. It is possible that the fishing gear and associated ITK originated form either of the two communities or from a third community of the region. The fishing gear and the method was found to be simple, low-cost and yet very effective for catching bottom dwelling spiny eels in shallow floodplain wetlands (beels/pitoni), which are otherwise very difficult to be caught except by complete dewatering of the water body. Both the Bhatiyas and Mising tribe are experts in making and operating Germe-Kenane in beels and other muddy water bodies. Ethnic communities of Assam are specialized in making bamboo handles for various day to day implements, which are used to operate at sudden high speed (e.g., dagger). Fitting of iron hook makes the frontal part of the gear heavy and apparently helps in operating the gear in swift swinging action. We tried to validate the ITK associated with Akra and Germe-Kenane fishing in the light of existing scientific literature. We tried to find out why the spiny eels did not escape from the fast approaching curved iron hook. Past studies on the fish eye showed that its ability to resolve detailed images, while not as good as that of terrestrial animals, is adequate in view of the degradation of edges caused by suspended particles in the water. Contrast direction and hue may therefore, have become more important as a means of object recognition13. Since the curved iron hook does not resemble any of the natural predators/ enemies of the spiny eels, it is possible that the eels do not perceive it as dangerous. Interviews with the fishers from Bhatiya community and Mising tribe who are specialized in operating Akra and Germe-Kenane revealed that this specialized fishing usually took place during the winter and pre-monsoon seasons (December - April) when the water level in the floodplain wetlands and other shallow water bodies is reduced to less than one metre. Since such shallow water depth facilitates intense fishing around this time, the water becomes highly turbid and muddy/ yellowish in colour. The physical properties of natural water produce varying limitations on the visual signaling capabilities of fishes (Guthrie and Muntz, 1993). Such changes in turbidity and water color apparently led to changes in the spectral quality of light in the waterbody. Obviously, the spiny eels (as also other demersal fish species like *Clarias magur*, *Heteropneustes fossilis* and *Nandus nandus* that formed stray catches) could not effect corresponding changes in their visual systems, especially in their visual pigments. According to available reports, migratory fishes such as salmon show appropriate changes in their visual pigments when they enter or leave fresh water (Beatty, 1975). The retino-motor movements that lead to light and dark adaptations in fish will tend to follow a dial cycle, but there are several other modifications that influence the visual sensitivities of fish in different light intensities. The relative portions of the different visual pigments may also change due to shifts in spectral bandwidths that occur on a seasonal basis (Jobling, 1995).

The spiny eels are benthic fishes having elongate eyes. The light-gathering ability of the eye is improved due to the absence of the iris and the incoming light is focused on the retina at the bottom of the tube by the enlarged lens. Overall, these series of adaptations lead to an increase in light-gathering at the expense of narrowing of the visual field (Jobling, 1995). We observed that the fishers moved the curved pointed iron hook from side to side (in an oscillating manner) at a fast pace to pierce the body of the eels. Thus, narrow visual field of the spiny eels appears to be a limiting factor for the fishes in giving them sufficient time to escape from the fast-approaching hooks.

Conclusion

Indigenous technical knowledge accumulated by different fisher communities for many generations have resulted in development of low-cost and effective fish harvesting methods/gear for different fish groups. Such methods are crucial for ensuring livelihood security of the fishers including those who are dependent on the floodplain wetlands for their sustenance. The unique fishing method discussed above is simple, low-cost and yet found to be very effective in catching bottom dwelling spiny eels. There is need to document such techniques along with associated ITKs so that the fishing gear can be upgraded for the benefit of resource-poor fishers (including some form of intellectual property right for the evolving/user community).

Acknowledgement Funding support received under NICRA project through ICAR-CRIDA, Hyderabad is duly acknowledged. We are grateful to Director, ICAR-CIFRI, Barrackpore for providing facilities and encouragement. Thanks are due to Mr. Bipul Phukan, College of Fisheries, AAU, Assam and Mrs. Niti Sharma, ICAR-CIFRI Regional Centre, Guwahati, for their help in collecting relevant literature. We thank the villagers/ fishers from the villages of Dighalichapari, Kulamua, Pityangchapari, Udmoradigholi (Dhemaji district), Chamata, Nagarbera (Kamrup district) and Baniarapara (Barpeta district) who helped us in documenting the gear and the ITK. We also thank key informants Mr. Mohan Pegu (36 years), Mr. Sashikumar Pegu (45 years), Mr. Loknath Pegu (26 years), Mr. Premnath Doley (38 years) and Tankeswar Pegu (64 years) of Dighalichapari village and Kalam Ali (47 years), Ayen Ali (58 years) and Gonu Bepari (65 years) of Baniarapara village for sharing their indigenous traditional knowledge on the fishing gear.

References

Anonymous, 1997. Wetlands of Assam, Assam Remote Sensing Application Centre, Guwahati

Baruah D, Dutta A, Pravin P (2013) Traditional fish trapping devices and methods in the Brahmaputra valley of Assam. Indian Journal of Traditional Knowledge 12:123-129

Beatty DD (1975) Visual pigments of the American eel, Anguila rostrata, Vision Research 15:771-770

Bhattacharjya BK, Manna RK, Choudhury M (2004) Fishing Crafts and Gear of North East India, Bulletin no. 102, CIFRI, Barrackpore, Kolkata, p.67

Dutta R, Bhattacharjya BK (2008) An indigenous community fishing practice of Tirap district, Arunachal Pradesh. Indian Journal of Traditional Knowledge 7:624-626

Dutta R, Bhattacharjya BK (2009) A traditional fishing method of Assam for catfishes using duck meat as an attractant. Indian Journal of Traditional Knowledge 8:234

Dutta R, Dutta A (2013) Bheta fishing-A traditional community fishing practice of Nocte tribe of Tirap district, Arunachal Pradesh. Indian Journal of Traditional Knowledge 12:162-165

Guthrie DM, Muntz WRA (1993) Role of vision in fish behavior, In Pitcher, T. J. (ed), Behaviour of Teleost Fishes, 2nd edition, Chapman and Hall Ltd., London, p. 89-128

Jobling M (1995) Environmental Biology of Fishes, 1st Edition, Chapman and Hall Ltd., London, p. 455

Saud BJ, Chetia M, Borah S, Landge AT, Bhagawati K, Roul SK, Chetia BR (2015) Traditional fishing technique of Clupisoma garua using fats of freshwater river dolphin in Brahmaputra river, Assam. Fishing Chimes 35:43-45

Schonut M, Kieveltiz V (1994) Participatory learning approaches - Rapid rural appraisal; Participatory rural appraisal- An introductory guide, Springer-Verlag, Berlin, p. 183

Talwar PK, Jhingran AG (1991) Inland fishes of India and adjacent countries, Volume 1&2, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, p. 1158

Townsley P (1993) Rapid appraisal methods for coastal communities, Bay of Bengal Programme, Madras, p. 110

Yadav YS, Choudhury M (1986) Bana fishing in beels of Assam, Journal of Bombay Natural History Society 83:452

Yadav YS, Choudhury M, Kolekar V (1981) Katal Fishing - A special device for catching fish in beels of Assam, Journal of the Inland Fisheries Society of India 8:81

Topographic distribution pattern of *Posthodiplostomum sp.* metacercariae on body surface of cyprinid fishes of river Ganga

Raju Baitha • Sanjib Kumar Manna • Vettath Raghavan Suresh • K. Paniprasad • Malay Naskar

Received: 12 June 2018 / Accepted: 15 December 2018
J.Inland Fish. Soc. India, 50(2), 2018

Abstract The clinical condition 'blackspot', caused by larval stage (metacercariae) of digenetic trematodes, is observed in fishes of inland freshwater. Topographic distribution of *Posthodiplostomum* sp. metacercariae on body surface of cyprinid fish species, *Pethia conchonius* and *Catla catla* were investigated. Quarterly samplings were conducted in lower stretch of river Ganga from Farakka to Balagarh and sectoral abundance of metacercariae of the trematode parasite within and between the fish species were compared. The Sector or body region 1 (S_1: head, gill, operculum, eyes and buccal cavity) and Sector 2 (S_2: body trunk below imaginary line) of *C. catla* and *P. conchonius* were found to be the most infected parts in the respective host. But Sector 4 (S_4: fins excluding fin base) did not harbour any parasite in both the host species. Foraging behaviour and habitat preference might be the reasons for differential distribution pattern of the fish parasite stage, but absence of infection in the fins could be related to comparative difficulty in attachment and penetration of fins by the cercariae.

Key words *Posthodiplostomum* sp., *Pethia conchonius, Catla catla,* metacercaria, river Ganga

R. Baitha · V. R. Suresh · M. Naskar · S. K. Manna(✉)
[1]ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, India

K. Paniprasad
ICAR-Central Institute of Fisheries Education, (Deemed University) Versova
e-mail: sanjibmanna@yahoo.com

Introduction

The clinical condition 'Blackspot'is a pathological state caused by encystment of larval stage (metacercariae) of digenetic trematode *Posthodiplostomum cuticola*, *Apophallus* sp. (Hoole et al. 2001), *Uvulifer ambloplitis* and *Crassiphiala bulboglossa* (Woo et al. 2006). The trematode *U. ambloplitis* and *C. bulboglossa* are distributed mainly in temperate inland waters of Northern hemisphere (Paperna and Dzikowski, 2006). Distribution of *A. brevis* is limited to North America, infecting Yellow perch *Perca flavescens* only and has never been reported from Europe and Asia. Genus *Posthodiplostomum* has only two known species, *P. cuticola* and *P. minimum,* involved in parasite related disease occurrence in fish. Among two species of *Posthodiplostomum*, *P. cuticola* is the only known species that causes 'black spot' in freshwater fishes and has worldwide distribution including in India (Athokpam and Tandon, 2014), Japan (Nguyen et al. 2012), Croatia (Zrncic et al. 2009), Uruguay (Teixeira-de Mello et al. 2008), Turkey (Soylu, 2006), Czech Republic (Ondračkova et al. 2002, 2006), Poland (Rolbiecki 2004, 2006; Dzika et al, 2008), Bulgaria (Shukerova, 2005), Germany (Schuster et al, 2001), and Finland (Koie 1999). *P. minimum* is known to cause 'white grub' disease in fish.

Fish, usually young and juvenile cyprinids, serve as the second intermediate host for *Posthodiplostomum* (Karimian et al. 2013; Vytautas and Èeslovas, 2009; Rolbiecki, 2004; Ondračková et al. 2004). This digenetic trematode infects different body parts of fish such as fins, skin, gill, and sub-epidermal tissues (Rolbiecki 2004). The metacercariae accumulate melanin pigment of host origin at the infected site which is easily

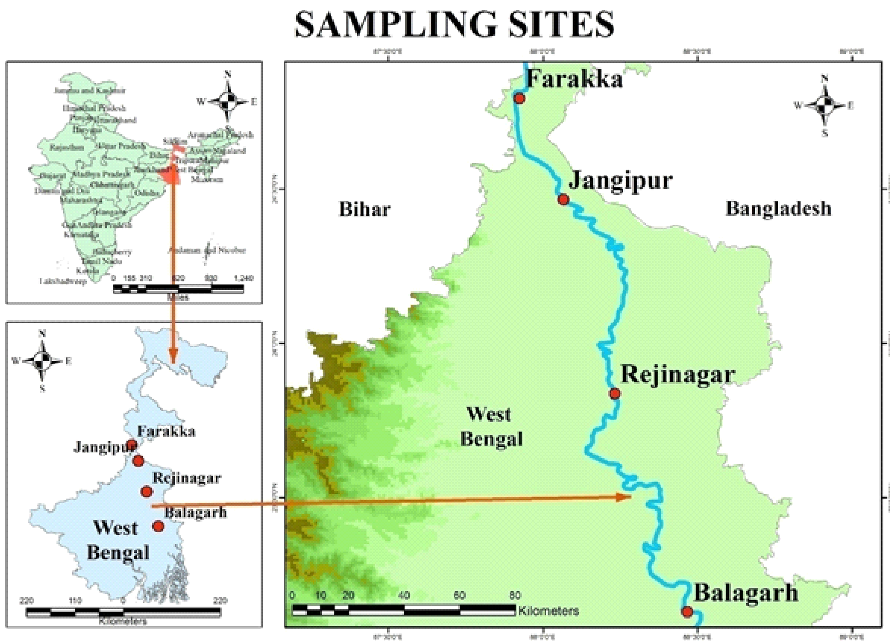


Fig. 1 Sampling stations along lower stretch of river Ganga

recognized as abnormally hyperpigmented area, called 'Blackspot' (Schäperclaus, 1979). The parasite is moderately pathogenic, particularly to early stages of fishes (Lyayman and Sadkovskaya, 1952). The manifestations of infection include emaciation, pathological changes in the blood (reduced erythrocyte count and haemoglobin content, increased erythrocyte sedimentation rate, and leukocyte count) (Rolbiecki, 2004; Williams and Jones, 1994), deformation on the body surface, growth retardation and loss in body condition (Schäperclaus, 1979).

The Ganga is the longest river of India which sustains a large number of large and small cities and towns along its long course which is divided in to upper, middle and lower stretches. The river supports 297 fish species, with more than 100 species having commercial importance (Tare et al. 2013). Cyprinids, viz., Indian major carps, minor carps and other cyprinids like *Puntius* form a significant part of the fish diversity and fisheryin the river. However, there have been meagre studies on parasitic infection in cyprinid fishes of the river.

