7.11 Freshwater fish seed resources in India

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ABSTRACT

India is the sixth largest producer of fish in the world (6.41 million tonnes) and second in world aquaculture production (2.22 million tonnes). About 95 percent of India's aquaculture production comes from inland aquaculture. Of late, inland fish production has surpassed marine fish production. India produces about 17 000 million fry annually. Among the different states, West Bengal is ranked first in inland fish production as well as fish seed production (8 400 million fry).

Indian freshwater aquaculture is based mainly on polyculture of Indian major carps, such as catla, rohu and mrigal and three exotic carps, namely, silver carp, grass carp and common carp. Fish seed destined for aquaculture are obtained from three sources, i.e. rivers, bundhs and hatcheries. During the period from 1964 to 1965, 92 percent of the country's fish seed were obtained from rivers, while in the 1980s, bundhs contributed to 63 percent of the total seed source.

Rivers are traditional sources of fish seed for aquaculture. The Ganga River system is the largest river system and is the home to Indian major carps. Fertilized eggs, spawn, fry and fingerlings constitute riverine seed. Spawn/fry collection is undertaken in few States. Among coldwater fish seed resources, trouts (exotic) and mahseers are found in the Himalayan region and the Peninsular Indian rivers that originate in the Western Ghats.

Presently, hatcheries account for 95 percent of seed source. A steady increase in fish seed production from the 1980s can be attributed to the use of Chinese type carp hatchery technology and the application of ready-to-use spawning agents. There are more than 420 carp hatcheries, producing about 34 292 million spawns (17 000 million fry). The Chinese type carp hatchery is most widely used, followed by the jar hatchery. Ovaprim is the most popular spawning agent and ovatide is the next best. Fish pituitary extract also finds use in some states. Carp seed are also produced in bundhs by simulating riverine conditions during monsoon. Of the two types, dry bundh breeding is more widely practiced as it leads to the production of pure seed and is more economical.

The source of broodfish is mainly seed farms or grow-out farms. Broodfish is normally fed with the traditional feed of rice bran and oilcake as well as special feed consisting of locally available ingredients, with fishmeal being an essential component. Carp seed rearing is carried out in two stages: nursery and rearing, where the survival of
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Fry is only 30 percent and 50 percent, respectively. Larval feeds used are mostly rice bran and oilcake. Natural food is promoted through manuring.

Availability of quality fish seed at the right time is important for sustainable aquaculture. The causes of poor quality fish seed are: (i) poor pond hygiene, (ii) presence of pests, (iii) inbreeding, (iv) poor management of broodfish and seed, (v) transportation stress, (vi) mixed breeding and (vii) diseases and parasites.

Until the 1980s, the Fish Seed Syndicate in Kolkata was the only source of carp seed. Thereafter, several states started producing seed and some states are now self-sufficient in seed production. There is no organized fish seed trade in India. However, the best seed trade exists in Kolkata. Carp seed production in hatcheries and bundhs are found to be profitable. No definite seed certification exists in the country. Although the Indian Fisheries Act exists, it is not possible to enforce/implement policy matters.

The traditional method of transportation of fish seed is the open system, which uses earthen/aluminium/galvanized iron or tin containers for seed transportation. The closed method of transportation of fish seed in plastic bags with oxygen and water is more widespread. Broodfish are transported in open FRP tanks/plastic pools/tarpaulins mounted in trucks. Hatchery production of sterile common carp fry is now receiving increased attention.

INTRODUCTION

India is the sixth largest producer of fish (6.4 million tonnes) in the world and second in inland fish production. The fisheries sector contributes Indian Rupees (Rs.) 19.56 billion to the national income which is 1.2 percent of the total Gross Domestic Product (GDP) and 4.2 percent of the agricultural GDP of India (Ayyappan and Biradar, 2004). India, with a total aquaculture production of about 2.22 million tonnes (5.2 percent) is ranked second in world aquaculture production, next only to China which occupies the first place with a staggering production of 27.76 million tonnes (68 percent) from aquaculture (Crespi, 2004). Carps constitute the bulk of the world aquaculture production, with silver carp, grass carp and common carp occupying third, fourth and fifth places, respectively (Crespi, 2004). The widely cultivated Indian major carps, namely, *Labeo rohita*, *Catla catla* and *Cirrhinus mrigala* occupies thirteenth, fourteenth and sixteenth place, with 0.57, 0.55 and 0.52 million tonnes, respectively (Crespi, 2002). About 95 percent of India’s aquaculture production has been reported through inland aquaculture and per capita consumption of fish also increased from 5 kg to 16 kg during the last 50 years (Ayyappan and Biradar, 2004). For the year 2003-2004, inland fish production has been estimated to be 3.46 million tonnes, as against the marine fish production of 2.94 million tonnes. Over the years, the proportion of inland fish production showed an increase, while the marine fish production showed a decline (Table 7.11.1). A viable technology for freshwater fish culture in rural India which emerged over the years significantly contributed to an increase in the country’s inland fish production (Figure 7.11.1).

Table 7.11.1
Trends in fish production of India (million tonnes)

<table>
<thead>
<tr>
<th>Year</th>
<th>Marine</th>
<th>Inland</th>
<th>Total</th>
<th>Percentage of inland fish</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996-1997</td>
<td>3.00</td>
<td>2.10</td>
<td>5.10</td>
<td>41.20</td>
</tr>
<tr>
<td>1997-1998</td>
<td>2.95</td>
<td>2.44</td>
<td>5.39</td>
<td>45.30</td>
</tr>
<tr>
<td>1999-2000</td>
<td>2.90</td>
<td>2.70</td>
<td>5.60</td>
<td>48.20</td>
</tr>
<tr>
<td>2000-2001</td>
<td>2.78</td>
<td>2.84</td>
<td>5.63</td>
<td>50.40</td>
</tr>
<tr>
<td>2001-2002</td>
<td>2.83</td>
<td>3.13</td>
<td>5.96</td>
<td>52.50</td>
</tr>
<tr>
<td>2002-2003</td>
<td>2.99</td>
<td>3.10</td>
<td>6.09</td>
<td>50.90</td>
</tr>
<tr>
<td>2003-2004</td>
<td>2.94</td>
<td>3.46</td>
<td>6.40</td>
<td>53.60</td>
</tr>
</tbody>
</table>

Source: *Fishing Chimes* 24(7): 31
Among the different states and Union territories (Figure 7.11.2), West Bengal is ranked first in freshwater fish seed production (Table 7.11.2). The State of Andhra Pradesh, which witnessed a revolution in carp culture and seed production during the 1980s, is placed third in fish seed production (Table 7.11.2). The data (for the year...
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1995 to 1996) showed that in many of the states of the country, there is a deficit of fish seed (to an estimate of nearly 6 000 million fry), with the exception of the States of West Bengal, Assam and Himachal Pradesh, which have a surplus of fish seed (Table 7.11.2).

India has vast freshwater resources in the form of ponds, tanks, lakes, reservoirs, rivers, bheels, canals, swamps, marshes, etc. Ponds and tanks account for about 2.25 million ha. Lakes comprise 26 million ha, while reservoirs (major and medium) have spread over an area of 3.0 million ha. Rivers have a total length of more than 27 000 km. Canals and channels and their network run up to 112 000 km. Bheels (water bodies formed due to the serpentine course of a flooded river), marshes and swamps constitute 7.9 million ha. Hence, India is one of the richest in terms of freshwater resources.

Carp species are the most widely cultured freshwater fish in India. Mixed species culture is most common where the three species of Indian major carps (IMC) (Plate 7.11.1), i.e. catla (Catla catla), rohu (Labeo rohita) and mrigal (Cirrhinus mrigala) are stocked together. Sometimes, along with the three IMCs, three exotic carps (Plate 2), namely, silver carp (Hypophthalmichthys molitrix), grass carp (Ctenopharyngodon idella) and common carp (Cyprinus carpio) are also stocked. However, the number of species and their combination vary depending on seed availability, consumer acceptance and ability to grow well in different environments. Although these carps possess all the prime requirements of ideal species for aquaculture, with the exception of common carp, they do not satisfy one important quality, i.e. ease of reproduction in confined waters. They spawn naturally only in flooded rivers and also in tanks, where riverine conditions are simulated during the southwest monsoon months of June to September.

Fish seed destined for aquaculture in India is being obtained from three sources: (i) riverine collection, (ii) bundh breeding and (iii) hatcheries (through induced breeding). In addition to these sources, common carp seed produced without hormone injection, was initially included as the fourth source and was accordingly categorized as ‘common carp breeding’ until 1964 –1965. Since then, the data of the common carp seed is included with that of the other carps produced through induced breeding.

TABLE 7.11.2

<table>
<thead>
<tr>
<th>State</th>
<th>Carp seed requirement (million fry)</th>
<th>Carp seed produced (million fry)</th>
<th>Deficit/surplus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andhra Pradesh</td>
<td>3 020.0</td>
<td>709.0</td>
<td>Deficit</td>
</tr>
<tr>
<td>Assam</td>
<td>220.0</td>
<td>2 547.15</td>
<td>Surplus</td>
</tr>
<tr>
<td>Bihar</td>
<td>860.0</td>
<td>320.0</td>
<td>Deficit</td>
</tr>
<tr>
<td>Goa</td>
<td>15.0</td>
<td>0.03</td>
<td>Deficit</td>
</tr>
<tr>
<td>Gujarat</td>
<td>440.0</td>
<td>191.17</td>
<td>Deficit</td>
</tr>
<tr>
<td>Haryana</td>
<td>212.0</td>
<td>200.73</td>
<td>Deficit</td>
</tr>
<tr>
<td>Himachal Pradesh</td>
<td>5.6</td>
<td>23.10</td>
<td>Surplus</td>
</tr>
<tr>
<td>Jammu &amp; Kashmir</td>
<td>98.0</td>
<td>12.60</td>
<td>Deficit</td>
</tr>
<tr>
<td>Karnataka</td>
<td>340.0</td>
<td>164.34</td>
<td>Deficit</td>
</tr>
<tr>
<td>Kerala</td>
<td>32.0</td>
<td>20.26</td>
<td>Deficit</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>740.0</td>
<td>564.0</td>
<td>Deficit</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>320.0</td>
<td>293.0</td>
<td>Deficit</td>
</tr>
<tr>
<td>Orissa</td>
<td>860.0</td>
<td>186.64</td>
<td>Deficit</td>
</tr>
<tr>
<td>Punjab</td>
<td>172.0</td>
<td>44.0</td>
<td>Deficit</td>
</tr>
<tr>
<td>Rajasthan</td>
<td>600.0</td>
<td>175.0</td>
<td>Deficit</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>1 040.0</td>
<td>467.73</td>
<td>Deficit</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>1 160.0</td>
<td>546.62</td>
<td>Deficit</td>
</tr>
<tr>
<td>West Bengal</td>
<td>3 800.0</td>
<td>8 180.0</td>
<td>Surplus</td>
</tr>
<tr>
<td>North-eastern States</td>
<td>520.0</td>
<td>334.078</td>
<td>Deficit</td>
</tr>
<tr>
<td>Others</td>
<td>6.0</td>
<td>12.0</td>
<td>Surplus</td>
</tr>
<tr>
<td>Total</td>
<td>14 460.6</td>
<td>15 006.40</td>
<td></td>
</tr>
</tbody>
</table>

Source: Sinha (2000)
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PLATE 7.11.1
Indian major carps

Catla catla

Labeo rohita

Cirrhinus mrigala

Labeo fimbriatus

PLATE 7.11.2
Exotic carps and mahseer

Common carp

Silver carp

Mahseer

Red tilapia
Over the years, the hypophysation technique has been standardized and refined, new broodstock diet developed, spawning agents (alternative to pituitary) used successfully, new breeding and hatching devices evolved and better larval rearing techniques developed. However, there still remains a big gap between seed production and requirement. At present, the lion’s share of India’s fish seed production comes from hatcheries. India now produces about 17 000 million fish fry which is much less than the demand.

**RIVERINE FISHERY RESOURCES**

The freshwater fish resources of India (Table 7.11.3) are found mainly in five major river systems, i.e. (i) the Ganga, (ii) the Brahmaputra and (iii) the Indus in the North, (iv) the Peninsular East Coast and (v) the West Coast River in the South (Figure 7.11.3) (Jhingran, 1991).

**The Ganga River System**

The Ganga River system has a total length of about 8 047 km and is among the largest river systems in the world. It harbors the richest freshwater fish fauna of India ranging from the cultivable Gangetic (major) carps to mahseers and other coldwater fishes of the Himalayas, the hilsa (a clupeid) catfishes and a wide array of other fishes of considerable commercial importance.

**The Brahmaputra River system**

The Brahmaputra River system, with a combined length of 4 023 km has a rich fauna in its upper stretches, but without much economic value. However, its middle and lower stretches have several species of carps, catfishes, the anadromous hilsa and other air breathing fish.

**The Indus River system**

The Indus River system, though massive as a whole, covers only a small part of northwest India, harboring the exotic rainbow and brown trouts in the upper reaches and a variety of indigenous carps and catfishes in the lower sections. The trout streams of Kashmir constitute one of the world’s richest sport fishing waters attracting anglers and tourists all over the world.

**The East Coast River system**

The East Coast River system in peninsular India is rather a composite system of rivers, the main constituents of which are the Mahanadi, the Godavari, the Krishna and the Cauvery, with a combined length of about 6 437 km. The Mahanadi has all the Indian major carps common with the Ganga system. The other rivers, besides their own indigenous fish fauna of several carp species, catfishes, murrels, prawns, etc. have had their water enriched by repeated transplantation of the Gangetic carps from the north. The transplants have...
established themselves and contributed significantly to the current fish fauna of these rivers. The tributaries of the Cauvery from the Nilgris have coldwater fishes like trout and tench.

**The West Coast River system**
The West Coast River system in the south drains the narrow belt of Peninsular India, west of Western Ghats and includes the basins of the Narmada and the Tapti which are rich in fauna. The other rivers that originate in the Western Ghats possess carps, catfishes, mahseers, murrels, perches, prawns, etc.

### OTHER FRESHWATER RESOURCES

#### Reservoir fish seed resources
Information on India's reservoir fish seed resources is scanty. The reservoirs in Uttar Pradesh and Madhya Pradesh, by virtue of their being connected with the Ganga River system have natural stocks of major carps. But in view of the large volume of water impounded by them, the original stocks are being supplemented through regular stocking with major carp fingerlings. The reservoirs across other basins, however, do not have natural stocks of major carps. Hence, major carp fingerlings produced elsewhere are brought and released in these reservoirs. Several schemes were formulated for the construction of fish seed farms at reservoir sites to facilitate effective stocking operations. In most cases, where they were constructed, they did not function successfully due to poor soil quality (high porosity). The population of predatory and weed fishes dominated the catches of many reservoirs, thus reservoir stocking with desirable varieties of fish proved to be not fruitful. However, in many instances fish breed either in the reservoirs or in tributaries or streams which eventually drain into the rivers or reservoirs, leading to natural stocking of reservoirs.

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**TABLE 7.11.3 Important freshwater fishery resources of the Indian river systems**

<table>
<thead>
<tr>
<th>River system</th>
<th>Fishery resources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The Brahmaputra</strong></td>
<td>Carps: <em>Catla catla</em>, <em>Labeo rohita</em>, <em>Cirrhinus mrigal</em>&lt;br&gt; Catfishes: <em>Silonia silondia</em>, <em>Osteobagrus aor</em>, <em>O. Cavasius</em>, <em>Bagarius bagarius</em>&lt;br&gt; Mahseers: <em>Tor putitora</em>, <em>T. progenius</em>&lt;br&gt; Murrels: <em>Channa punctatus</em>, <em>C. marulius</em>, <em>C. gachua</em>&lt;br&gt; Clupeids: <em>Hilsa ilisha</em> Other fishes: <em>Rhinomugil corsula</em>, <em>Glossogobius giuris</em>, <em>Colisa lalia</em></td>
</tr>
<tr>
<td><strong>The Indus</strong></td>
<td>Carps: <em>Cyprinus carpio</em>, <em>Schizothorax spp.</em>, <em>Labeo dero</em>, <em>Puntius conchonius</em>&lt;br&gt; Mahseers: <em>Tor putitora</em>&lt;br&gt; Catfishes: <em>Glyptothorax kashmirensis</em>, <em>G. reticulatum</em>, <em>Osteobagrus seenghala</em>&lt;br&gt; Other fishes: <em>Botia biri</em>, <em>Nemacheilus kashmirensis</em></td>
</tr>
<tr>
<td><strong>The East Coast</strong></td>
<td>Carps: <em>Catla catla</em>, <em>Labeo rohita</em>, <em>Cirrhinus mrigal</em>, <em>Labeo fimbriatus</em>, <em>Labeo calbasu</em>&lt;br&gt; Catfishes: <em>Osteobagrus aor</em>, <em>O. Seenghala</em>, <em>Silonia silondia</em>, <em>Wallago attu</em>, <em>Pangasius pangasius</em>, <em>Bagarius bagarius</em>, <em>Rita rita</em>, <em>Ompok bimaculatus</em>, <em>Notopterus notopterus</em>&lt;br&gt; Mahseers: <em>Tor khudree</em>, <em>T. mosal</em>, <em>T. mussulla</em>, *Murrels: <em>Channa striatus</em>, <em>C. marulius</em>, <em>C. gachua</em></td>
</tr>
</tbody>
</table>
Coldwater fish seed resources

From the fisheries viewpoint, waters of temperatures falling within the tolerance limits of trouts belonging to the family Salmonidae are termed as cold. The optimum range of temperature for coldwater fish is between 10 °C to 12 °C. In India, lakes and streams located 914 m above mean sea level, where major carps do not thrive, qualify for coldwater.

Trout, salmon and char: Trout and salmon are the only exotic game fishes introduced to India. The species of trout introduced were: rainbow trout, brown trout, eastern brook trout, golden rainbow and tiger trout (a hybrid between brown trout and Salvelinus fontinalis).

The initial introduction of trouts to India was intended for European residents of the country during the later half of the nineteenth and in the beginning of the twentieth century. Details of introductions are given by Jones and Sarojini (1952) and Sehgal, Shah and Shukla (1971).

In Peninsular India, trout has been introduced in the Nilgiris and Kodai hills in Tamil Nadu and in the high ranges of the erstwhile Travancore in Kerala. In the Himalayas, trout has been introduced to Kashmir and Himachal Pradesh, to Garhwal Himalayas, Arunachal Pradesh, Nagaland, Meghalaya and to some parts of Nepal.

After introduction, trouts are known to have established only in six to eight reservoirs, in the Nilgiris (Sehgal, 1971) and in the high range of Travancore (Gopinathan, 1972).

In Kashmir, the brown trout was found to have established at Harwan and in 1980, a hatchery was built at Achhabel from where eyed-eggs were sent to other parts of the Himalayan region (Mitchell, 1918). Of the different trout species introduced, the brown and rainbow trouts acclimatized well both in streams and in the farms. Among other problems, poor hatching rate and diseases hindered the spread of trouts into the farms of Kashmir (Jhingran and Sehgal, 1978). Trouts in Kashmir streams attract anglers from all over the world; brown trout is most common and rainbow trout is available only in certain streams.

Mahseers: India is blessed with some of the world’s best game fishes like the mahseers. Mahseers are regarded as a sacred fish by the Hindus. In the past, these game fish had attracted the attention of the best anglers and naturalists from several parts of the world. Ogale (2002) described the mahseers as a sport fish that provide unparalleled recreation to anglers even better than salmon. There are seven important species of mahseers belonging to the genus Tor in India. These are: Tor tor, T. putitora, T. khuadree, T. nelli, T. progenius, T. mussullah and T. mosal. Over the years, their natural stocks have depleted (NCA, 1976; Ogale, 2000) due to anthropogenic activities; hence, they are now considered as threatened species. Mahseers inhabit fast-flowing streams and rivers of the hilly areas, with a temperature (optimum) range of 10 °C to 20 °C, but some species can thrive and grow well in coastal regions at temperatures ranging between 20 °C and 32 °C (Bazaz and Keshavanath, 1993; Nandeesha et al., 1993; Basavaraja et al., 2002).

