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Manila, Philippines, 1-3 February 1984

Edited by
R.C. May, R.S.V. Pullin
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ASIAN DEVELOPMENT BANK

ICLARM INTERNATIONAL CENTER FOR LIVING AQUATIC RESOURCES MANAGEMENT

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Cover: Carp fingerlings produced at the Central Fish Seed Hatchery, Manawan, Lahore, Pakistan. Photo by R.S.V. Pullin.

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Preface

In February 1983 the Asian Development Bank initiated a regional Technical Assistance Project for Research and Training in Aquaculture. The project concentrated on technology improvement and training in new methods for carp hatchery and nursery systems, encompassing work on all the main species of cultured carps: common carp, Chinese carps and Indian major carps. Two Bank consultants, Dr. V.G. Jhingran, formerly Director of the Central Inland Fisheries Research Institute, Barrackpore, India, and Dr. R.S.V. Pullin, Director of the Aquaculture Program, International Center for Living Aquatic Resources Management, undertook joint advisory missions to Bank-supported carp hatchery and nursery projects in Bangladesh, Burma, Indonesia, Nepal, Pakistan and Sri Lanka. Their observations and recommendations were subsequently taken up in further research and training missions by Dr. Jhingran and the late Dr. B.I. Sundararaj (Delhi University).

As part of the regional project the Bank convened a Regional Workshop on Carp Hatchery and Nursery Technology in Manila, 1-3 February 1984. The objective of the Workshop was to bring together carp hatchery/nursery personnel to review and disseminate the results obtained under the project's research phase, to discuss the status and problems of carp hatchery and nursery technology in the region and to consider practical means of solving the problems and implementing the consultants' recommendations.

Two participants were invited to attend the Workshop from each of the six countries that had participated in the research phase of the project. In addition, participants were invited from other Bank developing member countries with interests in carp culture (Hong Kong, India, Malaysia, the Philippines, the Republic of China, Singapore and Vietnam). Opening remarks were given by Mr. Basudev Dahal, Manager of the Bank's Fisheries and Livestock Division. This Summary Report contains summaries of the various workshop sessions along with abstracts of the papers presented.

On behalf of the Asian Development Bank we would like to thank the participants for their contributions to the Workshop. We would also like to express our appreciation to Dr. S.V. Goswami for agreeing to take the place of Dr. B.I. Sundararaj, who died of a heart attack in October 1983.

We hope that this Summary Report will help to clarify the present status of carp hatchery and nursery technology in developing countries of Asia. We also hope that, through summarizing the status of carp culture in these countries and identifying key subjects in need of further research and development, we have added to knowledge of current methods and stimulated applied research on critical problem areas.

R.C. MAY
R.S.V. PULLIN
V.G. JHINGRAN
April 1984, Manila

Introduction

The most important group of cultured fish in Asia is the carps, including common carp, Chinese carps and Indian major carps. The major technical requirements for carp culture are seed (fry and fingerlings), feed, technical know-how and marketing and distribution systems, but the key factor is seed of the cultured species, since aquaculture cannot be considered without it.

Traditional aquaculture practices for carp in Asia utilized wild fry and fingerlings caught from natural waters. In recent years this supply has been found inadequate, and seed supply has become a major constraint in developing carp culture. The situation has arisen partly because requirements for seed are increasing as carp culture develops, and partly because naturally available seed supplies are declining due to pollution, overfishing and alterations in river flow patterns. This problem is gradually being overcome through the use of hatcheries which ensure dependable production of seed.

The general methods for producing carp seed in hatcheries are based on research conducted in India as well as in other Asian countries and Europe. Application of these techniques in other developing countries, however, has often proved problematic. Differing local conditions preclude the direct transfer of technology. Without adequate research capability to adapt the techniques to local conditions, most developing countries have encountered problems in their hatchery programs. The problems include poor gamete quality, which is directly related to broodstock quality and husbandry; lack of standardized methods for inducing spawning; and high mortality after hatching due to factors such as predation, inadequate nutrition, poor water quality and improper transport methods.

The upsurge of interest in aquaculture in recent years has led to intensified research and a number of developments which hold promise for improving carp seed production. Among these developments are (i) an increased awareness of the dangers of stock deterioration and growing, albeit still very limited, attention to the genetics of cultured carps; (ii) the development of more standardized methods for inducing spawning, particularly through the application of recently developed chemicals; and (iii) enhanced fry and fingerling survival through the use of improved facility designs and the application of better techniques for feeding and predator control. Many of these techniques and approaches, which were described by the resource speakers at the Workshop, are very new and have not yet been widely applied. Moreover, knowledge of the more recent methods has not become widespread, and appreciation of the range of options open to the manager of a carp hatchery/nursery has been limited. In addition, many of the newer chemicals of actual or potential applicability in carp seed production are not easily available in most developing countries.

Another difficulty is that all too often there has been inadequate communication and exchange of information between workers attacking similar problems in different countries. In organizing the present Workshop, the Asian Development Bank attempted to bring together management or seed production personnel personally involved in the practical business of carp fry and fingerling production. The contributed papers therefore reflect the experiences and practices of hatchery workers and give a reasonably accurate picture of the present status of carp hatchery/nursery techniques in Asia. In spite of the regrettable lack of regular exchanges of personnel and information between countries, it is interesting to note in these papers and discussions various common themes and approaches to carp breeding and rearing as well as common problems. It is also significant that approaches successfully applied in one country appear to have great potential value in others, yet due to budgetary constraints and other factors limiting communication there has been little awareness of these approaches outside the countries where they are presently used; cases in point include broodstock maintenance techniques used in Nepal and the culture of *Moina micrura* as a larval food in Singapore.

It is hoped that this Workshop has helped to improve this situation by promoting an awareness of the hatchery/nursery techniques presently used in the region and of the newer approaches which are only now being tested and applied. Detailed descriptions of the various techniques are given in another publication, "A Hatchery Manual for the Common, Chinese and Indian Major Carps" by Drs. V.G. Jhingran and R.S.V. Pullin, to be published by ICLARM and ADB.

Opening Session

Dr. R.C. May, Aquaculture Specialist, Asian Development Bank (ADB) presided over the opening session and, after welcoming the participants, invited Mr. Basudev Dahal, Manager, Fisheries and Livestock Division, ADB to make his opening remarks. Mr. Dahal pointed out that carps are the most cultivated group of fish in Asia, and a major source of animal protein for its people. Production of fish seed is the basis of aquaculture and the workshop was convened by the ADB so that scientists of the region could exchange views on techniques for carp hatchery management. ADB has already provided eight loans for aquaculture totalling over $126 million to member countries and thus has a major stake in aquaculture.

Dr. V.G. Jhingran, ADB consultant, next presented a report on his visits to the six ADB member countries participating in the Bank's Technical Assistance Project. He emphasized live-food culture work, such as the culture of rotifers, a subject of extreme importance in improving survival, growth and stocking rates of postlarvae and fry in fishponds. Water is fertilized by adding chicken manure at 400 g/m^3 and a dense culture of mixed zooplankton is generated by first inoculating the medium with the species concerned and applying organophosphates like Sumithion, Baytex and Dipterex at doses varying between 0.25 and 3.0 ppm. These substances are lethal to insects and crustaceans but not to rotifers. This enables the rotifers to bloom, feeding on phytoplankton. Rotifers are an ideal first food for postlarvae, whose stocking density may be raised perhaps even to 1,000 million/ha with adequate provision of rotifers. Rotifers can be transferred from mass culture to nursery ponds by the use of airlift pumps. The stocking rate of fry can also be raised to at least 10 million/ha with very high survival, by supplying a dense culture of crustaceans, such as *Moina* sp.

In induced breeding work, a combination of Pimozide and LHRH-A (Luteinizing Hormone-Releasing Hormone) donated by Syndel Laboratories, Canada was tried but the recommended protocol involved too many injections over too long a time. An alternative 12-hour protocol using pituitary material plus LHRH-A (Syndel) gave encouraging results.

It was difficult to cover six member countries in one year since peak spawning seasons are often restricted to the same period, especially during the southwest monsoon months.

Dr. Jhingran referred to the problem of high water turbidity, which can be rectified by several methods, notably the slotted filter-box system developed by Cansdale (1979)* in which a small portion of the natural terrain acts like a sandfilter. He also referred briefly to algal-clay mutual flocculation as a means of reducing pond turbidity. Dr. Jhingran then briefly introduced the carp-hatchery manual prepared by himself and Dr. Roger Pullin for the ADB, a draft of which was handed over to all workshop participants for discussion.

Dr. Pullin, ADB consultant, next presented themes on applied genetics, nutrition and diseases of cultured carps. He pointed out that inbreeding could lead to a degeneration of stocks, mentioning that the culturist should choose his stocks with extreme care. For common carp, the type chosen should suit the market in appearance (scale pattern and shape) and the production needs. For other carps for which stocks of known pedigree and performance are not available, fish with a broad genetic base from proven commercial stocks or from the wild, say riverine sources, should be used. A founder stock should consist of at least 2,000 mixed-sex fry/fingerlings to be reared to constitute the broodstock. At least 50 pairs of every species should be kept thereafter for breeding purposes. All introduced stocks should be from sources which are verified to be disease-free and should be subjected to quarantine procedures. Dr. Pullin pointed out that most data so far available on carp nutrition are on common carp. A great deal of research is required to find the most suitable frequency, duration and kind of feeding to be given to the cultured species. Food ingredients, particularly protein and carbohydrates, must be digestible and sufficient in chemical composition. On diseases, Dr. Pullin mentioned various types of pathogens that afflict cultured carps. A great deal has to be learnt by further research on prophylaxis and treatment of carp diseases.