Metazoan parasites infect different parts of fish body in a differential manner: all body parts are not equally affected by parasites. Topographic specificity has been reported for several parasitic taxa, chiefly from the monogeneans and copepods (Piasecki, 1995; Monni et al. 1999; Rolbiecki and Rokicki, 2000; Rolbiecki 2001). Though few workers have investigated tissue preference of *P.cuticola* in cyprinid fishes (Iqbal et al. 2014, Maza et al. 2012, Rolbiecki, 2004, Shukhgalter and Chukalova, 2002) and *Astyanax aff. fasciatus*, Characidae (Teixeira-de Mello and Eguren, 2008), but information on the topographic distribution pattern of *Posthodiplostomum* is not available to the best of our knowledge. Hence, the present investigation was undertaken to examine the topographic distribution pattern of *Posthodiplostomum* sp. in *Catla catla* and *Pethia conchonius* from lower stretch of river Ganga.

Materials and methods

The study was carried out in lower stretch of river Ganga, from Farakka to Balagarh, with sampling sites at Farakka (24°47´38.478"N, 87°55´26.413"E), Jangipur (24°27´58.16"N, 88°03´57.05"E), Rejinagar (23°50'10.64"N, 88°13'55.60"E) and Balagarh (23°07'44.05"N, 88°27'58.04"E), West Bengal (Fig.1). Quarterly sampling was carried out with gill nets (mesh size: 22-120 mm), cast nets (mesh size: 12-14 mm), and traditional traps between August 2016 and June 2017. At each site, samplings were done along shallow, semi-lotic and low-to-moderately vegetated areas of the

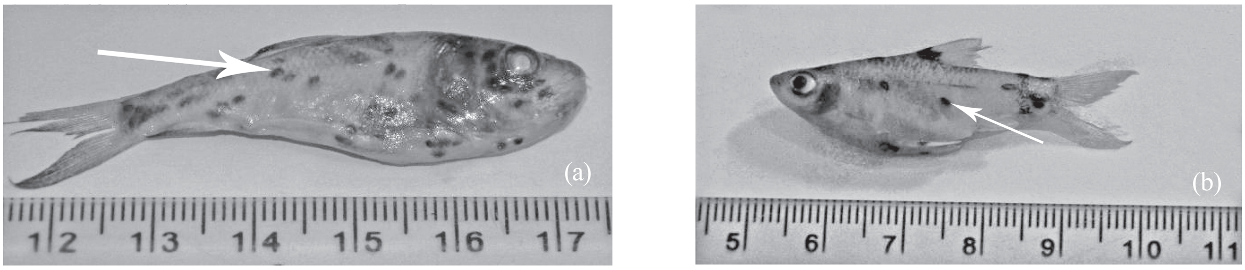


Fig. 2 'Black spot' (arrow head) on the fish body surface of *C. catla* (a) and *P. conchonius* (b)

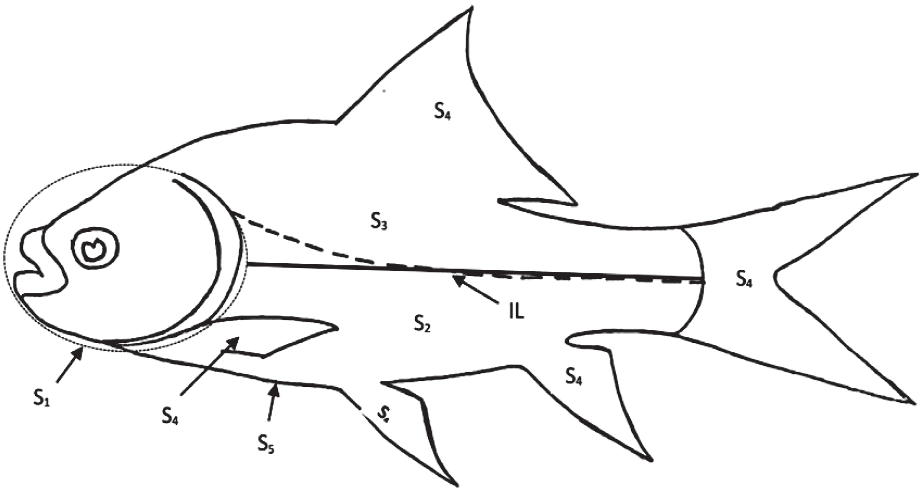


Fig. 3 Schematic body regions of a cyprinoid fish in which distributions of metacercariae were examined (***Legends:***Sector 1 (S_1: head, gill, operculum, eyes and buccal cavity), Sector 2 (S_2: trunk body below imaginary line), Sector 3 (S_3: trunk body above imaginary line), Sector 4 (S_4: fins excluding fin base), Sector 5 (S_5: ventral body part) and IL, Imaginary Line)

river, having depth ranging between 0.5 - 2 m. The fishes were carefully examined for presence of 'Blackspot' which deviated from natural colour of fish skin (Fig. 2) and other body parts, and positive specimens were preserved in 10% formalin in the field. In the laboratory, the sampled fishes were identified following standard literatures (Talwar and Jhingran,1991; Jayaram,1999). The Total length (TL) and weight (W) of fish samples were measured to the nearest 1 mm with a digital calliper and 0.01 g on an electronic balance, respectively. The infected body parts were carefully dissected out, fixed in buffered formalin and the 'black spots' were identified in histological tissue preparations under microscope.

To examine topographic distribution and better visualize the metacercarial distribution of the parasite cyst on fish, body surface of each infected fish was divided into five sectors or body regions following the methodology described by Rolbiecki (2004) and Lysne et al. (1994): Sector 1 (S_1: head, gill, operculum, eyes and buccal cavity), Sector 2 (S_2: trunk body below imaginary line), Sector 3 (S_3: trunk body above imaginary line), Sector 4 (S_4: fins excluding fin base), and Sector 5 (S_5: ventral body part) (Fig. 3). The number of black spots was counted and recorded from each sector on each side of the infected fish.

The difference in distribution of *Posthodiplostomum* sp. metacercariae among different sectors of the individuals of the same species was tested for the statistical significance using non-parametric Wilcoxon's Signed Rank test, whereas inter species differences in the distribution was analysed using Man-Whitney *U*-test (MW *U-test*).

Results

A total of 66 specimens of *C. catla* and 554 *P. conchonius* were examined from lower stretch of the river Ganga, out of which 3 *C. catla* and 13 *P. conchonius* were found to be parasitized with metacercariae of *Posthodiplostomum* sp. Although, we collected and examined all sizes of fish, *viz*. 9-182 mm sizes of *C. catla* and 5-38.66 mm sizes of *P. conchonius*, the parasite was detected only from small size fishes with mean length of 56.66 mm and 36.23 mm and mean weight of 2.52 and 0.82 g for *C. catla* and *P. conchonius*, respectively.

In both the cyprinid species, S_4 (fins) were found to be non-infected. In *C. catla*, S_1 (40.18%) harboured the highest number of metacercaria, followed by S_2 (29.1%), S_3 (20.1%) and S_5 (9.81%). In *P. conchonius* highest parasitic load was found in S_2 (37.31%), followed by S_5 (29.85%), S_3 (20.9%) and S_1 (11.95%) (Table1). For *P. conchonius*, there was no significant difference in the distribution pattern of *Posthodiplostomum* sp. metacercariae in the different sectors, except in S_2 which had more metacercarial load than S_1 (Wilcoxon's signed-rank test, $p<0.05$) (Table 2). Furthermore, the infection and distribution pattern of *Posthodiplostomum* sp. metacercariae between *P. conchonius* and *C. catla* were significantly different (MW*U* test, $p<0.05$) (Table 3). The calculated MW *U* statistics for *P. conchonius* and *C. catla* were 0 and 39, respectively and the lowest value (zero) was taken for critical value calculation.

Discussion

'Blackspot' disease, caused by *P. cuticola*, affects tropical and temperate freshwater fishes, especially cyprinid fishes. The present investigation also identified *Posthodiplostumum* infection in *P. conchonius* and *C. catla* in river Ganga. The infection was detected in 0.45% of *C. catla* and 2.34% of *P. conchonius*. Although we examined all size groups of the fish, the infection was detected only in small size groups, indicating that juveniles and small sized fish were more susceptible and larger fishes were resistant to the infection. No physical deformities were detected in infected fish and hyper-pigmented spots under the skin were easily recognizable.There was notable growth retardation and 'pin-head' appearance, especially in heavily infected *C. catla*.

In affected fish samples of both the species, the fins were not found to harbor the metacercariae which corroborated with earlier studies on *Gadus morhua* (L.) (Lysne et al. 1994) and cyprinid fish *Scardinius erythrophthalmus* (L.) (Ondraèková et al. 2002). Although exact cause of this is unknown, probably rapid fin movement of these fishes prevented attachment and localization of the parasite on fins. In contrast, large number of metacercariae were reported in fins of *S.erythrophthalmus*, *Hypophtalmichthys molitrix*, *Vimba vimba*, *Abramis brama* and *Percafluviatilis*. While, fewer metacercariae were observed in fins of cyprinid fish species *Rutilus rutilus* (L.), *Abramis brama* (L.), *A. bjoerkna* (L.), *Crassius auratus gibelio* (Bloch) and *Rhodeus sericeus* (Bloch) (Ondraèkováet al. 2002) and more number of metacercariae of several digenean species were found significantly on the fins than on other body parts of cyprinid fish *Phoxinus* spp. (Paradis and Chapleau, 1994), *Ctenopharyngodon idella* and *Aristichthys nobilis* (Maja et al. 2012). Probably, mechanical rigidity and movement frequency of fins differ in different fish species which make them differently susceptible to the parasite. Compared to fins

Table 1 Distribution of *Posthodiplostomum* sp. metacercariae in *P. conchonius* and *C. catla*

Sector/body region	No. of metacercaria		% distribution	
	P. conchonius (n=13)	*C. catla* (n=3)	*P. conchonius*	*C. catla*
S1	8	86	11.95	40.18
S2	25	64	37.31	29.10
S3	14	43	20.9	20.10
S4	-	-	-	-
S5	20	21	29.85	9.81
Total	67	214	100	100

n- Number of infected fish sample.

Table 2 Wilcoxon signed-rank test for sectoral comparison of metacercarial distribution on *P. conchonius*. Sector 1, S_1 (head, gill, operculum, eyes and buccal cavity), Sector 2, S_2 (trunk body below imaginary line), Sector 3, S_3 (trunk body above imaginary line), Sector 4, S_4 (fins excluding fin base) and Sector 5, S_5 (ventral body part)

Sector	Wilcoxon signed-rank test statistics	P value
S1 versus S2	8.5	<0.05
S1 versus S3	13.5	>0.05
S1 versus S5	19	>0.05
S2 versus S3	19	>0.05
S2 versus S5	23.5	>0.05
S3 versus S5	14	>0.05

proper, base of the fins was found to be easy site of predilection. In the present investigation, the base of dorsal, pelvic and caudal fins harboured parasites and their number was comparatively higher in *C. catla* than in *P. conchonius*.

The distribution pattern of metacercariae may be influenced or determined by habitat of the host, its behaviour, as well as, behaviour of the parasite. In *P. conchonius* S_2 is the most preferred site followed by S_5than any other sector of the body. This may be due to easiness in cercarial attachment and penetration, higher surface area to volume ratio compared to other parts of the body and constant exposure during foraging activities of fish in bentho-pelagic zone of near shore waters.This is well corroborated with earlier study done on *C. auratusgibelio* (Bloch) (Ondraèkova et al. 2002). The S_1 sector is the least infected part of the body of *P. conchonius*. However, in *C. catla*, S_1 harboured most number of parasites followed by S_2 and infectionwas least in sector S_5 of the body. This indicates *Posthodiplostomum* sp. metacercariae has no preferred microhabitat in the host body. It has also been reported in earlier studies (Lysne et al. 1994; Ondraèkova et al. 2002; Chapman 1974) that the random distribution of metacercariae is attributed to habitat preference of fish during life-stages within species and between species, life stage, foraging activity and cercarial behaviour.

Conclusion

The distribution of metacercariae in different sectors of fish body was random within and between the cyprinid species. However, the pattern of infection of metacercariae may be correlated with foraging behaviour and habitat preference during infection development.

Acknowledgements The authors are thankful to the Director, ICAR-Central Inland Fisheries Research Institute, Barrackpore, and the Director, ICAR-Central Institute of Fisheries Education, Mumbai for providing facilities for this work. The authors also acknowledge cooperation extended by fishing communities along the landing centres of the Ganga River during the course of study. The authors are also thankful to Subodha Kumar Karna, Archisman Ray and Manisha Bhor for helping in sample collection and preparation of location map respectively.