In view of the depleting mahseer resources in India, it was concluded at a national workshop on Conservation of Mahseer Resources in India held in August 1986 that natural stocks of most species of mahseers are seriously depleted. The same was attributed to low fecundity, extreme vulnerability to predation of early larval stages and fry and environmental degradation.

Snow Trout: Snow trout (Schizothoracinae) are believed to have migrated into lakes and streams of Kashmir from Central Asiatic watersheds. Most of them are now regarded as endemic to the Kashmir valley. Presently, there are 11 valid species of Schizothorax. Vass, Raina and Sundar (1978) and Sunder, Raina and Kumar (1979)
reported successful artificial propagation of schizothoracids collected from different lakes and streams.

**Hilsa:** The anadromous Indian shad, *Tenulosa ilisha* (Hamilton), commonly known as hilsa or river shad is, undoubtedly, one of the most commercially important fish of the country. The hilsa ascends the freshwater stretch of all the major river systems from the sea mainly for breeding, thereby forming a lucrative fisheries in both freshwater and brackishwater. However, its upstream migration has greatly been hampered by the construction of dams, weirs and barrages across the rivers. As a remedial measure, fish pass or fish lock, constructed on dams and barrages has not proved a success. Over the years, the natural stocks of hilsa have declined in major rivers, including the Ganga. Hence, there was a need to rehabilitate and save the dwindling hilsa fishery from extinction. The developmental measures such as artificial fecundation and stocking of the young ones in selected stretches of rivers were suggested.

**SEED RESOURCES/SUPPLY**

Until the late 1970s, riverine seed collection was the main source of seed of IMC for aquaculture (Figure 7.11.4), contributing to 91.67 percent of the total fish seed production during 1964–1965. Bundhs (a special type of tanks where riverine conditions are simulated during monsoon and carps bred) accounted for a major portion of fish seed from the 1960s through to the 1980s (Figure 7.11.5). With the advent of the technique of induced breeding of IMC by Chaudhuri and Alikunhi (1957) and exotic carps by Alikunhi, Sukumaran and Parameshwaran (1963a) through hypophysation, it became possible to obtain quality seed of major carps for aquaculture. This resulted in an increased reliance on induced breeding for obtaining quality fish seed. During 2002–2003, induced breeding accounted for most of the seed produced in the country (Figure 7.11.6), with bundhs and rivers contributing to nearly 5 percent.

Inspite of the intensive collection of carp spawn and fry in certain sections of rivers, a regular survey of such resources had not been made prior to 1964–1965, except for a few cases. The Central Inland Fisheries Research Institute (CIFRI) located at Barrackpore, Kolkata (formerly Calcutta), helped in locating new carp seed collection centres from 1949 through to 1957. In 1964, CIFRI initiated, in 1964, a pioneering programme on seed prompting investigations in various river systems with a view to assess the the following: (i) quality and quantity of fish seed, availability, (ii) gears used for spawn collection, (iii) methods of collection, (iv) measurement of fish seed, (v) factors responsible for fluctuation in seed availability and other aspects on an all-India basis.
The diverse geographical and climatic conditions of India are reflected in the riverine resources of the country. The most significant difference in the rivers of the north and those of peninsular India lies in the greater abundance of the IMC in the former and their poor availability in the latter which naturally has a bearing on the production of quality fish seed and its potential in the two regions. The riverine fish spawning grounds are generally located in the middle reaches of rivers. Of all the river systems, the Ganga is the richest in terms of carp seed resources.

**RIVERINE FISH SEED RESOURCES**

**Egg collection:** Large-scale egg collection is possible only where locations of the breeding grounds are known and easily accessible. Eggs are collected from one or two feet deep water by disturbing the bottom and scooping them with a “gamcha”, a rectangular spawn collecting net. Generally, large-scale egg collection is not practised in rivers.

Collection of eggs, both from the breeding grounds and in the immediate downstream vicinity of the Ganga River system, is done by the Fisheries Department of Madhya Pradesh (Dubey and Tuli, 1961). Drifting eggs are collected by fixing a shooting net (a gear used for collecting riverine spawn) in the tributaries of the Ganga River system (Khan, 1959). Two breeding grounds of major carps are located in Bihar, which have been found to be extremely rich in major carp seed resources, with 90 percent catla and 90 percent rohu at the two centres.

In the Brahmaputra River system, the proportion of major carps collected was low and hence egg collection was uneconomical. The river system changes its current pattern very rapidly due to its torrential and flashy nature owing to steep gradients. A systematic collection of carp eggs was a trend in some tributaries of the river (Alikunhi, 1957).

The Indus River system is rather poor in seed resources. Only a small portion of the system comprising the Beas and the Sutlej and their tributaries is within India. Large-scale egg collection is not done except in the upper reaches of the system which harbor only coldwater forms. A systematic collection of fish eggs has not been reported for the other major river systems of India.

**Spawn collection:** Collection of spawn (larvae measuring up to 8 mm) on a commercial scale was prevalent in Bihar, West Bengal and Uttar Pradesh. Most of the spawn collection centres were located in the main Ganga, yielding quality spawn. About 75 important spawn collection centres are registered with the Uttar Pradesh Government in the Ganga, Yamuna and other tributaries (Motwani, 1964). In the lower section of the Ganga and its tributaries in West Bengal, large-scale spawn collection was carried out by private fishermen. There existed a private trade and the method of collection, distribution of collection centres, ecological conditions of the river and the trade have been described by Ganguly and Mitra (1957), Mitra (1961, 1964) and Government of India (1966). The Ganga system contributed to about 89.5 percent of the total fish seed produced in the country during 1964–1965 (Government of India, 1966). Bihar accounted for 2,010 million fry, while West Bengal contributed 1,200 million fry.

Investigations carried out by CIFRI in 1961 revealed that major carp spawn is available in the lower Brahmaputra and the spawn can profitably be exploited on a commercial scale, notably rohu spawn.

Spawn collection from the Indus River system in Punjab was unknown until 1963. However, spawn was later exploited considerably, particularly after the spawn prospecting investigations were carried out by CIFRI during 1966. Work carried out by Rajan and Kaushik (1958) and Dubey (1959) showed that spawn collection was a trend in the Narmada and Tapti river systems in Madhya Pradesh. While the collections
were found to be rich in *Labeo fimbriatus*, the IMC contributed to 20-25 percent of the total spawn from the Narmada in Madhya Pradesh. Investigations carried out by CIFRI from 1959 to 1964 showed that productive centres could be located in the Gujarat State (Karamchandani et al., 1967). The Narmada was the only river in India which was exploited for mahseer seed regularly during October-January every year, when lakhs of fry were collected and directly stocked in tanks (Dubey, 1959). Studies conducted by CIFRI during 1961 and 1962 monsoon season revealed, for the first time, the presence of catla and rohu spawn in the Tapti River in the Gujarat State. The occurrence of these species in the spawn suggested that they breed upstream (Karamchandani and Pisolkar, 1967). However, the spawn comprised a high percent of minor carpss.

The Mahanadi, the largest riverine source of fish seed in Orissa, being the State's only major riverine source of fish seed, has been considerably exploited over the years. The river mainly harbors the hill stream fishes in the upper and middle stretches. A survey conducted by the Department of Fisheries of Orissa located a large number of spawn collection centres. However, not a single breeding ground of major carps was observed.

The Godavari and Krishna and their tributaries drain mainly in Andhra Pradesh and are sufficiently exploited for their fisheries in their deltaic region, with their upper reaches in Maharashtra being poor in commercial species. CIFRI helped in locating a centre where catla was found to be the only major carp available in the spawn (Malhotra et al., 1966). *Labeo fimbriatus* was the dominant carp species. The deltaic stretches of the two river systems are sufficiently rich in carp fishery, major carp spawn constituted about 20.3 percent (Ibrahim, 1961). Systemic survey of the spawn resources of the Krishna was not made until 1966.

The upper reaches of the Cauvery are poor in carp species. The middle and lower reaches harbor a fairly good fishery for major as well as indigenous carps, such as *Labeo kontius*, *Cirrhinus cirrhosa*, *Puntius dubius* and *P. carnaticus*. The IMC which were transplanted into the Cauvery and its tributaries (Raj, 1916; Thyagarajan and Chacko, 1950) have established themselves well and not only provided a lucrative fishery, but are also available as fry and fingerlings in the deltaic paddy fields of Tamil Nadu. Ganapathi and Alikunhi (1949) reported the collection of spawn and fingerlings of major carps in large numbers from the Cauvery and its tributaries.

**Fry and fingerling collection:** The collection of fry (larvae measuring up to 8-40 mm) and fingerlings (40-150 mm length) is normally carried out by cast and drag nets. Established fry and fingerling collection centres are very few, located in the States of Haryana, Delhi, Madhya Pradesh, Uttar Pradesh and Rajasthan. Although billions of carp fry and fingerlings are caught in the northern Bihar from July to October, they are generally not used for fish culture but consumed as food. Fry and fingerling collection as source of fish seed is prevalent in the Indus River system in the Punjab State (Plates 7.11.3 and 7.11.4).

Fry and fingerlings of major carps, along with those of medium-sized carps are collected from paddy fields in the Godavari during post-monsoon months. Chacko (1946) and Chacko and Ganapathi (1951) reported the occurrence of fry and fingerlings of major and medium carps in the Godavari and Krishna rivers.

**Identification of eggs, spawn, fry and fingerlings of culturable fishes in India**

In order to avoid wastage of precious rearing space, identification and segregation of different species from a mixed collection of fish seed should be accorded utmost importance. An exhaustive account on the egg and larval (spawn, fry and fingerlings) stages of carps, catfishes, murrels, mullets, cichlids, featherbacks and other fishes has been given by Jhingran (1991).
The eggs of IMC and medium carps are non-adhesive, while those of catfishes (e.g. *Notopterus* and *Mastocembelus*) are adhesive. The eggs of murrels and *Anabas* are identified by their floating nature (Jhingran, 1991). The colour of eggs is used as a reliable criterion for the identification of species.

**Spawn:** It is difficult to identify major carps at spawn stage as the spawn of medium and minor carps also have similarity with the former. However, a mixed collection of fish seed can be categorized as desirable and undesirable spawn. If the length of spawn is more than 5 mm when yolk sac is completely absorbed, it is considered a desirable spawn wherein the IMC account for more than 10 percent of the total spawn. The spawn is regarded as undesirable if the length is less than 5 mm when yolk sac is completely absorbed. The undesirable spawn have less than 10 percent IMC. On the other hand, it is relatively easy to identify IMC at fry stage based on the number of dorsal fin rays and morphological characters.

**Fry (14-25 mm):** The carp fry can be distinguished from that of catfishes and murrels by the number of dorsal fin rays as follows:

- a) Major carps: number of undivided dorsal fin rays >11
- b) Minor carps: number of undivided dorsal fin rays 11 or <11
- c) Catfishes and murrels: pigmented (either black, brown or orange)

**Keys to identify species/group**

- **Catla:** large head; no distinct spot on caudal peduncle, opercular region brightly reddish
- **Rohu:** a dark spot present on caudal peduncle; a pair of barbels present; lips fringed
- **Mrigal:** small head and slender body; a triangular dark spot on caudal peduncle; no barbels, lips thin, not fringed
- **Common carp:** eyes prominent; no reddish glow on operculum; deep body; 2 pairs of barbells; no prominent spot on caudal peduncle
- **Silver carp:** small scales and eyes; lower jaw upturned; fins dark
- **Grass carp:** body elongated; head broad with short, round snout; no barbells; body dark grey above and silvery on the belly
- **Catfish fry:** head large; thin body; large barbells; scaleless body and movement wriggling
- **Murrel fry:** orange/ brownish; move in shoals near the surface of water

**SEED PRODUCTION FACILITIES AND SEED TECHNOLOGY**

**Hatcheries**

Presently, hatcheries account for the lion’s share of India’s fish seed production. Seed production of about 211 million fry in 1964-1965 increased to 17,000 million fry in 2003 (Figure 7.11.7). A quantum jump in fish seed production from the 1980s is attributed mainly to the introduction of the technology of the Chinese type of carp hatchery and refinement of the technology of induced breeding, coupled with usage of ready-to-use fish spawning agents like ovaprim. Despite these, India still faces shortage of quality fish seed.

Fish hatchery was earlier used as a facility for hatching of fish eggs collected from rivers and bundhs. At that time, rivers and bundhs were the main sources of carp seed. Over the years, the development and refinement of the technique of induced breeding of carps has been enlarged. Hence, more emphasis is being given to hatcheries for large-scale production of fish fry. Details on the number of Indian major carp hatcheries (both public and private sector), spawn production, conversion rate from spawn to fry, type of hatchery, spawning agent used, etc. are presented in Table 7.11.4. It is evident...
PLATE 7.11.3
Gear used for riverine fish seed collection

A river course showing suitable fish spawn collection sites

A typical shooting net (Midnapore type) used to collect riverine fish spawn

A battery of shooting nets ready to be commissioned for riverine/brackishwaterfish seed collection (Photo courtesy: Dr. Utpal Bhowmick)

PLATE 7.11.4
Drawings and photographs showing riverine fish seed collection activities

Collection of riverine fish seed using a gamcha, a rectangular mosquito netting cloth

A haul of fish fingerlings from a riverine stretch (Photo courtesy: Dr. Utpal Bhowmick)

Fish seed being collected along the bank of a river (Photo courtesy: Dr. Utpal Bhowmick)
that the Chinese type of circular hatchery is the most widely used hatchery for large-scale seed production all over the country. Jar hatchery (glass or fiberglass) and double-walled hatching hapa are used for medium or small-scale operation in some parts of the country. Among the different fish spawning agents, the ready-to-use ovaprim is the most popular hormone among fish hatchery operators.

Magur, trout and mahseer hatchery details are given in Tables 7.11.5, 7.11.6 and 7.11.7, respectively. However, the seed of these fishes is not produced on a large-scale, except for mahseers.

**TABLE 7.11.4**
Indian major carps (indicative spawn production)

<table>
<thead>
<tr>
<th>State</th>
<th>Number of hatcheries</th>
<th>Spawn production (lakhs p.a.)</th>
<th>Spawn to fry conversion rate (percentage)</th>
<th>Type of hatchery</th>
<th>Spawning agent used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andhra Pradesh</td>
<td>20</td>
<td>55 000</td>
<td>30%</td>
<td>Jar/circular</td>
<td>Pituitary extract/ ovaprim</td>
</tr>
<tr>
<td>Arunachal Pradesh</td>
<td>1</td>
<td>n.a.</td>
<td></td>
<td>Circular</td>
<td>n.a.</td>
</tr>
<tr>
<td>Assam</td>
<td></td>
<td></td>
<td></td>
<td>Circular</td>
<td>Pituitary extract/ ovaprim</td>
</tr>
<tr>
<td>Bihar</td>
<td>4</td>
<td>3 300</td>
<td>&lt;25%</td>
<td>Circular</td>
<td>Pituitary extract/ ovaprim</td>
</tr>
<tr>
<td>Gujarat</td>
<td>12</td>
<td>2 200</td>
<td>25%</td>
<td>Circular</td>
<td>Pituitary extract/ ovaprim</td>
</tr>
<tr>
<td>Haryana</td>
<td>21</td>
<td>5 150</td>
<td>25%</td>
<td>Hapa, circular, jar</td>
<td>Pituitary extract/ ovaprim</td>
</tr>
<tr>
<td>Karnataka</td>
<td>28</td>
<td>6 343</td>
<td>20%</td>
<td>Circular, jar, hapa</td>
<td>Pituitary extract, ovaprim, HCG, ovatide</td>
</tr>
<tr>
<td>Kerala</td>
<td>28</td>
<td>21 000</td>
<td>20%</td>
<td>Jar, circular,</td>
<td>Pituitary extract/ ovaprim</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>72</td>
<td>15 800</td>
<td>30%</td>
<td>Circular,bundh</td>
<td>Ovaprim/ovatide</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>28</td>
<td>10 655</td>
<td>30%</td>
<td>Circular, hapa</td>
<td>Ovaprim/ovatide</td>
</tr>
<tr>
<td>Manipur</td>
<td>4</td>
<td>160</td>
<td>n.a.</td>
<td>Circular</td>
<td>Ovaprim, pituitary extract</td>
</tr>
<tr>
<td>Orissa</td>
<td>37</td>
<td>19 672</td>
<td>30%</td>
<td>Circular</td>
<td>Pituitary extract/ ovaprim, ovatide</td>
</tr>
<tr>
<td>Punjab</td>
<td>6</td>
<td>950</td>
<td>30%</td>
<td>Circular</td>
<td>Ovaprim, ovatide, pituitary extract</td>
</tr>
<tr>
<td>Rajasthan</td>
<td>19</td>
<td>6 550</td>
<td>n.a.</td>
<td>Circular</td>
<td>Ovaprim, ovatide, pituitary extract</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>84</td>
<td>8 968</td>
<td>n.a.</td>
<td>Hapa, circular</td>
<td>Ovaprim, pituitary extract</td>
</tr>
<tr>
<td>Tripura</td>
<td>5</td>
<td>2 960</td>
<td></td>
<td>Ovaprim, pituitary extract</td>
<td></td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>45</td>
<td>11 970</td>
<td>Up to 50%</td>
<td>Circular</td>
<td>Ovaprim/pituitary extract, HCG</td>
</tr>
<tr>
<td>West Bengal</td>
<td>30</td>
<td>33 600</td>
<td>Over 30%</td>
<td>Circular</td>
<td>Ovaprim, ovatide, pituitary extract, HCG</td>
</tr>
</tbody>
</table>

Total 420 342 918

One million = 10 lakhs
n.a.: data not available; data of Assam State not included in the total;
* There are attempts to be more carp hatcheries, particulars of which could not be obtained.
A modern fish seed farm now comprises breeding tanks to produce eggs, hatching tanks (hatchery-proper) to produce hatchlings, nurseries to rear spawn to fry, rearing ponds to grow fry to fingerlings and grow-out ponds to produce adult fish. A fishery establishment may have only a hatchery or nursery or rearing or stock ponds or a combination of two or three or more facilities. The magnitude of operations is highly variable, varying from just a few spawnings to commercial-scale operations.

### Hatchery proper

The evolution of fish (carp) hatchery systems in India was traced by Dwivedi and Zaidi (1983). Several types of fish hatchery devices were/are in fashion in India. These range from the simplest hatching pits to the most modern eco-hatcheries. The hatching devices commonly used in India are: (i) hatching pits, (ii) Chittagong type hatchery pits, (iii) earthen pot hatchery, (iv) double-walled hatching hapa, (v) floating hapa, (vi) tub hatchery, (vii) cemented cistern hatchery, (viii) glass jar hatchery, (ix) transparent polythene jar hatchery, (x) galvanized iron jar hatchery, (xi) Shirgur’s bin hatchery, (xii) hanging dip net hatchery, (xiii) circular cistern hatchery, (xiv) Chinese type of hatchery and (xv) low density polyethylene (LDPE) hatchery.

Of these, hatching hapa, glass jars and the Chinese type are widely used for the hatching of carp eggs.