Dr. S.V. Goswami, the last speaker of this session, presented the theoretical basis of fish maturation cycles. He pointed out that the late Dr. B.I. Sundararaj and he had conducted fish breeding experiments in the recent past using a superactive analogue of LHRH (HOE 766; Hoechst Pharmaceuticals Ltd., W. Germany), which can reliably induce ovulation and spawning in a variety of fishes, including the Indian major carps and the Chinese carps. The recommended dosages are 150 μg/kg for female catla and 200 μg/kg for the other carps. While catla spawns after a single injection of HOE 766, other carps require a second injection of progesterone (5 μg/kg) six hours after the HOE 766 injection. The males in all cases are administered a single injection of HOE 766 at the same time as the female in the case of catla and along with the second injection in the case of other carps.

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*Cansdale, G.S. 1979. Report on second regional consultancy low-cost water filtration. SCS/79/WP/84. 48 p. South China Sea Fisheries Development Coordinating Programme. Manila, Philippines.

Session II: Summary of Presentations by Hatchery Staff from Countries Participating in the Research Phase of the Technical Assistance Project

Participants from Bangladesh, Burma, Indonesia, Nepal, Pakistan and Sri Lanka presented papers on the current status of carp hatchery/nursery technology in their respective countries. The main feature of this session was that all appeared to be using similar approaches, aiming for high standards of broodfish husbandry; using two pituitary gland injections for induced spawning of Chinese and Indian major carps and kakabans ('nests' of natural vegetation or fibrous material) to stimulate spawning for common carp; preparing rearing and nursery ponds by liming and manuring; and manufacturing supplemental feeds from agricultural residues. However, the quantitative details varied considerably between countries. For example, the Nepalese doses of pituitary glands for induced spawning are relatively low and the Burmese rates of manure application to ponds are high. The methods in current use all work, but there are still many problems, some common to all or most of the countries represented, others more location-specific. There are also differences between countries in the hardware (including chemicals) and equipment in use, while use of Chinese-style circular concrete tanks is becoming widespread.

The following common problems were mentioned: the restricted nature of spawning seasons (except common carp); the problems of matching supply of seed to demand (limited pond space); the difficulty of spawning *Catla catla;* postlarval, fry and fingerling mortality due to predation, especially by frogs and birds; and control of filamentous algae.

Location-specific problems included water quality aspects, especially turbidity for which the Cansdale filter box was recommended as an answer for hatchery supply; salinity in salt-laden areas, such as parts of Pakistan; and dissolved gas levels, including the dangers of low levels of dissolved oxygen and the problems of supersaturation (gas bubble disease) in hatcheries. On fish health, the parasitic copepods and protozoans appear to cause the most serious problems. Hatchery/nursery hardware was discussed, including the use of Chinese-style circular concrete tanks. It was agreed that they are very useful for mass seed production if well-built with adequate water flow provision. New hatchery equipment such as the 'Dwidevi' polyethylene systems were also mentioned. These systems are not cheap, but give very high standards of hygiene. For fry rearing, the use of organophosphates to control predators and encourage rotifer blooms was highly recommended. For induced spawning the new LHRH analogue HOE 766 was hailed as a potential breakthrough with many advantages over pituitary gland preparations and other hormones (see p. 6).

Session III: Summary of Reports from Other Countries

The influences of latitude and local climatic conditions in breeding cycles were apparent in the year-round spawning of Chinese carps in Malaysia in contrast with the situation in most other countries. There were some complaints from participants that artificial spawning substances, particularly LHRH analogues, could not be readily obtained. Several countries use pituitary dosages based on the relative weights of donor and recipient fish, and some participants felt that these systems needed to be improved. Rematuration of common carp spawners is practiced in Vietnam such that fish can be induced to spawn again 30 to 40 days after the initial spawning. Temperature and feeding are the most important factors.

There was considerable discussion regarding feeding and the culture of live-food organisms for postlarvae and fry. In Taiwan, steamed egg yolk is fed for one week, and rotifers are cultured using organic fertilizer, although *Daphnia* is a more important food for advanced fry. Many participants were interested in the culture of *Moina micrura* for feeding postlarvae as practiced in Singapore. This organism is administered as the sole food until day 10 (when fry are 1.5 cm in length), with 95 to 99% survival. *Moina* culture is done commercially in Singapore, mainly for feeding ornamental fish; it is grown in ponds fertilized mostly with chicken manure or, less frequently, with pig manure.

Participants placed great emphasis on the importance of broodstock maintenance for the proper functioning of hatcheries. Concern was expressed regarding possible inbreeding depression, and various participants felt the need to "recharge" their broodstock from natural sources. This was considered a particular problem in countries like Sri Lanka, where none of the important cultured carps occurs naturally. In some cases there was suspicion, but no proof, that hatchery problems were due, in whole or in part, to genetic factors, and for this reason there was a strong desire to bring in new broodstock. As an example, common carp was introduced into most Asian countries long ago, and there have been few attempts since to bring in the improved strains which have subsequently been developed in other parts of the world. A comment was made that the common carp cultured in India appears to be weak compared to some other strains. One participant, however, warned of possible dangers in introducing exotic species which might become established and outcompete desirable local species; a possible example could be introduced silver carp competing with catla. It was generally felt that hatchery managers needed ready sources of high quality broodstock strains: pools from which hatcheries could obtain breeders. It was pointed out that extensive facilities are required to maintain pure strains, and that the strains must be checked regularly by electrophoresis and tested for performance. India has recently established a National Bureau of Fish Genetics under the Indian Council for Agricultural Research. Despite the call for more sophisticated work in this area, some participants felt that much could be accomplished by simple techniques, such as applying optimal management practices to available strains, and selective breeding based on a list of desirable characteristics. The introduction of new varieties could be resorted to at a later time. The suggestion was made that the manual to be written as part of the Technical Assistance Project should include a list of carp varieties, but the authors pointed out that the information needed for a comprehensive table was extremely difficult to acquire.

On broodstock husbandry, stocking density was felt to be a critical factor, but varied widely in different countries. Interactions between species were noted, such as the presence of large numbers of silver carp adversely affecting bighead carp broodstock. Experience in Nepal showed that frequent water changes in broodstock ponds facilitates spawning of grass carp. It was agreed that diseases must be eliminated from broodstock. In Indonesia, antibiotics are added to broodstock diets, and in Bangladesh the antibiotic terramycin is routinely injected into broodstock during handling. It was agreed that broodstock nutrition is extremely important, but unfortunately among the cultured carps little or no work has been done on this subject except for the common carp. Several participants noted that very old or large broodstock produced poor quality eggs, indicating a need for a firm policy of broodstock replacement.

Session IV: Discussion on Controlled Breeding

Spawning cycles

The chairman, Dr. S.V. Goswami, pointed out that the carps breed naturally at a time when environmental conditions, such as availability of water and food for the survival of the progeny, are most favorable. Annual breeding periodicities of fish in the tropics vary generally with the monsoon rains. In Malaysia and Singapore, where rainfall is spread throughout the year, the Chinese carps can breed almost throughout the year with peaks of breeding during the main months of southwest and northeast monsoons. In Nepal, the main controlling factor for maturation and spawning of common carp appears to be temperature rather than rainfall. This fish breeds in Nepal in February-March when there is no rainfall but when the water temperature starts rising after the winter. The Indian major carps breed naturally in association with monsoonal floods when there is plenty of water and larval food.

On manipulation of spawning seasons, the spawning of the catfish *Heteropneustes fossilis* has been advanced by subjecting the fish to artificial photoperiods. There are certain crucial times, in this case at about

10:00 p.m. when a 30-minute exposure to light will advance the maturity of the adult fish as if it were an increase in day length. This approach has yet to be applied to cultured carps in the tropics. However, the breeding season of the minor carp *Cirrhinus reba* has been extended by two months of exposing fish to increased day length artificially, which hastens maturation of the gonads.

In Bangladesh, it has been observed that prior exposure of the pond bottom to sun and the presence of very firm pond soil encourage maturation of catla. However, this is probably less important than the good growth of zooplankton in the pond which such conditions stimulate. Catla is in many ways a difficult fish to breed. In Nepal, catla maturation is achieved by a low stocking rate (500 kg/ha) in deep ponds such that each fish gets plenty of natural food (mainly zooplankton). Also recommended for proper maturation of catla are frequent changes of water. For care of Chinese carp broodfish, changing the water once or twice a week is recommended. At the Raipur fish hatchery, Noakhali, Bangladesh, the water has a very high iron content, which interferes with hatchery operations; aeration of the water by agitation precipitates the iron which is then filtered off. High iron levels do not affect maturation.

Induced breeding

Dr. Goswami drew attention to the various methods used for induced spawning of carps. Hypophysation is the time-honored method, but a number of substances such as Human Chorionic Gonadotropin (HCG), Pregnant Mare's Serum (PMS), LHRH analogues and steroids have also been tried in different species. Moreover, the dry-bundh breeding method, in which riverine conditions are simulated for mass breeding of Indian major carps and the fish breed without recourse to hypophysation, has been very useful in India. In dry-bundh breeding, there must be a large catchment area and before the fish spawn there must also be one or more heavy showers, depending on the species.