References

Athokpam VD, Tandon V (2014) Morphological and molecular characterization of *Posthodiplostomum* sp. (Digenea: Diplostomidae) metacercaria in the muscles of snakeheads(*Channapunctata*) from Manipur, India. *Helminthologia* 51(2):141–152

Chapman HD (1974) The behaviour of the cercariae, *Cryptocotyle lingua*. *ZeitschriftFürParasitenkunde*, 44**:**211-226

Dzika E, Kusztala M, Kozlowski J (2008) Metazoan parasite fauna of fish species in lake Kortowskie. *Archives of Polish Fisheries*, 16:75-86

Hoole D, Bucke D, Burgess P, Wellby I (2001) Diseases of carp and other cyprinid fishes. *Fishing news books, Blackwell Science Ltd, Oxford, UK.107 p*

Iqbal Z, Shukerova SA, Minhas IK (2014) Occurrence of black spot disease in *Labeorohita* (Hamilton)fry in carp fish hatchery Lahore, Pakistan. *Canadian Journal of Pure and Applied Sciences*, 8(1):2727-2731

Jayaram KC (1999) The freshwater fishes of Indian region. *Narendra Publishing House. Delhi*

Karimian E, Ghorbani R, Hajimoradlou A(2013) First occurrence and intensity of *Posthodiplostomumcuticola* (Nordmann, 1832) (Digenea; Diplostomatidae) metacercariae in monkey goby (Neogobiuspallasi Berg, 1916) in the Zarringol stream, Golestan Province, Iran. *Global Veterinaria*, 10(5):505–510

Koie M (1999) Metazoan parasites of flounder *Platichthysflesus* along the transect from thesouthwestern to the north eastern Baltic sea. *ICES Journal of Marine Science*, 56:157-63

Lyayman E M, Sadkovskaya OD (1952) The black-spot disease of carps and treatment. *TrNauchIsslInstPrud Oz RechRybKhoz* USSR, 8:108-116

Lysne DA, Hemmingsen W, Skorping A (1994) The distribution of *Cryptocotyle*spp.metacercariae in the skin of caged Atlantic cod (*Gadusmorhua*). *Journal of Fish Biology.*45:352–355

Maja M, Circovic M, Nevenka A, Nikolina M, Bjelic-Cabrilo O, Ljubojevic D, Ksenija A, Marina R(2012) Posthodiplostomiasis in a fish pond in Serbia. *ActaVeterinaria (Beograd)*, 62(1):101-109

Monni G, Orrú P, Cognetti-Varriale AM (1999) Distribution of *Pseudodactylogyrusanguillae* (Monogenea) on the gills of European glass-eels (*Anguilla anguilla*, L.) in closed-circuit, intensive breeding farms. *Bull. Eur. Ass. Fish Pathol*. 19:28-30

Nguyen TC, Li Y-C, Makouloutou P, Jimenez LA, Sato H(2012) *Posthodiplostomum* sp. metacercariae in the trunk muscle of Northern snakeheads (*Channaargus*) from the Fushinogawa River, Yamaguchi, Japan. *Journal of Veterinary Medical Science*, 74(10):1367–1372

Ondraèková M, Jurajda P, Gelnar M(2002) The distribution of *Posthodiplostomumcuticola*metacercaria in young-of-the-year cyprinid fishes. *Journal of Fish Biology*, 60:1355-1357

Ondraèková M, Davidova M, Gelnar M, Jurajda P(2006) Susceptibility of Prussian carp infected by metacercariae of *Posthodiplostomumcuticola* (v. Nordmann, 1832) to first predation. *Ecological Research*, 21:526-529

Ondraèková M, Reichard M, Jurajda P, Gelnar M(2004a) Seasonal dynamics of *Posthodiplostomumcuticola* (Digenea, Diplostomatidae) metacercariae and parasite-enhanced growth of juvenile host fish. *Parasitology Research*, 93:131–136

Paperna I, Dzikowski R (2006) Digenea (Phylum Platyhelminthes). *In* Woo PTK (Ed.), *Fish diseases and disorders*, **1** *Protozoan and Metazoan Infections* (2nd ed., pp. 345-371). CAB International, Wallingford, UK

Paradis AR, Chapleau F (1994) Impact de la maladie des points noirs sur la biologie du complexePhoxinus (Cyprinidae) du lac Fortune, Québec. *Canadian Journal of Zoology,* 72:1611–1615

Piasecki W (1995) Life cycle of *Caliguselongatus* von Nordmann, 1832 (Crustacea, Copepoda, Siphonostomatoida). *AkademiaRolnicza, Szczecin*, **69**. (in Polish with English summary)

Rolbiecki L (2001) Topographic specificity of *Diplozoonparadoxum* Nordmann, 1832 (Monogenea: Diplozoidae) in the bream, *Abramisbrama* (Linnaeus, 1758) in the Vistula Lagoon, Poland. *Wiadomosci Parazytologiczne*, 47:687-691

Rolbiecki L (2004) Distribution of *Posthodiplostomumcuticola* (Nordmann, 1832) (Digenea; Diplostomidae) metacercariae in cyprinids of the Vistula lagoon, Poland. *Archives of Polish Fisheries*, 12(1):93–98

Rolbiecki L (2006) Correlation between the occurrence of parasites and body length of roach, carp bream, European perch, zander, and ruffe in the Vistula Lagoon estuary. *International Journal of Oceanography and Hydrobiology*, XXXV(3):257-267

Rolbiecki L, Rokicki J (2000) The topographic specificity of *Achtherespercarum*Nordmann, 1932 (Copepoda: Lernaeopodidae) in the pike-perch *Stizostedionlucioperca* (L., 1758). *Crangon*.4:47-53

Schäperclaus WM (1979) *Fish Diseases*. *AcademieVerlag* (in German). Berlin

Schuster R, Wanjek K, Schein E (2001) Investigations on the occurrence of muscle metacercariae in the roach (*Rutilusrutilus*) from Berlin waters. A contribution to the food hygienic importance of indigenous freshwater fish. *Archivfürlebensmittelhygiene*, 52(4):102-104

Shukerova S (2005) Helminth fauna of the Prussian carp, *Carassiusgibelio* (Bloch, 1782), from the Srebarna biosphere reserve. *Trakia Journal of Sciences*, 3:36-40

Shukhgalter O, Chukalova N (2002) An investigation of “black spot” disease of bream (*Abramisbrama*) from the Curonian Lagoon, south-eastern Baltic Sea.*Bull. Eur. Ass. Fish Pathol*. 22:218-221

Soylu E (2006) Some metazoan parasites (Cestoda, Trematoda and Mollusca) of Bliccabjoerkna Linnaeus, 1758 from Sapanaca lake. Turkey. *Journal of Fisheries and Aquatic Science*, 20**:**33-42

Talwar PK, Jhingran AG (1991) Inland fishes of India and adjacent countries (**1 & 2**). *Oxford and IBH Publishing Co., Pvt.Ltd, 1158p.New Delhi*

Tare V, Roy G, Bose P (2013) Ganga River basin environment management plan: Interim Report. *IIT (Indian Institute of Technology) Consortium*

Teixeira-de Mello F, Eguren G (2008) Prevalence and intensity of black-spot disease in fish community froma subtropical stream (Santa Luc´ýa river basin, Uruguay). *Limnetica*, 27(2):251-258

Vytautas R, Èeslovas B (2009) Distribution, prevalence and intensity of roach (*Rutilusrutilus* (Linnaeus, 1758)) parasites in inland waters of Lithuania in 2005-2008. *Actazoologicalituanica*, 19(2):99–108

Williams H, Jones A (1994) Parasitic worms of fish. *Taylor and Francis, London*: 1-593

Woo PTK (2006) Digenea (Phylum Platyhelminthes). *In* Woo PTK (*Ed*.), *Fish diseases and disorders,* ***1*** *Protozoan and Metazoan Infections* (2nd ed., pp. 345-371). CAB International, Wallingford, UK

Zrncic S, Oraic D, Mihaljevic Z, Caleta M, Zanell D, Jelic D, Jelic M (2009) First observation of *Posthodiplostomumcuticola* (Nordmann, 1832) metacercaria in Cypriniformes from Crotia. *Helminthologia*,46(2):112-116

Socio-cultural tradition of the Rabha tribes of North Bengal, India : In relation to fisheries

Aparna Roy · Archana Sinha · Ranjan K. Manna
Basanta Kumar Das · Sucheta Majumdar

Received: 08 October 2018 / Accepted: 30 November 2018

Abstract Socio-cultural aspects of Rabha tribes in Terai-Dooars region of West Bengal have been studied to document their traditional knowledge in relation to fisheries. Survey revealed that in addition to agriculture, 39% of the Rabhas especially mid-aged women are also engaged in fishing from the rivers and streams. So, fishing is a secondary source or alternative source of livelihood for them. Their fish consumption pattern has been described. Five types of fishing gears and two types of plant piscicides commonly used by the Rabha community have been reported. A unique song sung during fishing dance has been recorded and described. Traditional knowledge associated with Rabha tribe is attempted to be documented and preserved in view of rapid social transformation of the community.

Keywords Socio-cultural, Rabha, tribe, fisheries

Introduction

Tribe is primitive social group consisted of many clans, nomadic brands usually occupying a definite geographical area. As per definition of Imperial Gazette of India, tribe is a collection of families, bearing a common name, speaking a common dialect, occupy or professing to occupy a common territory. Sense of unity, common language, common territory, common name, endogamy etc are the specific characteristics of a tribal society. The Terai- Dooars region of West Bengal is known for the primitive people and their associated indigenous culture. This part of Bengal is populated by tribes like Koch, Mech, Rabha, Munda, Santhal, Paik, Toto, Garo, Oraon etc. and many of them are still forest dwellers (Bose, 2011). Life of these tribal people is simple. Their social life is not yet compartmentalized into the economic, religious, educational or recreational categories. Rabha is one of the important tribes of this area. The Rabhas belong to the Indo-Mongoloid group (Roy,2016; Mandal and Roy, 2013). They have similarities with other members of Bodo group such as Garos, Kachari, Mech, Koch, Hajong and others. Rabhas are found in significant numbers three States in India, in; Assam followed by Meghalaya, West Bengal (Chakrabarty, 2015). Rabha is a unique community, having rich socio-cultural inheritance. According to the rule of lineage, Rabhas belong to matri-lineal family (Roy, 2016). Due to age old association with nature, Rabha people have congregated vast amount of valuable knowledge. According to Bose (2011), they are the traditional people of West Bengal who have retained most of their knowledge about the use of a large part of the plants in their environment for various purposes. Fishing from the rivers and streams is a part of life of the Rabha people. It is a popular hobby and also a means of livelihood to the Rabhas. Fishery has a major contribution in their social and recreational life. A case study was conducted on socio-cultural aspects of Rabha tribes in Terai-Dooars Region of West Bengal with the objective to explore the socio-cultural aspects of Rabha tribe.

A. Roy (✉) A. Sinha · R. K. Manna
B.K Das· S. Majumdar
Central Inland Fisheries Research Institute, Barrackpore, Kolkata-700120
e-mail: aparnandrister@gmail.com

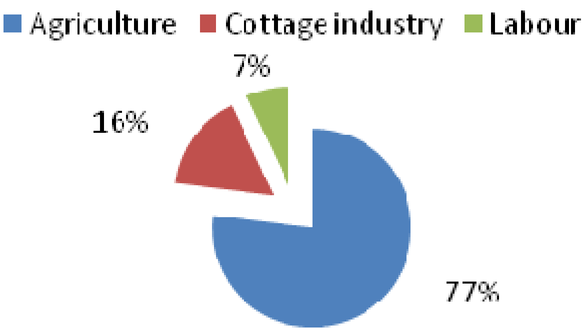


Fig. 1 Livelihood options of the Rabha tribes

Methodology

A total of 80 Rabha households were surveyed and information was collected from them using semi-structured interview schedule. Information regarding the indigenous knowledge was collected with Prior Information Consent (PIC) from the elder generation. Data collection and documentation was performed during 2015-16 in two mono-ethnic village namely; Rabha Basti, near Rajabhat Khaoya, Bauxa Reserve Forest and Chokhoya Kheti, near Chhilapota reserve Forest. In this study, attempt was made to do an in-depth analysis regarding the socio-cultural aspects of the Rabha tribes from fisheries aspect through case study method.

Result and discussion

Alipurduar district of West Bengal comes under Eastern-Himalayan Agro Climatic region, Sub region is Terai (http://rkvy.nic.in/static/SAP/WB/WB.PDF). The portion which is lying west of Teesta river is known as Terai, and the portion lying East is known as Dooars. The Terai-Dooars region of West Bengal is blessed with innumerable streams and rivers and the average rainfall of the area is 3500 mm. Numbers of tribe live in Terai-Dooars region of Bengal since the period of pre-colonial India. During colonial period migration happened in the Terai-Dooars region. And, now the tribes of this region (North Bengal) are divided into two categories: migrant tribe and indigenous tribe (Roy, 2016). The Rabhas are the inhabitants of Dooars region between the river Teesta and Sankosh (Chakrabarty, 2015). Though the Rabhas in Terai-Dooars region of Bengal is minor in number but they have distinct and rich culture.

Rabhas are primitive tribe of India and have a defined history. They are having the property inheritance and the descent takes place among the female line. Like Garo tribes, Rabhas are also matrilineal. In Rabha society, the 'Gotra' of the women doesn't change. The children carry the name of their mother. The Rabhas are divided into five Gotras viz. Rangdania, Pati, Dawari, Maytori and Koch (Nath, 2015) ; whereas according to Roy (2016), Rabhas are divided into eight distinct groups. In the study area, the influence of Rajbanshi tribe is noted among the Rabhas. But, the Rabha people inhabited adjoining the forest are still trying to withhold their culture. Also, due to influence of Christian Missionaries (Mandal and Roy, 2013) , a socio-religious transformation has been occurred lately. It was found in the study area that 67% of the sampled population has faith in their conventional religious belief that is God Rishi, whereas 33% of the Rabhas have been converted to Christianity and Hindu also. Illiteracy is also quite prevalent among the Rabhas of that region.

The occupational structure of a community determines the income or economic structure of the community (Gogoi,2016). Agriculture is the main way of livelihood adopted by the Rabhas (Fig. 1). In early days, they followed shifting cultivation Jhum, which was called as 'Tajina'. But, nowadays they cultivate rice, different pulse seed, mustard seed along with other vegetables. In addition to agriculture, considerable sections of the Rabhas are engaged in cottage industry (16%). Weaving is a source of earning for the Rabha women. They are good weaver of handloom. Fishing is also a source of livelihood of Rabhas. Rabhas generally involved in fishing activities from rivers, streams, rivulets, wetlands, etc. Female are involved in community fishing with handmade traps. In the present study, it was found that 77% of the Rabhas are involved in agriculture whereas a study conducted by Mandal and Sengupta in 2016 found that 59% of the Ravas in Porobasty, Alipurduya district, North Bengal are invovled in Agriculture (Mandal & Sengupta,2016). In addition to agriculture, 39% of the Rabhas are also engaged in fishing from the rivers and streams. So, it is a secondary source or alternative source of livelihood for them. About, 7% of them are agricultural labour or labour in tea gardens.