### Double-walled hatching hapa

The double-walled hatching hapa is one of the commonest devices to serve as an outdoor hatchery. Installable in a pond or in the margin of a river, up to 10,000 eggs can be hatched in the inner mosquito net wall of the hapa (with a of size 1.75 × 0.75 × 0.90 m). The hatchlings wriggle out through the round mesh of the inner wall and gather themselves in the outer whole cloth enclosure. Larval survival is much higher when the hatching hapa is installed in a gently or fast-flowing canal or a river because of superior exchange of water.
Glass jar hatchery
The credit of developing India’s first transparent hatching device in which the developing eggs can be seen by the naked eye goes to Bhowmick (1974). In this system, the hatchings are automatically transferred to a storage hapa spawnery, situated within the hatchery building itself. The main components of Bhowmick’s glass jar hatchery are: (i) an overhead tank, (2) fish breeding tank, (3) incubation and hatching jars and (4) a spawnery to hold the newly hatched spawn. The capacity of the overhead tank is 5 500 l and each of the 20/40 hatching jars is 6.35 l. The spawnery comprises of two cement tanks (1.8 × 0.9 × 0.9 m each) which can hold a nylon hapa (measuring 1.65 × 0.8 × 1.0 m), projected above the tank and hence deeper than the tank and has an overhead shower for spray. Each jar can accommodate 50 000 hardened water and swollen eggs at a time. Water flow rate is maintained at 600-800 ml/minute. Hatchery jars used to be a very successful system, nowadays hatchery jars are obtained through orders.

Chinese type hatchery
Circular breeding and hatching tanks in which water flows in a circular or centrifugal motion originated in China. Such type of hatcheries are used for hatching carp eggs and popularly known as the Chinese type of carp hatcheries. Within a small space, this system simulates some aspects of riverine environment and has proved itself to be a very successful method for breeding carps for commercial production of carp seed. In modern times, more and more hatcheries are incorporating circular breeding tanks with continuous water flow. In the system, the outlet lies in the middle of the circular tank guarded by a circular perforated structure or a sloping outlet. The principle of a hatching tank is similar to that of a breeding tank, except that the former is smaller and normally has two chambers, giving the shape of a double doughnut to the hatching tank. The outlet lies in the middle of the circular tank guarded by a straight, circular perforated pipe which regulates the water level of both chambers. One wall of the double doughnut lies at the periphery and the other at the inner end surrounding the outlet. The space between the two walls is where water flows in a circular fashion with the help of water jets/inlets placed at 45° from the bottom and where the eggs are hatched. Depending upon the system adopted, the same breeding tank can serve as a hatching as well as larval rearing tank.

The important merits of this system are that it simulates some characteristics of a riverine habitat where the fish naturally belong, with very efficient hatching (almost 100 percent), combines breeding, hatching and larval rearing and is suitable for commercial-scale operation.

The disadvantages are: (i) water requirement is high and in many hatcheries, water is usually in short supply and a large breeding tank is normally not utilized for small-scale breeding operations and (ii) concrete structures are expensive to install and once installed, subsequent modification becomes virtually impossible.

Modern hatchery proper
A hatchery proper is the most essential component of the modern fish seed farm. It is here that fish are bred, eggs hatched and hatchlings produced. Further rearing can even be done outside, but according to the latest concepts of a hatchery, fingerling rearing is done in the hatchery or fish seed farm. A modern hatchery which incorporates all the essential components and where ecological conditions are simulated is sometimes referred to as eco-hatchery. The components of a hatchery proper are: (i) ante-tank, (ii) fish breeding tanks, (iii) hatching tanks and (iv) larvae holding tank or spawnery (Plates 7.11.5 and 7.11.6).

Modern carp eco-hatchery is the most appropriate system to produce seed of IMCs and exotic carps. It is an integrated one, with infrastructure for broodfish care, breeding tank, hatching/incubation tank, spawn and fry rearing, packing and marketing
PLATE 7.11.5
An aerial view of the Tungabhadra Fish seed farm, one of the best managed and largest fish seed farms in south India

PLATE 7.11.6
Different types of carp hatcheries

Doubled-walled hatching hapa consisting of inner (round-meshed mosquito cloth) and outer (nylon) hapas

Outdoor fibreglass jars, provided with water supply from the bottom, used for hatching major carp eggs

Top view of a Chinese type of circular breeding tank, with an overhead shower

A view of a Chinese type of circular hatching tank, with the inner chamber covered with nylon netting

**Trout hatcheries**
The important trout hatcheries in India are located in the areas of: (i) Avalanche in Nilgiris (Tamil Nadu); (ii) Rajamallay in the high range of Travancore (Kerala); (iii) Achhabal, Laribal and Harwan in Kashmir; (iv) Patlikuhal, Mahili, Barot, Chirgaon and Sangala in Himachal Pradesh; (v) Kaldyani and Talwari in Uttar Pradesh; (vi) Bomdilla in Arunachal Pradesh and (vii) Shillong in Meghalaya (Jhingran, 1991).

**Avalanche Hatchery.** The hatchery at Avalanche, situated at an altitude of 2 280 m was the first trout hatchery to be established in the country. The hatchery has a miniature ova-house with four wooden hatching troughs each of which are provided with six glass hatching trays. It has seven stocking ponds and 20 earthen nurseries; water source is from a nearby stream. The survival from green eggs to fry is found to be 16.9-67.4 percent. The breeding season is from September to February.

**Rajamallay Hatchery.** Situated at an altitude of 2 295 m, the hatchery has a small ova-house containing two hatching troughs. It has four nursery and six stocking ponds. The stripping season extends from October to January. The average survival from eggs to fry of *Salmo gairdneri* was 71 percent during 1967–1970.

**Hatcheries at Achhabal, Laribal and Harwan.** The Achhabal hatchery is one of the oldest and biggest in Kashmir State, with water supply coming from a spring; those at Laribal and Harwan come from streams. Trout hatcheries in Kashmir comprise raceways-type stock ponds, circular ponds, a battery of nurseries and ova-houses with a series of hatching troughs and wooden trays. The stripping season of brown trout lasts from mid-November to December. The rainbow trout has a shorter stripping season lasting for about 25 days between February and March. The hatching period of brown trout eggs is 104-130 days at water temperature range between 3 °C to 7 °C as against 28-71 days of rainbow trout at 7 °C to13 °C. Application of prophylactic measures against diseases and maintenance of high dissolved oxygen level in hatching troughs resulted to improved cumulative survival from eggs to swim up fry up to 94.9 percent as against the average range of 17.1 to 37.5 percent.

**Barot Hatchery.** This hatchery is located at an altitude of 2 068 m in the Uhl Valley of Himachal Prudish. Hatching troughs and trays are arranged in series. The source of water is a spring. The stripping season of rainbow trout is the same as in Kashmir. The survival from green eggs to fry has been found to be 26.5 and 51.7 percent for controlled and treated hatching troughs, respectively.

**Kulu Hatcheries.** In the Kulu valley, there are two hatcheries, both located at an altitude of 1 462 m and fed by small channels connected to the nearby streams. The average survival from green eggs to fry stage for rainbow trout was 40.6-58.3 percent.

**Hatchery Production of Mahseer Seed**
To conserve mahseer and develop sport fishing, the Government of India encouraged the establishment of mahseer hatcheries. Investigations carried out by Tata Power Companies Limited (TPCL) at Lonavla, Maharashtra State, revealed the possibility of artificial propagation of mahseer (Kulkarni, 1971). Breeding techniques are now being developed for several species of *Tor* in several countries of Asia. In India, broodfish for hatchery production are derived from reservoirs, lakes and rivers during spawning.
season and are bred with or without hormone injection (Kulkarni, 1971; Kulkarni and Ogale, 1991; Tripathi, 1977; Ogale, 2002; Basavaraja et al., 2006).

The first mahseer hatchery to be established in India was at TPCL at Lonavla in Maharashtra State and the credit goes to C. N. Kulkarni. It supplied nearly 0.8 million mahseer fingerlings (as of 1994) to different states of India and also to other countries (Ogale, 2000). In addition, approximately 0.2 million mahseer fingerlings are released annually in the reservoirs of TPCL and the mahseer population therein has increased substantially (Kulkarni and Ogale, 1991). The second mahseer hatchery was established at Harangi Fish Farm in Kodagu District of Karnataka, with a capacity of 1.0 million seed per year. Later, the National Bureau of Fish Genetic Resources (NBFGR), located at Lucknow, Uttar Pradesh, standardized the technique for large-scale production of mahseer fry in Uttarakhand State using the method adopted by TPCL. Subsequently, the Department of Fisheries of Uttarakhand established two mahseer hatchery units, one at Dehradun and the other at Bhimtal. Recently, the Jammu and Kashmir governments constructed a mahseer hatchery at Anji near Salal Hydel Project with a capacity to hatch 1.0 million eggs per year. Very recently, the Government of Kerala established one hatchery at Wayanad and the Government of Tamil Nadu has just sanctioned one mahseer hatchery which is coming up at Salaiyar Dam in Coimbatore District, under the Western Ghat Development Programme.

**Artificial propagation of *Tenulosa ilisha***

Various attempts were made to artificially propagate hilsa (*T. ilisha*), in India (Wilson, 1909; Kulkarni, 1950), but none succeeded in rearing the resultant hatchlings beyond three days. Karamchandani (1961) located the spawning ground of hilsa (about 100 km above the sea) in the freshwater zone of the River Narmada. Malhotra et al. (1969, 1973) successfully bred hilsa by stripping specimens collected from the Ganga River and reared the fry in freshwater pond for more than two years. Hatching of fertilized eggs was tried in different environments. Successful results were obtained when hapas, made of muslin cloth, were fixed in the river bed. The stocking density of eggs ranged between 180,000 and 240,000 per hapa. Malhotra et al. (1969) produced about 420,000 hatchlings which were reared in nursery ponds and attained 155 and 320.5 mm at the end of the first and second year, respectively (Malhotra et al., 1973).

CIFRI made further progress in the refinement of the technique of artificial propagation *T. ilisha* and fry rearing (Anon., 1984). Live male and female specimens in good condition were collected from the river Ganga using gill net and wet stripping was done. Incubation of the developing embryos was carried out in an improvised field laboratory. Hatching period was 16–20 hrs. A total of 0.26 million hatchlings were produced and reared. Hatchlings were transported in open containers without oxygen filling at a density of 1,000 hatchlings/l. CIFRI designed a model hilsa hatchery and a circular grid hatchery for incubation, hatching and rearing of hatchlings (Anon., 2000). Each hatching jar unit can hatch 150,000 water-hardened eggs and the overall hatching rate is found to be 50–85 percent.

**Hatchery establishment programme in India**

During the 6th Five Year Plan (1979–80 to 1984–85), carp hatcheries of 10.25 ha with production capacities of 10.27 million fingerlings were set up under the World Bank Assistance Programme in Madhya Pradesh, Orissa, West Bengal, Bihar and Uttar Pradesh. This led to a national programme for fish seed production. Under the 6th plan, the targeted production of nearly 2,224 million fry was reached (Figure 7.11.8).

**Induced breeding**

During 1964–1965, the major share of India’s fish seed supply was derived from riverine collection, which almost inevitably comprised a mixed lot and included uneconomic and
Assessment of freshwater fish seed resources for sustainable aquaculture

even predatory forms. Moreover, the seed were available at some specific centres located in the rivers only and great difficulty was encountered in transporting them to markets. Such a process, being expensive, involved heavy mortality of seed during transit.

There was a need to develop a method for procuring pure seed of cultivable fishes and this was made possible when the technique of hypophysation was successfully applied to Indian major carps in 1957–1958 at Cuttack Substation of the CIFRI.

Trends in induced breeding of fish in India

The present day concept of induced breeding of fish can be traced back from the work of Houssay (1930) of Argentina who attempted the application of pituitary hormones for spawning of fish. However, Brazil was the first country to develop the technique of hypophysation (Von Ihering, 1935).

In India, Chaudhuri (1955) successfully induced spawning, for the first time, in an Indian major carp species using pituitary gland extract. He also bred *Pseudotropius atherinoides* by administering pituitary extract from *Cirrhinus reba*. Ramaswami and Sundararaj (1956, 1957) reported successful breeding of the catfishes, *Heteropneustes fossilis* and *Clarias batracus*, by hormone injection. In 1957, Chaudhuri and Alikunhi (1957), for the first time, succeeded in inducing breeding of IMCs, rohu and mrigal and minor carps by injecting them with carp pituitary extract. Since then, the application of this technique has spread widely and now, with modifications, forms a regular part of fish culture programmes all over the country. Induced breeding of Chinese carps was successful in 1962 by employing similar technique (Alikunhi, Sukumaran and Parameshwaran, 1963a, b). Chondar (1970, 1984) described in detail the induced breeding technique for the difficult-to-breed IMCs and Chinese carps. By judicious management of broodfish, he was able to make the specimens of several species of carps breed three times in the same season. Varghese *et al.* (1975) successfully bred carps with pituitary gland of marine catfishes, *Tachysurus thalassina* and *T. jolla*.

Induced Breeding of Indian Major Carps

The technique of hypophysation of carps has been described by several workers. Induced breeding of IMCs, which normally spawn once a year either naturally or through hypophysation during monsoon, became successful within an interval of about two months (Bhowmick *et al.*, 1977). Almost equal quantities of eggs were obtained in each of the two spawnings, thereby doubling the production of spawn.
Somashekarappa et al. (1990) succeeded in advancing maturity of catla by two months using a precooked diet formulated using black gram, horse gram, sunflower cake, rice bran, ground nut oil cake, broken rice and fish meal and monthly injection of the fish with HCG at 6 mg/kg body weight. Such fish could be bred once in April and again in July through hypophysation. Similarly, Gupta, Reddy and Pani (1990) successfully advanced maturity in IMCs and Chinese carps using a special feed and bred them during April-June.

**Environmental factors affecting the breeding of fish**

Environmental factors such as light, temperature, ecological factors, meteorological conditions and others are known to play important roles in stimulating the release of pituitary gonadotropin, thereby controlling reproduction in fish.

**Light.** Light is an important factor that controls reproduction in fish. Early maturation and spawning of fish as a result of enhanced photoperiodic regimes have been reported by several workers for temperate fishes. In India, *Cirrhinus reba* was found to attain early maturity when subjected to artificial day lengths longer than natural day even at a low temperature (19 ºC to 20 ºC) during the winter months (Verghese, 1968).

**Temperature.** The role of environmental temperature on sexual maturation and spawning of fish in India has been studied (Chaudhuri, 1960a; Alikunhi, Sukumaran and Parameshwaran, 1963a; Ibrahim, Bhowmick and Panikker, 1968). All observations show that there are optimum temperature ranges for induced breeding of cultivable fishes and critical temperature limits, above and below which fish will not reproduce. The IMCs are found to breed within a range of 24 ºC to 31 ºC (Khan, 1945; Chaudhuri, 1960a). At higher temperature fish do not spawn (Chaudhuri, 1960a).

**Other factors.** It is known that fresh rainwater and flooded condition in a tank are the primary factors in triggering the spawning of carps. The presence of repressive factors may be responsible for inhibiting spawning of carps in confined waters (Swingle, 1956), but when this repressive factor is sufficiently diluted by the onrush of floods in bundhs or ponds, spawning occurs. Sinha, Jhingran and Ganapathi (1974) suggested that it is the sudden drop in the electrolytic level in the environment caused by heavy monsoon rain or water current which induces gonadal hydration, resulting in natural spawning of carps.

Rainwater and weather conditions are observed to be important factors for induced breeding of fish. Successful spawning in the majority of fishes has been induced during cloudy and rainy days, especially after heavy showers (Chaudhuri, 1960a). The carps are known to breed at a fairly wide range of pH and dissolved oxygen content. The Chinese carps that have more or less similar breeding requirements and can also be bred under conditions optimum for the IMCs.

**Alternative spawning agents**

Studies conducted by numerous investigators on induced breeding of fishes have indicated the superiority of several ovulating agents over fish pituitary extract. Although fish pituitary extract was used extensively for fish breeding all over the world, synthetic spawning hormones are now being used widely due to their efficacy and convenience. Of all the mammalian hormones tested on fish, chorionic gonadotropin (CG) has resulted in successful spawning of fish, probably because CG behaves primarily as a luteinising hormone (LH). Synahorin (a mixture of CG and mammalian pituitary extract) in combination with pituitary gave positive results when injected to rohu (Barrackpore, 1968). Sinha (1969) reported the fractionization of pituitary extract from carps and tilapia. He obtained success in spawning of carps (Sinha, 1971). However, Bhowmick *et al.*
Assessment of freshwater fish seed resources for sustainable aquaculture

(1986) found mammalian hormones antuitrin-s, leutocyclin and LH-RH ineffective when injected singly or in combination with carp pituitary extract. CIFRI in Barrackpore undertook detailed studies on the use of LH-RH alone or in combination with progesterone and obtained breeding success which ranged between 25-49 percent in carps and 100 percent in catfish (cited by Jhingran, 1991).

Synthetic spawning agents. The stimulation of pituitary gonadotropin secretion by synthetic LH-RH has been demonstrated in a number of teleosts. Since LH-RH (natural or synthetic) alone is not very effective in inducing spawning in fish, a combination of LH-RH-a (GnRH-a) and a dopamine antagonist for induced ovulation and spawning in cultured fish is a highly effective procedure, also called the Linpe method (Peter et al., 1988). Kaul and Rishi (1986) and Sahu and Biswas (1988) reported successful spawning of catla, rohu and mrigal with LH-RH analogue at 10-20 μg/kg b.w. They also obtained 100 percent ovulation with pimozide at 10 mg/kg b.w.

Investigations of Jose, Mohan and Sebastian (1989) with LH-RH-a indicated successful breeding of mrigal and Labeo fimbriatus. The Linpe method rapidly gained acceptance in fish farms in China and India and has now been commercialized by Syndel Laboratories, Inc. (Vancouver, British Columbia, Canada) under the trade name ovaprim. The ovaprim spawning kit is especially formulated for use with salmonids, cyprinids and other freshwater cultured fish. It has been used successfully in a number of species in several countries and is gaining wide acceptance as the preferred method for induced ovulation and spawning of cultured freshwater fish (Plate 7.11.7). For example, in India, based on field trials (in 1988-1990) with ovaprim for induced spawning of IMCs, fringe lipped carp, silver carp, bighead carp and grass carp in various fish farms located in different agro-climatic regions, Nandeesha, Ramacharya and Varghese (1991) concluded that in economic terms, the use of ovaprim is advantageous. The spawning success, quantity of eggs obtained, the fertilization rate and hatching percentage remained consistently higher with ovaprim than carp pituitary extract (CPE) or human chorionic gonadotropin (HCG) in almost all instances. The results also indicate that nearly 40 percent more fry can be obtained by using ovaprim in place of commercial CPE. Most of the carps tested generally spawned within 10-14 hrs after injection.

Ovulation and spawning has been successfully induced in India by the Linpe method in the Asian catfish, Clarias batrachus (Manickam and Joy, 1989) and Indian catfish, Heteropneustes fossilis (Manickam, 1992). Similarly, indigenous preparations such as Ovatide (M/s. Hemmopharma Ltd., Mumbai) and WOVA-FH (M/s. WOCKHARDT Ltd., Mumbai) are also being used commonly for the commercial spawning of carp and other fishes in India (Table 7.11.8). A combination of busereline (LHRH-a) and domperidone has been successfully used for the spawning of IMCs.

SEED PRODUCTION OF OTHER COMMERCIALY IMPORTANT FRESHWATER FISHES

Exotic species

Important exotic fishes introduced into India for food, sport and vector control are listed by Jhingran (1991). They include cyprinids, salmonids, tilapia and larvicidal

<table>
<thead>
<tr>
<th>Females of the following fish species</th>
<th>Dosage of spawning agents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catla</td>
<td>0.4-0.5 ml/kg body weight</td>
</tr>
<tr>
<td>Rohu</td>
<td>0.3-0.4 ml/kg body weight</td>
</tr>
<tr>
<td>Mrigal</td>
<td>0.25-0.3 ml/kg body weight</td>
</tr>
<tr>
<td>Fringe-lipped carp</td>
<td>0.3-0.4 ml/kg body weight</td>
</tr>
<tr>
<td>Catfish</td>
<td>0.6-0.8 ml/kg body weight</td>
</tr>
<tr>
<td>Silver carp</td>
<td>0.4-0.7 ml/kg body weight</td>
</tr>
<tr>
<td>Grass carp</td>
<td>0.4-0.8 ml/kg body weight</td>
</tr>
<tr>
<td>Bighead carp</td>
<td>0.4-0.5 ml/kg body weight</td>
</tr>
<tr>
<td>Mahseers</td>
<td>0.6-0.7 ml/kg body weight</td>
</tr>
<tr>
<td>Males of all species of carps</td>
<td>0.1-0.3 ml/kg body weight</td>
</tr>
<tr>
<td>Males of catfish</td>
<td>0.15-0.4 ml/kg body weight</td>
</tr>
</tbody>
</table>
fishes. Of the important food fishes listed, the following are more important from the point of aquaculture: common carp, silver carp, grass carp, tilapia and gourami.

