AQUACULTURE GENETICS RESEARCH IN INDONESIA

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ABSTRACT

This paper presents genetics research conducted by the institutional members of the Indonesian Network of Fish Genetics Research and Development (INFIGRAD) during 1998. The research included: (1) identification and genetic characterization of freshwater and brackishwater fish and (2) genetic improvement through selection and hybridization. This paper also reports on the contribution of the GIFT strain Nile tilapia (Oreochromis niloticus) to the development of floating net culture in reservoirs and on the research collaborations with the International Network on Genetics in Aquaculture/International Center for Living Aquatic Resources Management on common carp and with the L’Institut Francais de Recherche Scientifique pour le Developpement en Cooperation on genetic characterization of catfish.

Introduction

Fresh and brackishwater aquaculture contributed 733 000 t (16.5%) to the total fish production of about 4.452 million t in Indonesia (DCFA 1998). Of this, freshwater aquaculture production was about 328 800 t, of which common carp (Cyprinus carpio) was 54.3% (Table 1). Nile tilapia (Oreochromis niloticus), which was first introduced in Indonesia in 1969 from Taiwan has been widely accepted by fish farmers. Common carp and Nile tilapia (recently the GIFT strain) are cultivated intensively, especially in floating net cages in reservoirs.

Common carp culture started in West Java in the middle of 19th century (Ardiwinata 1971) and subsequently, was taken up in other parts of Java, Sumatra and Sulawesi islands since early 20th century. There are at least ten stocks of common carps known in Indonesia: Punten, Sinyonya, Majalaya, Domas, Merah, Kancra-domas, Kaca (mirror carp), Kumpai, Taiwan carp and Koi (Japanese fancy carp) (Taniguchi et al. 1992). Recent collections include Rajadanu, Wildan Cianjur and Sutisna Kuningan (Nugroho and Wahyudi 1991).

In recent years, the genetic improvement of common carp and Nile tilapia has been considered important in aquaculture operations. Research on genetic characterization of both fresh and marine fishes is also gaining importance and has been part of the government’s conservation efforts.
Research activities conducted in 1997/1998, included:
(1) identification and genetic characterization of wild, freshwater and brackishwater cultivated species, such as common carp, catfish (Pangasius sp. and Clarias sp.), milkfish (Chanos chanos), groupers, eel and shrimp; (2) genetic improvement of C. carpio, O. niloticus and Macrobrachium rosenbergii; and (3) hybridization of C. carpio and O. niloticus. Research on production of gynogenetic common carp for parent stocks of hybrids was undertaken earlier. Although brackishwater species played an important role in the development of the aquaculture industry, the genetic research of even the most important species is just in the early stages, with characterization of stocks and search for better strain from the wild. The other research includes the development of technology for mass production of seed, including gonad maturation of broodfish, spawning, hatching, and larval and fry rearing.

Since intensive aquaculture development needs a large supply of high-quality seed of genetically improved fish, research on genetic improvement is receiving high priority. The introduction of the GIFT strain O. niloticus from the Philippines, in 1994 contributed to the development of intensive culture in floating net cages and of the seed production industry in West Java, as the aquaculture center in the country.

Information provided in this paper was collected from:
- institutions under the Agency of Agricultural Research and Development:
  - Research Institute for Freshwater Fisheries (RIFF)
  - Gondol Research Station for Coastal Fisheries (GRSCF)
- universities
  - Department of Fisheries, University of Brawidjaja (UNBRA)
  - Faculty of Fisheries, Bogor Agricultural University (BAU)
  - Agency for Assessment and Application of Technology (AAAT)
  - institutions under the Directorate General of Fisheries, e.g., Freshwater Aquaculture Development Center (FADC).