The endocrinology of maturation is complex; fish gonadotropins are macromolecules which cannot be prepared in a pure form. In classic hypophysation techniques, a crude pituitary preparation containing gonadotropin triggers the release of steroid-releasing hormones in the blood which causes final maturation, meiosis and oviposition. This could be performed also by direct injection of steroids: a short-cut to induce spawning after vitellogenesis has occurred but the yolk-laden oocytes have reached a resting phase before final maturation and meiosis. A negative feedback operates between gonadal steroids and pituitary gonadtropin involving receptor centers in the pituitary and hypophthalamus. The anti-estrogen substance clomiphene, on which high hopes were pinned at one time as an inducement to spawning by stimulating a surge in endogenous gonadotropin, has never been adequately investigated in terms of dosage and timing of injection.

On the question as to whether the sex of the donor fish influenced the potency of pituitary preparations, Nepalese experience is that mature female donors, as a source of pituitary material are superior to males. However, in Burma pituitary gland extracts for breeding rohu are made from fully-ripe rohu donors, regardless of sex.

Pituitary glands can be preserved in alcohol or acetone-dried and refrigerated. In Nepal and Sri Lanka, acetone-drying is preferred to alcohol preservation. In Sri Lanka, acetone-dried pituitary glands have been kept in a refrigerator for 2.5 years without loss of potency. Regarding the potency of homo- and heteroplastic preparations, pituitary gland extracts from the marine catfish *Plotosus* have been found effective in India for breeding carps but larger doses are necessary than when using carp material. Salmon gonadotropin is not very effective on carps, probably because of phylogenetic specificity. Crude HCG from human pregnancy urine is useful for induced spawning in some species but high doses are required and HCG preparations from pregnant women up to the third month of pregnancy are more effective than those from later months.

The difficulty of ascertaining the state of maturity of female fish for the timing of induced spawning injections was discussed. The acentric position of the oocyte nucleus was considered an unreliable indicator of receptiveness to injections.

In the Chinese system of spawning Chinese carps, a priming injection of carp pituitary is followed by injection of LHRH-A. The priming injection probably causes the nucleus to move to the periphery. However, at times a single massive injection of LHRH-A and gonadotropic hormones will cause ovulation. Regarding standardization of pituitary preparations, gonadotropic potency can be assayed by radioimmunoassay techniques, but these are expensive and difficult to implement widely.

Gamete quality

The viability of eggs obtained by induced breeding was regarded as very important. In some cases, eggs show color variations due to the pigments incorporated in the yolk. Fish sperm, including that of carps, can now be preserved for several weeks at near-zero temperatures. Mobility of the sperm is not a reliable indicator of its fertilizing capability.

Egg incubation

In Bangladesh, Chinese-style concrete circular hatching tanks give good results. In Nepal, Zuger jars were first used but their capacity was too low. Water requirements were too high and there were difficulties in adjusting and maintaining water flows. Excellent results are now obtained with one-cubic-meter capacity metallic drums (funnel shaped at the base) and with brick tanks supplied with water from an 18-m^3 concrete reservoir. The metallic 1-m^3 drums are very portable and efficient. Spawning takes place in 5-7 m diameter circular concrete tanks of 1.2-m height. It was agreed that if Chinese circular concrete tanks are well-designed in regard to location, level, water supply and capacity, such that the entire contents (fertilized eggs) of a tank can be flushed into one or more hatching tanks and the water flow requirements can be easily met, then such tanks can be very cost-effective for large-scale seed production. In all incubation systems, control of water flow and aeration are very important. These must be gentle. Vigorous bubbling can damage egg shells.

Session V: Discussion on Postlarval and Fry Rearing and Nursing Fry to Fingerlings

Postlarval and fry feeding

There was discussion on the factors influencing food selection by first-feeding postlarvae, including particle size, movement and chemical cues. Unlike most marine fish postlarvae, which have limited swimming ability, carp postlarvae are quite mobile and active and can actively search for food over relatively large distances.

The microencapsulated egg diet is useful for feeding postlarvae for the first 2-3 days, after which alternative artificial and/or live planktonic food must be given. In Nepal, whole microencapsulated egg diet is fortified with soyabean and rice bran. For fry ponds, fertilization with poultry manure is recommended, including the construction of duck pens over the ponds. In Indonesia, rotifers are mass cultured as a first food for postlarvae. The water temperature of rotifer culture tanks can be kept relatively constant by covering with plastic sheeting. The dissolved oxygen content of the water should be at least 7-9 ppm.

In Pakistan, dense cultures of rotifers and cladocerans have been raised as carp postlarval and fry food, respectively. Interest centered on the techniques devised in Singapore for culturing *Moina.* If the cultures are protected from rain, production is constant. There was some problem in obtaining enough organic fertilizer in Singapore. A brief description was also given of the technique for decapsulating *Artemia* eggs.

Most of the discussion on artificial feeds dealt with growth-promoting substances, such as anabolic steroids and thyroid hormones. The general feeling was that the benefits might justify the cost, but little specific information was available. Private industry involvement in artificial feed manufacture was considered essential. Cobalt chloride has been used as a growth-promoting substance in postlarval and fry feeds in experimental work at Cuttack, India.

Some fry grow much faster than others. Fast growers are often selected to be breeders, but there is little evidence that such selection has been advantageous. It was suggested that abnormally fast growth could be due to a hyperthyroid condition; synthetic thyroid hormone is known to stimulate rapid growth.

Predator control

Various natural substances for controlling unwanted fish were discussed, including mahua oil cake, tea seed cake and tobacco dust. Artificial pesticides were also mentioned, such as malathion which degrades rapidly. However, some felt that the use of agricultural pesticides to kill fish should be avoided. Frogs were considered very significant predators on postlarvae and fry. Control measures were suggested, including fences and the organophosphate Dipterex (at 2.5 kg/ha to kill tadpoles). Cemented vertical walls also help to control frogs and snakes and prevent birds from standing along the pond side. For birds, netting was used by some but was considered by others too expensive for large-scale use. There were reported instances of eggs and larvae being sucked through the meshes of breeding cages by predatory fish in ponds. However, keeping fry in cages for several days before release into ponds in some cases helped increase survival. Snails can be controlled by Dipterex (2.5 kg/ha) and Bayluscide. Snails also attach to palm tree branches immersed in pond water at night; the branches with the snails can be removed in the morning.

Fish health

The participants first considered how fish health could be assessed without applying complicated procedures and killing fish as samples. Many symptoms, such as loss of appetite and sluggishness, are vaguely defined, but condition factor is a useful index of well-being. Various participants described deformities they had observed among fry and fingerlings, including spinal curvature, fin and tail deformities, "pug-headedness" and protruding lower jaw. Suggested causes included high temperatures (over 30.5°C) at certain embryonic stages (e.g., during gastrulation), low-oxygen stress in heavily manured ponds, physical shock to eggs such as stripping into a dish from a height, and the process of stripping itself. These various problems should be addressed by researchers.

Shipment methods

Participants emphasized the importance of conditioning before transport. It takes 4 to 10 hours for 2.5-4.0 cm fry to evacuate their guts, and up to 24 hours for large fish, although the silver carp can evacuate its gut within 6 hours. In Bangladesh, fish are treated with Acriflavin and conditioned in the transportation water for 8 to 10 hours before shipment. Mucus accumulation is thought to be an important cause of deterioration in water quality during transport. Deaths may be due to osmoregulatory failure from skin injury, and a bath in an isotonic balanced salt solution before transport might reduce mortality. The use of anaesthetics is generally restricted to breeders and is not used for fry and fingerlings. Older procedures include use of lateritic soil to control pH during shipment and earthen pots which keep the water cool. There was general agreement that double polyethylene bags with oxygenated water were the best means of transporting batches of fry and fingerlings to large numbers of small-scale farmers. Transport trucks with specially designed tanks may also be used when larger numbers of fish need to be transported to a single location, but some participants expressed concern over the high cost of this equipment.

Session VI: Final Discussion and Formulation of Recommendations for Followup Research and Other Activities

The final discussion session was devoted to determining priority areas for followup research and technology development, other activities and needs.

Priorities for research and technology development

Stock improvement

There was unanimous agreement on the need for more attention to applied genetics to improve stocks of cultured carps. It was recognized that genetic improvement work has many aspects. More information is needed on the genetic characteristics of existing stocks, including wild populations. This requires careful morphometric, meristic and electrophoretic studies and such work should ideally be undertaken by research scientists in all countries seeking to promote carp culture programs. The execution of sustained programs of stock improvement was recognized as a difficult task best undertaken by experts in centers with adequate facilities, but it was also suggested that farmers themselves could undertake simpler work, such as hybridization and evaluation of stocks under farm conditions.

The participants agreed that little or no genetic improvement work had been attempted for the Chinese and Indian major carps. The common carp, although it has been the subject of many genetic studies still merits further investigation; there is a wealth of common carp genetic resources available in Asia. The various Indonesian strains should be fully characterized and promising genetic material exchanged between countries. It was noted that a number of countries, for example Nepal, possess common carp stocks which are the descendants of a few introductions made many years ago. Such stocks could be upgraded by new introductions if adequate facilities are provided to segregate and maintain founder stocks.

The new Indian National Bureau of Fish Genetics is to oversee a nationwide effort to survey existing genetic resources and to instigate the development of pure lines through sustained stock improvement programs. The Bureau will also coordinate with the Central Board of Fisheries and the Environmental Control Board and will promote and help to enforce relevant legislation such as the Wildlife Acts.