**Common carp.** The common carp is perhaps the world’s most extensively cultured species. In India, it is widely cultivated singly or in polyculture with IMC and silver carp and grass carp. Detailed studies on the cultivable aspects of common carp have been carried out at the Pond Culture Division of CIFRI. The common carp breeds naturally in confined waters. Spawning occurs in shallow marginal weed-infested areas. It spawns throughout the year in a tropical country like India, with two peak breeding seasons, one lasting from mid-January to March and the other during July and August. However, diverse breeding techniques of this species have been described (Hora and Pillay, 1962, Alikunhi, 1966).

**Silver carp and grass carp.** Silver carp and grass carp occur naturally in the rivers of China and the USSR and have been introduced and cultured in many countries. Both the species were introduced into India in 1959 at the Pond Culture Division of CIFRI (Orissa). In 1963, they were bred successfully by hypophysation and their fry distributed to various states of India.

Like the IMCs, silver carp and grass carp attain gonadal maturity, but do not spawn normally in captivity in India. They, however, could be induced to breed through hypophysation (Alikunhi, Sukumaran and Parameshwaran, 1963a; Chaudhuri, Singh and Sukumaran, 1966). Complete natural spawning of both the species was also reported (Chaudhuri *et al.*, 1967).

The technique of breeding Chinese carps in India is similar to that of breeding IMCs. Although the criteria used for selecting mature broodfish of IMCs and the Chinese carps are almost same, the selection of a female grass carp is rather difficult, because the bulging nature of the abdomen which can be seen as an outcome of heavy feeding. Hence, the prospective females are starved inside breeding hapas for 6-8 hr to empty the gut, before making the final selection. The dosage of hormone given to female and male silver carp and grass carp are almost double the doses given to IMCs. Since they do not normally spawn in breeding hapa after injection, both female and male need to be stripped to facilitate artificial fertilization of eggs. The details of hypophysation of the Chinese carps in India have been presented by Jhingran (1991). The fecundity of silver carp and grass carp is 0.1-0.15 million eggs/kg body weight.

**Tilapia** (*Oreochromis mossambicus*). Tilapia breeds throughout the year except in tropics. The interval between two spawnings varies between 30 and 45 days and the fecundity ranges between 80 and 1 000 eggs per female. The fertilized eggs are picked by the female for buccal incubation for 10-14 days (Panikkar and Tampi, 1954). The newly hatched fry is transparent and measures 5 mm in length. No special spawning technique is followed in India as the fish breeds readily in almost all water bodies. The presence of tilapia in carp nurseries seriously affects the survival and growth of carp fry. Large-scale cultivation of *O. mossambicus* is not presently undertaken in India. However, tilapia forms an important fishery in the states of West Bengal, Kerala, Karnataka and other coastal states where it contributes significantly to commercial fish catches.

The research and development centre of Vorion Chemicals and Distilleries Limited (VCDL), Madras developed a technology for growing hybrid tilapia [red tilapia × gray tilapia (*Oreochromis* spp.)] using the distillery effluent. Male dominated hybrid fry, referred to as golden tilapia, is produced by hormonal sex reversal. The stocking density of tilapia fingerlings practised in grow-out ponds ranges from 25 000 to 120 000/ha (Rangaswamy, 1993). The yields of 50, 100-120 and 250-400 tonnes/ha/yr under semi-intensive, intensive and super-intensive culture, respectively, are obtained in
2 crops a year. Of late, the VCDL is known to have closed down its culture operations due to practical difficulties.

**Gourami** (*Osphronemus goramy*). Gourami occurs naturally in the freshwaters of Southeast Asian countries. In India, gourami was first introduced in Calcutta during the first half of the nineteenth century from Java. The breeding of gourami was first reported in 1916 (Raj, 1916). It however, established itself well in India. Subsequently, it was transplanted to several states of the country. Gourami has successfully been cultured in India (Bhimachar, David and Muniappa, 1944). Gourami breeds naturally in streams and ponds during the dry season in open waters and throughout the year in confined waters. No special pond is provided for breeding. Gourami is bred and cultured in one and the same pond in which plants such as *Typha* are grown in the marginal areas where nests are built.

**Tawes** (*Puntius javanicus*). Tawes was introduced into India in September 1972 to determine its efficiency as weed control in fish ponds. A consignment of about 5 000 fry (10-20 mm) was procured from Indonesia and reared initially at a fish farm in West Bengal. Tawes breeds in ponds in Indonesia where riverine conditions are simulated as in dry bundhs in India. Sinha and Saha (1979) spawned the fish for the first time in Indian conditions in 1979 by administering pituitary extract. The fish bred three hrs after the second injection. A female weighing 600 g can produce about 0.1 million eggs (Sinha and Saha, 1979).

**SEED PRODUCTION OF AIR-BREATHING FISHES**

**Murrels** (*Channa spp.*), **singhi** (*Heteropneustes fossilis*), **koi** (*Anabas testudineus*) and **magur** (*Clarias batrachus*) thrive well in swamps and weedy marshes and can also withstand slightly brackish water.

**Murrels**: Murrels are known to spawn naturally in paddy fields during pre-monsoon months. All the three culturable species of murrels (*C. marulius*, *C. striatus* and *C. punctatus*) were successfully bred for production of large-scale stockable material in Karnataka and Bihar (Parameswaran and Murugesan, 1976; Banerji, 1974). Indoor rearing of murrel spawn has been successfully carried out when fed on boiled chicken egg yolk (Parameswaran and Murugesan, 1976). The murrel fry accepts zooplankton from the eighth day when it also develops air-breathing habitat (Dehadrai, 1972). Until recently fish pituitary extract was being used for induced breeding of murrels. Due to inadequate supply of pituitary glands, their high dose and the availability of alternative hormones, attempts are being made to find out a suitable spawning agent for producing murrel seed. Francis *et al.* (2000) tested carp pituitary extract, HCG, carp pituitary extract + HCG and ovaprim and obtained the best fertilization rate (93 percent) with ovaprim, in *Channa striatus*.

**Magur**: Magur (*Clarias batrachus*) inhabits freshwater rivers, swamps and ponds. It is a highly esteemed food fish in India, Thailand and Cambodia. Magur breeds in confined waters during monsoon months. It deposits eggs in holes made in the pond bank and about 2 000-15 000 fry are found in one hole. It can be induced to breed through hypophysation and the method employed for breeding in India is almost similar to that adopted for IMCs. Since magur normally breeds once in a year during a very short spell, coinciding with monsoon, CIFA (Bhubaneswar) succeeded in prolonging its breeding period, i.e. prior and after the normal breeding period, by manipulating the broodstock. Such fish could be bred more than once in a season so that their seed will be available for longer periods (Sahu *et al.*, 2000). At the Freshwater Fish Farm of CIFE, Balabhadrapuram
(Andhra Pradesh), a magur hatchery has been established with a production capacity of 0.4–0.5 million fry/season (Venugopal et al., 2000). They reported mean fertilization, hatching and larval survival rates of 75, 70 and 60 percent, respectively.

Singhi: Singhi (*H. fossilis*) breeds in confined waters during monsoon months. Singhi is a highly priced freshwater fish and is recommended to convalescing persons because of its protein, iron and fat content. The major constraint to its culture is the non-availability of quality seed. Singhi was induced to breed by hypophysation (Ramaswamy and Sundararaj, 1955) the optimal dose being ½ homoplastic pituitaries from the male donors or ½ pituitary from the females (Sundararaj and Goswami, 1969). Goswami and Sundararaj (1971b) reported that a mixture of carp pituitary and HCG had a greater effect than other combinations of hormones in inducing spawning in Singhi. Fish breeds 8–10 hr after being injected with pituitary hormones. Singhi fry, during rearing stage, shows very poor survival due to non-availability of adequate quantity of choice of food and also due to cannibalism. Singhi has been successfully bred using LH RH-a + pimozide and ovaprim (Nayak and Singh, 1995, cited by Singh, 1995). Marimuthu et al. (2000) have reported successful spawning of this species with ovaprim. They have also demonstrated that ovatide at 0.4 ml/kg body weight is the optimum dose for effective seed production in Singhi and found to be cost-effective, compared to pituitary extract.

Koi: Koi (*A. testudineus*) breeds in swamps, marshes and paddy fields. Hypophysation is very successfully used to produce large-scale fry of koi (Banerji and Prasad, 1974). Moitra et al. (1979) described the spawning behaviour and larval development of koi and found 28.5 ± 1 ºC to be a vital factor in inducing spawning of the fish. The hatchlings are small and tender and require careful rearing to achieve high survival.

**Breeding of carps in bundhs**

Bundhs are special-type of tanks or impoundments where riverine conditions are simulated during monsoon months for breeding carps. They may be perennial (wet bundhs) or seasonal (dry bundhs). Bundh breeding, which accounted for 5.4 percent in 1964–1965, contributed to about 63 percent in 1980. Bundh breeding is popular in Madhya Pradesh and West Bengal. Bundhs have been described in detail by Mookerjee et al. (1944).

Bundh breeding seems to have its origin in Bengal. Majority of bundh-type tanks, where major carps are stimulated to breed are located in the districts of Midnapore and Bankura in West Bengal and around Nowgong in the Chhattarpur District of Madhya Prudish. The first dry bundh was located in Sonar Tàlliya in Nowgong district of Madhya Pradesh.

The initial success achieved on dry bundh breeding of carps in Sonar Tàlliya by the Department of Fisheries, Government of Madhya Pradesh, in 1958 led to the construction of many more dry bundhs with improved designs. The most modern constructions are generally masonry structures with arrangements for a sluice gate in the deepest portion of bundh for complete draining and one or two waste weirs for overflow of excess water. In most cases, apart from the bundh itself, a dry bundh unit consists of storage ponds for stocking brooders, an observation tower with arrangements for storing necessary equipment and a set of cemented hatcheries (2.4 m x 1.2 m x 0.3 m) with a regular supply of water for a large number of eggs at a short time. In some cases, the embankment is a *pucca* stone masonry with a small sluice gate and a portion of the embankment itself serves as the waste weir (Dubey, 1969).

A typical wet bundh of Midnapore (West Bengal) is a perennial pond or tank, situated in the slope of a vast catchment area of undulating terrain, with proper embankments having an inlet towards the upland and an outlet towards the
opposite lower end. During summer, only the deeper portion of the bundh retains water where carp brooders are released for spawning. The remaining portion is dry and oftentimes used for agricultural purposes. After a heavy shower, a major portion of the bundh gets submerged with water from catchment area (catchment area: bundh, 20-100:1), coming into it in the form of streamlets.

With the onset of the southwest monsoon, the rainwater from the catchment area rushes into the bundh, creating an artificial current. The brooders, already present in the deeper area of the bundh, migrate to the shallower areas and start breeding. After the breeding is over, egg/spawn collection is done.

A typical dry bundh is a shallow, seasonal depression, having a bundh on one side and a catchment area on the other three sides. The bundh may be of varying shape and size and made of earthen wall or masonry wall. A dry bundh is smaller and shallower than a wet bundh. The bundh gets flooded in monsoon, but remains completely dry for a considerable period during a year. It consists of a sluice gate for quickly draining the water and an outlet for the excess water to flow away (Figure 9). In dry bundhs, spawning sometimes takes place in deeper areas also (Alikunhi et al., 1964).

**Technique of breeding major carps in a dry bundh**
The mature carp brooders which are raised in perennial ponds elsewhere are introduced into the bundh at a ratio of 1:2 (Female:Male). The fish are left undisturbed for 2-3 days so that they get acclimatized to new environment. After this, 10-20 percent of the fish is given intramuscular injection of the pituitary extract or ready-to-use solution like ovaprim. Water current is created in the bundh by drawing water from a store tank. The following morning, the spent brooders are removed, eggs collected, water drained and the bundh dried for 2-3 days. The bundh is then utilized for the next breeding by releasing a fresh batch of breeders. Five to six spawning are generally conducted in each bundh during one season as opposed to only one spawning in a wet bundh. Silver carp and grass carp have been successfully bred in bundhs without stripping. Sinha et al. (1974) have reported natural spawning of both grass carp and silver carp in a dry bundh in Bankura District where they were able to spawn the two species without stripping. They consider dry bundhs to be one of the most reliable means of mass breeding of Chinese carps to meet the increasing demand of their seed.

**Collection and hatching of eggs**
After spawning, eggs are collected from bundhs, after lowering the water level, by dragging a piece of mosquito net cloth (gamcha) and releasing the eggs hatching either in improvised pits or double-walled hatching hapas or cement hatcheries. Each pit may contain about 0.9-2.2 million eggs, of which 2.5-25 percent hatch successfully. A double-walled hapa, fixed in the bundh itself and consisting of an outer hapa (182 cm × 91 cm × 91 cm) and an inner hapa (152 cm × 76 cm × 46 cm), accounts for a spawn survival rate of 32 to 50 percent (Alikunhi et al., 1964). The provision of cement hatcheries (2.4 m x 1.2 m x 0.3 m) near the dry bundhs in Madhya Pradesh has aided
in improving the survival of hatchlings to 97 percent. A cement hatchery of Madhya Pradesh has three times more capacity than a double-walled hapa and is far more economical than the latter (Dubey, 1969).

**Factors responsible for breeding of fish in bundhs**

No single factor can probably be attributed to spawning of major carps in bundhs and rivers. The act of spawning involves the completion of a chain of interrelated pre-conditions. Heavy monsoon flood capable of inundating vast shallow areas is believed to be a primary factor responsible for spawning. Some workers believe the availability of shallow spawning ground to be a deciding factor for spawning. The rise in the level of water, naturally or artificially, is known to bring about spawning. There is a diverse opinion about the pattern of current required for spawning. Spawning is observed in both still and flowing waters. The temperature of water for spawning is found to be between 22 °C and 33 °C. Other factors like pH, high dissolved oxygen, alkalinity, chloride and minerals do not seem to play any significant role in spawning. Soil type is not very important. Spawning is inhibited due to the presence of hormone-like secretion in captive waters. Water that has flown through a dry bed of land rich in humus has stimulatory effect on spawning. Until today, no single factor has been clearly implicated for induction of spawning of carps in bundhs and rivers.

**Management of broodfish and nursery ponds**

Broodfish is a prerequisite for all induced breeding programmes. Proper broodstock will lead to better breeding responses, increased fecundity, fertilization, hatching and larval survival rates and more viable fish seed. Hence, the subject of broodfish management has assumed great importance in hatchery management.

**Carp broodfish pond.** Carp broodstock ponds are generally large (0.2-2.5 ha), 1.5-2.5 m deep, rectangular, seasonal or drainable and earthen in nature. Water inlet and outlet should be such that they simulate riverine/fluviatile conditions, which is the natural habitat for IMCs and Chinese carps.

**Source of broodfish.** Since selective breeding and hybridization programmes of pedigree fish are not carried out in fish seed farms, the source of broodfish is stock ponds from the same farm or different farms. In order to avoid inbreeding in a hatchery, it is necessary that fresh fish germplasm from natural sources or other hatcheries is introduced regularly with timed periodicities. If this is not done, inbreeding depression may set in, which has been reported to have occurred in some carp hatcheries in India (Eknath and Doyle, 1985).

**Care of broodfish.** The recommended stocking density of carp broodfish is 1 000-3 000 kg/ha, depending upon the species. Systematic studies on nutritional requirements of carp broodfish are limited. It is customary to feed carp broodfish with a traditional diet consisting of rice bran and oil cake (1:1 ratio) at a feeding rate of 1-2 percent of their body weight daily. In addition to the artificial feed, the grass carp is also given tender aquatic weeds/terrestrial grass. However, the breeding habits of some species like common carp demand their separation from other carp species due to their natural breeding in ponds with aquatic vegetation. As a result the common carp broodfish is segregated sex-wise and stocked in separate ponds to prevent accidental spawning in pond. However, the rest of the species can be stocked in a communal pond or stocked in separate ponds after species-wise and/or sex-wise segregation. Catla, in particular, needs to be separated from the rest of the species as it shows poor response to hormonal injection when stocked with other species. It is believed that catla broodfish
need special care and diet such that deposition of mesenteric fat in the maturation phase does not hinder gonadal development of the species.

**Broodstock management practice in Kannataka State**

Basavaraja *et al.* (1999) have described the carp broodstock management practice followed in Karnataka State. Proper broodfish management is a pre-requisite for successful spawning. The number and quality of eggs produced is significantly affected by the conditions under which the broodstock is maintained. The quality of broodstock diet, feeding regime, the quality of broodstock and water management are the principal factors that influence the condition of the broodstock. Most seed farms raise broodstock on their own farm and maintain them in ponds at densities of 1 000-2 500 kg/ha. The earthen broodstock ponds vary in area from 0.2 to 1.0 ha, with depth ranging from 1 to 2 m. Most farms use water from perennial reservoirs. The main steps in the preparation of broodstock ponds are: (i) control of aquatic weeds, which is done manually; (ii) eradication of unwanted fish by applying mahua oilcake at 2 000-2 500 kg/ha and pond liming at 100-200 kg/ha depending on the pH of soil and water; (iii) fertilizing the pond with cattle dung, at 15 000-20 000 kg/ha/yr or poultry manure at 5 000-10 000 kg/ha/yr to enhance heterotrophic food production. In addition, 200-400 kg/ha/yr NPK mixture is applied in split doses at fortnightly or monthly intervals. The initial dose of organic manure is reduced by half if mahua oil cake is used for eradicating unwanted animals. After stocking, the pond with carps that are one-year-old or more, are fed with a conventional feed containing a mixture of groundnut oilcake and rice bran (at 1:1 or 1:2 ratio) at 1-2 percent body weight once daily. To ensure better and timely development of gonads, fish breeders use a special broodstock diet (protein: 25-30 percent) prepared using locally available cheap feed ingredients (Table 7.11.9). This diet is nutritionally superior, advances maturation and spawning by one or two months and results in increased fecundity and better seed quality.

**Management of nursery ponds**

Carp culture is carried out in three phases (three-tier system) comprising nursery phase (rearing three-day-old spawn to fry), rearing phase (rearing fry to fingerling stage) and grow-out phase (rearing fingerlings to marketable size). Of the three phases, the nursery phase is most crucial and needs greatest attention of fish seed farm managers. Jhingran and Pullin (1985, 1988) have reviewed the subject of nursery and rearing pond management.

According to Alikunhi (1957), under Indian conditions, the allocation of land for different types of ponds and other purposes can be described as: a four ha farm should be divided into: (i) nursery ponds, 0.2 ha; (ii) rearing ponds, 0.8 ha and (iii) stocking ponds, 3 ha. Considering the enhanced rate of stocking and survival of spawn, fry and fingerlings (Barrackpore, 1973), the ratio of nursery to rearing to stock ponds should be 1:40:1280. The preparation of nursery, rearing and stocking ponds before releasing the stocking material is an important step for successful rearing of carp spawn to fry, fry to fingerlings and fingerlings to table-sized fish. The occurrence of large-scale mortality of stocked spawn in unprepared nurseries is a common experience of fish culturists throughout the country. About 90-95 percent mortality of carp spawn in nurseries has been reported from Orissa State (Alikunhi, Chaudhuri and Ramachandran, 1952). On the other hand, Basavaraja and Antony (1997) obtained survival as high as 100 percent in the IMC nursery. However, the average survival of carp fry in nursery ponds does not normally exceed 30 percent (Basavaraja, 1994), which is attributed to poor nursery

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**TABLE 7.11.9**

<table>
<thead>
<tr>
<th>Feed ingredients and their contribution to broodstock diet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ingredients</td>
</tr>
<tr>
<td>Rice bran</td>
</tr>
<tr>
<td>Groundnut oilcake</td>
</tr>
<tr>
<td>Fish meal</td>
</tr>
<tr>
<td>Maize</td>
</tr>
<tr>
<td>Broken rice</td>
</tr>
<tr>
<td>Horse gram</td>
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<tr>
<td>Black gram</td>
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</tbody>
</table>

Source: Basavaraja *et al.* (1999)
practices. The three-day-old spawn is ready to accept external feed and is transferred to
nursery pond where predatory fishes and insects, algal blooms and poor water quality
are major causes of mortality.