These institutions are members of the Indonesian Network of Fish Genetics Research and Development (INFIGRAD). Other members of the network include the: Faculty of Fisheries, University of Riau; Department of Fisheries (DOF), University of Bung Hata; Faculty of Fisheries, University of Pajajaran; DOF, University of Gajah Mada; Faculty of Fisheries, University of Lambung Mangkurat; and Faculty of Fisheries, University of Hasanuddin. Table 2 lists the different aspects of genetics research being carried out by the institutions. Also, there is an ongoing research collaboration between the Central Research Institute for Fisheries (CRIFI)/RIFF and the International Network on Genetics in Aquaculture/International Center for Living Aquatic Resources Management (INGA/ICLARM) called Genetic Improvement of Common Carp, and between CRIFI/RIFF and the L'Institut Francais de Recherche Scientifique pour le Developpement en Cooperation, called Characterization, Utilization and Maintenance of Biological Diversity for the Diversification and Sustainability of Catfish Culture in Southeast Asia.

**Genetics Research**

Research was conducted by 11 institutions (including research collaborations) on five freshwater and five brackishwater fish species (Table 2).
Table 2. Genetics research on freshwater and brackishwater fish species and the institutions involved in Indonesia.

<table>
<thead>
<tr>
<th>Species</th>
<th>Characterization</th>
<th>Gynogenesis</th>
<th>Selection</th>
<th>Hybridization</th>
<th>Institutions involved</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>C. carpio</em></td>
<td>RAPD</td>
<td>Punten strain</td>
<td></td>
<td>AAAT</td>
<td>UNBRA and Punten Hatchery, CRIFI/RIFF and INGA/ICLARM</td>
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<tr>
<td></td>
<td></td>
<td>Majalaya, Sinyonya</td>
<td></td>
<td></td>
<td>FADC</td>
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<tr>
<td></td>
<td></td>
<td>Majalaya, Sinyonya,</td>
<td></td>
<td></td>
<td>BAU</td>
</tr>
<tr>
<td></td>
<td></td>
<td>mirror carp</td>
<td></td>
<td></td>
<td>CRIFI/RIFF and INGA/ICLARM</td>
</tr>
<tr>
<td><em>Clarias</em> spp. (1)</td>
<td>Allozyme</td>
<td></td>
<td></td>
<td></td>
<td>ORSTOM and RIFF</td>
</tr>
<tr>
<td><em>C. batrachus</em> (2)</td>
<td>Isozyme electrophoresis</td>
<td></td>
<td></td>
<td></td>
<td>RIFF</td>
</tr>
<tr>
<td><em>Pangasius</em> spp.</td>
<td>Allozyme</td>
<td></td>
<td></td>
<td></td>
<td>ORSTOM and RIFF</td>
</tr>
<tr>
<td><em>O. niloticus</em></td>
<td></td>
<td>Heritability, family</td>
<td>Diallele crossing</td>
<td></td>
<td>FADC</td>
</tr>
<tr>
<td><em>M. rosenbergii</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RIFF</td>
</tr>
<tr>
<td><em>Brackishwater</em></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td><em>C. chanos</em></td>
<td>Isozyme electrophoresis</td>
<td></td>
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<td>GRSCF</td>
</tr>
<tr>
<td><em>Epinephelus</em> spp.</td>
<td>Isozyme electrophoresis</td>
<td></td>
<td></td>
<td></td>
<td>GRSCF</td>
</tr>
<tr>
<td><em>Chromileptes</em> altivelis</td>
<td>Isozyme electrophoresis</td>
<td></td>
<td></td>
<td></td>
<td>GRSCF</td>
</tr>
<tr>
<td><em>Anguilla</em> bicolor</td>
<td>RAPD</td>
<td></td>
<td></td>
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<td>AAAT</td>
</tr>
<tr>
<td><em>Penaeus</em> monodon</td>
<td>Isozyme electrophoresis</td>
<td></td>
<td></td>
<td></td>
<td>GRSCF</td>
</tr>
</tbody>
</table>

Carps

Documentation of the genetic resources of carps (Cyprinus carpio, Barbodes gonionotus, Osteochilus hasselti, Leptobarbus hoeveni and Neolissochilus thienemanni) in Indonesia

This activity was a collaboration between CRIFI/RIFF and INGA/ICLARM. Literature searches were made from 12 faculties or divisions of fisheries of universities in West, Central and East Java and West Sumatra, and from related fisheries institutions, such as the Institute for Evaluation and Application of Technology, Provincial Fishery Extension Services, Central Hatchery and RIFF. Questionnaires were distributed to the Provincial and Regional Fishery Extension Services and Central Hatcheries in West and Central Java. Common carp genetic resources, which focused on strains of Rajadanu, Wildan Cianjur, Sutisa Kuningan and Majalaya, were documented. Information was collected on the biology of species; status of genetic quality evaluation and utilization of genotypically different common carp.