In the study site, it was found that 32% of the Rabha women of middle age group (35-50) are involved in fishery activities for both consumption and earning purpose. They use to catch fish from streams and rivers by using Jhakoi, a small bamboo made gear. Sometimes they sell fish catch to the markets also.

Traditionally the Rabhas were hunters; they used to hunt animals and fishes. From nomadic stage, hunting was one of the options to lead their livelihood. Various traps/ gears and herbs are used by the Rabhas to catch fishes from rivers, streams etc.Rice is the staple food of the Rabhas. They take major food three times in a day. Rabhas are non vegetarian. As Rabhas were forest dweller so they lead their life by having fruits, fish (Na) and meat (Kan) from forest in their nomadic stage. They eat all type of fishes including small fishes like Puti (Nousan Na), Shati (Naran Na), Khalisha (Napar NA), Singi (Singee Na), Magur (Magur Na), Prawn (Nakchen Na), Mystus (Tangra Na) etc. Other than those fishes, IMCs are also included nowadays in their food habit.Dry fish is very much preferred by the Rabha people. They used to keep excess fish after drying it in the sun. They prepare fish powder (especially prawn) and it is known as Nisuchepa. Rabhas also eat dried small fish in a separate way. They keep the dried fish with Pudina, Colocasia and other spices in bamboo hole and eat this whenever required after boiling it with alkaline substance obtained from banana stem.In Rabha society, fishes like Shal (*Channa marulius*) and boyal (Wallago attu) cannot be eaten by a person who is under the custom of funeral system.

Indigenous technical knowledge related to fishery

Burung:

Rabha and Rajbansi tribes use this fish trap to harvest small fishes from different rivers like Torsa, Bania, Holong and various other streams of north Bengal. It is a spindle shaped trap made of split bamboo strips (Fig. 2a). A small opening is made in the front of the trap as inlet of fishes pointed inwards. Sometimes Burung is made up from a single bamboo. These traps are of small sized (12-15 cm length) and specially use to catch small fishes. In Assam, it is named as Chepeti (Bhattacharjya *et al*, 2005.)

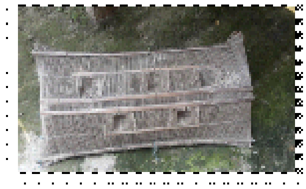
Doksa/Thusi/Thorko/Kumni: Rabha and Rajbansi tribes use this trap to harvest fishes from different rivers like Torsa, Bania, Holong etc and various other streams. It is a large conical shaped trap made by split bamboo strips used to catch small and medium sized strips (Fig. 2b). Length of the trap is 5-5.5ft and the diameter is 20-30 cm. The body of the trap is

Name of the traps **Figure**

2a..Burung

2b. Doksa/Thusi/ Thorko/Kumni

2c.Tapai



2d. Jhakoi & Duku

Names of Picicidide **Figure**

2e.Bishkutul/ Sukurkota

2f.Tejma

Fig. 2 Fish traps and plant piscicides commonly used by Rabha community of north Bengal, India

strengthened by rings made of bamboo. Iron rings are sometimes placed in the mouth of the trap. In Assam, it is named as Khaki/Khoka/Baha (Bhattacharjya et al, 2005).

Tapai: Rabha, Toto, Oraon tribes use this trap to harvest fishes from different rivers like Torsa, Bania, Holong etc. Tapai is a rectangular shaped trap with 12-14 fish inlets (Fig. 2c). CPUE of this trap is high, up to 15-18 kg as reported. It is also made of Bamboo. The trap is placed in the river water generally in the evening and the catch is collected in the morning. Small fishes are the targeted species of this trap.

Jhakoi: Rabha women extensively use this trap to collect fish from the rivers or streams. It is a triangural shaped hand operated trap made with bamboo frame (Fig. 2d). The mesh is made with bamboo splits.

Duku: This is a storage device to collect fish made of splitted bamboo (Fig. 2d).

Sukurkota/Bishkutul: Sukurkota/Bishkutul (Polygonum hydropiper) widely available in swamps of Dooars is commonly used as fish poison by the Rabhas (Fig. 2f). For harvesting the fishes, the whole plant (Polygonum hydropiper) paste is broadcasted in a particular area of a river stream and after sometime the fishes come to upper surface and cannot move fast due to the toxic effect of the plant. Then fishes are collected from the stretch with the help of small meshed gears or Jhakoi. Polygonum hydropiper is also used by the fishers of Assam in wetlands to harvest the fishes (Bhattacharjya et al, 2005) .

Tejma: Tejma (Zanthoxylum armatum) is a shrub or small tree growing up to 6 m tall on shrubberies (Fig. 2f). The bark of this shrub is widely used by Rabhas as fish poison in Bania River as reported.

Culture associated with Fishery

Singing and dancing is a part of entertainment of Rabha community. They gather together and dance in various social functions like religious ceremony, marriage ceremony, welcoming others. Though Rabhas in Terai-Dooars region is minor in number but they are very distinct in their culture. Fishing is an important activity in the life of the Rabha people, and it is assimilated in their culture in the form of dance, which is performed by the women-folk of the Rabha community for depicting their daily lives. Rabha people perform dance with melodious music wearing colorful costumes.

Fig. 3 Traditional fishing dance by women of Rabha tribes

Fishing dance is one of the important dances performed by the Rabha women among the other dances like welcome dance, celebration dance and war dance (Fig. 3).

Common Fishing dance song of Rabhas is given below

"Nai logo par nai / Chika jora hasmai nai / Na loya nang / Duku songai hai moun / Palao jasi lai mon / Shouri shouri chika jor hasmai / Na loya nang /Par mandar par dinoyang /Par ponch par dileai / Rasan ban dungnatang bhugil doban pulungtang / Nai anao negoyang leisei". The meaning of the song in a nutshell is, friends lets go for fishing in the river in groups with fishing traps like Dukhu and Paloi/Jhakoi for capturing the fishes; as the flowers are blooming, so it is time for fishing. In the time of sunset, we should return back to home after fishing.

Inland fisheries contributing significantly in the life of Rabhas: Socially, culturally and even economically. Rabhas are the primitive tribe who are very close to the nature. Their knowledge, perception regarding nature may help the researchers to find new avenues to conserve nature and natural diversity. The social metamorphosis taking place in the life of Rabha may cause extinction of their language, culture, food habits and other things. Fishery is an important part in their life and traditionally they are crafted with the knowledge of fishery. So, their knowledge can be utilized to conserve the endangered fish species of Terai-Dooars Region. Their knowledge related to fishery should be conserved through documentation before it goes into oblivion.

Acknowledgement Authors are indebted to Technical personnel of CIFRI viz. Mr. S. Choudhury and

Mr. M. Roy for assistance in collection of data and photographic documentration.

References

Bhattacharjya BK, Manna RK & Choudhury M (2005) Fishing crafts and gear of northeast India, Bull No 142 (CIFRI, Barrackpore, Kolkata), 67p

Bose D (2011) An ethno-medicobotanical investigation among Rava tribe of Jalpaiguri District. NBU Journal of Plant Sciences 5(1):61-65

Chakrabarty Suman (2015) People's Perception on Climate Change: A Case Study among the Rabha Tribe Living in Fringe Forest Areas of North Bengal, India. TTPP (TTPP,p_1):1

Gogoi MCP(2016) A Socio - Economic Study of the Slum Dwellers of Assam, The International Journal Of Humanities & Social Studies 4(2):211-219

http://rkvy.nic.in/static/SAP/WB/WB.PDF

Mandal B, Roy M (2013) The Rabha and their social movement (1925-1950): a case study of North Bengal. J Humanit Soc Sci. 10:5-8

Nath Pramod (2015) Uttarbanger Lokjibone Khaddo o Pani. The Shee Book Agency. 22p

Mandal J, Sengupta P (2016) Socio-Economic Status of Tribe: A Case Study of Porobusty, Alipurduar, West Bengal. Imperial Journal of Interdisciplinary Research, 2(5)

Roy M (2016) A Historical Outline of the Rabhas of North Bengal. Imperial Journal of interdisciplinary Research 2-(3):650-659

Analysis of profitability of inland fish farming through ponds and tanks in Gujrat

Shakti Ranjan Panigrahy · Dilip Vahoniya

Received: 29 October 2018 / Accepted: 15 November 2018

Abstract Inland fisheries enjoys prime place in Indian economy. It provides employment and livelihood for fishers who solely depend on it. Gujarat ranks third in total fish production in India, but production through Inland resources is not so significant. Day by day demand of Inland fish has been increasing in this state that motivates producers' to produce more from their impounded land resources. Analysis of profitability of Inland fishery production is a move towards improved productivity anddetermining resource use efficiency, adds value in it as it provides information for better economies scale of production. Thirty ponds have been selected in two major districts of Gujarat purposively where more than fifty four percent of productions of inland fisheries were done through ponds and tanks.Cobb Douglas production function was used for getting relevant output in this study. At the end, selling price of fish was about six times than the cost of fish production per hectare of pond. Producer was getting benefit higher than its cost of production which was a better sign of indication. Vehicle cost, Fingerling cost, feed cost and Watch and ward cost had major share in overall cost of production but feed cost, fuel cost in transportation and pond repairing cost were major cost that impact on cost of Inland fish production. Here, in this study, feed cost and fuel cost wereunderutilized whereas pond repairing cost was over utilized. If all input resources are managed efficiently profitability from Inland fisheries will have better result for the Inland Producers.

Keywords Cobb Douglas Production Function, Cost of Inland Fish Production, Resource Use Efficiency

S. R. Panigrahy(✉) D. Vahoniya·
International Agribusiness Management Institute, AAU, Gujarat
e-mail: panigrahy.shakti@gmail.com

Introduction

Inland fish is a commodity that have been captured or cultured; but whatever may be its route of production, day by day its demand is increasing among Indian consumers. That's why, Out of total fish production in India; only 36 percent contributes from marine sector and rest 64 percent from inland sector and this percentage for marine fish recedes from 71 percent marine fish production in 1950-51 to 64 percent in 1980-81 and 36 percent in 2013-14 (Department of Animal Husbandry, Dairying and Fisheries, 2014).Not only that Inland fish consumption more suits to consumer of developing and under developed countries due to their less disposable income for consuming Inland fish over marine one (FAO, 2014). According to one of the report of CSO-MFS, 2011, Inland fisheries enjoys prime of place in Indian economy. It provides employment and livelihood for fishers who solely depend on it. Nevertheless, unlike marine sector, inland fisheries cannot claim a satisfactory status with regard to data collection. So a stringent data collection has been done here for getting more accuracy in cost analysis of Inland fish in Middle Gujarat.

Gujarat is bestowed with ample water resources of 3865km of rivers and canals, 2.43 lakh hectares of reservoirs, 0.71 lakh hectares of tanks, lakes and ponds,

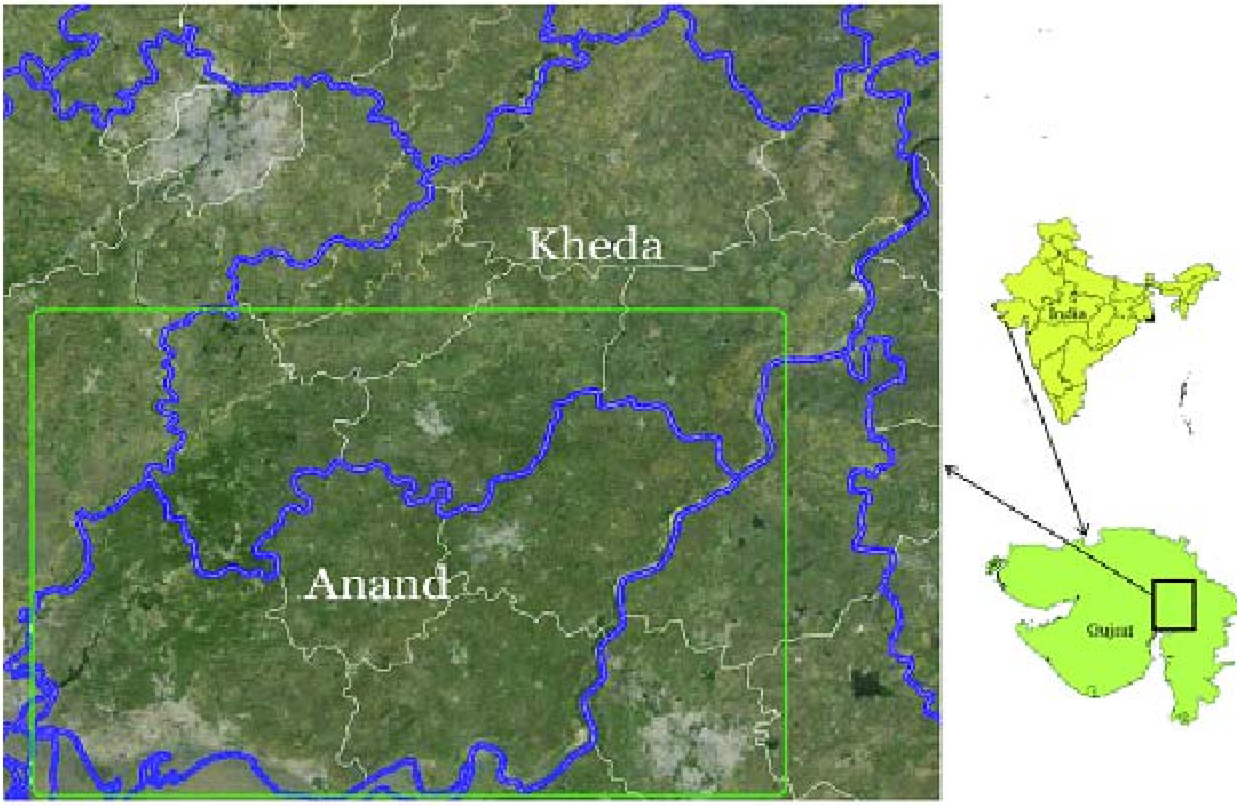


Fig. 1 Area of study, ref 10

0.12 lakh hectares of flood plain lakes and derelict water, 1 lakh hectares of brackish water (Commissioner of Fisheries Government of Gujarat,2012). Among different geographical destination in Gujarat, Middle Gujarat has its own significance in Inland fish production as it is the region where major Inland fish production have been carried out though Ponds and Tanks. Production through Ponds and Tanks reflect their entrepreneurial attitude for Inland fish production. Besides that Gujarat ranks third in total fish production in India, but production through Inland resources is very much negligible and it ranks eleventh in this category (Gujarat Fishery Statistics, 2012-13).