Control of predatory and weed fishes
Predatory fishes are harmful to carp spawn and fry. They not only compete with
stocked fish for food and space, but also directly prey on them. The term “weed fish”
is used to include all species of uneconomic, small-sized fish that naturally occur or
are accidentally introduced in ponds along with carp spawn. Weed fishes have high
fecundity and mature in summer months and even breed in captivity, in the absence of
rains. According to Alikunhi et al. (1952), even the young weed fishes directly feed on
carp hatchlings and take a heavy toll as soon as they are released in nursery pond.

The common method of removing unwanted fishes from nursery pond is
by repeated drag netting. However, certain bottom-dwelling fishes like murrels,
catfishes and climbing perch burrow themselves in mud and are difficult to be caught
by repeated dragging. The position worsens in ponds which cannot be drained
completely. In such a situation the nursery should be poisoned using fish toxicants,
plant derivatives, chlorinated hydrocarbons and organo-phosphates. Of these, the
chlorinated hydrocarbons are perhaps the most toxic to fish. Organophosphates are
generally less toxic to fish. Plant derivatives are least toxic and are widely used.

Plant derivatives. Derris powder, with 5 percent rotenone content, is probably the most
commonly used fish poison in fish ponds. At doses of 4-20 ppm, most fishes, tadpoles
and bottom dwelling organisms are killed. Even zooplankton and aquatic insects are
destroyed to a great extent. The toxicity of the chemical lasts up to 4-12 days. The seed
powder of Barringtonia acutangula kills a wide variety of fish at 20 ppm, with toxic
effect lasting for 48 hrs. Tea seed cake (75-100 ppm) can be used both as a piscicide and
a fertilizer. It can kill fish, tadpoles and insects. Mahua oil cake (cake obtained after
extracting oil from the seed of the plant, Madhuka latifolia) is widely used to control
predatory and weed fishes in Karnataka. Mahua oil cake (toxic component: saponin,
4-6 percent) is used as a fish poison at 200-250 ppm, killing fish within eight hrs and
the toxicity lasts up to 96 hrs. Later, it acts as a pond fertilizer. Bleaching powder with
30 percent chlorine content, when applied at 25-30 ppm, kills all varieties of fishes,
including catfishes, murrels, weed fishes and carps. The cost of treatment at 25-30 ppm
is economical as it has the advantage of ready availability at low cost.

Fertilization
Fertilization is an important step in the preparation of nursery pond. The main purpose
of manuring nursery pond is to stimulate the production of zooplankton, the most
preferred natural food of carp spawn and fry. After liming (200-400 kg lime per ha,
depending upon soil pH), nursery ponds are treated with organic manures such as
cow dung (10 000 kg/ha) or poultry manure (5 000 kg/ha) and the small quantity of
inorganic fertilizers (NPK at 200-400 kg/ha). When mahua oil cake is used as a piscicide
for eradicating unwanted animals the dosage of organic manure is halved.

Aquatic insects and their control
The destructive role of insects in fish nurseries has been described by Khan and
Hussain (1947), Alikunhi (1957), Chaudhuri (1960a), Ganguly and Mitra (1961) and
Julka (1965). Nursery ponds are invariably populated with a large number of aquatic
insects either in their larval and/or adult stages. They not only prey directly on carp
spawn and fry but also compete with the latter for food. Of the eleven orders of the
class Insecta, the members of the Orders Coleoptera, Hemiptera and Odonata are
important in nurseries.
Predatory aquatic insects multiply rapidly in a nursery pond and they move from pond to pond. To ensure better survival of carp spawn, it is important to effectively clear the pond of its insect population prior to stocking. Repeated dragging of pond with a fine-meshed net can remove most of the insects. For effective control of insects, insecticides are recommended. Since the common insecticides adversely affect the zooplankton and fish spawn, it is recommended to use selective poisons which are capable of killing only the insects, but not the spawn and fish food organisms.

Spraying diesel or kerosene on the surface of pond is a well-known and routine practice in malaria control. CIFRI's substation in Orissa developed a method for the control of predatory aquatic insects, which consists of spraying, on a non-windy day, an emulsion of oil and soap in the ratio of 56:18 kg/ha (Pakrasi, 1954). Chatterjee (1970) advocated the substitution of soap with Teepol B-300 (a detergent) in the emulsion. The recommended dose of Teepol B-300 which is readily soluble in water and easy to mix with oil, is 560 ml, emulsified with 56 kg of mustard oil. Alikunhi (1956a) recommended the use of gammexane at 0.6-1.0 ppm which kills insects within 0.5 to 11 hrs. The Department of Fisheries of Maharashtra Government prescribed an emulsion prepared by mixing light speed diesel (1 l), the emulsifier hyoxide 1011 (0.75 ml) and water (40 ml) for every 200 m² water surface (Shirgur and Kewalramani, 1967). Butox (a veterinary drug used to heal wounds in livestock) at 2 ml per 100 m² can effectively control all types of aquatic insects.

Stocking of nursery pond

Nursery pond is stocked with 3-day old spawn when adequate plankton appears in it. For maximum survival of spawn, nurseries should have a rich crop of zooplankton, preferably rotifers and cladocerans. According to Alikunhi (1957), a minimum of 1.5-2.0 ml zooplankton in 54.5 ml water is essential for satisfactory stocking of the pond. Mitra and Mohapatra (1956) suggested that the optimum density of zooplankton in a nursery pond is 0.1-0.33 ml per spawn. Alikunhi (1956a) recommended a stocking density of 10-20 million/ha, depending upon the plankton density. Much higher stocking densities [78.13 million spawn/ha as mentioned by Hora and Pillay (1962)] are known to be adopted by fish farmers. In well manured nurseries provided with artificial feed, 1.0-2.0 million spawn has been stocked with satisfactory results at the Pond Culture Substation of the CIFRI. Sen (1974) reported stocking pawn at a high density of 10 million/ha with a survival rate as high as 66.6 percent. Tripathi et al. (1979) reported stocking rohu spawn at an average rate of 10.21 million/ha with an average survival rate of 82.73 percent, leading to the production of 8 million fry in a single crop, during 11-12 days rearing. The stocking of a nursery pond is best done either in the morning or early evening.

Supplemental feeding

The stocked spawn immediately start feeding on microscopic zooplankton. The spawn feed so voraciously that within 2-3 days after stocking the density of plankton gets reduced significantly. It is known that a single specimen of live carp spawn (6.5-7.2 mm) consumes 3-34 cladocerons within an hr; the actual number depends on the size of the spawn. Alikunhi (1956a) found that during the first two days after feeding commences, the spawn do not take artificial feed but subsist mainly on natural food. After this period, both artificial and natural feeds are utilized by the larvae. The commonly used feed for IMCs and exotic carps is a mixture of rice bran and oilcake composed of groundnut, coconut, mustard, etc. The quantity of artificial feed to be given daily depends upon the weight of the stocked spawn (Alikunhi, 1957; Hora and Pillay, 1962). While the former recommended feeding rates of 200, 300 and 400 percent of body weight of the spawn during the first five days, sixth to tenth day and 11th to 15th day after stocking, respectively, the latter advocated 100, 200 and 300 percent feeding
rates for the corresponding periods. Artificial feed is either broadcasted on the surface of water or fed as a thick paste (dough) in the form of small balls.

Khan (1971) and Nandeesha (1995) reviewed the literature on the practice of artificial feeding in Indian freshwater aquaculture. Although a great deal of literature is available on the nutrient requirements of sub-adult and adult fish, very little information is available on the nutrient requirements of fish spawn and fry.

**Rearing ponds**

Spawn stocked in nursery ponds normally attain a length of 20-25 mm in 15 days with artificial feeding, giving survival rates ranging from less than 10 percent to as high as 95-100 percent. If the fry is to attain better growth and survival, it should be netted out and released in rearing ponds. The rearing ponds are pre-prepared more or less on the lines of the nursery ponds (Alikunhi, 1956a). The rearing ponds form the second phase of carp culture and are used for growing fry to fingerlings by providing more space and food so that they reach the latter size as early as possible. The rearing period may vary between 2 and 3 months.

**Rearing of carp seed in pens/cages**

Carps are generally grown in ponds with little water exchange. The alternatives are cage and pen systems. These can be used for rearing spawn, fry and fingerlings. Cages and pens in flowing waters can enjoy an abundant supply of oxygen, flushing of metabolic wastes of the stocked fish and nutrients from the catchment area. Grow-out of fish in cages is well known in the Indo-Pacific region, but the rearing of fish seed in pens, located in running waters, has not been widespread.

In India, rearing of major carp seed in pens located in the Bhavanisagar and the Tungabhadra reservoirs was carried out as early as 1978. Abraham (1980) reported the use of pens for rearing carp hatchlings. Swaminathan and Singit (1982), Basavaraja (1994) and Gireesha et al. (2003) conducted investigations on rearing carp spawn up to fingerlings in the periphery of the Tungabhadra Reservoir, located in Karnataka. Rearing of common carp fry up to fingerlings in pens installed in an irrigation tank was also demonstrated (Jayaraj, Devaraj and Chowdary, 1998).

**Rearing of carp seed in pens in the Tungabhadra Reservoir**

In the early 1980s, initial trials were conducted to establish pens in the periphery of the Tungabhadra Reservoir (Swaminathan and Singit, 1982). The main objective was to nurse the delicate carp spawn in pens up to fingerling stage and then stock them in the same reservoir in order to improve fish landings and boost the socio-economic status of fisherfolk. Since then, the practice of raising carp spawn up to fingerlings has become well-established.

The Tungabhadra Reservoir has a water spread area of 37 814 ha and offers vast scope for fish production. It produced 24 tonnes in 1954–1955 and 4 200 tonnes in 1981–1982 consisting mainly of catfishes, minor carps, minnows, etc. With the release of pen-reared carp fingerlings starting from 1982, the major carps, which were not formerly part of the catch, accounted for nearly 60 percent of the total catch in 1994.

Basavaraja (1994) and Gireesha et al. (2003) described the method of rearing carp seed in pens, located in the Tungabhadra Reservoir. An ideal site for a pen system will generally have a gentle slope with red loamy soil where water remains for a period of 2-3 months between August and November. The site should be well-protected from wind and wave action by small hill surrounding the area. A pen is normally made up of casuarina poles, 2 m high, fixed at intervals of about 1.2 m, enclosing an area of 200-5 000 m². Between the vertical poles, three horizontal rows of spilt bamboo stripes are tied to give support for the net materials. Close mesh (monofilament nylon fabric, 30 mesh) having a width of 1.5 m is used as the pen wall material. The bottom of the
nylon fabric is inserted firmly into the mud and the vertical part securely tied to the poles and bamboo strips. Pen preparation starts 15-20 days before the dam reaches its full level. After establishment of pen, the enclosure is limed, fertilized with cattle dung and treated with soap-oil emulsion. The water in the pen is about 1.0-1.2 m deep. The pen is then stocked with 3-day old major carp larvae (4-5 million/ha), produced in the adjacent fish seed farm, fed thereafter from a boat, with a mixture of groundnut oil cake and rice bran at a ratio of 1:1. In addition, the pens are periodically manured with organic and inorganic fertilizers to sustain production of zooplankton. There is a basal application of 10 000 kg cow dung, 400 kg urea and 100 kg super phosphate per ha, followed by monthly applications at 10 percent of the initial dose. Survival to 70-80 mm fingerlings is as high as 60 percent after three to four months. Periodic sampling is done to monitor growth and adjust the feed quantity. The fingerlings thus grown are stocked in the same reservoir to enhance major carp production. Fishing licenses are given to local residents to uplift their socio-economic status. Although the pen construction is simple, easy, less expensive and efficient for the nursery rearing of carp fry, one drawback is the shortage of area for large-scale pen operation.

**FISH SEED QUALITY**

India is the second largest producer of farmed fish and shellfish in the world, next only to China. The rapid growth of aquaculture in Asia in general and India in particular has been due mainly to ready availability of fish seed to farmers. Even though the seed of the major cultivated species are now produced in large quantities in hatcheries, poor quality is still perceived as a major constraint to expansion of fish culture in India. Other constraints to carp culture in India have been underlined by Basavaraja (1994). Poor quality seed can have a deleterious effect on fish production and broodstock development. In contrary, quality seed will help realize better returns from aquaculture. Little, Satapornvanit and Edwards (2002) have emphasized the importance of freshwater fish seed quality in Asia and suggested criteria for selecting good quality seed for aquaculture.

In India, the availability of quality fish seed at the right time and at the right location is a prerequisite for sustainable aquaculture. Although carps, both indigenous and exotic, catfishes and murrels make up the bulk of fish raised in the country, several other species like mahseer, hilsa, trout, gourami, etc. are also important.

After the technique of hypophysation of fish was developed in India in 1957, the seed production from this source was initially restricted to the State Fisheries Departments. Bundhs as a source of carp seed has been in trend for years. A number of agencies (both government and private) are now involved in fish seed production and distribution, often as part of complex networks. In addition, seed production by farmers themselves is now widely practiced in India. However, there is still a shortage of quality fish seed.

In genetic terms, quality seed may be defined as those having better food conversion efficiency, high growth rate potential, better ability to changing environmental conditions and resist diseases (Padhi and Mandal, 1999). While the ease of production of fish seed in India has revolutionized farming, there now appears to be a major problem of poor or substandard quality seed supplied to farmers and entrepreneurs. The possible underlying causes for the gradual deterioration in yields and individual size of many species of cultured fish in Asia have been reviewed by Little, Satapornvanit and Edwards (2002). The quality and management of broodfish and hatchery practices that lead to inbreeding or contamination, in addition to poor husbandry during nursing, handling or transportation have been implicated. Prevalence of pathogens and parasites may also result in poor performance of fish seed. Attempts to upgrade stocks with wild or improved fish are currently practiced, but these (selective breeding
and or hybridization programmes) have rarely been applied in aquaculture in India. For most species including carps, basic knowledge of genetic parameters is limited. Simple but reliable methods that can be used at the hatchery or farm gate to assess seed quality are lacking for freshwater fish. On the other hand, challenge/stress tests and morphological and molecular diagnostic kits are now available for testing shrimp seed quality in India.

**Causes for poor seed quality**

The reasons for the gradual deterioration in fish yield and individual weight of many farmed fish are not very clear. Improper production and delivery of seed to farmers or poor management of fish seed by farmers once stocked, may lead to decline in fish production.

**Poor pond hygiene.** Mass mortality of seed in carp nursery ponds has been frequently encountered in Karnataka (Mohan and Shankar, 1995). Mortality of seed is attributed mainly to prevalence of protozoan parasites, particularly in ponds which are not dried properly prior to stocking. Pond drying followed by liming is known to reduce mortality considerably and improve seed quality.

**Presence of pests.** The presence of fairly shrimp (*Streptocephalus* spp.) in carp nurseries is known to hamper its growth and survival by competing with fry for food, space and oxygen. Presence of weed fishes in nursery ponds was also known to affect production of carp seed.

**Inbreeding.** Since carps are highly fecund, hatchery operators tend to maintain a low effective population size (number of broodstock that contributes genetic material to the next progeny) and do not exchange broodfish between hatcheries. Poor performance of the resultant seed had been linked to inbreeding of carps in India (Eknath and Doyle, 1985). A communal or mixed spawning system for major carps in West Bengal is being practiced and is known to produce approximately 10 percent hybrids (Padhi and Mandal, 1997). This technique may lead to loss of genetic purity of important major carps. Fish farmers often complain about poor growth of fish procured from particular hatcheries (seed farms) and feel that such fish do not reach marketable size within the stipulated period. This is also attributed to inbreeding.

**Poor management of brood fish and Seed.** Competition among fish seed producers to meet demand sometimes leads to poor management of broodfish and fish seed which may negatively affect seed quality. Substandard quality seed are frequently observed as a result of high stocking density in nurseries. Reddy (1995) thought that most fish hatcheries in India are concerned more about the quantity rather than the quality of fish seed and produce them without following any selection norms. Consequently, seed suffer from high rates of mortality, poor growth and high susceptibility to diseases and parasites.

**Transportation stress.** During transportation, fish seed are subjected to confined environment, higher metabolic load, stress, strain and exhaustion. As a result, seed becomes susceptible to diseases and parasites.

**Conditioning of fish seed.** One type of challenge test, conditioning is nothing but acclimatizing seed to a restricted environment prior to packing and transportation. During this period, seed are stocked at a very high stocking density in a *hapa* or a pond with running water, but without provision for food so that the weak seed dies and only the healthy fry survives. Only seed that survives the ‘stress test’ is selected for transport.
to a required destination. This type of conditioning of fish seed is commonly practiced in several states of India.

**Mortality of hatchlings.** Fish farmers in West Bengal at times encounter heavy mortality of hatchlings during incubation period (Sinha, 2000). This was reportedly due to immature bursting of egg shells and release of premature hatchlings before the anticipated period of hatching. Such hatchlings either do not survive or suffer mortality at subsequent stages. To overcome this problem, fish farmers have been using a solution which is a mixture of extract of catechu (*Acacia catechu*) and Myrobalan (*Myrobolus indica*). The plant extract enhances hatching period and prevents hatchlings from premature release due to the presence of tannin which helps toughen the egg membrane (chorion).

**Diseases and parasites**
Fish culture in general and carp culture in particular is gaining significant momentum in several parts of India. A large number of carp hatcheries and seed farms have cropped up in several parts of the country to cater to the increased demand for seed. High stocking density, artificial feeding, water fertilization, etc. have become common husbandry practices to optimize returns in carp nursery and rearing systems. These high density systems offer the ideal environment for disease outbreaks. Depending on the nature and severity, the disease may cause mass mortality of the affected population in a short time, produce protracted small scale mortality, reduce growth and make the larvae unsuitable for stocking. The need for adopting suitable health management measures to reduce the loss due to diseases is being increasingly felt by hatchery operators.

**Common disease problems in carp hatcheries and early rearing systems**
Carp hatcheries are regularly faced with disease problems. The nursery and rearing systems of carps are often very rich organically and provide an ideal environment for many pathogens. Important problems in hatcheries and early rearing systems are caused by some of the following pathogens (Mohan, 1998):

- **Protozoan parasites** like *Ichthyophthirius multifilis* (white spot disease), *Trichodina* complex and ectodermal ciliates like *Epistylis* and *Vorticella*. All these ectoparasites can cause mass mortality of younger stages of carp very quickly and the situation becomes worst in waters with low oxygen and high organic matter.
- **Diseases caused by myxosporidians** are a serious threat to the fish seed farms. These sporozoan spores present in the pond soil are normally ingested by the developing fry. Once inside the target tissue, the sporozoans can cause massive destruction of their target tissue and produce large scale mortality.
- **Worm parasites** like *Dactylogyrus* (gill fluke) and *Gyrodactylus* (skin fluke) with their well-developed attachment haptor and feeding apparatus can cause mortality in early developmental stages of carps.
- **Opportunistic secondary bacteria** (*Aeromonas*) and fungi (*Saprolegnia*) can become serious problem in fish larvae which are heavily parasitized.
- **In carp rearing ponds, major problems** are because of larger ectoparasites, secondary invaders, systemic bacterial pathogens and viruses. Ectoparasites like *Dactylogyrus* and *Argulus* (fish lice) and endoparasites like sporozoans are very important. Bacterial problems like surface ulcerative conditions and acute systemic diseases are common in carp rearing systems. Oftentimes, mortalities seen in carp culture systems are a result of ectoparasitic and systemic bacterial diseases. External fungal problems are normally associated with fish which are poorly handled. The possibility of viral diseases causing mortalities in carp nurseries cannot be ruled out.
Bacterial and fungal diseases in carp rearing systems

Bacteria can cause diseases either as secondary invaders or as primary pathogens. Bacterial diseases in larvae can be broadly classified as surface ulcerative, acute systemic and chronic granulomatous type. Surface ulcerative type of diseases are characterized by haemorrhagic surface ulcers and are normally caused by *Aeromonas*, *Pseudomonas*, *Vibrios*, *Flexibacteria*, *Myxobacteria*, etc. Surface ulcerative disease conditions at times develop to acute systemic disease. These are characterized by the presence and proliferation of bacteria in internal organs like kidney, heart, spleen, blood and other visceral organs. These diseases produce significant necrotic changes in all the affected organs and can cause mortality in a short time scale. Bacterial haemorrhagic septicemia caused by numerous serotypes of *Aeromonas hydrophila* is a major problem.