Broodstock care and husbandry

The participants also discussed the need for more information on broodstock care and husbandry. The special nutritional requirements of broodstock are little understood. In general, provision of natural feeds (through pond fertilization) and stocking at low densities result in the best reproductive performance, especially for difficult species like *Catla catla*. However, most of the available information is anecdotal. There is not even agreement on the best size and age of broodstock to use for the various species. Most broodfish are 5-10 kg in weight, but some culturists keep broodfish, especially Chinese carps, to much larger sizes, accepting the handling difficulties involved.

There appear to be no good data on the effects of handling stress on broodstock or on the best methods to reduce post-spawning or post-stripping mortality. The only point of general agreement was that hatcheries should maintain *planned programs* of broodstock replacement, preferably keeping stocks of all age classes.

It was suggested that stunting broodstocks by nutritional and/or environmental restrictions, which keep them relatively small for their age and useful for many years with few handling difficulties, may be practical. However, the methods for and efficiency of this approach are not yet known.

Controlled breeding

There was widespread interest in the promising results obtained with LHRH analogues for induced spawning, especially the compounds LHRH-A (Syndel) in combination with Pimozide and HOE 766 (Hoechst) alone or in combination with other hormones, notably progesterone. However, it was clear that much more developmental work is needed before routine standardized techniques are available. Meanwhile, a range of options exists for the culturist: reliance on pituitary gland (PG) preparations; use of HCG for the Chinese carps (usually in combination with PG) and use of more recent preparations such as LHRH analogues alone or in combination with PG, HCG and other compounds (for those who can obtain them). It was agreed that the cost of LHRH analogues will be a major determinant of their future acceptance and use by carp culturists. No prices are available yet. It was proposed that a program of multi-agency field testing be investigated in cooperation with suppliers.

For the wider field of controlled reproduction, including control of reproductive cycles, the need for more basic research was endorsed. It is clear from the year-round breeding of carps at some latitudes that environmental control of spawning could free the hatchery industry from the restrictions caused by seasonal cycles. However, this requires much experimentation on photoperiod, temperature and other environmental controls. More research is also needed to investigate the reticence of some species to mature and spawn in some locations, for example, *Catla catla* in many countries and mrigal in Burma.

Egg incubation and larval rearing technology

There is scope for much improvement in the design of hatcheries and equipment used for egg incubation and larval rearing. The Chinese circular tank systems in current use allow mass production at relatively low cost but are inflexible in situations where multispecies rearing is required. Alternatives range from simple cage systems, with attendant disease and predation problems, to sophisticated indoor plastic systems for high density rearing. Economic factors will normally be major considerations in determination of which system suits a particular location, but progress towards cheaper, more flexible, durable, *high stocking density* systems (which should preferably be portable) would enable large increases in seed production to be accomplished.

Postlarval, fry and fingerling rearing technology

Postlarval and fry nutrition were identified as priority areas for further research. For postlarvae and fry there was a consensus that provision of live foods (rotifers, *Artemia* and cladocerans) is the key to good survival and growth. However, it was agreed that the development of dry artificial feeds should be further pursued, especially since this would enable rearing densities at first-feeding to be very high (up to 10,000/m^3) which would fit well with development of new high stocking density incubation and larval rearing systems. Live-food culture methods also need improvement. For rotifer culture, the most important consideration is that rotifers should be a nutritionally-complete feed, especially in respect of essential fatty acids. The work done in this field for marine fish larval rearing should be repeated for carp rearing. The experience of Singapore in developing commercial production of cultured *Moina micrura* should be noted for future mass rearing of carp fry in other countries.

Improvement of fry and fingerling growth by growth-promoting feed additives, such as anabolic steroids, thyroid hormones and cobalt chloride, was also discussed. This was not felt to be a priority area for research until more information was available from basic endocrinological studies.

Fish health and control of predators

Control and treatment of fish diseases and parasitic infestations were identified as common problems. A major research initiative is needed to study these problems in the tropics. This can best be achieved by cooperation between national, regional and international institutions and agencies. In many countries there is total reliance on traditional methods using 'cure-all' treatments with compounds such as malachite green, potassium permanganate and methylene blue, while new drugs are often unavailable for trials and data on their use in warm water are lacking. Official permission is often required to enable the use of drugs on fish destined for human consumption.

Predators exact a serious toll on postlarvae, fry and fingerlings. The most serious are the predatory crustaceans, insects, frogs, snakes, birds and others. It was generally agreed that the use of organophosphate pesticides, such as Dipterex against parasitic and predatory crustaceans and predatory insects, was a very successful technique and that there was at present no cause for concern about any environmental or health hazards from their use. For the vertebrate predators, physical features such as mesh fences, nets, vertical concrete pond walls and bird alarms are the preferred methods.

Other activities and needs

Information

It was clear that hatchery operators have great difficulty in obtaining up-to-date information on equipment, chemicals, techniques and new advances in hatchery methods. It was noted that several agencies and institutions are currently operating or planning aquaculture information systems. The FAO Aquaculture Development and Coordination Programme (ADCP) has a Network of Aquaculture Centres in Asia (NACA) which is gearing up to receive and disseminate computerized data on all aspects of aquaculture research, development and production. The International Center for Living Aquatic Resources Management (ICLARM) operates a variety of information services including a quarterly newsletter which is free by surface mail to individuals and institutions in developing countries. ICLARM also maintains in Manila a library and a terminal for searching computerized bibliographic databases. ICLARM's facilities are open to use by all. The confused state of fisheries information services in Asia is well described in the proceedings of a seminar held in Bangkok, 16-20 August 1982.* However, it was recognized that the tremendous advances made in the field of information handling and the interest of agencies such as the International Development Research Centre of Canada, the Southeast Asian Fisheries Development Center and ICLARM in improving services should soon result in improved access to aquaculture information.

Training and extension services

There is a lack of skilled hatchery manpower throughout Asia and improved training facilities are needed. Training is possible through the NACA centers but every country

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*The Seminar on Fisheries Information Science in Southeast Asia, 16-20 August 1982. Available from the SEAFDEC Secretariat Liaison Office, Olympia Bldg., 4th floor, 956 Rama 4 Road, Bangkok 10500, Thailand.

should look to improving national training facilities as well. Extension services to fish farmers and hatchery operators, especially those in remote rural areas, generally need much improvement. This in turn requires more training of skilled extension officers.

Quarantine measures

It was agreed that fish quarantine measures to control the spread of disease are highly inadequate. Within Southeast Asia only Indonesia and Singapore are carrying out quarantine measures on exports and imports on a routine basis. Mr. George Tay Seng Hock described the system used in Singapore. Since Singapore is a major exporter of ornamental fish, there is a quality control scheme in force called the 'accredited scheme' in which exporters' fish are quarantined in an export center before shipment. An associated government laboratory samples the fish and their water for microbial and metazoan (but not virus) pathogens and parasites. The laboratory monitors the health of imports and exports and is now beginning a program of sampling fish and water at Singapore's farms and hatcheries. Investigations have shown serious disease problems in imported stocks from various other countries.

Chemicals and equipment

Several participants stated that chemicals for hatchery use were difficult to obtain in their countries and that even when available there was little documentation on their use in aquaculture. For example, organophosphate pesticides are designed primarily for agricultural use. This is a complex problem and can only be solved by the manufacturers recognizing the situation and pressing for official approval for the use of chemicals in aquaculture, where such is required by law.

On equipment, it was stated that good advice on choosing and purchasing hatchery equipment is often difficult to obtain. Sometimes large items like food pelleting machines break down and cannot be repaired because of lack of spare parts or expertise. The "Aquaculture Buyer's Guide", published annually by Aquaculture magazine was cited as a useful source of information.

Summary of recommendations

Priority areas for follow-up research and technology development

a. Genetic improvement for *all* cultured carps–it was noted that little or no genetic improvement work has been attempted for the Chinese and Indian major carps.

b. Broodstock management and husbandry, especially nutrition.

c. Improvement and standardization of controlled breeding, including induced spawning. New and promising chemicals such as LHRH analogues should be further evaluated. Continuing basic research on the reproductive physiology of cultured carps is essential.

d. Egg incubation and larval rearing technology should be improved, especially the design of hatcheries and hatchery equipment to maximize survival.

e. Improvement of postlarval, fry and fingerling rearing technology, especially basic studies on nutritional requirements and the formulation of cost-effective complete or supplemental feeds.

f. Development of guidelines regarding the use of chemicals for prophylaxis and treatment of carp diseases at tropical temperatures and for better control of predators.

Other activities and needs

a. Improved communication/information flow between hatchery/nursery technologists.

b. Improved opportunities for training of hatchery/nursery operators and improved extension services.

c. Improved quarantine measures for disease prevention.

d. Improved documentation on and availability of useful chemicals and equipment.

e. A followup workshop/conference in three years time to report and discuss progress.

Abstracts

Presentations from the Countries Involved in the Technical Assistance Project

STATUS OF CARP HATCHERIES OF BANGLADESH

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and

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Abstract

Broodfish ponds, measuring 0.4 ha each are sun-dried for at least a week, filled and then limed and fertilized with urea and phosphates, followed by treatment with 3-4 ppm rotenone. They are stocked with fish at 1,000 kg/ha in ratio 30% silver carp *(Hypophthalmichthys molitrix)*: 15% catla *(Catla catla)*: 35% rohu *(Labeo rohita)*: 10% mrigal *(Cirrhinus mrigala)*: 5% grass carp *(Ctenopharyngodon idella)* and 5% calbasu *(Labeo calbasu)*. Sometimes catla broodfish are stocked separately at 500-750 kg/ha to improve their gonadal development. Common carp *(Cyprinus carpio)* broodfish are kept at 1,000 kg/ha, with the sexes segregated. Broodfish are fed 3% of their body weight/day with mustard oil cake and wheat bran (1:1) from August to January. Natural food present in broodfish ponds is checked by Secchi disc readings: 20-40 cm indicates an adequate amount of plankton. Ectoparasitic infestations are usually due to *Argulus* and *Lernaea* and are controlled with 0.25-0.50 ppm Dipterex. Fungal infections are controlled by malachite green (0.05 ppm) and bacterial infections with 10 ppm potassium permanganate or 0.25 ppm Baytex.