All most all labour forces in agriculture are unorganized where as 98.7 percent unorganized labours are dwelling in fishing sector. Even Fish farmers' were inefficient in the application of productive resources, the low output prices and the imperfect condition of input markets hampered efficient utilization of production inputs (INONI, 2007). Rahaman et.al (2015) pointed out that Fish seed and labour were underutilized in fresh water production system where as fish seeds, labour and area were under used in wastewater fish production system. Similarly in another study by Akenbor&Ike (2015) revealed that pond size, fingerlings, feeds and fixed cost of items were underutilized, while labour and operating cost were over utilized. Coefficients of human labour, feed, cow dung and manure had significant impact on gross return, whereas Coefficients of feed, harvesting and making sanctuary had significant impact on gross return of Beel fish farming (Uddin&Farjana, 2012). Looking into producers' perspective, profitability analysis of Inland fishery is very much essential to be determined and resource use efficiency adds substances in the direction of productivity. That's why, this study adhered with two basic objectives; i.e., to estimate the costs and returns of Inland fish production and to study subsequent resource use efficiency in Inland fish production.

Materials and methods

Two major districts i.e. Anand and Kheda of Gujarat were selected according to presence of maximum numbers of Ponds and Tanks (appx. 54%) for Inland fisheries production through ponds and tanks (Gujarat Fishery Statistics 2012-13). All data have been collected through well-structured schedules, in the time period of August- December, 2017. This is the period when demand of fish had been increased may be due to advent of winter season, festival and post mansoon supply of fish after their fertilization. About thirty ponds were purposively selected after doing cluster sampling from the list of registered Ponds and Tanks of both the districts. It has been done because of presence of numbers of impounded water resources within some specified areas of these districts; may be due to water soil characteristics or may be due to availability of leased ponds at some specific areas. For that sake, selection of Ponds and Tanks were considered mainly from Anand, Tarapur, Petlad, Sujitra&KhambatTaluka of Anand District and NadiadTaluka ofKheda district. Data were gathered and analysed through different statistical technique; mainly Cobb Douglas production function for getting significant in cost along with their resource use efficiency. In this study, cost of carp fish (Rohu, Catla, Mrigal) production have been considered, as these were profusely found (about 47%) of total Inland fisheries production in Gujarat (Gujarat Fishery Statistics 2012-13). Here monoculture ponds were not considered for avoiding any outliers in data, due to less sample adequacy and getting more homogeneity in data.

Cobb- Douglas Production Function

Cobb douglas production function is used to understand the impact of two or more independent variables (input) on dependent variables (output) when data that were collected were nonlinear in nature.

$$Y = a X_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} X_5^{b5} X_6^{b6} X_7^{b7} X_8^{b8} X_9^{b9} X_{10}^{b10}$$

Where,

Y= Gross income of the producer per day basis

X1= Cost of fish seed in kg

X2 = Cost of fish feed in kg

X3= Cost of fuel cost of transportation in Rs

X4= Cost of fuel cost for water pump in Rs

X5= Cost of pond repairing in Rs

X6= Cost of wage labour in Rs

X7= Cost of Lime cost in Rs

X8= Cost of Medicine Cost in Rs

X9= Cost of depreciation cost in Rs

X10= Cost of Watch and ward cost in Rs

a= Intercept and b1, b2, b3, b4,b5, b6,b7,b8,b9 and b10 are regression coefficients

Resource Use Efficiency

The Marginal value of Productivity (MVP) Analysis was used for determining resource use efficiency (r) using the equation: r = MVP/Pxi, where Xi = mean value of inputs

$$MVP(X_i) = b_i \frac{\overline{Y}}{\overline{X}_i} P_y$$

Where,

$MVPX_i$ = Value marginal product of i[th] input

b_i = Elasticity of production of i[th] input

$\overline{Y}$ = Geometric mean of gross returns

$\overline{X}_i$ = Geometric mean of input of i[th] input

P_y = Price of output

For determining resource use efficiency of resource the following criteria was used

MVP/MFC > 1 under utilization of resource

MVP/MFC = 1 Optimum use of resource

MVP/MFC < 1 Excess use of resource

MFC = Px = it is the cost or price of one unit of a specific input resource

Source: Rahaman et.al (2015)

Methodology for Collection and Estimation of Inland Fisheries Statistics in India

Resource concepts and definitions

Ponds: Ponds are usually earthen, shallow, excavated water bodies, though masonry dykes are also not uncommon. Pond represents a restricted environment without a continual interaction with populations of neighbouring biotopes. The water level and biomass within are highly influenced by the rate of evaporation and precipitation. Inundation is often the lone factor leading to exchange of biological communities with adjacent water bodies.

For fisheries enumeration purposes, all such water bodies having an area of less than 5 ha at full water level are designated as ponds. Fish production from these ponds is estimated at 800-2000 kg ha⁻¹ without application of fertilizers and supplementary feed, the productivity level being determined by the inherent nutrient status of soil and water, and to a great extent, the nutrient leaching from the surroundings. Scientific farming, however, has resulted in yield exceeding 10 tonnes per ha pond area per year.

Tanks: Tanks are generally referred, in common parlance, to denote varying types of water bodies in different parts of the country. Tanks are larger than ponds, created on seasonal streams, mainly for irrigation purposes by constructing earthen or masonry barricades. These shallow water bodies generally get dried up during summer. Large excavated community ponds or temple tanks also fall under this category. Tanks, on management, have a potential to yield 500-1000 kg or often up to 2000 kg under scientific fish farming. Many authors consider tanks as an interchangeable expression for ponds and small reservoirs and these resources are often clubbed in resource assessment. Water bodies having an average area of 5-10 ha, irrespective of their water source, may be considered as tanks. These include small irrigation impoundments, temple tanks, community tanks and natural tanks fed by catchment from neighbouring areas.

Source: Bulletin 58 (Revised Edition), CIFRI, 1991

Table 1 Showing cost-revenue bifurcation of Inland fish per month per ha basis

Parameters	Cost/ha/month	Parameters	Cost/ha/month
Cost of Boat	104.17 (0.91)* (0.53)**	Fingerling cost	1999.29 (24.8)* (10.28)**
Vehicle cost	6858.71 (60.26)* (35.27)**	Feed Cost	1348.21 (16.72)* (6.93)**
Water pump Cost	555.13 (4.87)* (2.85)**	Fuel Cost transportation	76.20 (0.94)* (0.39)**
Weighing Scale Knives Cost	96.92 (0.85)* (0.49)**	Fuel Cost Water pump	462.96 (5.74)* (2.38)**
Outhouse cum shed Cost	1020.23 (8.96)* (5.24)**	Pond repairing Cost	52.73 (0.65)* (0.27)**
Dragnet Cost	200.68 (1.76)* (1.03)**	Wage labour	1123.11 (13.92)* (5.77)**
Leased rental 18 month	2544.38 (22.35)* (13.08)**	Lime Cost	37.47 (0.46)* (0.19)**
Total fixed cost	11380.16 (100) (58.53)**	Medicine Cost	25.72 (0.31)* (0.13)**
Cost-Revenue Bifurcation of Inland Fish		Depreciation Cost	25.44 (0.31)* (0.13)**
		Chowkidari Cost	1759.26 (21.81)* (9.04)**
		Total variable cost	8063.54 (100) (41.47)**
Total cost	19443.7 (100)	Gross Margin	143094.14
Net Margin	123650.44	BC Ratio	6.35
Per kg. Fish Production cost	14.6		

Table 2 Showing different Model and their specificity

	R Square	Adjusted R Square	Standard Error	F value	RMSE
Linear	89.10	87.30	46053.15	51.06	230265.75
Semi log	83.40	82.20	54687.92	67.75	284166.768
Cobb Douglas	88.30	87.0	0.14243	65.60	0.72625

Table 3 Showing three proposed model after stepwise regression in Cobb Douglas Production Function

Model	R Square
1	.808
2	.843
3	.883

Table 4 Showing different cost according to their significance on Inland fish production

Model		Standardized Coefficients Beta	Sig.
1	(Constant)		.003
	Total Feed Cost	.899	.000
2	(Constant)		.016
	Total Feed Cost	.696	.000
	Fuel Cost transportation	.277	.020
3	(Constant)		.176
	Total Feed Cost	.358	.025
	Fuel Cost transportation	.548	.000
	Pond repairing Cost	.306	.006

Results and discussion

Table 1 showing cost-revenue bifurcation of Inland fish per month per ha basis. According to this table, fixed cost has contributed almost 58percent of cost and variable cost contributed the rest. In fixed cost, vehicle cost purchased by the owner has a considerable share whereas fingerling cost, watch and ward cost and feed cost has contributed major share in variable cost. It may due to vehicle was an investment for long run for transportation of feed, fingerlings and fish from and to the market place. Fingerling cost was higher due to non-availability of sufficient quantity in nearby places and it has been supplied at a fixed amount irrespective of pond size. Many a times, producers has depended on fingerlings from Kolkata and has been transported the same through airway. As majority of ponds were licensed in origin and have found away from the home premises of the owner, that's why, watch and ward cost has also played a great role in the study area. Here in the study area, fish producer has taken a net margin revenue up to Rs 1, 23,650/- per month per ha basis and per kg profit per ha of pond was found to be Rs14/-. It may be due to organized way of production by the producer and many activities has been outsourced in the study area.

Though it has not been cleared from Table 1 that which costs have major impact and significant role in Inalnd fish production, that's why; cost- benefit analysis have been carried out in Table 2, where it was found that cobb douglas production function was a better model in comparision to Linear and Semi log model due to better data explanation by the independent variables on dependable one and data dispersion aswell. According to Table 3 and 4, Model 3 is the better one due to High R square value. Total feed cost, fuel cost

Table 5 Showing issues regarding resource use efficiency in Inland fish production

	B Value	Y (Geometric mean)	(Geometric mean of Sig. Variable)	MVP	MFC	r= MVP/MFC	Resource Efficiency
Feed cost	0.358	5.0979	4.7933	34.26	28	1.22	Under Utilization
Fuel cost	0.548	5.0979	3.6438	69.00	4	17.25	Under Utilization
Pond repairing cost	0.306	5.0979	3.5480	39.57	700	0.056	Over Utilization

for transportation and Pond repairing cost has been found as significant (table 4) that impact on cost of production and further revenue for the Inland fish producer. Whether there use was judicious at farm level, resource use efficiency has been carried out here for understanding through marginal value of productivity on marginal value of cost.

Table 5 shows that though feed cost and fuel cost of transportation were significant still they were underutilized and producer may incur some more cost on them for getting substantial revenue. Whereas, pond repairing cost was over utilized in resource point of view and its use should be reduced for betterment of production.

Conclusion This study has been carried out in Anand and Kheda district by looking in to the abundance of Inland fish production through ponds and tanks. In this study, the selling price of fish is about about six times than the cost of fish production than hectare of pond. Producer is getting benefit higher than its cost of production which is a better sign in social economical aspect of the producer in Inland fish production. Vehicle cost, Fingerling cost, feed cost and Watch and ward cost has major share in overall cost of production but feed cost, fuel cost in transportation and pond repairing cost are major cost that impact on cost of Inland fish production. Here, in this study, feed cost and fuel cost are underutilised whereas pond repairing cost is over utilised.

Suggestion Supply of oxygen is essential for maintaining pond internal ecology that helps for better growth of inland fish in its environment. Over stocking hamper the growth and leads to eutrophication. Effective and optimised pond preparation enrich the inland fish production and water loss due to leakage and evaporation

References

Akenbor AS; Ike PC (2015). Analysis of Technical Efficiency of Catfish Farming in Edo State, Nigeria. Journal of Biology, Agriculture and Healthcare,5(2):96-101

CIFRI (1991). Bulletin 58 (Revised Edition). Methodology for Collection and Estimation of Inland Fisheries Statistics in India. 1-64

CSO-MFS (2011). Manual on Fishery statistics. Ministry of Statistics and Programme Implementation, Government of India

Department of Animal Husbandry, Dairying and Fisheries (2014). Handbook on Fisheries Statistics. Ministry of Agriculture, Government of India, 1-166

FAO (2014). World Review of Fisheries and Aquaculture. State of World Fisheries and Aquaculture.1-10

Gujarat fishery Statistics (2012-13). Department of Agriculture and Cooperation, Government of Gujarat

InoniOE (2007). Allocative Efficiency in Pond Fish Production in Delta State, Nigeria: A Production Function Approach. AgriculturaTropica Et Subtropica, 40(4):127-134

RahamanSkM, Ghosh A, Pal S, Nandi,S (2015). A comparison of resource use efficiency and constraints of wastewater and freshwater fish production system in West Bengal. Economic Affairs, 60(2): 249-255

Uddin MT,Farjana I (2012). An Economic Study of Low Lying Inland Fish Farming in Selected Areas of Kishoreganj District. Progressive Agriculture,23(1 &2): 81-90

https://www.google.com/search?biw=1366&bih=657&tbm=isch&sa=1&ei=U710XNSACumkggfUnbOoCA&q=Anand+and+Kheda+district+of+Gujarat+&oq=Anand+and+Kheda+district+of+Gujarat+&gs_l=img.3...29275.29275..29499…0.0..0.0.0.……0….1..gws-wiz-img.gj-1rKslzvY#imgrc=zBzQRZw7nfMckM,accessed on 26-2-2019

The dynamics of fish seed production in West Bengal over the years

Prasenjit Pal

Received: 20 June 2017 / Accepted: 21 November 2018

Abstract In the current study, an attempt has been made to study the trend of fish seed production over the years and to find the appropriate model to characterize the dynamics of fish seed production not only in West Bengal but also in India. The appropriate trend equation has been identified and it has been evaluated by the model accuracy parameters like R^2 and AIC. The importance of such studies stems from the fact that the policy makers need the specialized scientific information in the form of advisory services in respect of the dynamics of fish seed production.