Reports of viral diseases in freshwater carp rearing systems of India are very few. This may be due to the lack of facilities and personnel for viral disease investigations. Fish seed reared under controlled condition are particularly stressed making them prone to parasitic and nonparasitic infection. Prophylactic measures are taken for the diseases encountered. The affected fish are normally treated with solution of either KMnO₄ (3-5 ppm) or common salt (3-4 percent) or CuSO₄ (2-3 ppm) for all common bacterial and fungal diseases and with gammaxane for fish lice infection.

Mohan and Shankar (1995) reported mass mortality of 12-15 day old catla fry in a fish farm in Karnataka. The fry stocked in nursery ponds were found to have dark coloration, lethargic, swimming in circle, settling at the bottom and dying in large numbers. The entire stock of more than one million fry died within 3-5 days of appearance of the first clinical signs. Histological tissues sections of gills and kidney positively confirmed massive infestation by the myxosporidian *Myxobolus* spp. Fresh examination of gill smears made from several moribund fry consistently showed the presence of large numbers of *Myxobolus* spp. spores (Mohan and Shankar, 1995).

<table>
<thead>
<tr>
<th>Disease agent</th>
<th>Chemical</th>
<th>Method</th>
<th>Concentration/time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ectoparasitic protozoans</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. <em>Ichthyophthirius</em> spp.</td>
<td>Formalin</td>
<td>Short bath</td>
<td>60-100 ppm for 30 min</td>
</tr>
<tr>
<td>b. <em>Trichodina</em> spp.</td>
<td>Formalin</td>
<td>Long bath</td>
<td>20-30 ppm</td>
</tr>
<tr>
<td>c. <em>Epistylis &amp; Vorticella</em> spp.</td>
<td>Formalin</td>
<td>Dip</td>
<td>200-300 ppm for 1 min</td>
</tr>
<tr>
<td>d. <em>Ichthoebodos</em> spp.</td>
<td>Formalin</td>
<td>Dip</td>
<td>20-30 ppm for 30 min</td>
</tr>
<tr>
<td>2. Monogenetic worms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. <em>Dactylogyrus</em> spp.</td>
<td>Organophosphorus</td>
<td>Dip</td>
<td>10 ppm for &lt; 1 min</td>
</tr>
<tr>
<td>b. <em>Gyrodactylus</em> spp.</td>
<td>Nuvian, Dipterex</td>
<td>Long bath</td>
<td>0.5 ppm for 24 hrs</td>
</tr>
<tr>
<td>3. Crustaceans</td>
<td></td>
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</tr>
<tr>
<td>a. <em>Lernaea</em></td>
<td>Nuvian, Dipterex</td>
<td>Long bath</td>
<td>0.5 ppm for 24 hrs</td>
</tr>
<tr>
<td>b. <em>Argulus</em></td>
<td>Nuvian, Dipterex</td>
<td>Long bath</td>
<td>0.5 ppm for 24 hrs</td>
</tr>
<tr>
<td>4. Endoparasites</td>
<td></td>
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</tr>
<tr>
<td>a. Sporozoans</td>
<td>Nuvian, Dipterex</td>
<td>Long bath</td>
<td>0.5 ppm for 24 hrs</td>
</tr>
<tr>
<td>b. Cercaria and metacercaria of</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>digenetic trematodes</td>
<td>Nuvian, Dipterex</td>
<td>Long bath</td>
<td>0.5 ppm for 24 hrs</td>
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<tr>
<td>5. External Mycosis</td>
<td></td>
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<tr>
<td><em>Saprolegnia</em></td>
<td>Malachite green</td>
<td>Dip</td>
<td>60 ppm for &lt; 1 min</td>
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<td></td>
<td></td>
<td>Bath</td>
<td>1-2 ppm for 1 hr</td>
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<td></td>
<td></td>
<td>Bath</td>
<td>50-75 ppm for 30 min</td>
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<td></td>
<td></td>
<td>Bath</td>
<td>100-200 ppm for 1-3 min</td>
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<tr>
<td></td>
<td>Formalin</td>
<td>Dip</td>
<td></td>
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<tr>
<td>6. Surface bacterial diseases</td>
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<tr>
<td></td>
<td>Proflavine</td>
<td>Bath</td>
<td>20 ppm</td>
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<td></td>
<td>Oxytetracycline &amp;</td>
<td>Short bath</td>
<td>1-5 ppm</td>
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<td></td>
<td>Furnace</td>
<td></td>
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<tr>
<td>7. Systemic bacterial diseases</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Furanazolide</td>
<td>In feed</td>
<td>50 mg/kg fish/day</td>
</tr>
<tr>
<td></td>
<td>Oxonilic acid</td>
<td>In feed</td>
<td>10 mg/kg fish/day</td>
</tr>
<tr>
<td></td>
<td>Chloramphenicol</td>
<td>In feed</td>
<td>50 mg/kg fish/day</td>
</tr>
</tbody>
</table>

Source: Mohan (1998)
there was no known effective systemic therapy for histozoic sporozoans in fish, it is vital to prevent the infestation in nurseries by resorting to drying and liming of the pond. Mohan et al. (1999) observed acute and chronic mortalities of common carp seed due to invasion of metacercaria of a digenetic trematode (Centrocestes spp.). Histopathological examination indicated that the metacercaria can be highly pathogenic when they encyst in the integument and gills.

Four separate cases of mortalities due to the dinoflagellate, Piscinoodium spp. in fry of common carp, mahseer (Tor khudree) and tilapia reportedly occurred in rearing tanks of a fish farm in Mangalore (Ramesh et al., 2000). Mortalities coincided with decreasing temperatures in the months of September and October. Clinical signs consisted of rust or dust coloured appearance of the skin, lethargic swimming near the surface, gasping accompanied with conspicuous daily mortalities. In three cases, where the size of juvenile was small, mortalities reached 100 percent. They attributed the observed mortality to massive gill and skin pathology induced by the attachment and feeding of the parasite.

Gas diseases. Heavy mortality of catla (10-12 in size) due to gas disease was observed in a municipal pond of Madras during 1947 (Chacko and Job, 1948). The symptoms of the diseases were presence of gas bubbles in gill filaments, heart and blood vessels and also in the gut. The air bladder was highly distended. The gas disease also referred to as gas embolism which occurs due to super saturation of water with either oxygen or nitrogen and is generally encountered in fish nurseries.

The crustacean parasites (Lernaea and Argulus) infestations are often encountered in carp broodfish, with catla being the most susceptible species (Basavaraja, 1994). The remedial measures taken by fish breeders are: (i) manual removal of the parasites and (ii) subsequent treatment of fish with a solution of KMnO₄ (5 ppm) for 5-10 min.

FISH SEED MARKETING

Fish seed syndicate

Until the 1980s, Fish Seed Syndicate, Calcutta was the major supplier of fish seed to different states. Seed dispatches made by the Syndicate between 1959–1960 and 1981–1982 indicated that Maharashtra and Madhya Pradesh were consistent buyers (Singh and Gupta, 1984). Maharashtra’s purchase of fish seed increased from 43 lakhs in 1959–1960 to 402 lakhs in 1981–1982, while Madhya Pradesh’s purchases of fish seed increased from 82 lakhs to 301 lakhs. The other states also procured seed from the Syndicate, but not regularly. The percentage expenditure on fish seed varied across the states and was the highest (18.9 percent) in Karnataka and the lowest (3.4 percent) in Assam. While some farmers preferred seed supplied by Department of Fisheries, FFDA and Corporations, other farmers preferred seed supplied by the private sector (Sreenivasa Rao, 1984). No state has attempted to integrate seed production and marketing. There exists a lot of variation in the price of carp seed between private and public sectors and even within private farms or public farms. The productivity and profits of private farms have been found to be better than that of public seed farms. Transportation of fish seed from site to market is one of the most important activities in fish seed marketing. Besides head load, other means of transportation include bicycle, tricycle, slings, jeep, tempo, etc.

Seed selling rate

Seed selling rate of fry and fingerlings not only varies with size and species, but also from region to region and from state to state. For example, the selling rate of carp seed adopted by Department of Fisheries, Karnataka (Table 7.11.11) is different from that of Tamil Nadu. In Karnataka, like in other states, the price of fingerlings is highest. While the price of fry is next highest, the selling rate of spawn is least.
In Tamil Nadu, the selling rate of fingerlings of catla, rohu, mrigal and common carp is Rs 480, 300, 300 and 270, respectively. Among the carps, the silver carp and grass carp command the maximum price in Karnataka, whereas catla fingerlings fetch the highest price in Tamil Nadu. Other charges, if any, are shown separately. Although it is not possible to have a uniform rate for the entire country due to vastness, it should be possible to have a uniform rate at state level.

Data on fish seed production is highly variable. Another gap in fish seed data is the absence of grading system of fish seed, i.e. spawn, fry and fingerlings. The sizes are not standardized. Various agencies classify them differently and size grades recommended by different agencies are listed by Katiha (1999) (Table 7.11.12). The general classification of carp seed is presented in Table 7.11.13. It neither provides information regarding source nor species composition.

Like in many other states, in Uttar Pradesh, the Department of Fisheries is the main agency involved in managing fish seed farms and seed procurement. The World Bank provided loan for development of fisheries and as a part of loan agreement, the Fisheries Corporation was started during 1979–1980 with the primary objective of fish seed production and its marketing on a commercial scale. A survey conducted by Indian Institute of Management (IIM), Ahmedabad, which is solely responsible for collection of data on fish seed production and marketing in India, showed that the public rearing farms were running at huge losses in Uttar Pradesh (Sreenivasa Rao, 1984). Private rearing farms were both efficient and profitable. Similar situation exists in many other states including Karnataka (Krishna Rao, 2005).

### TABLE 7.11.11
The selling rate of carp seed adopted in Karnataka

<table>
<thead>
<tr>
<th>Sl. no.</th>
<th>Description</th>
<th>Price (Rs) per 1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Catla</td>
<td>a. Spawn</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>b. Fry</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>c. Fingerlings</td>
<td>258</td>
</tr>
<tr>
<td>2. Rohu</td>
<td>a. Spawn</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>b. Fry</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>c. Fingerlings</td>
<td>240</td>
</tr>
<tr>
<td>3. Mrigal</td>
<td>a. Spawn</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>b. Fry</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>c. Fingerlings</td>
<td>210</td>
</tr>
<tr>
<td></td>
<td>b. Fry</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>c. Fingerlings</td>
<td>210</td>
</tr>
<tr>
<td>5. Grass carp</td>
<td>a. Spawn</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>b. Fry</td>
<td>125</td>
</tr>
<tr>
<td></td>
<td>c. Fingerlings</td>
<td>400</td>
</tr>
<tr>
<td>6. Silver carp</td>
<td>a. Spawn</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>b. Fry</td>
<td>125</td>
</tr>
<tr>
<td></td>
<td>c. Fingerlings</td>
<td>400</td>
</tr>
<tr>
<td>7. Other charges</td>
<td>a. Plastic bags</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>b. Oxygen filling per bag</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>c. Packing charges</td>
<td>4</td>
</tr>
</tbody>
</table>

US$ 1 = INR 45 (July, 2007)
Source: Department of Fisheries, Government of Karnataka

### TABLE 7.11.12
Fish seed grades according to different sources

<table>
<thead>
<tr>
<th>Source</th>
<th>Grade (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spawn</td>
</tr>
<tr>
<td>1. Fish Seed Committee</td>
<td>0-8</td>
</tr>
<tr>
<td>2. National Committee on Agriculture</td>
<td>0-8</td>
</tr>
<tr>
<td>3. Fish Seed Syndicate</td>
<td>-</td>
</tr>
<tr>
<td>4. Private Trade in West Bengal</td>
<td>0-8</td>
</tr>
<tr>
<td>5. Indian Institute of Management, Ahmedabad</td>
<td>0-10</td>
</tr>
</tbody>
</table>

Source: Katiha (1999)
Transportation of fish seed and broodfish

Transportation of fish seed

Transportation of fish seed is gaining increased importance due to the ever increasing global trade in live fish. Successful transportation of fish seed from the site of production to the place of culture is an important factor which influences the viability of aquaculture. Traditional methods of transporting fish seed in hundies (earthen or aluminium pots) results in heavy mortality of fish seed during transport. The main reasons for the mortality of seed during transportation are: (i) lack of oxygen, (ii) accumulation of metabolites like ammonia, CO₂, faeces, etc., (iii) hyperactivity, strain and exhaustion, (iv) diseases and parasites and (v) physical injury.

Now, with the innovative changes brought about in the system, complemented by the technological breakthrough achieved in aquaculture, fish seed and broodfish transportation has become fairly dependable and safe, although there is still ample scope for further refinement. In general, the methods for seed transport can broadly be classified into two systems: (i) open system, where seed transported with or without aeration/oxygenation/water circulation and (ii) closed system, where seed are transported in sealed air-tight containers with oxygen/aeration.

Open system

Until the late 1940s, fish seed were mainly transported using traditional methods. Under this method, prior to transportation, fry and fingerlings were conditioned to empty their digestive tract and move in a restricted area during transport (Figure 7.11.9). Alikunhi (1957) thought that the fry can possibly stand the strain of long distance transport better if they are fed on animalcules like cladocerans during conditioning and transport. The most common method of conditioning is to store fry in a cloth hapa in ponds or in a still part of the river. Saha and Chowdhury (1956) suggested that the depth of water where a conditioning enclosure is to be installed should be 30-35 cm. The period of conditioning depends on the size and health of the spawn, fry and fingerlings. Jagannadhan (1947) indicated that catla fry need 48-72 hr of conditioning, while Alikunhi (1957) suggested that about 6 hr of conditioning is required before fry should be packed for transportation. During conditioning and transportation, fry and fingerlings should not be handled with bare hands to prevent the removal of slime and scales covering the body that will render them susceptible to fungal and bacterial infection (Jagannathan, 1947). After the fish seed have been properly conditioned, they are ready to be transported (Hora and Pillay, 1962). Saha

<table>
<thead>
<tr>
<th>Sl. no.</th>
<th>Name of fish seed</th>
<th>Size (mm)</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Spawn/hatchling/larva</td>
<td>5-10</td>
<td>For stocking nurseries and suitable for economic transport over long distance or long periods</td>
</tr>
<tr>
<td>2.</td>
<td>Early fry</td>
<td>15-25</td>
<td>For stocking rearing ponds or other small shallow ponds and transport (as above)</td>
</tr>
<tr>
<td>3.</td>
<td>Fry</td>
<td>26-40</td>
<td>For stocking small culture ponds and small transport</td>
</tr>
<tr>
<td>4.</td>
<td>Advanced fry</td>
<td>41-60</td>
<td>For stocking small ponds in semi-intensive systems</td>
</tr>
<tr>
<td>5.</td>
<td>Early fingerlings</td>
<td>61-80</td>
<td>For stocking medium sized shallow ponds</td>
</tr>
<tr>
<td>6.</td>
<td>Fingerlings</td>
<td>81-100</td>
<td>For stocking medium sized deeper ponds in semi-intensive systems, ponds and pens</td>
</tr>
<tr>
<td>7.</td>
<td>Advanced fingerlings</td>
<td>101-125</td>
<td>For stocking large ponds and tanks, pens and cages in semi-intensive systems</td>
</tr>
<tr>
<td>8.</td>
<td>Juveniles</td>
<td>126-150</td>
<td>For stocking large ponds, reservoirs and tanks, pens and cages, running waters, intensive systems</td>
</tr>
<tr>
<td>9.</td>
<td>Yearlings</td>
<td>151-200</td>
<td>For stocking reservoirs with major catfish population</td>
</tr>
</tbody>
</table>

Source: Internet (www.India-agronet.com)
and Chowdhary (1956) described the traditional method of transporting fry and fingerlings in *hundies*, practiced in Bengal. A traditional *hundi* is an earthen vessel, but later aluminium *hundies* were introduced. Though the *hundies* are of variable sizes, they are generally of two types, the smaller one has 22 cm mouth diameter and 23 l capacity carried as a head load and the other larger one has 23 cm diameter and 32 l capacity used for transport by rail or bicycle or as slings. The *hundies* are filled with water from the same source as the fry and they are stocked at 50 000 in the smaller and 75 000 in the larger ones. About 58 g of fine silt is sprinkled over the water surface in the *hundi*. During transport, the *hundies* are shaken periodically. Basu (1951) reported that addition of silt not only coagulated the suspended organic pollutants but also kept down the zone and extent of pollution. Saha and Chowdhury (1956) observed that addition of silt, removal of sediments by mopping them up with a rough cloth rope and partial exchange of water permitted transport up to a duration of 30 hrs. Saha, Sen and Mazumdar (1956) demonstrated that pulverized earth, activated charcoal and Amberlit tend to absorb carbon dioxide and ammonia from the medium, consequently increasing the survival of fry.

Improved open metal containers have increasingly come into use and are known to have an edge over earthen *hundies*. These are round vessels with a wide mouth, which can be closed with perforated pressed-in lids, the larger type being 53 cm diameter at the base, 20 cm at the mouth and 38 cm high. Transport of carp seed in aluminium pots mounted on bicycle or tricycle is a common sight in Kolkata (Plate 7.11.9). Another container traditionally used for the transport of fish fry and fingerlings is galvanized round tin carriers with a flat bottom of about 40-50 l capacity. The inner lid is perforated and dish-like and it serves as well for aeration by cascading down the water splashed into it during transportation.
In other parts of the country, the open method of transportation of fish seed is getting out of use mainly because it involves constant vigil and frequent renewal of water on long journeys. And also it is not economical to transport bigger fingerlings and adults in small packing units. For this purpose, truck-mounted open tank with facilities for mechanical aeration and/or water circulation were initially used quite successfully (Hora and Pillay, 1962; Patro, 1968).

**Closed system**

In the closed system, the source of oxygen is not air, but oxygen which is supplied with a cylinder, into an enclosed space above the water. In the early 1950s, CIFRI (Barrackpore) introduced the 18 l kerosene tins with air-tight screw-capped lids, provided with tubes for draining in oxygen from a cylinder and letting out displaced water. About 900-1 000 fry (1-2 cm long) could be conveniently transported by air for over 20 hours.