Indian major carps are bred with pituitary gland extract (PG) and Chinese carps with a combination of HCG and PG. Both single and double injection procedures are applied to Indian major carps. The single injection procedure consists of 8-10 mg/kg body weight for rohu and calbasu females; 7-8 mg/kg for mrigal females and 10-14

mg/kg for catla females. The double injection procedure comprises a priming injection of 2 mg/kg for rohu, mrigal and calbasu females and 2-4 mg/kg for catla females followed six hours later by a second injection: 6-8 mg/kg for rohu and calbasu; 5-8 mg/kg for mrigal and 8-10 mg/kg for catla. No single injected volume exceeds 2 ml. For silver carp and grass carp females the first injection comprises 220 IU HCG/kg body weight and the second injection, 12 hours later, is 1,350 IU HCG/kg for silver carp and 1,800 IU HCG/kg for grass carp. Grass carp females need a third injection of PG at 2.5 mg/kg, 12 or 24 hours after the second injection. Males are given 2 mg/kg PG.

Indian major carps spawn naturally in Chinese circular concrete tanks but the Chinese carps have to be stripped. The dry method is used for stripping and quinaldine is first applied to the gills to quiet the fish.

Nursery ponds are fertilized with cowdung/compost (5,000 kg/ha) and mustard oil cake (250 kg/ha) before filling with water. Inorganic fertilizers (urea, 37 kg/ha; triple super phosphate, 75 kg/ha; and potassium chloride, 25 kg/ha) are then applied. Aquatic insects are controlled with diesel oil or Dipterex. In single stage rearing, 4 to 5 day-old postlarvae are stocked at 625,000-750,000/ha for 4-5 weeks. In double stage rearing, postlarvae are stocked at 2.5 million/ha and after 15 days the fry are restocked into rearing ponds at 250,000-370,000/ha for further growout to 5-8 cm length. Postlarvae are fed twice daily with a 1:1 mixture of mustard oil cake and wheat bran at a total rate of 3 times their body weight in the first week, 4 times their body weight in the second week, 6 times their body weight in the third week, 8 times their body weight in the fourth week and 10 times their body weight in the fifth week. Water agitation is employed when oxygen depletion occurs.

STATUS OF CARP HATCHERY AND NURSERY TECHNOLOGY IN BURMA

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Abstract

With the expansion of fish culture in Burma, the demand for fish seed has increased considerably. Rohu *(Labeo rohita)* was first bred by hormone treatment in 1967. Common carp *(Cyprinus carpio)* breeds naturally. Large-scale production of fish seed has been achieved in several state farms. The Hlawga Fisheries Station in Lower Burma and the Thayetkone Fisheries Station in Upper Burma serve as the primary production centers, capable of producing millions of seed.

Broodfish are selected from induced-bred progeny when 3-7 years old and 3-7 kg in weight. They are stocked at a maximum of 2,500 kg/ha and fed on rice bran, oil cake and chopped aquatic vegetation. The water of broodfish ponds is changed regularly, which helps the fish reach maturity. Sexes are segregated in April and breeding is done in May-August.

For hypophysation a priming injection of 2-3 mg/kg of pituitary gland is given to the female fish followed by 5-8 mg/kg six hours later. The male receives only one injection of 2-3 mg/kg at the time of the second injection of the female. The source of pituitary gland is either mature rohu or mature common carp.

A double walled hapa system is employed for operations. In nursery management, ponds are dried by pumping, limed at 300 kg/ha and fertilized with cow manure at 10,000 kg/ha. Inorganic fertilization is also done. Water inlets are screened and bamboo fencing is raised at the pond perimeter to prevent the entry of air-breathing fish. Insect predators are controlled with a soap-oil emulsion. Supplemental feeds are made from powdered peanut oil cake and rice bran in the ratio of 1:1. Separate rearing and nursery ponds are not generally used in Burma.

An indoor hatchery comprising three spawning ponds (3 x 2 x 0.8 m each) plus a hatching trough and a water filter-cum-incubator have been built at the Thayetkone Fisheries Station, where 30-40 million seed are produced annually.

DEVELOPMENTS IN CARP HATCHERY TECHNOLOGY IN BURMA

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Abstract

For the last decade in Burma, induced spawning of Indian major carps has been done in outdoor hatcheries using cloth hapas. This method is totally dependent on weather conditions and the mortality of postlarvae is high. Now an indoor hatchery system, comprising circular concrete spawning tanks, and semi-concrete rearing ponds, has been introduced which reduces the use of manpower and gives high survival rates for postlarvae and fry. In broodfish care, the spawners are given supplementary feed at the rate of 3-4% of their body weight/day, but when there is abundance of natural food supplementary feeding is reduced to 1-2%. The supplementary feed comprises peanut oil cake and rice bran (1:2) mixed with vegetation, such as grasses and water hyacinth. For breeding, freshly extracted pituitary glands are preferred, the donor fish being either mature rohu *(Labeo rohita)* weighing more than 0.5 kg or mature common carp *(Cyprinus carpio)*. At times, pituitary glands are preserved in absolute alcohol and stored in a refrigerator. The injection protocol for females comprises a total of 6-12 mg/kg of pituitary extract, split into two doses of 1/3 and 2/3, administered intramuscularly or intraperitoneally with a 6-hour interval. The males receive only one injection at the same rate as the first female injection and concurrent with the second female injection.

Postlarvae are stocked at 1 million/ha in rearing ponds with brick and cement sides and an earth bottom. The feed given is very fine rice bran mixed with oil cake at the rate of 4-5% body weight, given twice a day. After 3-4 days the fry are transferred to nursery ponds. Nursery pond preparation consists of drying the pond bottom, spreading tobacco dust, applying lime at 1,000 to 2,000 kg/ha (when the pH is less than 7.0) and fertilizing with cow manure at 2-3 tonnes/ha broadcast evenly over the bottom before filling with water to a height of 2-3 m. Fingerling production ponds are fertilized with cow and chicken manure at 5-10 kg/ha weekly. Fingerlings are fed rice bran and peanut oil cake at 3-4% body weight/day.

DEVELOPMENTS IN CARP HATCHERY AND NURSERY TECHNIQUES IN INDONESIA

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Abstract

Lack of suitable first larval food is one of the main causes of poor survival of common carp *(Cyprinus carpio)* postlarvae in hatcheries. Techniques of rotifer culture have been developed which have reduced postlarval mortality rates from 40%-60% to 23%-33% in rearing ponds. Two systems have been developed: 1. treating conventional rearing ponds with Fumadol, an organophosphate pesticide; and 2. treating rotifer production ponds with Fumadol and transferring rotifers to concrete rearing tanks. In system 1, the application of 2-4 ppm of Fumadol kills aquatic insects, cladocerans and copepods without adversely affecting the fish postlarvae and rotifers. The same rearing ponds can then function as nursery ponds after the postlarvae have grown to fry. For this, cladocerans are inoculated from mass culture. In system 2, the rotifer production pond measures about 500 m^2 and the concrete rearing tank about 20 m^2. The rotifer pond is prepared by manuring with chicken manure (400 g/m^2), liming and spraying Fumadol (2-4 ppm). Rotifers are supplied to the rearing tank by a system of airlift pumps. This has allowed postlarval stocking rates to be increased from $500/m^2$ to $2{,}400/m^2$ and has reduced postlarval mortality to as little as 8.4% in tanks. Plastic sheets are used to cover the tanks to reduce fluctuation of water temperature from the range 18-27°C to 24-26°C; the sheets also help to exclude predators.

CARP HATCHERY AND NURSERY TECHNOLOGY IN LAMPUNG, JAMBI AND SOUTH SUMATERA PROVINCES, INDONESIA

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Abstract

Common carp *(Cyprinus carpio)* broodfish are stocked 1 kg/5 m^2 in 500-1,000 m^2 ponds of 0.6-1.0 m depth, with a water flow of 0.5-1.0 liter/second. A pelletized diet may be given, containing 50% rice bran, 25% fish meal, 12% leaf meal, 12% groundout oil meal + 1% vitamin, minerals and antibiotics at 2-3% of the body weight/day. Each female spawns 3-4 times/year and each male 4 times/year depending on the strain and the care exercised in husbandry. Different groups of fish are bred 4-5 times/month, a group comprising 1-2 female(s) weighing 1-4 kg each and 2-4 males weighing 0.5 to 2 kg each. Traditional kakabans for spawning are made from fibers of the palm *Arenga pinnata*, but *Hydrilla* has been found to be a better egg collector with 1.9 times higher egg yields, about 15% higher hatching rates and 50% higher postlarval production.

Traditionally, fine rice bran was given as the first postlarval food, but now a spray of hard-boiled egg yolk suspension mixed with vitamins and minerals is preferred: one egg for 100,000 postlarvae.