Establishment of synthetic base population of common carp from four strains

This study is being carried out by CRIFI/RIFF and INGA/ICLARM. At the first stage, complete diallele crossing of three strains (Rajadanu, Wildan Cianjur and Majalaya) and one cross of Sutisa Kuningan was made, with a total of 10 crossings. Each strain consisted of five females and five males. Crossing was accomplished by artificial fertilization, where eggs of each female were fertilized with sperm of five males. Simultaneous ovulation occurred after two injections with Ovaprim (combination of GnRH and domperidone). Fertilized eggs were distributed to kakabans (Arenga fiber egg collectors) set in hapas. The eggs of each female were hatched in five hapas. Rearing of eight-day old larvae was carried out in fine-mesh (1-2 mm) net cages set in two ponds, in which 50 net cages of 2 x 1.2 x 1 m in dimension were set in each pond. The stocking density was 1 300 larvae per cage. In one month, the larvae grew to fry with individual weight of about 1 g. The next step was rearing of fry to fingerling in net cages with
larger mesh. The base population will be established through 150 tagged fingerlings per full-sib family. This will be conducted in the second year.

Data collected from each breeder were fecundity, egg diameter, hatching rate, larval size, fry size and survival rate.

Gynogenesis of Punten common carp

Punten common carp is a well-known strain in Indonesia. Its phenotype characteristics include big belly and relatively wide body. The original Punten strain was the result of selection done by Goossens in 1928-1930 in Punten Hatchery, West Java (Ardiwinata 1971). This strain is not popular with fish farmers and competes with the widely spread Majalaya strain. In view of this, the Punten strain has become rare and is difficult to find. Punten Hatchery, in collaboration with UNBRA in East Java, has tried to conserve and make gynogenesis of the existing strain. This effort produced gynogenetic Punten with different color variation, red, green and blue, with the ratio of standard length to body depth 1:2.4; 1:2.5-2.7; and 1:2.6-2.9, respectively (Hasanudin 1998).

Gynogenesis of Majalaya and Sinyonya strains of common carp and their diallele crossing

The Majalaya strain is a big belly type one, with wide body depth and greyish-green scales. The Sinyonya strain is elongated and yellow. The eyes of the young fish are normal, while those of the old fish are covered by the eyelid membranes. The second generation of mitotic-gynogenetic diploid was produced for both strains. This diploid has a larger degree of phenotypic variation than the normal fish (Sumantadinata et al. 1990).

Diallele crossing was made to obtain better results. Progeny produced by crossing male Majalaya and female Sinyonya showed better growth and survival rates than the reciprocal and pure lines. The colors of the progeny were 70% green; yellow, 20%; and in between both colors, 10% (Hadadi et al. 1998).

Qualitative and quantitative characters of three C. carpio strains

The second generation of gynogenetic diploid common carp strains of Majalaya, Sinyonya and mirror carp were produced in 1992. Some fish of these strains were sex-reversed by oral administration of 17α-methyltestosterone. Females and the sex-reversed males were matured in early 1994. The fish were grown in earthen pond and in running water system with intensive feeding. Characteristics of the young fish to market size were observed and analyzed.

Slight differences among strains were found in the egg size before and after ovulation and in their further development. Fecundity of Sinyonya was higher than that of the mirror and Majalaya strains, but their fertilization and hatching rate were relatively similar. The growth rate of mirror and Sinyonya strains were similar under still or running water conditions, but they were better than that of Majalaya strain. The survival rate of mirror carp was the lowest. As regards body composition, the Sinyonya strain had the highest percentage of fillet; Majalaya strain, biggest viscera; and mirror carp, fillet remnant. The total quantity of muscular spines of the Sinyonya carp was the lowest. Proximate analysis of flesh showed it had the highest protein content and the lowest lipid content (Arfah and Sumantadinata 1998).