The Maharashtra State Department of Fisheries gets the credit for introducing polythene bags for the successful transportation of major carp fry. The fry (20-25 mm) were transported in polythene bags (840 mm × 610 mm; thickness 0.0622 cm) inflated with oxygen, kept in kerosene oil tins (18 l), from Calcutta to Bombay. Ranade and Kewalramani (1956) found that such bags approximately double the quantity of fry transportable compared to that being shipped through the bundies. Singh (1977) proved that rohu fingerlings need greater quantity of oxygen for transport during the same period than mrigal; the oxygen required for 50 fingerlings of rohu (109-126 mm) for transport during a 12 h period is 1 680 ml against only 475 ml for mrigal (98-100 mm) at 31 °C to 32 °C.
In Karnataka State, carp seed are commonly transported by road in 18 l capacity high-density polythene bag containing one third water and two thirds pure oxygen, sealed and packed in rectangular metal boxes (Basavaraja, 1994). The number of seed to be packed in each bag depends upon the size (from 2 000 -10 000, 600-700 and 150-200 for spawn (<8 mm), fry (8-40 mm) and fingerlings (40-150 mm), respectively. In Karnataka and Andhra Pradesh, fish farmers have, over the years, developed a method for transporting fish fry and fingerlings in large (1 000 l) plastic tanks, with continuous oxygenation during the journey hrs.

Transport of yearlings and brood fish
It is impossible to transport bigger fingerlings/yearlings and brood fish in small packing containers. For the transport of yearlings and broodfish, trucks mounted with open tanks which facilitates mechanical aeration and/or circulation were initially used quite successfully (Hora and Pillay, 1962; Mammen, 1962; Patro, 1968). Open canvas containers (1 m × 1 m × 1.25 m) are used in Punjab and Madhya Pradesh for transporting major carp breeders. In addition, galvanized iron drums of 180 l capacity are also used.

In India, two successful models of closed system carrying live-fish were designed. One is based on Mammen (1962), which is called 'splashless tank'. The later model of the 'splashless tank' is a 'petrol tank' design with 1 150 l capacity and an autoclave-type lid. It has a built-in aeration system for supplying compressed air, which works on a belt driven by the engine of the transporting vehicle. An oxygen cylinder is carried only as a stand-by for emergency. The inner surface of the tank is lined with U-foam which prevents physical injury to live fish during transport. Live fish with a total weight of about 250 kg or 90 000 carp fingerlings can be transported at a time in the "splashless tank". The load ratio of fish to water in this type of carrier is about 1 kg of fish per 4.5 l water.

Patro (1968) designed another live fish carrier which consists of a laboratory gas supply design type. It has an outer chamber of 120 cm diameter open from top and a slightly smaller one closed from top; the latter, during transport, fits inside the former. The top of the inner chamber is provided with an air vent and an oxygen valve. The outer chamber serves as a storage tank and is initially filled with water along with fish to be transported. The inner chamber, which is slipped from the upper open end of the water serves as an oxygen holding chamber at its top and is lined throughout with U-foam to prevent fish from sustaining injury during transport. This double-barrel type carrier can transport live fish with a total weight of 100 kg at a time.

Use of anaesthetics in live fish transport
Sedation would reduce the metabolic activity and decrease oxygen consumption by fish. It also reduces the excretion of ammonia, carbon dioxide and other toxic wastes. It controls the excitability of the fish, thereby reducing the chances of injury and the time required for handling them. However, care should be taken in selecting the sedative and also its dosage. Sedation should be such that it should not totally suppress the escape reaction of fish and it should be possible to revive the sedated fish quickly. Sodium amytol at 21 to 28 mg/l water, MS 222 at 50 ppm, urethane, thiouracil, quinaldine and hydroxyl quinaldine at 100, 10, 5-10 and 1 ppm, respectively, and quinaldine at 5 ppm are successfully used for the transport of fish seed, fingerlings and broodfish.

Use of antiseptics and antibiotics
The accidental introduction of infectious diseases and parasites along with fish consignments is a possibility that must be guarded against. This calls for prophylactic measures like the use of antiseptics and antibiotics in the transport medium or short-term bath prior to transport. The recommended chemicals and their dosages are given in Table 7.11.14.
FINANCING FISH SEED PRODUCTION

Though fish farming and fish seed production have been found to be a profitable business venture, financing for this sector has not been formalized. Funding agencies and banks are not fully convinced about the potentials of fish seed production. Recently, the National Bank for Agriculture and Rural Development (NABARD) is known to have modified its policy of direct funding and has come forward to provide financial services through primary societies at the village level. Although commercialized banks provided loans for fish seed production, not many farmers can avail of loans due to risks involved in it. Pathak (1990) discussed the commercial success of fish hatchery projects funded by International Development Association (IDA) and NABARD. IDA supported the construction of 27 modern fish hatcheries. Of these, NABARD sanctioned 18 fish hatcheries in the corporate sector and 9 in the private sector. In addition, NABARD also supported several carp seed production programmes in many states. In addition to the modern mega-hatcheries, several mini-hatcheries involving credit outlay approximately Rs 6 million was supported in the private sector in some states. Most of these hatcheries have become operational and are producing seed of commercially important fishes.

FISH SEED INDUSTRY

There appears to be no centralized freshwater fish seed trade in India. However, West Bengal plays a significant role in freshwater fish seed trade and ranks first in freshwater fish seed production as well as fish production (Sinha, 2000). The carp seed industry in West Bengal is dependent on riverine seed collection, bundh breeding and induced breeding. Rahman (1946) provided information about fish fry trade in Bengal. Ganguly and Mitra (1957) reported on the distribution of fry collection centres, methods of collection and fry trade for the river Bhagirathi (West Bengal). While Mitra (1961) described the fish trade in Dhulian area, Mitra (1964) also reported the nature of the fish trade in the Hooghly area.

Ghosh (1984) highlighted the carp seed trade at Kakdwip, giving information on trade centres, mode of arrival of fish seed, methods of purchase and sale and socio-economic condition of the traders. Trade starts from the middle of June with the onset of southwest monsoon and continues until the end of September. In order to carry out the trade, traders pay a rent of Rs 70-75/season to the landlord for construction of a hut. In addition, each hut owner pays electricity charges of Rs.15/ point/season. They build the huts at their own cost. A number of huts, locally known as a chala (size 6 m × 2.4 m) are constructed. There is a rectangular earthen pit in each hut which is locally known as Chowka or Jawa, which is divided into two distinct halves by a wooden partition to keep the fry and fingerlings separate to avoid overcrowding and also for easy disposal. Ordinary gamcha is used to collect the seed from the pit during sale or transfer. Seed are transported by road or rail.

The traders purchase and sell the fingerlings by weight and the fry by volume, i.e. by Kunke or kunka. Fingerlings are purchased at Rs 30-35/kg and sold at Rs 40-45/per kg. Each kunka is purchased at Rs100-110 and sold at Rs 120-140 per 10,000-12,000 fry depending upon their size. The price, however, varies from season to season. In both categories, i.e. fry and fingerlings, mrigal was found in highest number, followed by catla. Most traders belong to poor fishermen community and solely depend on fish trade. Some engage themselves in other trades during off season. However, they are unable to run the trade on a large-scale due to paucity of funds. Both joint and or single ownership is/are also noticed among the traders.

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Dosage (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acriflavine</td>
<td>10 ppm</td>
</tr>
<tr>
<td>Methylene blue</td>
<td>2 ppm</td>
</tr>
<tr>
<td>CuSO₄</td>
<td>5 ppm</td>
</tr>
<tr>
<td>KMnO₄</td>
<td>3 ppm</td>
</tr>
<tr>
<td>Chloromycetin</td>
<td>8-10 ppm</td>
</tr>
<tr>
<td>NaCl</td>
<td>3 percent</td>
</tr>
<tr>
<td>Formalin</td>
<td>15 ppm</td>
</tr>
</tbody>
</table>

TABLE 7.11.14
Recommended chemicals and their dosages for use in the transport medium
FISH SEED TRADE AT KOLKATA

Jhingran (1991) described fish seed trade practised at Calcutta during the 1970s and 1980s. The spawn collectors, during spawning season, form themselves into groups, each called *savar*, consisting of about 15 to 25 persons in West Bengal and about 20 to 45 in Bihar. Each *savar* has a leader who is usually a man native to the area of collection. There are about 100 *savar* in West Bengal, usually refugees from Rajasthan in Bangladesh settled in Murshidabad district of West Bengal, who regularly migrate to Bihar in boats every season, working first on the river Koki and its tributaries where the spawn appear by the middle of May and then operating on the main Ganga by about mid-June. Some fishermen from Midnapore district of West Bengal migrate to Orissa and collect spawn from the rivers Brahmani, Baitarani and Subarnekha. There are about 6 000 spawn catchers working privately in Orissa.

In the beginning of the season, Calcutta spawn merchants advance necessary funds to a group leader for the purchase of nets, boats, provisions, etc. *in lieu* of his commitment to bring the catches of his party to the merchants making such advances. Profits are shared usually at the end of the season. Carp spawn collected in Bihar, West Bengal and Orissa are mostly brought to special spawn markets in Howrah and Sealdah in West Bengal for public sale.

The stocking material, i.e. spawn, fry and fingerlings referred to earlier, has a special terminology in fish seed trade in India. In Bengal fish trade circles, eggs are known as *dim*, early hatchings or larvae with yolk sac called *dimpona*, older fry up to 4 cm long are called *dhanipona* (fine *dhanipona* as *phuldhanni*), older fry up to 4 cm long as *chara*, young fish (10 to 23 cm long) as *chala* and larger fish (more than 23 cm long) as *nala*. Spawns are sold by *kunka* (27 000 spawn per *kunka*) or *bati*. None of these measures is, however, standard. The *bati* used in the Howrah market has a fluid capacity of 135 ml and contains 40 500 to 81 000 spawn, measuring from 4.5 to 9 mm in length, while the Sealdah *bati* is little larger with a fluid capacity of 170 ml containing 51 000 to 1 02 000 spawn of the same size ranges as the above. The catch in the early season fetches a higher price as it is believed to be from young spawners and, therefore, perhaps more viable. The price fluctuations in the Calcutta markets during the 1964 season ranged from Rs 72 to Rs 1 000 per *kunka*. On the arrival of spawn in the market from various collection centres, merchants transfer them immediately into wide-mouthed earthen containers called *gamlas*. Spawn are poured from gamlas into the hollow through a piece of coarse cloth so that they may be measured by *kunka* or *batis* (Government of India, 1966).

In recent years, carp seed of specific purity produced in hatcheries as well as bundh-type tanks, in which partial induced breeding has been applied are replacing riverine seed for obvious reasons, specific purity being the main consideration.

DEVELOPMENTS IN FRESHWATER FISH SEED PRODUCTION IN ANDHRA PRADESH

Construction of 102 fish ponds covering an area of 2 050 ha by the Government of Andhra Pradesh for the benefit of fishermen and success achieved initially by a few farmers in 1972–74, encouraged other farmers in Krishna and Godavari districts to take up carp culture on large-scale (Jhingran, 1991). Freshwater fish culture developed at a rapid pace in the 1980s as a significant commercial enterprise in the rural areas of Andhra Pradesh. Semi-intensive carp culture, practiced by agriculturists-turned fish farmers in more than 30 000 ha of newly-dug out, earthen ponds, significantly increased India’s fish production. Initially, the fish seed requirements were met by the local government fish seed farms and imports from West Bengal. However, since 1976 many enterprising fish farmers have also ventured into carp breeding on their own, on a commercial scale by successfully adopting induced breeding and hatchery technologies (Jhingran, 1991). At present, the private hatchery operators even supply fish seed to neighboring states, including Karnataka. Data on the number of private
hatcheries, capacity, price of seed, etc. are not available since they hesitate to reveal
details, fearing income tax consequences. As a result, Andhra Pradesh has almost
become self-sufficient in freshwater fish seed production. Looking at the success of
Andhra Pradesh fish farmers, many other states are increasingly taking up freshwater
fish seed production and fish farming.

Fish seed trade in Karnataka
The present annual production of fish seed in Karnataka State of about 235 million fry,
limited to IMCs and common carp, is far short of demand and is not even sufficient
to meet the requirement of 400 million fry for stocking ponds and tanks, let alone
reservoirs (Krishna Rao et al., 2005). In addition, about 30-40 million fingerlings are
imported from West Bengal and neighboring Andhra Pradesh. The Andhra Pradesh
fish merchants collect the requirement of the farmers in advance and supply fingerlings
on credit at lower cost than the government rates. The seed of exotic carps (grass carp
and silver carp) are almost wholly imported from West Bengal. There is no trade of
seed of other varieties like catfishes and murrels.

Air-breathing fish seed trade
There has been no organized trade of air-breathing fish seed as yet in the country.
However, due to the concerted efforts of CIFRI, State Fisheries Departments and
State Agricultural Universities, some sort of organized method of collection and
marketing of seed, particularly in West Bengal, Bihar, Assam, Andhra Pradesh, Tripura,
Karnataka, Uttar Pradesh, Kerala and Manipur is prevalent (Dehadrai, 1981). Presently,
limited demand for air-breathing fish seed, particularly *Clarias* spp., are met from
natural resources and hatcheries. Presently, some sort of trade exists for *Clarias* spp.
at Kolkata.

Risks and uncertainties
The following risks and uncertainties were identified in this review:

- changes in climatic conditions such as untimely rainfall, drought, floods, etc. are
  common in certain parts of the country and these can adversely affect fish seed
  production;
- multiple ownership and multipurpose utilization of resources wherein aquaculture
  is given least priority in some states;
- conflicts between water users;
- mismanagement of seed farms particularly those owned by Department of
  Fisheries/FFDAs/Corporations. Oftentimes, farms are underutilized due to lack
  of technically qualified staff or officers/managers tend to indulge in undesirable
  activities like corruption, nepotism, etc.;
- predation of fish seed by birds (mainly cormorants, kingfisher, herons) and
  otters;
- poaching of broodfish by the staff or outsiders.

Impacts of exotic fish on native fish
In India, the introduction of exotic fish has had mixed reaction. Some species like trout
filled a vacant niche with no competition from any native species. Others like grass
carp, silver carp and common carp, have helped in boosting freshwater aquaculture
production, but in some cases have negatively impacted native fish (Das, 1997).

The introduction of silver carp in the Govindasagar Reservoir (Himachal Pradesh)
resulted in a sharp decline of the dominant native species catla due to overlapping
feeding habits and habitat. Similarly in Kalyani Reservoir (Madhya Pradesh), the
catla population has declined due to competition with silver carp. The introduction
of common carp in different lakes of Kashmir and Manipur has led to a sharp decline
in *Schizothorax* spp. The presence of tilapia in Amaravathi and Vaigai reservoirs and Powai and Jaisawand lakes has eliminated almost all other species, including the major carps and the indigenous catfishes, due to its prolific breeding and omnivorous feeding habits. The mosquito fish (*Gambusia affinis*) has practically eliminated all other indigenous species in Ooty Lake in Tamil Nadu, damaging the economy of the lake area (Das, 1997). Hybridization between introduced and native species has changed the composition of fish fauna of inland waters of India. Natural hybrids of common carp are available in the rivers of Ganga and Yamuna. Hybrids of IMCs and Chinese carps are known to occur in some reservoirs and lakes of India (Abidi and Lakra, 2005).

**Impacts of the introduction of Clarias gariepinus in India**

The exotic African catfish, *Clarias gariepinus*, is reported to have had a clandestine entry into India from Bangladesh, first into West Bengal and later spread to other parts of the country. It is known to be found in the rivers of Ganga, Yamuna, Sutlej, Godavari and several other rivers of India (Sugunan, 2000). Its highly cannibalistic nature prompted the Government of India to ban its culture in the country. Despite the ban, it has been gaining popularity among the farmers of Punjab, Uttar Pradesh, West Bengal, Andhra Pradesh, Orissa, Bihar, Karnataka, Assam and other states as an economically viable alternative species to Indian major carps. The African catfish accounted for nearly 16 percent of the total catch from the river Yamuna in a single day, with weights ranging between 1 and 2 kg (Sugunan, 2000). Clandestine fry production goes on in West Bengal and other northeastern states of the country. Many farmers sell the African catfish deliberately as the native *C. batrachus*.

**SUPPORT SERVICES**

The development of technique of induced breeding of fish is probably the most outstanding achievement in the field of Indian fisheries research. Subsequently, several developments took place in Indian freshwater aquaculture. They are: (i) commencement of an All-India Co-ordinated Research Project on Composite Fish Culture and Fish Seed Production, in 1971, by CIFRI, (ii) the commencement, in 1975, of rural aquaculture project by the CIFRI with the aid of International Development Research Centre (IDRC) of Canada in West Bengal and Orissa and (iii) the initiative taken by the West Bengal Government on the application and extension of CIFRI-developed technology to rural carp polyculture. Simultaneously, the National Demonstration Scheme and the Operational Research Project, involving, among others, demonstration and integration of aquaculture with livestock rearing were initiated (Sinha, 1978). The highlights of the Operational Research Project were the conduct of various training programmes on composite fish culture, induced breeding of IMCs and exotic carps, including maintenance of broodfish, spawn and fry rearing, in the project area. Besides the training programmes, demonstrations on different aspects of scientific fish farming and pond management were organized.

Next in the line of development of freshwater aquaculture was the establishment of FFDAs by the Ministry of Agriculture of the Government of India. This is regarded as the most important step in the removal of the field constraints in the spread of freshwater aquaculture as a rural small-scale industry. Subsequently, the entire inland culture fishery resources of the country are vested with Gram Panchayats or other local bodies, or the government and the water bodies are contracted on annual lease. FFDAs, started in 1975, were found to be a suitable organizational framework as well as nucleus of growth. Hence, the National Council of Applied Economics and the World Bank recommended further expansion of the programme. Presently, more than 450 FFDAs are in operation covering most of the states in the country. The FFDA meets the basic needs of fish farmers in respect to: (i) technical support, (ii) extension support and (iii) financial support.
The Government of India has been encouraging education, training, research and extension activities to enhance fish seed production in the country. Similarly, at the state level, various programmes are being undertaken to boost fish seed production. In Haryana, an outlay of Rs 1.41 million was earmarked for the year 1999–2000 for education, training and extension to provide needed training, refresher courses and to disseminate information on fish seed production and fish culture technology to fish farmers. It was proposed to provide short-term training to 800 fish farmers, organize 34 demonstrations and 80 film shows and exhibitions, besides giving publicity material.

**SEED CERTIFICATION**
India has an aquatic animal export and import business. Some legislation relating to the import and export of live aquatic animals does exist in India, but it is not complete. Some sort of health certification and quarantine procedure does exist in India and the aquatic animal health quarantine has been described by Punyabrata Das (1997). The NBFGR, located at Lucknow, Uttar Pradesh, has been recognized as the focal agency for formulating legislation on aquatic animal health certification and quarantine. However, there is no definite fish seed certification in India.

While a world-wide market exists for Indian ornamental fish, marketing of major carp seed is possibly restricted to south and southeast Asia. Until the early 1990s, the major centre for carp seed production was West Bengal from where uncertified seed were distributed to the rest of the country. Later on, other states started producing fish seed. In 1993–1994, West Bengal produced 7 540 million fry, accounting for nearly 75 percent of the country’s fish seed production (Das, 1997). In addition, there are private seed producers whose contribution to the total fish seed production is significant.

The decision-making procedure for importing and exporting aquatic animals rests with the Union Ministry of Agriculture, Government of India, New Delhi. Presently, no detailed legislation for aquatic animal quarantine or health certification exists in India.

**LEGAL AND POLICY FRAMEWORKS**
In the past, regulations, based on empirical knowledge, were imposed to cater to maximum sustainable yield. These regulations assumed the forms of protective legislations on mesh size limit, legal sizes, closed season, declaration of sanctuaries, limit on catches, restriction of efforts, prohibition of use of destructive methods of fishing, etc; the basis for the above regulations is the belief that every fish should be given a chance to breed at least once.

The Indian Fisheries Act came into being in 1897 (Government of India, 1956), relevant provisions are reproduced below:

1. If any person uses any dynamite or other explosive substance in any water with intent to catch or destroy any of fish that may be therein, he shall be punishable with imprisonment for a term which extend to two months or with fine which may extend to two hundred rupees.
2. Closed season, i.e. restriction on fishing during certain periods, is followed in Bihar, Madras, Jammu and Kashmir, Madhya Pradesh, Mysore, etc. In all large reservoirs, fishing is closed from June-July to end of September so that fishes are not disturbed during their breeding migrations.
3. In 1956, the Punjab State Government prohibited catching of rohu, mrigal, mahseer and catla smaller than 25.4 cm long. In Delhi, the capture and sale of these species below 20.4 cm in length has been prohibited since 1948. The State of Uttar Pradesh has prohibited, since 1954, the capture and sale of fry and fingerlings of major carps, 5.1-25.4 cm in length from July 15 to September 30.
and of breeders from June 15 to July 31 in the prohibited areas, except under a license issued by the proper authority. In Madhya Pradesh, a size limit of 22.9 cm was imposed in 1953, for the capture of rohu, mahseer, mrigal and catla.