For early rearing of fry to 1-3 cm (3-4 weeks), pond preparation comprises drying for several days, fertilizing with organic manure (0.5 to 1.0 kg/m^2), urea/ammonium nitrate (2-5 g/m^2) and triple super phosphate (2-5 g/m^2). If the water is acidic, lime at 15-40 g/m^2 is added to the fertilizer mix. The pond is then filled to a depth of 20 cm and treated for 2-3 days with 0.5-2.0 ppm organophosphate (Dipterex, Diazinon, Fumadol, Agrotion or Sumithion) after the depth is increased to 40-60 cm. Organophosphates reduce the numbers of cladocerans and copepods and allow the rotifers to increase. Rotifers are the preferred first postlarval food of carp and their use has increased survival by 25-38%. For further rearing to 3-8 cm fingerlings, the stocking density is 5-30 fish/m^2 and the food given is either fine rice bran and fish meal or broiler chicken starter feed at 2% of the body weight/day.

The main problems of hatcheries are: inadequacy of first postlarval foods; predators such as copepods, cladocerans, insects and wild fish in nursery ponds; high water turbidity; trapping of postlarvae and fry in filamentous algae; differences in water quality between hatchery and pond water sources and broodstock deterioration (particularly in Sumatra). Of the Majalaya, Taiwan, Sinyonya, Punten, 'Super' and local strains of common carp available in Indonesia, the Majalaya strain shows the highest growth rate in running water culture with good feeding.

CARP BREEDING AND NURSING TECHNIQUES IN NEPAL

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and

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Abstract

Common carp *(Cyprinus carpio)* were introduced into Nepal from India (1975) and Israel (mirror carp; 1960). Broodfish are sexually segregated and maintained in well-fertilized 1,000 to 2,000-m^2, 0.75 to 2-m deep ponds, stocked at 800-1,200 kg/ha. Common carp mature within a year in the Tarai plains of the southern parts of Nepal, breeding there in February (extending up to May). In the Kathmandu valley, they mature in two years and breed in March (extending up to July). The crucial temperature at which breeding occurs is .9°C. Broodfish of 2-5 kg (2-4 years old) are selected for spawning. A female lays 100,000 eggs/kg body weight.

Chinese carp introductions to Nepal were as follows: silver carp *(Hypophthalmichthys molitrix)* and grass carp *(Ctenopharyngodon idella)*, both species from India, 1966 and Japan, 1977; bighead carp *(Aristichthys nobilis)*, from Hungary, 1971. Induced spawning has been practiced since 1971 for the Chinese carps and since 1977 for the Indian major carps.

Broodfish are maintained in 2,000 to 3,000-m^2, 0.9 to 1.2-m deep ponds, stocked at 800-1,200 kg/ha depending on water depth. The ponds are fertilized weekly with 8 kg/ha of NP fertilizer and organic manures. Supplemental feeds are based on agricultural residues and industrial by-products, e.g., soya and wheat flour, rice bran and oil cake fed at 3-5% body weight/day. Broodfish species combinations depend on which is the major species, and are designed to minimize competition for food. With silver carp as the major fish (40-50%), 10-20% bighead or catla *(Catla catla)*, 15-20% grass carp and 10-15% rohu and mrigal *(Cirrhinus mrigala)* are stocked. For bighead carp as the major fish (40-50%), 10-15% silver carp, 15-20% grass carp and 10-15% rohu and mrigal are stocked. For grass carp as the major fish (40-50%), 15-20% silver carp, 10-15% bighead or catla and 10-15% rohu and mrigal are stocked. A water flow of 5-15 liters/minute is

maintained in broodfish ponds for Chinese and Indian major carps. The female to male ratio during breeding is 1:1.5 or 1:2 and generally 3-5 females with an appropriate number of males make a set. Chinese carps and rohu mature in two years in the Tarai plains but take a further year in the Kathmandu valley. Mrigal mature in three years and catla in 4-5 years. The best breeding seasons for the Chinese carps are March-May in the Tarai and April-June (also August-September) in the hills when the water temperature is 20-25°C. For the Indian major carps, the best breeding season is June-August, after the rains have commenced (when the water temperature is 25-30°C).

Initially, all pituitary material was imported but since 1980 self-reliance has been attained through locally-collected pituitary glands from common carp, bighead carp and silver carp. LHRH-A in combination with small amounts of pituitary extract has been very effective, but its use (as well as that of HCG) is confined to certain public sector fisheries development centers. Chinese carps need only 3-4 mg/kg, rohu and mrigal 4-5 mg/kg and catla only 2-3 mg/kg of pituitary extract, which is split into two injections, 1/3 and 2/3 given with a 6-10 hour interval. Glands are not weighed but are given after maceration only as a pituitary gland 'ball' count, the weights being estimated by the body weight of the donor fish. The required time interval between the two injections differs with temperature: 10 hours at 20-25°C and 6 hours above 26°C. The injected volume is restricted to 1-2 ml and is given intramuscularly or intraperitoneally.

The first feed given to postlarvae is whole beaten egg or boiled egg yolk. Nursery pond preparation comprises draining and sun-drying the pond bottom for 1-2 weeks and liming at 500 kg/ha. The ponds are filled with water to 1-1.5 m depth, seven to ten days before releasing the postlarvae; weekly fertilization with 8 kg/ha with inorganic fertilizer (N-P-0) is practiced. Postlarvae are also fed at the rate of two chicken eggs for every 50,000 postlarvae for 3-5 days, after which soya and wheat flour are given. This gives a survival rate of 25-30% to the fingerling stage after 20-28 days of rearing.

STATUS OF CARP HATCHERIES IN PAKISTAN

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Abstract

Until recently fish seed in Pakistan, especially that of major carps, was available only from the natural spawning grounds during the monsoon months, an inefficient and uneconomical source of supply. Industrialization, urbanization and changes in irrigation systems with the construction of new dams have adversely affected the spawning grounds. Several hatcheries have been established to produce seed of rohu *(Labeo rohita)*, catla *(Catla catla)*, mrigal *(Cirrhinus mrigala)* and grass carp *(Ctenopharyngodon idella)* through hypophysation. In addition, common carp *(Cyprinus carpio)* is also being bred. In the Punjab, there are four functional carp hatcheries (another two are under construction) with a total annual production capacity of about 14 million seed. Glass-jar hatchery systems are being established at these hatcheries under the Asian Development Bank (ADB)-assisted Pakistan Aquaculture Development Project. These will raise the annual seed production capacity to 30 million. In addition, there are small-scale facilities for seed production through hypophysation at 24 nursery units, one in each district of the Punjab.

In the Province of Sind, despite immense fisheries resources, there are no functional hatcheries. Two large hatcheries are being constructed under an ADB loan, with a total annual production capacity of about 12 million seed. The federal agency controlling inter-provincial water reservoirs, mainly the Mangla Dam, Chasma Barrage and Tarbela Dam, is also constructing a hatchery at Mangla and has plans for another two hatcheries.

In the Northwest Frontier Province and the Province of Baluchistan there are no carp hatcheries.

Broodstock are fattened at the hatcheries to weigh about 1.5 to 3.0 kg and the sexes are segregated in manured and fertilized ponds. Supplemental feed containing rice bran (30%), maize (30%) and grams (20%) is often given. Sometimes fish meal from tilapia *(Oreochromis mossambicus)* and trash fish is also included at 20%.

Hypophysation has become a standard procedure in all hatcheries, especially in the Punjab. The total dose for females is about 6-8 mg of pituitary gland/kg body weight, divided into two injections, the first 2-3 mg/kg body weight and the rest after an interval of six hours. Males are given only one dose of 3-4 mg/kg. The pituitary gland material,

obtained from local major carps and common carp, is injected intramuscularly in aqueous solution. Fresh material is considered better than preserved glands. HCG is also being successfully used at some hatcheries.

Postlarvae are reared on natural food, obtained by manuring and fertilization of water, as well as on supplemental feed prepared from encapsulated egg diet (made by mixing whole hen's egg homogenate with boiling water so that miniature yolk globules, encapsulated in denatured albuminous protein, are formed). Nursery ponds are manured and fertilized about seven days before stocking fry. Diesel oil and kerosene are used in some hatcheries to eradicate harmful insects. The survival rate of postlarvae varies from 20% to 40%.

Recent research at the Fisheries Research Institute, Lahore has shown that Sumithion (an organophosphate) at a concentration of 3 ppm is selectively toxic to cladocerans, copepods, notenectids and other insects, but harmless to rotifers. It can be applied to ponds to encourage rotifer production for live food. Another organophosphate (arthene) is under investigation. This technology is being passed on to the hatcheries. Fry to fingerling rearing is carried out in pre-manured and fertilized ponds. In addition, supplemental feeds are given, mainly fish meal, rice bran and oil cakes.

STATUS OF CARP HATCHERIES IN SRI LANKA

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Abstract

Sri Lanka lacks a tradition of aquaculture, but has now started a program on the culture of mainly herbivorous carp species, which require low cost inputs. The country has few natural inland waters and the indigenous freshwater fish fauna, with the possible exception of *Labeo dussumieri*, includes no suitable species for aquaculture. Therefore, exotic carps–common carp *(Cyprinus carpio)*, bighead carp *(Aristichthys nobilis)*, grass carp *(Ctenopharyngodon idella)*, silver carp *(Hypophthalmichthys molitrix)*, rohu *(Labeo rohita)*, mrigal *(Cirrhinus mrigala)* and catla *(Catla catla)*–have been introduced. The common carp is easily bred by minor manipulation of the environment, but induced breeding, using hormonal treatments is essential to breed the other species. *Labeo dussumieri* and common carp have also been subjected to induced breeding when circumstances have required.