Application of RAPD-PCR method for analyses of DNA polymorphism of C. carpio

Six strains of C. carpio (Majalaya, Sinyonya, Punten, Domas, mirror and Merah [red]) were collected from Wanayasa Hatchery, fish farmer ponds and floating net cages. Blood samples were collected for extraction of total DNA, visualization of DNA by electrophoretic gel agaros and ethidium bromide staining, test and assessment of DNA quality, and reaction of PCR by RAPD method. The results showed no difference in typical band pattern for the four strains, except Majalaya and Sinyonya. For these two strains, DNA polymorphism can be detected with the application of RAPD-PCR (Faizal et al. 1998).

Catfish

Identification and characterization of Clarias and Pangasius sp.

Collaborative research involving six institutions has been carried out, since November 1997. The institutions were ORSTOM and Centre de Cooperation Internationale en Recherche Agro-nomique pour le Developpement (France); Katholieke Universiteit Leuven (Belgium); Cantho University (Vietnam) and CRIFI/RIFF (Indonesia). The research project was entitled “Characterization, Utilization and Maintenance of Biological Diversity for the
Diversification and Sustainability of Catfish Culture in Southeast Asia.

The research work consisted of two parts. The first part aimed at identification and characterization of species and populations of the genera *Pangasius* and *Clarias* of actual or potential interest for aquaculture. Three complementary approaches were used: morphological analysis, estimation of genetic variation (protein electrophoresis, mitochondrial and microsatellite DNA analysis), and characterization of gill parasites communities (Monogenea). The results showed the: (1) phylogenetic relationships among Pangasiid catfish species (Siluroidei, Pangasidae) using allozyme data; (2) phylogenetic relationships among Clariid catfish species (Siluroidei, Clariidae) using allozyme and mitochondrial data; and (3) diversity of gill parasites of some catfish host species in Southeast Asia.

The second part of the research dealt with diversification and optimization of aquaculture production. The results showed: (1) aquaculture potential and artificial propagation in Pangasiids and (2) optimization of culture practices of *Pangasius hypophthalmus*.

**Table 3. Heterozygosity of each locus for each population of *C. batrachus***

<table>
<thead>
<tr>
<th>Locus</th>
<th>Allele</th>
<th>Lamongan</th>
<th>Depok</th>
<th>Parung</th>
<th>Palembang</th>
<th>Plaju</th>
<th>Tegineneng</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aat</td>
<td>100</td>
<td>0.925</td>
<td>0.925</td>
<td>0.925</td>
<td>0.800</td>
<td>0.925</td>
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<tr>
<td></td>
<td>80</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.125</td>
<td>0.100</td>
<td>0.000</td>
</tr>
<tr>
<td>H¹</td>
<td>60</td>
<td>0.075</td>
<td>0.075</td>
<td>0.075</td>
<td>0.075</td>
<td>0.100</td>
<td>0.075</td>
</tr>
<tr>
<td>Mpi</td>
<td>200</td>
<td>0.139</td>
<td>0.139</td>
<td>0.139</td>
<td>0.252</td>
<td>0.145</td>
<td>0.139</td>
</tr>
<tr>
<td></td>
<td>110</td>
<td>0.050</td>
<td>0.050</td>
<td>0.050</td>
<td>0.050</td>
<td>0.050</td>
<td>0.050</td>
</tr>
<tr>
<td>h²</td>
<td>40</td>
<td>0.795</td>
<td>0.795</td>
<td>0.795</td>
<td>0.795</td>
<td>0.795</td>
<td>0.795</td>
</tr>
<tr>
<td>Gpi</td>
<td>120</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
<td>0.025</td>
</tr>
<tr>
<td>H</td>
<td>50</td>
<td>0.048</td>
<td>0.048</td>
<td>0.048</td>
<td>0.048</td>
<td>0.048</td>
<td>0.048</td>
</tr>
<tr>
<td>H</td>
<td>0.038</td>
<td>0.038</td>
<td>0.038</td>
<td>0.057</td>
<td>0.059</td>
<td>0.061</td>
<td></td>
</tr>
</tbody>
</table>

Notes: H - total heterozygosity; h - heterozygosity per locus.