Keywords Trend, R^2, AIC, Dynamics

Introduction

Fish is one of the major sources of protein for most of the Indian population. Fisheries sector has a strategic role in food security, international trade and employment generation. According to the Food and Agriculture Organization (FAO) of the United Nations, fish output in India doubled between 1990 and 2010. Fish seed is one of the essential inputs for fish farm production. The supply of quality fish seed is a key factor to the expansion of fish farming as the demand for fish seed is growing day by day. The Government of India has paid keen interest to enhance the production and distribution of Asiatic carp seeds; i.e. major Indian carps and Chinese carps with the assistance of FAO. It would be an essential complement to the central project of "Fish Farmers Development Agency", in the states: Uttar Pradesh, Bihar, Madhya Pradesh, West Bengal, Orissa and Karnataka and covers a total of 0.3 million ha of ponds and small irrigation reservoirs for rehabilitation and improvement. Successful food-fish production is largely dependent on the availability of quality fish seed amongst various other factors associated with on growing. Difficulties in accessing adequate fish seed can therefore constrain production, business and food- fish supplies. Deficiencies in fish seed supply within India were anticipated eleven years ago with the then level of production estimated as being able to satisfy less than half of customer and consumer demands at the time (Pathak, 1990). Fish seed collected from rivers and other natural water bodies is mixed with wild fish seed and is unsuitable for stocking the ponds under the poly-culture system, because of difficulties in manipulating the fish populations required in this intensive farming method. Through application of hypophysation techniques, modern fish seed farms are producing better quality fish seed of selected species and varieties, desired size-groups in specific supply period, as required by specific fish population management practices adopted by fish farmers. Therefore, a technological basis for a carp seed industry has already been founded.

West Bengal is a 'rice-fish society'. The State has 37% of pond resources in India of which 70% are utilized for fish culture producing 1-3 million tonnes of freshwater finfish per year. West Bengal is also a major producer and supplier of fish seed to other Indian States. (Morrice et al., 1998). At present there are a total of about

P. Pal(✉)
College of Fisheries, CAU, Lembucherra, Tripura-799210
e-mail: prasenjit3agstat@gmail.com

Fig. 1 Different districts of West Bengal

3 state-owned fish seed farms in West Bengal. Dietary preference for freshwater fish in greater Bengal, as part of a rice-based diet has been the nutritional support for dense populations on the floodplains of one of Asia's largest rivers. Recently, cultured fish have become important in augmenting wild fish stocks with the capture and on growing of fish seed from the wild further developing into fish breeding in hatchery systems. Fish seed production began to develop as private sector enterprise. Through further networking, relationships and informal training hatchery businesses began to develop further afield from Naihati, which in the 1970's, had only three hatcheries, but is now the major concentration of fish seed production in India. In 1975 Naihati Fish Seed Market developed as a centre for fish seed marketing and distribution.

Fish breeding in hatcheries developed from the capture and on growing of fish seed from the wild. Natural and physical resources were influential in determining the initiation and growth of the industry; fish seed production is highly concentrated around Naihati which has developed a large fish seed market which facilitates the marketing and distribution of seed within and outside West Bengal. A study conducted by Milwain et al. (2002) revealed the different factors affecting fish seed quality were; oxygen deficiency in nursery ponds; high temperatures, disease and poor tube-well water quality in hatcheries; and during transportation, low water availability and delays from traffic congestion for some golders and patil wallahs. Hatchery brood stock management strategies are potentially disadvantageous to production from the sex ratio used in breeding, intensity of broodstock use and brood stock replenishment methods. Water pumping costs were also a constraint. Mortalities in hatcheries were induced by high temperatures and possibly tube-well water quality, possibly as a result of high iron and arsenic levels flooding from the Hooghly River caused stock losses in various areas. Marketing of fish seed was more problematic for nurseries generally and hatcheries in Bankura than elsewhere. Transportation delays and water exchange problems were less of a concern than high temperature, which also caused mortalities during transportation for middlemen. Competition is high in fish seed distribution and extra expenses are incurred by golders from unofficial tolls imposed by the police. An important trend was the increased competition lowering fish seed sale prices in hatcheries, reducing profit margins and influencing production strategies. Some hatchery owners with the knowledge and skills were diversifying from Indian Major Carp (IMC) production to more profitable species such as catfish. Food-fish production in the ECW is perceived to be constrained by limiting nutrient supplies, urban encroachment, increasing costs of production (especially labour) and theft problems.

In respect of the socio-economic, environmental and technical nature of the constraints to the system it is clear that both long-term macro level and micro- level approaches are required to device appropriate management plans for sustainable development in the fish seed network and associated livelihoods. Therefore, an attempt has been made to quantify and characterize the fish seed production potential of the area to determine the dynamics or trend pattern identifying the appropriate trend equation which will act as a guide for the future management plan in this area.

Materials and methods

In the present study, an attempt has been made to explore the pattern of fish seed production of West Bengal from 2002-03 to 2014-15. The production pattern helps to forecast the future production pattern of the region enabling the better prospect in fisheries sector to maintain near self-sufficiency in fish requirement. The data collected from the Director/Commissioner of Fisheries of West Bengal from 2002-03 to 2014-15. A non-parametric Mann-Kendall trend test has been employed to test the presence of statistically significant trend by applying the Gilbert procedure. Then the data set were fitted through polynomial regression. Polynomial regression models are usually fit using the method of least squares. In general, the expected value of y can be modeled as an nth degree polynomial, yielding the general polynomial regression model

$$Y= a_0+ a_1x+ a_2x_2+a_3\, x_3+\ldots\ldots+a_n\, x_n+e$$

Conveniently, these models are all linear from the point of view of estimation, since the regression function is linear in terms of the unknown parameters i.e.a_0, a_1,.....Some standard statistical measures were under taken to evaluate the performance of the fitted model. The accuracy parameters are R^2 and AIC criteria. The data was analyzed by SAS 9.3 for appropriate trend equation.

Table 1 Parameter estimates of the fitted model (Polynomial regression)

	Model	Prob.>|T|
W.B	$Y=-21.69x^2+684x+9817$	<0.0001
India	$Y=30.81x^2+1740x+1.494E04$	<0.0001

Table 2 Model accuracy parameters of the fitted model

Statistics	W.B	India
R^2	0.74328	0.95098
AIC	8.20E+06	3.38E+07

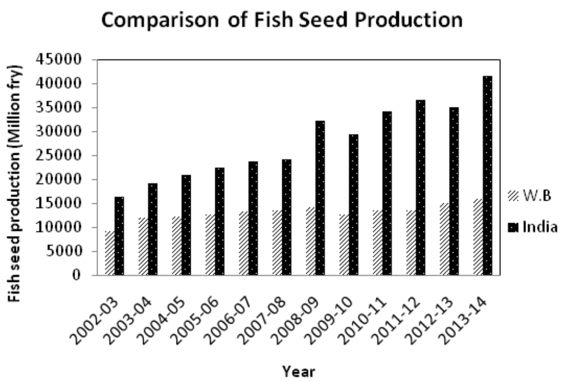


Fig. 2 Comparison of fish seed production data of West Bengal with India

Results and discussion

The data of fish seed production over the years has been tested by Mann-Kendall trend test which revealed that there is a statistically significant increasing trend in both the data sets of West Bengal (p (no trend) <0.001) and India (p (no trend) <0.001). Then both the data were fitted through different models. But the best fitted trend equation is Polynomial regression model. The superiority of the model was based on the parameter of the model found with their statistically significant value and the model accuracy parameters like R^2, Aikaike Information Criteria which are given in the Table 2. The AIC values which are presented in the Table 2 indubitably confirm the superiority of the representative power (in terms of higher precision or less AIC values). The comparison of fish seed production of west Bengal to the India has also given in Fig-2 to depict the dynamics of fish seed production data over the years.

Conclusion The polynomial regression model is capable to produce exact dynamics at any time point most precisely so as to provide accurate advisory services to fisheries sector, an advance knowledge of which is of utmost help to make the necessary futuristic planning for better management of the sector. However, in anticipation of emerging demands for food-fish, quality fish seed, environmental preservation and perhaps food safety standards, the sustainable growth of the industry is very much needed through different strategic and managerial measures to promote sustainable development in the sector.

Acknowledgement The author is thankful to the Dean, College of Fisheries, CAU, Lembucherra, Tripura, India, for providing necessary research facilities.

References

Food and Agriculture Organization of the United Nations. (2010) Nutritional studies, F.A.O., Rome Gilbert RO (1987) Statistical methods for environmental pollution monitoring. Van Nostr and Reinhold, New York Pathak SC(1990) Commercial success of fish seed hatchery projects - issues involved. In: P Keshavanath & KV Radhakrishnan (edts), Carp Seed Production technology:

proceedings of the workshop on carp seed production technology 2-4 September, 1998. Asian Fish. Soc.,Mangalore, India. 53-56 pp

Milwain GK, Little DC, Kundu N and Immink AJ (2002) Overview of fish seed production and distribution in West Bengal, India. Stirling, UK: Institute of Aquaculture, University of Stirling and Kolkata, India: Institute of Wetland Management and Ecological Design [Working Paper]

Morrice C, Chowdhury NI and Little DC (1998) Fish markets of Calcutta. Aquaculture Asia., April-June: 12-14

SAS 9 .3 (2012) Foundation for Microsoft Windows, SAS Institute Inc., Cary, NC

CIFRI CAGEGROW™ FLOATING FISH FEED

Ganesh Chandra • Basanta Kumar Das • M. A. Hassan

Received: 9 October 2018 / Accepted: 12 November 2018
J.Inland Fish. Soc. India, 50(2), 2018

In inland open waters, especially in reservoirs located in the warm temperature regime (22-32ÚC), cage culture of *Pangasionodonhypophthalmus*has the potential of booming aqua-farming option. Use of low quality feed (nutritionally poor) is causingbelow potential growth and poor feed to flesh conversion in cage farming of this species. As a result, low yield and poor feed conversion will make cage farming a venture of low return on investment threatening its economic viability. Extruded feed or floating feedis quite popular in different countries of Europe, America and China for intensive fish farming in both land based fish farm and cage aquaculture system. But it is a new concept in Indian fish farming system. Since 2011, with the ascending growth trend of cage culture adoption in India involving *Pangasionodonhypophthalmus* species the need for floating feed has become *sine qua non* and its demand has been increasing at a rapid pace. As a result there has been mushrooming of floating fish feed industry in the country. Quality balanced feed to meet the nutritional requirement of *Pangasionodonhypophthalmus* is of paramount importance in cage fish farming as fishes are entirely dependent on supplied feed. Similarly, cost effective feed is important determinant for economic viability of cage farming system. Keeping these factors in mind, CIFRI has been working on developing cost effective, nutritionally sound, water stable floating feed for cage aquaculture farming system. Keeping these attributes in focus, several formulations were made by incorporating meticulously chosen ingredients and supplements. These formulations were tested for their performance under field condition, over a period of time. These studies have led to the development of a floating feed "CIFRI CAGEGROW™" that ensured fast growth, better feed to flesh ratio and reduction in per Kg production cost of *P. hypophthalmus* in cage fish farming.

G. Chandra (✉) B. K. Das and M. A. Hassan
Institute Technology Management Unit,
ICAR-Central Inland Fisheries Research Institute,
Barrackpore, Kolkata - 700120

e-mail: ganesh.chandra@icar.gov.in

"CIFRI-CAGEGROW" is developed for grow out stages of *P. hypophthalmus* for their cage farming in reservoirs. The formulation takes care of the nutrient requirement of the target species and their growth stages. The protein and lipid level of the feed maintained at 28% and 5% respectively. Ingredients for the feed were carefully selected to ensure high digestibility and to meet essential nutrient need of the species. Vitamins and minerals were additionally supplemented to satisfy micronutrient requirement. Feed supplements were incorporated as attractant and also to assist digestibility and nutrient availability. Good digestibility of feed will ensure energy and nutrient availability for anabolic process and will minimise metabolic loss; thereby reducing eutrophication rate of the environment. While selecting the ingredients, care was also taken to optimise cost of feed in order to reduce expenditure towards feed cost facilitating economic feasibility of cage culture. Feeding fishes in reservoir cages, having wave actions, necessitates highly stable feed. In the developed feed selection of ingredients and their proportion and processing done in such a manner that provides water stability for 6-8 hours. The stable feed shall minimize disintegration of ingredients and nutrient leaching that will ensure good growth and help maintain water quality. The feed with good conversion efficiency is prerequisite for such farming practice where the fish is wholly dependent on supplied feed. The ready consumption of CIFRI-CAGEGROW feed in cages proves good palatability of the feed.