4. Certain areas have been declared as protected waters or sanctuaries and closed for fishing.

5. Other systems such as restrictions on the sale of legal sizes of fishes and issuing of licenses of fishing have been followed in various states of India.

6. While the Indian Fisheries Act and the Legislations framed by different State Governments exist, the machinery for the enforcement of the regulations in most cases is so inadequate that the objects of formulating these are hardly fulfilled.

Despite legal prohibition, the capture and destruction of broodfish and juveniles in large quantities are commonly practiced all over the country and are largely responsible for the impoverishment of the freshwater fisheries. Legislations based on empirical knowledge are of doubtful utility. The Indian Fisheries Act is under revision.

Presently, it appears that there are no legal policy parameters in force for regulating fish seed production in the country. However, the Assam State Government has recently introduced certain policy parameters (Anon., 2004). Among them, the notable ones are:

1. All hatchery owners must be registered with the Department of Fisheries.
2. Mixed spawning of carps by hatchery or hapa breeders is illegal and is an offence.
3. The Department of Fisheries (DOF) is to exercise necessary initiative to collect data on fish seed production.
4. The officials of DOF are to take necessary action to form a network of seed producers in their respective areas.
5. The farmers may be educated to grow only pure strains of cultivable varieties of carps as recommended by DOF.
6. The research and extension wings of DOF may be strengthened with competent persons and necessary research conducted on different aspects of fish seed production.
7. Fish seed markets may have to be established in each district through a network of seed producers for the benefit of both producers and buyers. Seed may be certified by the competent authority before being sold.
8. The DOF may instruct all seed producers to use a standard method (perforated steel bati) to count fish spawn, fry and fingerlings.
9. Entrepreneurs in the private sector may be encouraged to establish feed plants to produce pelleted feed for broodfish and larvae to improve their quality.
10. Non-functional hatcheries may be leased out to technically qualified persons to operate them profitably.
11. Utmost care must be taken while releasing hatchery produced carp seed in natural water bodies like bheels, as most hatcheries are engaged in mixed spawning.

**ECONOMICS OF FRESHWATER SEED PRODUCTION**

**Carp seed production**

Freshwater fish culture in ponds and tanks is traditionally carried out in India. Improved technology of fish culture should eventually lead to the maximization of fish production and profit. Right quality of seed supply is one of the most important factors influencing yield. However, the gap between the actual supply of fish seed and demand is increasing over the years. Large-scale production of fish seed through eco-hatcheries and nurseries is one of the most important technologies covered under institutional financing schemes by NABARD and other financial institutions.
Induced breeding of carps
Induced breeding is a major tool for spawn production of IMC and Chinese carps. A brief account of the technology together with its operational economics is given by Tripathi (1991). To produce 10 million spawn comprising 1.5, 2.5, 2.0, 2.5 and 1.5 million spawn of catla, rohu, mrigal and grass carp, respectively, during a single monsoon season, about 120 sets of broodfish is required, with a total weight of about 1,616 kg. Assuming 60 percent breeding response for IMCs and 40 percent for Chinese carps and 80 percent fertilization rate and 70 percent hatching rate, it could be possible to produce 10 million carp spawn in a breeding season. Based on this, a net profit of 130 percent on operational costs is easily possible.

Fish seed production using the Chinese type of circular carp hatchery
During one breeding season, lasting 120 days in a monsoon season, about 30 batches of spawn could be produced, each batch of 4 days duration. About 10 million carp eggs could be hatched in one batch (spawning pool measuring 8 m diameter and hatching pool of 3.6 m diameter), with 95 percent hatching success, resulting in the production of 285 million spawn (6 mm length). At the sale price of Rs 10/1,000, a total income of Rs 2.85 million could be derived during one season. After deducting 50 percent towards recurring and nonrecurring costs, nearly Rs 1.4 million could be realized in one season, assuming that uninterrupted operations are carried out. However, if only 15 batches of eggs are taken, the net profits would be about Rs 0.7 million per breeding season per circular hatchery.

Dry bundh operation
An increase in the number of bundhs in West Bengal, Madhya Pradesh, Rajasthan, Gujarat and other States of the country, indicated that spawn production through dry bundhs is an economically viable system. The cost of production in a bundh set up in 1962–1963 worked out to be Rs 635 per million spawn which was considered quite satisfactory for an old type of dry bundh. When 4 crops of spawn are taken from one bundh in a season, it is estimated that the cost of spawn production per million in Madhya Pradesh turns out to be Rs 75, Rs 80 and Rs 70 for rivers, wet bundh and dry bundh, respectively. In 1980, an account of the economics of as many as 18 dry bundhs revealed the cost of production to be Rs 200–450 per million spawn. The cost of production of spawn in bundhs of Midnapore and Bankura District of West Bengal is much cheaper than that of riverine spawn. A study conducted by CIFRI (Mumbai) demonstrated a profit of Rs 2,256 (one breeding) and Rs 10,000 (4-5 breeding) could be obtained from a bundh area of 426.55 m² in one season. A fish farmer of Madhya Pradesh has been running a 0.16 ha dry bundh since 1991–1992 and produces 7.0 million spawn and 1.0–1.2 million fingerlings every year and earns about Rs 0.1 million (Dubey, 2000). Besides spawn production, a dry bundh can be used to grow fry or fingerling stage more economically.

Carp spawn collection
The economic viability of a riverine spawn collection site was studied by Ghosh (1981). Production costs based on a unit of eight fishermen operating 15 nets in two months during a monsoon season showed annual depreciated of capital costs at Rs 1,200 (18 percent), labour costs Rs 4,000 (60 percent), services, interest on capital borrowings and loan refund each of Rs 500 (7.5 percent), giving a total of Rs 6,700 per unit. The profitability of spawn collection at centres located by CIFRI, has an average of 317 lakhs, ranging from 102 to 543 lakhs at eleven centres. Depending on production levels, the cost of production at site ranges from Rs 22.3 per lakh for a production level of 300 lakhs to Rs 134 per lakh for 50 lakhs of production. At a selling price of Rs 250 per lakh of spawn, the projected profits range from 51 percent to 377 percent for productions ranging from 50 lakhs to 300 lakhs in a season.
LIMITATIONS/ PROBLEMS/ CONSTRAINTS
A number of limitations/problems/constraints have been identified in this review. These are:

- Among the major bottlenecks faced in dry bundh breeding, the most vital one is poor spawning due to high mortality during hatching in earthen pits or hapas. It is particularly so with small farmers who cannot afford to adopt improved hatching devices. The bundhs can not be constructed everywhere.
- Inadequacy of quality broodfish for spawning in bundhs. In most cases, the broodfish ponds are located at some distance. Transport of broodfish from such locations to bundhs is cumbersome and adds to the cost of seed production.
- Fungal and bacterial infection of spent broodfish is commonly encountered in bundhs. This is important specially in the context of repeat spawning of broodfish as practiced by farmers of West Bengal.
- The prevention, diagnosis and treatment of diseases of fish seed and broodfish have not received the required attention.
- Lack of of nursery area and low survival in nurseries have led to the shortage of quality seed.
- Fish seed collected from rivers normally contains a high percentage of uneconomic species like predatory and weed fishes. Valuable nursery space is wasted by rearing such spawn to fry stage since it is not possible to segregate seed at spawn stage. The riverine seed also suffer high mortality during transport from collection site to rearing centres. The riverine seed collection is highly undependable due to uncertainty of monsoon.
- Wide gap between supply and demand for quality fish seed has affected freshwater fish production in several states.
- Indiscriminate destruction of broodfish, carps in particular, during their spawning migration or assembly at breeding grounds in rivers is a common event.
- Large-scale mortality of eggs and spawn sometimes occur especially when stranded at breeding grounds.
- Pollution (mainly industrial and agricultural) of rivers has adversely affected fish seed resources.

STAKEHOLDERS
Producers/farmers
In general, there exists a large extension gap which limits the dissemination of technologies to the rural community. Records from past several years reveal that due to the lack of technical support and basic infrastructure, fish breeding and seed rearing are rarely undertaken by farmers in the villages. Radheysham (2002) reported a case study on carp seed production as a commercial activity taken up in phases (over a period of 11 years, in Orissa) by farmers through a needs-based and problem-solving approach. Although technological packages were available to the farmers by researchers, farmers played a key role in planning, formulating and implementing the technologies.

Carp breeding was initiated using common carp in 1987. In the following years, induced breeding of catla, rohu and mrigal was introduced. The successful experience in the profitable carp breeding sustained the interest of the farmers so that they breed fish every year and this led to a rising trend in spawn production from 0.35 million in 1987 to 21.3 million in 1997. A total of 1 118.6 kg of female broodfish could be utilized producing 70.9 million spawn in 11 years, Fry and fingerling production technologies were demonstrated in the rural area. In 11 years, the production of 15.94 million fry and 1.88 million fingerlings made the neighboring villages self-sufficient in carp seed production.

The estimated net income from spawn production was Rs 207 246 (US$4 820) and the return on expenditure was 274 percent, whereas from seed rearing the net income
was Rs 606,550 (US$14,106) and the average return on expenditure was 131 percent. This technology was found to be viable, sustainable and employment generating. This success motivated other farmers to undertake seed production and carp farming (Radheysham, 2002).

New varieties/strains/innovations
The sterile common carp (*Chakri*)
The common carp, *Cyprinus carpio* (Linn.) is one of the widely cultured fishes in the world. In India, it is commonly cultured, either singly or in combination with the IMCs catla, rohu and mrigal and also with the Chinese carps, grass carp and silver carp. It grows almost at par with the fastest growing IMC, the catla. However, sometimes, due to its prolific breeding habit, it offsets the stocking density of the culture pond, resulting in a production of undersized fish of very low market value.

A technology has been developed at the University of Agricultural Sciences, Bangalore by Dr. G. P. Satyanarayana Rao and his team to induce sterility in common carp to overcome the problem of uncontrolled reproduction in the culture ponds. This sterile common carp (Plate 10) has been thoroughly screened for various parameters to determine its usefulness as a good candidate for augmenting fish production in the country.

The advantages of this sterile common carp, as compared to normal common carp, are: (i) fast growth, 47 percent faster, (ii) yields more meat per unit weight of fish, (iii) better conversion efficiency and (iv) better resistance to the most common bacterial pathogen, *A. hydrophila*.

This technology along with a special feed for the production of sterile common carp seed has been released for commercial culture by the University of Agricultural Sciences (Bangalore) in 2002. The University has also issued a license to M/s. Tetragon Chemie P. Ltd., Bangalore, on a non-exclusive basis, to commercialize the special feed.

Large-scale demonstrations on the culture of sterile common carp has helped the industry establish two hatcheries in 2003, one at KVT, Bhuj, Gujarat State and the other at Baballi, Shimoga District, Karnataka with an annual production capacity of 3.5 and 1.5 million fingerlings, respectively. Additional two hatcheries are in the pipeline. All these will ensure proper supply of sterile common carp seed to the farmers.

Encouraged by the progress made in this new field of biotechnology to augment fish production, a workshop was organized in June 2005, involving all the farmers, scientists and the officials of the Department of Fisheries, connected with the sterile common carp culture programme, to take stock of the situation and to review the strategy for popularizing its culture.
Genetically superior rohu (Jayanti)
The Norwegian Agency for Development Cooperation (NORAD) has funded an institutional cooperation project on Genetic improvement of the Indian major carp, rohu (*Labeo rohita*) for growth through selective breeding. The project is being operated, since 1992, at Central Institute of Freshwater Aquaculture (CIFA), Bhubaneswar, Orissa. The project was started with a broader gene base, i.e. fingerlings sampled from five rivers, the Ganga, the Gomati, the Brahmaputra, the Yamuna and the Sutlej. To these, the CIFA (Bhubaneswar) farm stock was added as the sixth stock. After three generations of selective breeding, rohu has shown an average gain of growth of 17 percent per generation (Jana *et al.*, 2002). Field testing experiments in different agro-climatic areas, such as Punjab, West Bengal and Andhra Pradesh also showed a similar trend of genetic gain. The genetically improved variety of rohu has been named *Jayanti* by the Indian Council of Agricultural Research (ICAR) in New Delhi and the commercial production of *Jayanti* seed is now being attempted for distribution to farmers.

Government institutions, extension services

**Government institutions:** Under the new Central Sector Scheme, i.e. National Fish Seed Programme, 25 commercial fish seed farms (hatcheries) were established in selected states of India, namely Andhra Pradesh, Haryana, Uttar Pradesh, Jammu and Kashmir, Karnataka, Kerala, Maharashtra, Punjab, Rajasthan, Tamil Nadu and Tripura, besides river valley projects (Singh and Sampath, 1983). These fish seed farms have a 10 ha water spread area, located near an indoor hatchery system with a capacity produce 10 million quality seed per annum per hatchery. Apart from this large-scale commercial fish seed production programme, Fish Farmers Development Agencies (FFDAs), functioning under the on-going Development of Aquaculture Programme in the states, have also been provided with small fish seed farms with sizes ranging from 2 to 5 ha.

The construction of these fish seed farms/commercial hatcheries under these two programmes necessitated a uniform design according to state/local conditions. The hatchery/fish seed farm complex would include an indoor hatchery unit, earthen ponds, water gates, central channel, tube wells, administrative building, staff quarters, store rooms, perimeter fencing, internal roads, etc. Each hatchery is set up to provide facilities to produce hatchlings by induced breeding, nursing and rearing them to fry stage (approximately 9 and 18 ponds for 5 and 10 ha hatchery, respectively). About 25 percent of this area is used for broodfish maintenance and the broodfish should be replaced to the extent of one-third each year to keep a healthy broodstock for undertaking breeding operations. It is envisaged to produce 5 and 10 million fingerlings of 5 cm size from each 5 and 10 ha hatchery, respectively. These commercial scale fish seed farms have been set up to overcome shortcomings/limitations of small-scale hatcheries. The budget estimated for a 10 ha commercial fish seed farm under the National Fish Seed Programme was Rs. 3.9 million (applicable to the year 1983). While 70 percent of the total cost is borne by the federal government, 30 percent of the cost is met by the concerned state government. With regards to fish seed farms under FFDAs, the federal and state’s share is 1:1.

**Extension services:** In order to transfer technologies developed by research institutions, universities, colleges, KVKs (Krishi Vignana Kenddra), etc. to end users/entrepreneurs, extension education units have been established in several central and state governments. The government sponsored programmes like KVKs, NCDC (National Cooperative Development Corporation), FFDAs, etc. which also provided extension services on fish seed production; state level Fisheries Departments, Fisheries Development Corporations, Cooperative Societies, etc. supported fisheries extension activities.
A detailed account of the packages of practices related to induced breeding, hatching, nursery and rearing pond management and cost and return of induced breeding, nursery and rearing pond management of major carps, developed at CIFRI, has been given by Das and Sinha (1985). Technology developed on these aspects has been described earlier in this report. The State of West Bengal is the pioneer in carp seed production in India. It has contributed to nearly 75 percent of the total fish seed production of the country (Sinha, 2000). This has been possible through the intensive training and demonstrations efforts of CIFRI, Directorate of Fisheries and NGOs, resulting in the establishment of a large number of glass jar and eco-hatcheries through out the state. The state produces about 45 percent surplus seed to cater to the needs of other states.

**Subsidies.** Subsidies are given mainly to boost fish seed production in the private sector. The Government of India offers subsidy to FFDAs at Rs 20 for every 1,000 fry transported and gives subsidy at 20 percent with a ceiling of Rs 40,000 per ha for fish seed rearing, but not to individuals. On the other hand, it provides subsidy of 10 percent with a ceiling of Rs 80,000 and Rs 1.2 lakhs to entrepreneurs in the Plains and Hilly areas, respectively. The government also offers subsidy for setting up a fish hatchery with a capacity of 10 million fry at Rs 8 lakhs and Rs 12 lakhs in the Plains and Hill States/Districts/Northeastern region, respectively.

In order to promote fish seed production and rearing, state governments offer subsidies. In Karnataka, in order to promote fish seed production in the private sector a subsidy of Rs one lakh for the construction of one ha pond for fish seed production and Rs 0.75 lakh for the construction of one ha pond for fish seed rearing, is provided by the Department of Fisheries. Also, the FFDA gives financial assistance of about Rs 8.0 lakhs per hatchery with a 10 million fry capacity. In Himachal Pradesh, a subsidy at 25 percent with a ceiling of Rs 12,500 for each set of aerators/pumps, is given. In Orissa, the government gives Rs 1.6 lakhs to a self-employed person for producing fish seed through hatchery.

**Researchers**
The ICAR (Indian Council of Agricultural Research) under the Ministry of Agriculture, Government of India is the nodal agency for all research and training pertaining to agricultural sciences, including fisheries. Under ICAR’s direct supervision, there are different fisheries institutions, such as CIFRI (Kolkata), CIFA (Orissa), CIFE (Mumbai), NBFRGR (Uttar Pradesh) and the National Research Centre for Coldwater Fisheries (NRCCF, Uttaranchal). Of these, CIFRI and CIFA are more actively engaged in research pertaining to fish seed production. Besides these institutes, a number of Fisheries Colleges which are part of the State Agricultural Universities are involved in research pertaining to fish seed production. Presently, there are 13 Fisheries Colleges, all of which have been established under the Agricultural Universities. Almost all the Colleges are engaged in teaching, research and extension in aquaculture (fish seed production). Seed production is carried out using hapas or jar hatchery or circular tanks of Chinese origin. Many traditional universities, NGOs, etc. are also involved in producing and rearing fish seed.

**Donors (funding agencies)**
The Norwegian Agency for Development Cooperation (NORAD), Norway has funded an institutional cooperation project on Genetic improvement of the Indian major carp, rohu (*Labeo rohita*) for growth through selective breeding. The project is being operated, since 1992, at Central Institute of Freshwater Aquaculture (CIFA), Bhubaneswar, Orissa.

The Department for International Development (DFID) of the United Kingdom has funded a similar mega project for the genetic improvement of another Indian
major carp, catla (*Catla catla*). This research project is being operated at the University of Agricultural Sciences, Bangalore, but has now been transferred to newly started Karnataka Veterinary, Animal and Fisheries Sciences University, Bidar, Karnataka. Initial results indicate that inter-hatchery crosses of catla produced better growth than intra-hatchery crosses.

**FUTURE PROSPECTS AND RECOMMENDATIONS**

Based on this review, the following future prospects and recommendations are provided:

1. A live gene bank for producing and supplying pure seed of IMCs and exotic carps may be established since the quality of carp seed produced in several hatcheries are reportedly not satisfactory due to continuous inbreeding.
2. Fish hatchery operators should be trained on better broodfish management, hatchery management and nursery management to produce quality fish seed.
3. Government or financial institutions should sponsor setting up of field laboratories for assessing and monitoring fish seed quality.
4. More emphasis should be laid on multiple spawning of carps so as to ensure the availability of seed over a longer duration in a year.
5. Greater support (technical as well as financial) from government agencies is needed for sustainable fish seed production.
6. Apart from the routine production of carp seed, emphasis needs to be given also to produce seed of valuable species like catfish and murrels, which command a good price in several parts of the country.
7. Mixed spawning should be prevented to protect the genetic purity of our precious carps gene pools.
8. Attempts should be made for efficient marketing and distribution of fish seed from surplus states to maximum deficit states.
9. The Government of India should explore the possibility of having a uniform fish seed grading system and pricing for the entire country.

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