The results indicated the possibility of less random mating due to a decrease in population as a result of intensive capture or introduction of other species, i.e., *C. gariepinus*. The introduction has been dominated by the local catfish, as it is easy to culture, has higher fecundity and faster growth, and is more resistant to diseases. At present, *C. batrachus* has become a threatened species. In Sumatra, where there is smaller population and vast area of open waters (rivers and swamps), there is a larger population of catfish.

**Nile tilapia**

**Heritability of growth rate of O. niloticus**

Three strains of *O. niloticus*, GIFT, Chitralada and Nile tilapia 69 (introduced in Indonesia in 1969 from Taiwan), each consisting of 25 families, were studied. GIFT showed higher heritability than both Chitralada and Nile tilapia 69. The values after a two-month rearing period were 0.74, 0.66 and 0.17, and after
Evaluation of diallele crossed tilapias

Diallele crossing of tilapias was carried out for the following strains: (1) Chitralada (black) strain of O. niloticus and Philippine red tilapia; (2) GIFT strain of O. niloticus (black) and red tilapia (NIFI - National Inland Fisheries Institute, Thailand); (3) GIFT strain and Philippine red tilapia; (4) Nile tilapia 69 (black) and NIFI strain; (5) Nile tilapia 69 and Philippine red tilapia; (6) Chitralada strain and GIFT strain; (7) Chitralada strain and Nile tilapia 69; and (8) GIFT strain and Nile tilapia 69.

The growth rate and color composition were observed for 16 weeks. Crossing male GIFT strain with other strains showed better growth rate (117-123 g) than either crossing male Chitralada strain with other strains (89-100 g) or pure GIFT strain (average weight, 98 g). The highest percentage of red tilapia (46%) was obtained from crossing male GIFT strain and female Philippine red tilapia, followed by yellow (42%) and black (11%) types (Hadadi et al. 1998).

Milkfish

Genetic variation of Chanos chanos samples (natural and hatcheries F₁ and F₂) and performance of F₁ and F₂ were examined. Among 15 enzymes, 29 loci were detected. Eleven were polymorphic, namely, Adh, Aat, 1, Est-2, Gpd, Gpi-1, Gpi-2, ldh-1, Ldh-1, Mdh-1, 6-Pgd, Pgm-2. Reduction in genetic variability was found in the hatchery stock (F₁). The reductions were 50% in the number of polymorphic loci, 22.36% in the number of allele per locus and 37.78% in the heterozygosity. The actual number of broodstock contributing in F₂ was 14 out of 50 fish individuals in the spawning tanks. GPI locus among the mostly polymorphic loci could be used as a marker in genetic improvement program. In order to avoid reduction in genetic variability in hatchery stocks, it is proposed to increase the number of broodstock for mass production of milkfish fry (Sugama and Prijono 1998).

Grouper

The study of genetics and characteristics of groupers Epinephelus spp. and Chromileptes altivelis was conducted by the Research Station of Research Institute for Coastal Aquaculture in Gondol, Bali. Four species of groupers (E. fuscogutatus, E. coioides, E. microdon and E. bonthoides) and one species of C. altivelis were analyzed by isozyme electrophoresis for 13 enzymes, such as Adh, Aat, Est, Gpi, ldh, Ldh, Mdh, M, 6-Pgd, Pgm, Sdh, Sod and Sp. Using TC-8 and CAPM-6 buffer systems combined with skeletal muscle and liver tissues, six polymorphic loci were detected in E. coioides and C. altivelis, four in E. fuscogutatus and E microdon and two in E. bonthoides. Genetic variability was highest in E. coioides, 1.78 allele per locus and 0.89 heterozygosity. The shortest genetic distance (D) was found between E. coioides and E. bonthoides with D value of 0.0832. D values between C. altivelis and other species were significant (D<0.8). The results also suggest that Adh locus is a reliable marker for species identification (Sugama and Trijoko 1998).
percentage in M. rosenbergii. Response of selection, selection differential and intensity, and predicted average dress-out of $F_2$ are presented in Table 4.