Field Trials: The feed was tested for its performance and evaluation in farmers' cages in Chandil reservoir,Jharkhand. The cage fish farmer Sri Kiran Hembram was provided with CIFRI CAGEGROW for comparing its performance involving the*P. hypophthalmus* in his cages having dimension of 6mX4mX4mduring September to November .Fishes with initial average weight of 163g were maintained at a stocking density of 52 fish/m^3. CIFRI CAGEGROW was compared against a popular commercial feed in terms of weight gain and conversion ratio

After 60 days of performance trial the average weight of fish increased to 336g and 232g corresponding to 142 % and 62 % increment in live weight gain in cages fed CIFRI feed and commercial feed, respectively. The CIFRI feed elucidated more than two times better growth compared to commercial feed.

The feed conversion ratio was 1.2 and 2.4 respectively for CIFRI feed and commercial feed, respectively when the environmental temperature was 31ÚC. The performance trial clearly demonstrated the supremacy of CIFRI CAGEGROW over the commercial feed.

Trademark: CIFRI fish feed "CAGEGROW" has been registered in Trade MarksRegistry under Trade Marks act 1999 with Trade mark number 3625921 in class 31 as of the date 01 September 2017 in respect of Fish feed, Animal Feed and registered in the name of INDIAN COUNCIL OF AGRICULTURAL RESEARCH. This trademark was sealed on 25 April 2018.

1ST BARRACKPORE PROTEOMICS WORKSHOP

Received: 15 July 2018 / Accepted: 18 August 2018
J.Inland Fish. Soc. India, 50(2), 2018

The 1st Barrackpore Proteomics Workshop was successfully organized by ICAR-Central Inland Fisheries Research Institute, Barrackpore during 27 June-2 July, 2018. The Workshop started with opening remarks by Dr. B. K. Das, Director, ICAR-CIFRI and Dr. B. P. Mohanty, HOD-FREM and Course Director. The participants of the workshop included faculties from Stewart Science College, Cuttack, Odisha, and CFSc, Sri Venkateswara Veterinary University, Nellore, Scientists from ICAR-CIFRI and Research

Scholars from College of Veterinary Sciences, OUAT, Bhubaneswar, and Kalyani University. The six-days' workshop included lectures by eminent researchers in this field including "Introduction to Proteins and Proteomics" (Dr BP Mohanty), "Proteomics in a research lab" (Professor Abhijit Chakrabarti, SINP, Kolkata), "Pharamcoproteomics of superior mesenteric artery under acid stress" (Prof. S.C. Parija, OUAT), "Parasite

Arabinda Mahanty (✉)
Crop Protection Division
ICAR-National Rice Research Institute
Cuttack - 753006, Odisha
e-mail : arabindamahanty5@gmail.com
Reema Das
Zoology Department
Stewart Science College, Cuttack, Odisha

Proteomics" (Dr. J. Mohanty, ICAR-CIFA), "Proteomics of Heat Stress" (Dr. A. Mahanty), "Fish microbial Proteome" (Dr. B. K. Das).

Dr. Mohanty in his lecture elaborated the basic concepts of proteins and proteomics and the implications of proteomics in biomarker discovery. He also explained the applications of proteomic biomarkers in a wide range of fields including diagnosis of human and animal diseases, stress management in aquatic animals, aquatic pollution monitoring, fish species identification for food authentication and fish flesh quality improvement. Dr. A Chakrabarti briefed about the potential and recent advances of proteomics technology and the difficulties researchers face in proteomics research. Dr. S. C. Parija explained how proteomics technology can be used in combination with the pharmacological studies to understand the stress physiology of an organism. Dr. B. K. Das briefed how microbial proteomic studies can help in identification of potential fish vaccine candidates. Hands-on training included analytical techniques like SDS-PAGE, 2D gel

electrophoresis, Western Blot, 1D and 2D Gel Image analysis and transcript analysis by RT-PCR was imparted to the participants. Evaluation of the trainees was carried out and feedback was taken for self-evaluation and improvement of the workshop if any. Most of the participants suggested that that the length of the program should be increased.

Practical sessions were handled by Dr. B. P. mohanty, Dr. A. Mahanty, Tandrima Mitra, Satabdi Ganguly. Technical Assistance was provided by Shri L. R. Mahaver and S. K. Paul.

Concept Building and Basic Statistical Analysis for Inland Fisheries Management" ICAR-CIFRI, Barrackpore, 3 -10 August 2018

Received: 12 September 2018 / Accepted: 15 November 2018
J. Inland Fish. Soc. India, **50** (2), 2018

A training program on "Concept Building and Basic Statistical Analysis for Inland Fisheries Management" was organized at ICAR-CIFRI, Barrackpore, during 3 -10 August, 2018. A total of 20 participants (9 females and 11 males) comprising Scientists (7 no.), Assistant Professors (3 no.), Students (3 no.), Scholars (5 no.), SRF and YP-II (1 each) from West Bengal University of Animal and Fishery Sciences and ICAR-central Inland Fisheries Research Institute, Barrackporeattended the training programme. The training program was designed to update and improve concept of basic statistics and the analytical skills, which will provide knowledge of different context specific statistical analytical techniques

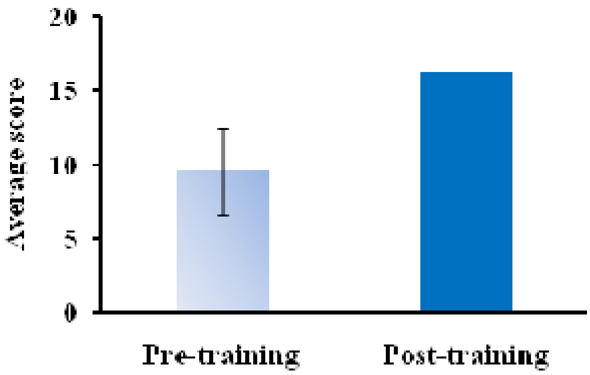


Fig. 1 Mean score of pre and post training evaluation Data expressed as mean±sd

R. K. Raman (✉)
ICAR- Central Inland Fisheries Research Institute, Fishery Resource and Environment management Division, Barrackpore, Kolkata - 700120
e mail: rohan.raman@icar.gov.in

M. Naskar, D.N.Jha, A.K. Yadav and R.K. Raman (Scientist ICAR-CIFRI & Cordinators of training programme)

and their software implementation for inland fisheries data. The course was structured in two modules, with theoretical lectures followed by hands-on practical using statistical software. The lectures of the training programme were on the topics:Utility of statistical tools and associated packages for the inland fisheries management: status and future prospects;Nature and sources of data for inland fisheries management; Descriptive statistics for data analysis; Basic concept of hypothesis testing; parametric and non-parametric testing of hypothesis;Analysis of Variance (ANOVA) and Design of Experiments; Concept of simple correlation and regression for fisheries data analysis, Introduction to R Software and its basic operation; Introduction to graphics in R; Analysis and interpretation of length-weight data of fish. The participants were introduced to different statisticalsoftware (SPSS, SAS and R) and their utility for data analysis in practical exercise, Introduction to Bioinformatics and BigData analysis in Fisheries.The

thrust was given on choosing a right statistical tools and interpretation of results. The impact of training was assessed by subjecting the participants to an objective type examination of 25 marks before and after the training. The difficulty level of questionpapers in pre and postevaluation was same. There was a significant difference in the mean scoreof participants before training (9.6±2.9) and after training (16.2±1.9), which was ensured by using paired-t test.(Fig. 1). The impact assessment revealed 69% improvement in their knowledge related to the subject taught in the training programme. A feedback session of the training program was also conducted. The overall rating of the training was 'Excellent' to 'Very good' in a five-point scale, based on feedback information of trainees.

19th World Congress of Food Science & Technology - IUFoST 2018 INDIA

Received: 15 November 2018 / Accepted: 15 December 2018
J. Inland Fish. Soc. India, **50** (2), 2018

The 19th World Congress of Food Science & Technology -IUFoST 2018 INDIA (www.iufost2018.com) was held in Mumbai (CIDCO Convention and Exhibition Centre, Navi Mumbai), India during October 23-27. A The first IUFoST Congress in India (INSA - IUFoST Adhering Body) brought in the who is who in Food Science and Technology & Engineering to the forum for deliberation for five days. Participation covered delegates from 73 countries in the world. PadmashriDr V. Prakash was the Congress Chair for IUFoST 2018.

The program consisted of over 66 sessions and 4 Workshops covering a wide spectrum of topics. In addition, there were 30 special addresses by eminent personalities which was an exciting new feature. The Congress' focal theme "25 BILLION MEALS A DAY BY 2025 - with Healthy, Nutritious, Safe & Diverse FOODS" covered the latest advances in our understanding of food in all its manifestations like food safety, food security, regulations, innovations in food processing, hygienic design and engineering, frontier areas in food science and technology, novel food products, markets and consumer preferences and much more of the latest of cutting edge technologies, networking with each sector.

The congress was loaded with nearly 1000 abstracts (including Invited Speakers, Oral and Posters) and set very high benchmarks with 66 Scientific Sessions well integrated with over 270 Invited Talks from leading experts globally and laced with four Plenary Talks, Keynote Address and the Distinguished Lecture of IUFoST by Prof. Ing. Erich Josef Windhab, Switzerland. These were other important benchmarks in such Congress enriches itself with knowledge. A large number of industries and Innovators and Start Ups and SMEs. Smt. Harsimrat Kaur Badal, Hon'ble Minister of Food Processing Industries inaugurated the Congress on the Inaugural Day.

B. P. Mohanty (✉)
EIC, Journal of Inland Fisheries Society of India, CIFRI Campus, Barrackpore, Kolkata- 70012
e mail: bimal.mohanty@icar.gov.in

There were eleven major track themes in the Congress covering the contemporary areas as well as trying to learn from thousands of years of Food Science and Technology both from the Traditional, Ethnic and Cultural heritage that India has over the last 5000 years as well as integrating Modern Science and Technology the latest anywhere is also in India with its Integrated Value addition.

The Day 1, 23rd October 2018, Tuesday was the WORKSHOP DAY. There were four parallel Pre-Conference Workshops under different themes conducted by world experts in the respective fields, as stated:

(1) Exploiting Internet Potential for Professional Development in Food Science and Technology led by Daryl Lund, Don Mercer & Team

(2) The Global Food Safety and Regulatory Developments and Food SafetyValidation and Verification led byPurnendu C. Vasavada, Larry Keener, Alvin Lee & Team

(3) Nutritionals and Nutraceuticals - Scientific Basis for Value Addition toHealthy Food Productsled byDilip Ghosh, Smarta, R.B. & Team

(4) Food Engineering Paradigms for Positive Health Functionality and Impactled byNiranjan, K., Paul Singh, Anantheswaran, R. & Team.

The Day 2, 24th October 2018, Wednesday was the OPENING INAUGURAL DAY. Inaugural program started with Keynote Address "Mind to market place through game changing ASSURED Innovations" by Dr. R. A. Mashelkar, FRS, National Research Professor, India. This was followed by the Video Message from

Prof. M. S. Swaminathan, titled "Who will feed India in the Future?" This was followed by opening of Poster Session aand Plenary Talk titled "Macro trends boosting food innovation in Asia" by Dr. Yongjing Li, China. There were six Special Addresses on the inaugural day including two from India. One by Dr. M. Vijay Gupta, the World Food Laureate (Title: Technical innovations and policy interventions needed for increasing contribution of fish to nutritional security) and the other by Dr. Trilochan Mohapatra, Secretary DARE and Director General ICAR (Title: Sustaining India's food and nutritional security: Challenges and opportunities). Both of them were also honoured with "Life Time Achievements Award" from the IUFoST Congress.

The Day 3, 25th October 2018, Thursday was the ACADEMY DAY. There were 12 special Addresses, including one each by VenkateshMannar, M. G.; University of Toranto, Canada (Title: Public private partnerships for improved nutrition through food fortification); Panjab Singh, National Academy of Agricultural Sciences (NAAS), India (Title: Food for future); HuubLelieveld, Global Harmonization Initiative (GHI), The Netherlands (Title: Removing barriers to enable 25 billion nutritious meals a day by 2025); Kenneth Peterson, OSI Group, LLC, USA (Title: Thoughts on food safety standards, inspection and food manufacturing: What works and what to consider).

The Day 4, 26th October 2018, Friday was the HEALTHY MEAL DAY. There were 12 Special Lectures on this day, including one each by Mahtab S. Bamji, formerly of National Institute of Nutrition (NIN) and INSA Emeritus Scientist, India (Title: Women's diet, Nutrition, health and empowerment are bedrock of national development); Larry Keener, International Product Safety Consultants, Inc., USA (Title: Innovation and validation: Essential tools for ensuring food safety and regulatory compliance); Pawan Agarwal, Food Safety and Standards Authority of India (FSSAI) (Title: Food Safety in India: A viable model for low- and middle-income countries); Gerald Moy, formerly of WHO, Switzerland (Title: We are what we eat).

The Congress was conducted in a grand way with lot of scientific deliberations providing the Indian researchers in this field and allied fields, entrepreneurs and food testing agencies and students an unique opportunity to participate and greatly benefit from the participation in learning what is happening around the globe in the important field of Food Science and Technology.