Broodstock management emphasizes provision of appropriate feeds, regular water flushing through the holding facility and minimizing stress. These factors together with conducive climatic conditions bring the fish to maturity for spawning. Common carp can be bred throughout the year. *Labeo dussumieri* matures twice a year in association with the southwest (April-May) and northeast (October-December) monsoons with greater spawning activity in the latter. Induced breeding of all the Chinese carps has been successfully done since 1977 and records show a distinct peak of maturation during the northeast monsoon and at somewhat low temperatures. A low

percentage of the population may mature in most months of the year, but for cost-effective mass production it is better to time hatchery operations to coincide with peak maturation. Experience in breeding the Indian major carps has been very short: the first breeding season experienced was in June 1983.

Induced breeding substances such as pituitary glands, HCG and LHRH-A have been used singly or in various combinations and in different dosages. Two injections are used for Chinese carps and sometimes for Indian carps. Stripping of broodfish and the dry method of fertilization are used for Chinese carps. Various types of holding facilities such as large elliptical or circular concrete tanks, small concrete cisterns, breeding hapas and Chinese portable hatchery jars have been used for spawning. Chinese double-walled concrete incubation tanks, Indian hatching hapas, glass jar hatcheries and portable Chinese plastic hatchery jars have been used for egg incubation. For large-scale incubation of eggs in most species, the plastic hatchery jars have given the best results.

For fry rearing, concrete cisterns, plastic pools, and more commonly earthen ponds are used. However, plastic net cages in reservoirs and pens in smaller water bodies are also being tried. Fingerlings are reared in earthen ponds and concrete cisterns. Organic fertilization of rearing ponds and the supply of cheap supplementary feeds have become important in fry and fingerling rearing.

CARP SEED PRODUCTION IN INDIA

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Abstract

India uses a polyculture system comprising the three major carps, catla *(Catla catla)*, rohu *(Labeo rohita)* and mrigal *(Cirrhinus mrigala)*; the Chinese carps, silver carp *(Hypophthalmichthys molitrix)* and grass carp *(Ctenopharyngodon idella)* and the common carp *(Cyprinus carpio)*. Seed production is from riverine collection, bundh breeding and hypophysation in modern hatcheries. In 1980-81, total seed production was 802 million: 30% from rivers, 63% from bundh breeding and 7% from hatcheries. Riverine collection is declining and there is little hope for its expansion. Bundh breeding remains a useful technique although large perennial 'wet' bundhs are difficult to harvest effectively and give mixed seed. Dry bundhs with stone dykes, sluice gates, and associated cement hatchery tanks are preferable. Hypophysation in hatcheries has the greatest scope for growth of seed production. In 1980-82, only 15% of 550 fish-seed farms used induced breeding techniques.

Broodfish management is often poor. Broodfish of 2-4 kg are stocked at 1,000-2,000 kg/ha in well managed hatcheries, and fed daily with rice bran: oil cake (1:1) at 1% body weight/day. Hatchery systems in use include indoor glass-jar and polyethylene systems, Chinese circular concrete tanks and an earthen pot system for rural use (which produces eggs at Rp 500/million). Postlarval and fry mortality is a serious problem. Fry can be stocked up to 10 million/ha and with good supplemental feeds (groundnut oil cake, rice bran and fish meal mixtures) survival can be up to 66%, with 10 crops possible from well-prepared ponds in a single monsoon season. Fingerlings are reared at 90,000 to 100,000/ha and survival can be over 75%. Fingerling yields can be as good as 300 kg/ha per three-month season without aeration.

The seed requirements, production potential and infrastructural aspects of carp culture are discussed for different Indian States. An

Integrated Inland Fishery Project (World Bank-assisted) in the five Eastern States, 1980-85, has a projected annual output of 460 million fingerlings from hatcheries of individual size 10-25 ha. Hatcheries below 8 ha are considered uneconomical in this project, although in another scheme under the Fish Farmer's Development Agency, farmers in 18 States are encouraged to take up induced breeding in small nursery areas (0.5 ha) and seed farms (2.5 ha) giving a projected total production of 25 million seed by late 1985.

CARP BREEDING AND HATCHERY TECHNOLOGY IN MALAYSIA

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Abstract

Carps contribute 94.9% to production and 96.8% to the wholesale value of cultured freshwater fish in Peninsular Malaysia. The cultured species include the grass carp *(Ctenopharyngodon idella)*, bighead carp *(Aristichthys nobilis)*, *Puntius gonionotus*, common carp *(Cyprinus carpio)* and the indigenous carp, *Leptobarbus hoevenii*. Rohu *(Labeo rohita)* has also been recommended for culture. Other species, such as silver carp and mud carp, are also cultured at times in polyculture but are not economically important. Fingerlings of *Puntius gonionotus* and common carp, both of which spawn naturally, are produced and distributed in large quantities.

Based on the emphases and priority accorded to each species, the availability of pond facilities and also the breeding biology of the species concerned, broodstocks are kept in mono- or polyculture and sometimes sexes are segregated. For species which will not spawn naturally, induced breeding techniques are employed using various sequences of injections involving homoplastic, heteroplastic and semi-pure hypophyseal extracts, with or without HCG. The percentage spawning success of different procedures are compared. Though considerable progress has been made, problems still exist including: lack of knowledge of broodstock husbandry, especially nutrition and environmental manipulation; lack of reliable standard procedures for selecting fish for induced spawning, particularly females (in most cases, only external characteristics are used); the need for improved handling techniques, particularly for highly active species such as *Leptobarbus hoevenii;* lack of standardization of the gonadotropic potency of injected hormones (for piscine pituitaries this is affected by the species, state of maturity, sex and origin of donors and the methods of collection and preservation); lack of information on the critical period of postlarval development, particularly first feeding, when irreversible starvation can occur; difficulty in supplying suitable feeds (live or artificial) for postlarvae; the need for improved nursery management techniques to improve postlarval survival to fry; and the need to store the gametes of important species.

STATUS OF CARP HATCHERY AND NURSERY TECHNOLOGY IN THE PHILIPPINES

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Abstract

Carps have been introduced to the Philippines on various occasions since 1915 and have formed fisheries in some inland waters. In the Philippines, common carp *(Cyprinus carpio)* spawn throughout the year with peak season from late January to early July, while Indian and Chinese carps breed only once a year during June to September. Hatchery and nursery activities are confined to the areas bordering Laguna Lake, with production of common carp, silver carp *(Hypophthalmichthys molitrix)*, bighead carp *(Aristichthys nobilis)* and rohu *(Labeo rohita)*. Common carp broodstock (0.8 to 3.0 kg) are reared either in broodstock ponds or in pens and cages and are fed rice bran and molasses, rice bran and copra meal (1:1) or rice bran alone. The kakaban method of induced spawning is used, with kakabans set on collapsible iron frames. The breeders are placed in a concrete indoor rectangular spawning tank, two males to one female; spawning usually takes place in the early morning. The breeders are then removed and the eggs are hatched in the same tank. Chinese carps and rohu are induced to breed by hypophysation using fresh pituitary glands from common carp, at a dose of 1.5:1 live weight ratio of donor to recipient fish. Supplementation with HCG has also been tried with encouraging results. Two injections are given with a six-hour interval. Spawning takes place usually nine hours after the second injection, in 2 m x 2 m x 1 m breeding hapas installed in concrete rectangular breeding tanks. Rohu are allowed to spawn in the hapas but silver carp and bighead carp are stripped and the dry method of fertilization is used. Eggs are collected and transferred to polyethylene hatching funnels for incubation. Postlarvae/fry are kept in the tanks from 4-7 days.

Rectangular nursery ponds (150-800 m^2) are used with concrete sides and a soil bottom. These are prepared prior to stocking, following usual procedures of draining, drying, levelling and fertilization. Dried chicken manure is applied at 1,000 kg/ha. Zooplankton develops in the nursery ponds consisting mainly of *Daphnia, Cyclops* and rotifers. Fry are stocked at a rate of 3 million/ha. Supplemental feed consisting of fine rice bran or fish pellets (26% protein) is given starting on the 14th day. The nursery phase to produce fingerlings lasts from 30-45 days. Problems from diseases, predation and filamentous algal blooms have been minimal.

CARP HATCHERY AND NURSERY TECHNIQUES IN SINGAPORE

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Abstract

Hatchery and nursery techniques for bighead carp *(Aristichthys nobilis)* and common carp *(Cyprinus carpio)* are described. The mass production of bighead carp fry is carried out in an indoor hatchery. Air bubbles are used for the hatching of the eggs. About 95% of the postlarvae develop into the fry stage. The fry are fed with mass-cultured *Moina micrura* for ten days. They have a survival rate of 99%. They are stocked in nursery ponds for a period of 1.5 months and are fed with a carp grower bran feed. Survival of fingerlings has been estimated at 95%. The mass production of common carp fry is also carried out in an indoor hatchery. Water hyacinth (*Eichornia* sp.) is used in spawning tanks for attachment of eggs. The fry are fed with *M. micrura*. The survival rate of the fry is 99%. The fry are stocked into nursery ponds for a period of two months and the survival rate is 95%.