**Shrimp**

The association between heterozygosity at two loci of isocitrate dehydrogenase (Idh) and glucose phosphate isomerase (Gpi) and the development rate in P. monodon were examined. The purpose of this study, which was conducted by GRSCF, was to test the prediction that heterozygous prawn develops faster than the homozygous one. There were significant differences in fecundity, hatching rate and vitality between heterozygous and homozygous individuals. Larvae derived from heterozygous broodstock developed faster than those from homozygous one. The results suggest that heterozygous individuals are superior to homozygous ones (Sugama et al.1998).

The study of genetic variation and population structure of P. monodon was another collaborative research among GRSCF, Faculty of Agriculture, Kochi University, and Faculty of Fisheries, BAU. Five populations of P. monodon in the coastal waters of Indonesia (Aceh, Madura, Bali, West Nusa Tenggara and South Sulawesi) were sampled electrophoretically for evaluation of genetic variation at 21 loci. Six loci (Est-2, ± Gpd, Gpi, Idh, Ldh-1 and Mdh-1) were polymorphic in at least one of the samples. All polymorphic loci at all localities were in Hardy-Weinberg equilibrium. The genetic variability of the species, as indicated by number of alleles per locus (Na) and heterozygosity (H), was low, with average (Na=1.428), ranging from 1.333 to 1.523 and $H=0.034$, ranging from 0.023 to 0.047. The mean genetic distance between population pairs was 0.00045, ranging from 0.00004 to 0.00112. Clustering samples according to their paired genetic distances showed that the population of P. monodon consisted of three geographical groups. However, the absolute amount of genetic variation among populations sampled appeared to be very low (Sugama et al.1998).

**0. niloticus (GIFT strain) culture in Indonesia**

The GIFT strain O. niloticus was introduced in Indonesia in 1994 as part of the INGA program. The fry were studied in three locations, RIFF at Bogor, FADC at Sukabumi and Cangkringan Hatchery at Yogyakarta. Studies on growth rate, conducted in three locations in West Java, showed that GIFT performs better compared to O. niloticus strains already existing in Indonesia.

The economic crisis during 1998 had a strong impact on intensive fish culture, primarily because the high price of pelleted feed, which increased by 70% (from Rp 1 400 to Rp 2 400 or from US$0.15 to US$0.30). However, the number of pellet feed industries also increased; trademarks increased from four to 12, with different qualities. The quality of some feeds is poor resulting in low feed conversion. Efforts were made for the intensive fish culture to survive and become profitable through the use of fish species that are easy to handle and have fast growth rate, good marketability, and efficient feed conversion. GIFT strain has met these requirements particularly with regard to rearing in floating net cages in Saguling, Cirata and Jatiluhur reservoirs in the province of West Java.

On the other hand, the use of C. carpio, the lead species cultured in cages, has decreased dramatically; at present, it is estimated to be less than 10%. A total of 25 560 cages (7 x 7 x 3 m) need a large supply of GIFT fry. The high demand is due to the shift from C. carpio carp fry to GIFT production, and the establishment of large-scale GIFT hatcheries by new investors.

In single-bottom floating net cages, only GIFT fish or C. carpio are stocked, while in double-bottom cages, C. carpio are stocked in the inner cage and GIFT fish in the outer cage. Feeds are applied only to C. carpio, while GIFT fish are fed food droppings from the inner layer, in addition to periphyton growing on net walls. The rearing period varies from 60 to 110 days. In Jatiluhur reservoir, the stocking densities per cage in single-bottom net cages varied from 60 to 130 kg of C. carpio or 100 to 150 kg of O. niloticus. The production was from 875 to 1 940 kg of C. carpio and from 626 to 1 200 kg of O. niloticus per cage. In double-bottom cages, stocking densities of C. carpio were 50-60 kg in inner cages and 18-50 kg of O. niloticus in lower cages. The production was 1 080-1 326 kg and

### Table 4. Response, selection differential, intensity, and dress-out of M. rosenbergii.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parental response, $F_1$ (%)</td>
<td>07.69</td>
</tr>
<tr>
<td>Selection differential</td>
<td>13.74</td>
</tr>
<tr>
<td>Selection intensity</td>
<td>04.05</td>
</tr>
<tr>
<td>Average dress-out (%)</td>
<td>56.63</td>
</tr>
<tr>
<td>Prediction of average dress-out (%)</td>
<td>64.32</td>
</tr>
</tbody>
</table>
The fish are usually harvested at the individual size of 250-300 g with the price of GIFT strain at the producer level of Rp 3 500 (US$0.44) and for individual fish over 500g the price was Rp 4 500 (US$0.56). Production of C. carpio and O. niloticus in floating net cages in Cirata reservoirs is shown in Table 5.