ICAR - Worldfish Collaborative Research Strategy Development and Theory of Change Workshop July 17-19, 2018

Received: 20 November 2018 / Accepted: 15 December 2018
J. Inland Fish. Soc. India, **50** (2), 2018

A joint meeting cum workshop involving WorldFish, ICAR and other important stake holders to discuss and A joint meeting cum workshop involving WorldFish, ICAR and other important stake holders to discuss and plan the five-year strategy development. The basic purpose is to outline a plan for collaborative activities between ICAR and WorldFish from April 2018-March 2019 to produce a comprehensive integrated program of research between ICAR and WorldFish for the new CRP, covering the 5 years to 2013. The five year (2019-2023) collaborative program aims to define the clear role and impact of ICAR research institutes within the CGIAR research program on FISH. The overall objective is to increase the impact of research on aquaculture and fisheries in India and also through the partnership to increase the impact of aquaculture and fisheries research on global development goals and aim to increase the impact of CGIAR FISH research through a new WorldFish-India partnership, with special focus on Africa and Asia.
The broad areas of research collaboration are
Flagship 1: Sustainable Aquaculture (CIFA)
Research output:
(a) Farm performance trials for improved varieties and Genomics
(b) Farming systems and LCA
Flagship 2: Resilient Small scale Fisheries (CIFRI)

Research output:
(a) Fish productivity enhancement from wetlands and flood plains
(b) Nutrient profiling of small indigenous species (building on NutriFishIN) and assessment of contribution of SIS to human nutrition in India
Flagship 3: Value Chain and Nutrition (CIFT)

Research output:
(a) Fish products for first 1,000 days
(b) Fish consumption patterns of rural and urban consumers in India
The main goal is to develop a detailed 5 years (2019-2023) collaborative work program for ICAR participation as partner to CGIAR research and WorldFish.

The workshop was inaugurated by Dr. J.K.Jena,Deputy Director General (Fisheries Science& Animal Science) in presence of Dr. Michael Phillips, Director Worldfish and Dr. C.V.Mohan, Worldfish, Penang, Malaysia; Dr. Bindu Pillai, Director (Acting), ICAR-CIFA; Dr. B.K.Das, Director, ICAR-CIFRI; Dr. Ravishankar C.N, Director, ICAR-CIFT and other team members of both Worldfish and ICAR participating institutes (CIFA, Bhubaneswar; CIFRI, Barrackpore and CIFT, Cochin) on 17 July 2018.

The 'Collaborative Research Strategy Development Workshop' on 17 July 2019 focused on developing a cohesive 5-year collaborative research strategy in three areas - sustainable aquaculture, resilient small scale fisheries, value chains and nutrition. The participants were scientists from three premier ICAR institutions- CIFA (Bhubaneswar), CIFRI (Kolkata) and CIFT (Cochin); representatives from WorldFish HQ and WorldFish Odisha Projects.

The 'Theory of Change (ToC) Workshop' on 18 July 2018 was innovative and the discussion focused on Theory of Change and mechanisms for translating research outputs to develop outcomes and impact in relation to the three areas -sustainable aquaculture, resilient small scale fisheries, value chain and nutrition. First the concept of 'Theory of Change' was introduced to the participants by the expert from Wageningen

B. P. Mohanty (✉) A. K. Sahoo · B. K. Das
ICAR- Central Inland Fisheries Research Institute, Barrackpore, Kolkata 700120, India
e mail: bimal.mohanty@icar.gov.in

Fig 1. Inaugural Session of the ICAR and WorldFish collaborative research strategy development and theory of change workshop at ICAR- CIFA, Bhubaneswar; 17 July 2018.

Fig 2. TOC (Theory of Change) Workshop in progress; 18 July 2018.

Fig 3. TOC Workshop - Group-3 (Value Chain and Nutrition) in a Brainstorming Session.

Fig 4. Group Photo: Resource Persons and Organizers from WorldFish and ICAR- Fisheries Science Division and Participants from ICAR- CIFA, Bhubaneswar (host institute); CIFRI, Barrackpore and CIFT, Cochin.

University who also moderated and facilitated the program. Here also the participants were same as above besides representatives from various partner institutions. Three working groups, a mix of researchers from government, private sector, NGOs etc) each worked on one of the three areas and the final product was the 'draft' theory of change for the three areas in India.

Awards/Honours/Recognition To IFSI Fellows/Life Members/ Office Bearers

Dr. M.V. Gupta, World Food Laureate & Life Member and Former Editor, JIFSI was honoured by the International Union of Food Science and Technology (IUFoST) with 'LIFETIME ACHIEVEMENT AWARD' at the 19th World Congress of Food Science and Technology at NaviMumbai, India on October 24, 2018.

Dr. B. K. Das, Director, ICAR- CIFRI and President, Inland Fisheries Society of India (IFSI) was elected Fellow of the prestigious National Academy of Agricultural Sciences (NAAS), New Delhi.

OBITUARY

DR. V.R. DESAI

(25 July, 1936 - 12 October, 2018)

IFSI family pays tribute to the great researcher

Dr. Vasant Ramchandra Desai was born on 25th July, 1936 at Gwalior, the then Gwalior State, (now in Madhya Pradesh). After passing M.Sc. in Zoology with specialization in 'Fishes' and having undergone Inland Fisheries Training Course at Central Inland Fisheries Research Station, Calcutta (Ministry of Food and Agriculture, Government of India), Desai joined Central Inland Fisheries Research Station (now an Institute under ICAR) as Research Assistant in 1958. During the assignment to work on riverine fishery investigations of River Narmada (Narmada Tapti Unit, Hoshangabad) Desai studied in detail the fishery and biological aspects of a fish, Tor tor (Hamilton) also known as Tor mahseer, an important food and game fish of India from River Narmada, which is now known to be an endangered fish. Desai utilized this work for his Ph.D degree awarded to him by Agra University in 1982. Looking to the endangered state of this fish, the Food and Agriculture Organization (FAO), Rome, assigned the work to write a synopsis on biological data on Tor mahseer to Desai, which was published by FAO in 2003. Desai was one of those few fishery scientists in India to whom the FAO assigned the work of writing such a synopsis. Desai during his service period of 38 years (1958-1996), worked for 25 years in reservoir fisheries development to gain enormous experience in this field. During this assignment, Desai as Project Officer, studied the Ecology and Fisheries of some reservoirs in India under an All India Coordinated Research Project and thereby prepared the final reports of the projects. With this prolonged experience in reservoir fisheries development, Desai was appointed as Head and Regional Director of Reservoir Fisheries Division of CIFRI at Bangalore (now as Bengaluru). He also officiated as Director, Central Inland Fisheries Research Institute,

Dr. N. P. Shrivastava (✉)
C/o Inland Fisheries Society of India
Barrackpore, Kolkata - 700120
email: nps_cifri@yahoo.co.in

Barrackpore (West Bengal) for six months before his retirement on 31st July, 1996. He has over 80 research papers to his credit published in different reputed journals of India and abroad. Moreover, he has contributed some articles also for some books. He worked for three years in Madhya Pradesh State Fisheries Department as Assistant Research Officer during the lien period of his service. He also participated in good number of National Seminars and Conferences to present research papers. Desai was also appointed as one of the members of Research Advisory Committee of ICAR for two years.

Dr. Desai had deep knowledge in the subject and received highest regards and recognitions from the scientific fraternity, yet always remained humble, caring, and rooted to the ground. He will be ever remembered for his excellent contributions to fisheries science, especially Narmada fisheries and Mahseer. He was one of the doyens of Indian fisheries, who pioneered research on reservoir fisheries under the All India Coordinated Project during the 1970s. The fisheries sector has lost a great stalwart. During his entire service period he worked with lot of patience, discipline, courage, sincerity and dedication. He was a simple and noble person besides being a great human being.

He is survived by his wife, two sons, two daughter-in-laws, one granddaughter and one grandson.

We pray to the Almighty to give enough strength to his near and dear ones to bear the shock and overcome the grief from this big loss.

May the pious departed soul REST IN PEACE.

INLAND FISHERIES SOCIETY OF INDIA

C/o Central Inland Fisheries Research Institute, Barrackpore - 700 120,
West Bengal, Email : cifri@vsnl.com; Website : www.cifri.ernet.in
(Estd : 1969 : Registered under West Bengal Society Act xxvi of 1961)
Phone & Fax : (91) 033 2545 0330; Website : www.ifsi.in
E-mail : ***Administrative :*** ifsi3@yahoo.co.in ***Editorial :*** ifsi4@yahoo.co.in

APPLICATION FOR MEMBERSHIP

Name (in CAPITAL) : ....
Occupation/Designation : .... Sex : Male/Female ....

Address for correspondence :

Town/Vill./Lane : ....
P.O. : .... District : .... State : ....
Pin : .... Tel :.. Mob :..
E-mail : ....

Permanent Address :

Town/Vill./Lane : ....
P.O. : .... District : .... State : ....
Pin : .... Tel :.. Mob :..
E-mail : ....

Nationality : Indian/......................... Date of Birth :(DD/MM/YYYY)................/................./.................
Educational Qualification : ....
No. of Years of Experiences in fisheries Activities : ....
Area/ Field of Interest : ....

Membership Option : (Tick in the box): **(Revised w. e. f. June, 2013)**

Life membership (For 10 years only)	-	Rs. 5000/-*	or	US $ 300 (For members abroad)
Institutional Membership	-	Rs. 2500/-	or	US $ 150
Annual Membership	-	Rs. 1500/-	or	US $ 90
Student Membership	-	Rs. 1000/- **	or	US $ 60

(All fees are inclusive of Registration fee of Rs. 20/-)

(i) **Applicants for student membership need to attach a Student's Bonafide Certificate from the Head of the Institution with which he/she may be attached at present)

(ii) *Life Membership should be renewed after 10 years and please send 2copies of stamp size photograph for Life Membership Card.

Note : Application may be addressed to **The Secretary, Inland Fisheries Society of India, C/o Central Inland Fisheries Research Institute, Barrackpore-700 120 Kolkata, West Bengal.**
Payment : Cheques/DD may be drawn in favour of **Secretary** or **Treasurer, Inland Fisheries Society of India** payable at **SBI Barrackpore (Code NO 0029)** ***Please include Rs. 30/- as bank commission while issuing cheques only.***

All the authors of any paper(s) should be a member of the Society for publication of papers

Declaring above information as true and complete, and accepting the bye laws of IFSI, I submit my application for membership as opted above.

Signature

****

GUIDELINES FOR SUBMISSION OF PAPERS

From Volume 50 onwards JIFSI is following different style
and format for the manuscript

For guideline for submission of papers
Authors may visit

http://ifsi.org.in

Authors may also refer the Journal
"Fish Physiology and Biochemistry"(Springer)
for manuscript preparation

****

J. Inland Fish. Soc. India, **50**(2), 2018

Registered with the Registrar of Newspaper for India, No. R. N. 1837870

CONTENTS

EDITORIAL		**01-02**
REVIEW PAPER		
Rai Milan Bhowmick	Development of inland aquaculture in India, with special reference to hypophysation technology	**03-32**
RESEARCH PAPERS		
Preetha Panikkar, U. Amala , P.K. Jesna, Feroz Khan, M . Das, B.K . Chandish, R. Ballal, M.A Hassan	Black soldier fly (Hermetia illucens) pre-pupae meal as a fish meal replacement in diet for amur carp (*Cyprinus carpio*)	**33-38**
A. K. Nath . B. M. Majhi	Studies on the seasonal abundance of the juveniles of *Tenualosa ilisha* from Hooghly River estuary of West Bengal, India	**39-45**
Shilpa Sahoo . U. Acharya . J. P. Sahu	Effect of dietary probiotic supplement on growth performance and survival of *Labeo rohita* (Hamilton) fingerlings	**46-51**
Manas Kumar Das · Srikanta Samanta · Keya Saha · Sanjoy Bhowmick P. K. Srivastava · S. Bandopadhyay	Effect of phenol and sulphide on the reproduction of sexually maturing riverine cat fish *Rita rita* (Hamilton)	**52-57**
Monika Gupta . N. N. Pandey . V. K. Tiwari, Raghabendra Singh . Chandra Prakash . C. S. Chaturvedi	Optimization of stocking density for successful larval rearing of *Labeo dyocheilus* in coldwater conditions	**58-62**
Hiramoni Das . Sudhir Kumar Das . Dibakar Bhakta	Effects of periodical starvation on growth and muscle composition in fingerlings of *Labeo bata* (Hamilton, 1822)	**63-67**
B. K. Bhattacharjya . B. J. Saud . V. K. Verma D. Debnath . A. K. Yadav . Simanku Borah Hiron Pegu . U. K. Sarkar	Indigenous fishing method used for catching spiny eels (*Macrognathus* spp.) in floodplain wetlands of Assam, India	**68-72**
Raju Baitha . S. K. Manna . V. R. Suresh K. Paniprasad . M. Naskar	Topographic distribution pattern of *Posthodiplostomum* sp.acercariae on body surface of cyprinid fishes of river Ganga	**73-78**
Aparna Roy . Archana Sinha . Ranjan K. Manna . B.K Das . Sucheta Majumdar	Socio-cultural tradition of the Rabha tribes of North Bengal, India : in relation to fisheries aquatourism in floodplain wetlands as a potential alternative livelihood option for the fisherfolks - A case study of Deepor beel in Assam	**79-83**
Shakti Ranjan Panigrahy . Dilip Vahoniya	Analysis of profitability of inland fish farming through ponds and tanks in Gujrat	**84-88**
SHORT COMMUNICATIONS		
Prasenjit Pal	The dynamics of fish seed production in West Bengal over the years	**89-92**
Ganesh Chandra . B.K. Das . M.A. Hassan	CIFRI Cagegrow™ floating fish feed	**93-94**
Meeting / Training Report	1st Barrackpore Proteomics Workshop	**95-96**
	Concept Building and Basic Statistical Analysis	**97-98**
	19th World Congress of Food Science & Technology - IUFoST 2018 INDIA	**99-100**
	ICAR - Worldfish Collaborative Research Strategy Development and Theory of Change Workshop July 17-19, 2018	**101-102**
Awards	Awards/Honours/Recognition To IFSI Fellows/Life Members/ Office Bearers	**103**
Obituary	Prof. V. R. Desai	**105-106**
GUIDELINES FOR SUBMISSION OF PAPERS		Inner Back Cover