CHINESE CARP BREEDING IN TAIWAN

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Abstract

In 1982, Taiwan produced 28,387 mt of cultured carps from an area of 10,223 ha. A program of artificial propagation has been in operation since 1962. Taiwan has been self-sufficient in carp seed production since 1964 and has also exported some seed. Common carp *(Cyprinus carpio)* spawn naturally, but bighead *(Aristichthys nobilis)*, silver carp *(Hypophthalmichthys molitrix)* and grass carp *(Ctenopharyngodon idella)* are subjected to induced spawning techniques. The optimal stocking density for broodfish is 2,000 kg/ha. With silver carp as the major species (2.5-4.0 kg each) 200-250 fish are stocked/ha, with 20-30 bighead and 200-250 grass carp/ha. With bighead as the major species (5-10 kg each) the stocking densities/ha are: bighead, 100-150; silver carp, 10-20 and grass carp, 100-150. With grass carp as the major species, the stocking densities/ha are: grass carp, 150-200; silver carp, 100-150 and bighead, 10-15.

Broodstock ponds are limed and manured. Soybean cake, rice bran and peanut cake are used as supplemental feeds, but for silver carp and bighead natural plankton is more important. Grass carp receive 20-40% body weight/day of fresh-cut vegetation and sometimes 2% soybean cake. Diets with high lipid content are avoided. Broodstock pond water is changed 3 to 4 times per month to encourage maturation. Grass carp mature at over 3 kg body weight (3 to 5 years old) and silver carp and bighead at about 2 kg (2-3 years old). Fish are starved 6-7 hours before sorting those ready for induced spawning, since a distended belly can sometimes be mistaken for ovarian enlargement. For induced spawning of females injection of 800-1200 IU HCG/kg body weight for silver carp and bighead and 1-2 mg pituitary/kg body weight for grass carp and black carp *(Mylopharyngodon piceus)* are used. Homo- or heteroplastic pituitary is equally effective. Two injections are given to females with an interval of 6 to 8 hours, the first injection of 50% of the dose is given in the evening and the second the remaining 50% at midnight or daybreak. Males receive a single injection concurrent with the second female injection. All injections are intramuscular or intraperitoneal.

Stripping is done about 12-16 hours after the first injection at 25-28°C. Artificial fertilization is by the dry method. Eggs are incubated

in conical nets with flowing water. Each net (48-cm diameter) holds 40-50,000 eggs and hatching success exceeds 90%. After 1-2 days feeding on steamed egg yolk, soybean milk, powdered milk and pig blood meal, postlarvae are transferred to 3 x 1 x 1-m net hapas for similar feeding for 3-5 days. Fry are raised in predator-free, manured and fertilized ponds at 3 million/ha, although 5 million/ha stocking is used to hold and stunt fry before shipment. Supplemental feeding of steamed egg yolk and soybean milk is continued for one week followed by peanut cake at 4-10% body weight/day. Insect predators, especially the great diving beetle, are controlled with 0.5 ppm Dipterex. At 2-3 cm, fry are graded and stocked at 700,000-800,000/ha. One month later, 4-5 cm fingerlings are regraded at 500,000/ha and can be sold, but 10 cm fingerlings are preferred by buyers.

A REVIEW OF CARP BREEDING PRACTICES IN THAILAND

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Abstract

Chinese carps and rohu *(Labeo rohita)* reach maturity in 2 to 3 years in Thailand. Broodfish are stocked in various polyculture combinations in fertilized ponds, one fish (2-4 kg)/20-30 m^2 of pond area. At higher densities the fish do not ripen. Broodstock are fed 25% protein (from fish meal) pellets for 30-40 days before anticipated spawning. Grass carp are fed at 1-2% body weight/day plus supplementary vegetation. Hypophysation is widely used and homoplastic pituitary extracts are prepared whenever possible, although common carp preparations can be used for all species. HCG is often used to supplement the pituitary preparations. For most species, two injections are given with an interval of six hours. The first dose contains 15-40% of the total dose (judged subjectively on the degree of ripeness of the recipient). *Puntius gonionotus* requires only a single injection. Dose regimens are given for silver carp *(Hypophthalmichthys molitrix)*, bighead *(Aristichthys nobilis)* and grass carp *(Ctenopharyngodon idella)*, rohu and a number of Thai carp and catfish species. Eggs and milt of all species are usually stripped by hand for artificial fertilization by the dry method. After incubation in hatching funnels, first feeding postlarvae receive finely minced hard-boiled egg yolk, soybean milk and wheat flour in concrete tanks.

Fry and fingerlings are stocked in limed, manured nursery ponds at 300-500/m^2 and receive supplemental feed (fish meal: soybean meal: rice bran at 1:1:2), except for herbivorous species which are first kept for 4-5 weeks in concrete tanks on a diet of *Moina* sp. and mixed plankton. Common carp and Thai carp receive the following supplemental feed during the nursery phase: fish meal 30%; fine rice bran, 45%; peanut meal, 24%; vitamin/mineral premix, 1%.

THE BREEDING OF COMMON CARP, *CYPRINUS CARPIO* L. IN VIETNAM

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Abstract

Common carp *(Cyprinus carpio)* accounts for 20-30% of freshwater fish production in Vietnam. The main breeding season is in the spring, although there is a secondary autumn spawning (August-September). Broodstock are kept in ponds previously treated with lime (7 to 10 kg/100 m^2) and pig manure (30-40 kg/100 m^2). The sexes are segregated and stocking densities are 1-kg males/5-8 m^2 and 1-kg females/10-20 m^2. Males are 2-6 years old (0.3 to 3.0 kg) and females 2-8 years old (1.0-4.0 kg). A few grass carp *(Ctenopharyngodon idella)* and silver carp *(Hypophthalmichthys molitrix)* (< 10% of common carp weight) are stocked as well. Periodic fertilization with pig manure (30-40 kg/100 m^2), green manure (compost) (10-20 kg/100 m^2) and NP inorganic fertilizers together with supplemental feeding is necessary for good gonadal maturation. The supplemental food is 10-30% protein (fish meal, soya meal, peanut cake or fish sauce waste) and 70-90% carbohydrate (rice bran, flour meal, maize, sweet potato or manioc). A good feed is: rice bran (70%), wheat flour (10%), fish meal (5%), soybean cake (12%) and fish sauce waste (3%), plus trace elements. In the last two months before spawning, all fish receive 1-2% body weight/day of germinating rice (for its high vitamin E content). About 70-80% females and 90-100% males are brought to maturity.

Water hyacinth on wooden frames, stripped of old petioles and disinfected for several minutes in 5% potassium permanganate solution is used for kakabans. Most common carp spawn naturally (1 ♀: 2-3 ♂, about 15-20 kg of fishes in each small spawning pond or rice field). Sometimes spawning of many fish is synchronized by hypophysation, injecting one gland/female. Each female gives 70,000-120,000 eggs/kg body weight. For silver carp and grass carp, hypophysation is essential to induce spawning. Two injections are given. The first consists of 1 gland/kg of female recipient at 4:00 to 5:00 p.m.; the second is 5-6 glands/kg female at midnight, when the males also receive a single injection of 1 gland/kg body weight. Stripping is followed by artificial fertilization (dry method). Incubation is in glass jars after desticking eggs by stirring in a 0.25% urea:0.4% NaCl solution for one hour

followed by rapid rinsing in a 0.15% tannin solution (three rinses of 3 seconds each). Alternatively eggs can be incubated in the spawning tanks or by a dry incubation method in humid air on wooden shelves spraying with water every three hours. For all methods, saprolegniasis is controlled with 0.1 ppm malachite green.

Rearing is in two stages in manured ponds: from postlarvae to 2.5-3.0 cm advanced fry (3-4 weeks) and advanced fry to 5-7 cm fingerlings (about 60 days). Fry are stocked at 100-200/m^2 and receive supplemental feed: cooked rice flour, wheat flour and soybean meal. Survival to advanced fry is 25-30%. Fingerlings are stocked at 10-15/m^2 and receive supplemental rice bran and soybean cake. Survival is 70-90%.

There are eight local common carp races in Vietnam plus imported European and Indonesian strains. Cross-breeding local carp with Hungarian carp gives high performance hybrids with yields 150-200% more than the local races.

Program of Activities

February 1 1984	*Opening Session*	(Chairman, Dr. R.C. May)
	Opening remarks	Mr. Basudev Dahal, Manager Fisheries and Livestock Division Asian Development Bank
	Consultants' reports	Dr. V.G. Jhingran Dr. R.S.V. Pullin Dr. S.V. Goswami for the late Dr. B.I. Sundararaj
	Session II	(Chairman, Dr. V.G. Jhingran)
	Presentations by hatchery staff from countries participating in the Technical Assistance Project: Bangladesh, Burma, Indonesia, Nepal, Pakistan and Sri Lanka.	
February 2	*Session III*	(Chairman, Dr. R.S.V. Pullin)
	Reports from other countries: India, Malaysia, the Philippines, the Republic of China, Singapore, Thailand and Vietnam.	
	Session IV	(Chairman, Dr. S.V. Goswami)
	Discussion on controlled breeding (spawning cycles, induced breeding, gamete quality and egg incubation). Filmshow on carp hatcheries.	
February 3	*Session V*	(Chairman, Dr. V.G. Jhingran)
	Discussion on postlarval and fry rearing (first feeding diets, live food culture, artificial feeds, predator control, health, shipment methods) and nursing fry to fingerlings.	
	Session VI	(Chairman, Dr. R.C. May)
	Final discussion and formulation of recommendations for followup research and other activities; discussion on a draft hatchery/nursery manual and evaluation of the Workshop by participants.	

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