Brackishwater ponds, with a maximum salinity of 15 ppt, is another source for culture of GIFT strain. In Karawang area (West Java), such culture has been carried out since 1997. There are 130 units of ponds of 4 000 m² each that can produce 1.7-2.0 t/pond in 110-day rearing period with a stocking density of 10 000 fingerlings (3-5 cm). Fish are harvested at the average individual size of 200 g, and the survival rate is about 80-85%. A trial in ponds of 3 000 m² each, with a stocking density of 75 000 fry of 1 g/fish produced fingerlings of 15-20 g/fish with a survival rate of 80% in 110-day period. To maintain the genetic quality of GIFT strain, broodstock management should be done by seed producers, with assistance from authorities and the scientific community.

**Future Research**

Following are various future research collaborations on genetic research in Indonesia:

- **CRIFI/RIFF and INGA/ICLARM** - genetic improvement of carp in Asia: establishment of base population of the second ten crossings among strains of Rajadanu, Wildan Cianjur, Majalaya and Sutisna Kuningan. During 2000/2001, the project will continue to undertake estimation of the breeding value of 100 half-sib and 200 full-sib families from the best cross of the first generation.
- **CRIFI/RIFF and ORSTOM** - characterization, utilization and maintenance of biological diversity for the diversification and sustainability of catfish culture in Southeast Asia. For genetic characterization of Claridae and Pangasiidae, more samples will be collected from rivers in Java, Sumatra and Kalimantan, and analyzed thorough protein electrophoresis and mtDNA.
- **INFIGRAD** (Fig. 1):
  - enzymatic characterization of C. carpio - to be conducted by RIFF for four strains of C. carpio, i.e., Majalaya, Rajadanu, Sutisna Kuningan and Wildan Cianjur;
  - DNA polymorphism analysis for carp species - to be carried out by AAAT;
  - hybridization of C. carpio strains - to be done

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**Table 5. Production of C. carpio and O. niloticus in floating net cages in Cirata reservoirs.**

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of cages (unit)</th>
<th>Operating</th>
<th>C. carpio</th>
<th>O. niloticus</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>10 950</td>
<td>8 700</td>
<td>15 896</td>
<td>9 218²</td>
<td>25 114</td>
</tr>
<tr>
<td>1997</td>
<td>25 558</td>
<td>15 289</td>
<td>36 532</td>
<td>12 639²</td>
<td>49 171</td>
</tr>
<tr>
<td>1998</td>
<td>17 477</td>
<td>10 485</td>
<td>9 349</td>
<td>5 916²</td>
<td>15 265</td>
</tr>
</tbody>
</table>

¹Data collected from Fish Culture Station of Saguling-Cirata reservoirs.
²Consisted of Nile tilapia 69.
³Mostly Nile tilapia 69.
⁴Mostly GIFT strain.

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**Fig. 1. Distribution of members of Indonesia Network of Fish Genetic Research and Development (INFIGRAD)**
by FADC at Sukabumi;
- evaluation of heterosis of Pangasius hybrids (P. jambal and P. nasutus) – to be conducted by RIFF at Sukamandi;
- family selection of the sixth generation of GIFT strain of O. niloticus – to be conducted by RIFF, Sukamandi;
- study on the application of RNA:DNA ratio to evaluate growth of tilapia – to be done by AAAT, Serpong;
- hybridization of tilapia – to be done by FADC, Sukabumi;
- morphological and DNA characterization of P. monodon - to be carried out by GRSCF and Faculty of Fisheries, BAU; and
- studies on allozyme heterozygosity and growth rate of C. chanos fry – to be done by GRSCF.

References


Arfah, H. and K. Sumantadinata. 1998. Qualitative and quantitative characters of three common carp (Cyprinus carpio) strains in Indonesia. Department of Aquaculture, Faculty of Fisheries, Bogor Agricultural University, Indonesia.


