BREEDING PLAN FOR NILE TILAPIA (*OREOCHROMIS NILOTICUS*) IN VIETNAM: COMBINED MULTI-TRAIT SELECTION

Report No. 1

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INTERNATIONAL NETWORK ON GENETICS IN AQUACULTURE
July 1996

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FOREWORD

The International Network on Genetics in Aquaculture (INGA) was established in 1993 and is being coordinated by the International Center for Living Aquatic Resources Management (ICLARM), with the objective to contribute through collaborative research, to the domestication and sustainable performance of tropical finfish species farmed in developing countries and to strengthen national capabilities for genetic enhancement of farmed fish through exchange of germplasm, methodologies and through training and interactive forums.

Studies undertaken in recent years for improving breeds of salmon in Norway and tilapia in Philippines by ICLARM and collaborating Philippine and Norwegian institutions, have led to increased awareness among researchers the need for undertaking programs for improvement of breeds of species that are of aquaculture importance in their countries. INGA has been assisting the member countries in developing national breeding programs. This report on **Breeding Plan for Nile Tilapia *(Oreochromis niloticus)* in Vietnam: Combined Multi-Trait Selection** is an outcome of such an effort and has been prepared by Drs. Hans Bernhard Bentsen and Trygve Gjedrem of the Institute of Aquaculture Research (AKVAFORSK), Norway and Dr. Tran Mai Thien and Mr. Nguyen Cong Dan of Research Institute for Aquaculture No.1 of Vietnam. Dr. A.E. Eknath of ICLARM has assisted INGA and the authors in planning and development of this breeding program, which is greatfully acknowledged.

We hope that this document will be useful to other researchers and planners in developing breeding programs in their countries.

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03 June 1997

INTRODUCTION

Total freshwater aquaculture production in Vietnam in 1995 was about 300 000 tons and total brackish water aquaculture production was about 115 000 tons. Total tilapia production was about 15 000 tons, mainly produced in fresh water. Until now, most of the production has been based on Mozambique tilapia, that was introduced in Vietnam in 1951 and after the introduction of Nile tilapia from Taiwan in 1973, also on hybrids between Mozambique and Nile tilapia. Because of the small size of the fish at sexual maturation, when the fish has to be harvested, the consumers' demand for tilapia has been limited. Recent experiences with culture of Nile tilapia after the reintroduction in 1994 of the GIFT, Thai and Egypt strains have been encouraging.

Fingerlings have been stocked in mangrove brackish water ponds in the rainy season (salinity may be up to 15-20 ppm). Size at stocking has been about 10 grams and the stocking density about 1 fish per square meter. After a culture period of 5 months using supplementary feeding with rice bran, the fish has reached a size of 250-300 grams. The quality of brackish water farmed tilapia is appreciated by the consumers. The demand for Nile tilapia fingerlings is rapidly increasing, in particular in the brackish water areas. A total area of 340 000 ha is considered suitable for brackish water aquaculture.

Rice-fish culture with tilapia is also practised. A total area of 580 000 ha of paddy fields are suited for this kind of culture, but only a small fraction is presently used for this purpose.

In the cities, in particular in the Thanh Tri district, Hanoi, tilapia has also been stocked in the sewage areas with good results. The fish will feed on the organic waste in the sewage areas and make the water cleaner. It will grow to a size of 200-250 grams in 4 months. Studies have shown no harmful residuals in the fish meat, and the fish is used for human consumption.

In North Vietnam, the culture period for tilapia is limited by the temperature. Fry production may start in April/May, and the grow-out season will last until December. In South Vietnam, tilapia may be cultured throughout the year.

BASE POPULATION

Through ICLARM and INGA, RIA 1 has established contacts with the GIFT project in the Philippines. A request for a transfer of a complete tagged family material of the latest generation from the GIFT project to RIA 1 should be forwarded as soon as possible. As soon as possible after arrival

at RIA 1, at least 2 males and 2 females from each full sib family should be electronically tagged (e. g. with PIT-tags). Efforts should be made to transfer the material before the end of 1996 or in early 1997. This will then form the base population for a breeding program for Nile tilapia in Vietnam. The Nile tilapia stocks presently available at RIA 1 may be considered as complementary broodstock and may be tested as breeders in the program if desired. The number of non-GIFT broodstock tested in the breeding program in each generation should be limited.

BREEDING GOAL

At present, the breeding goal of the GIFT program is to increase growth rate and reduce the frequency of early maturing females. This goal should be maintained in the Vietnamese breeding program. In addition, the great potential for brackish water culture of Nile tilapia calls for breeding for improved growth performance at high salinity levels. The survival at high salinity levels should also be recorded. In North Vietnam, the growth performance during the cold months (January, February and March), is greatly reduced. In addition, occasional periods of temperatures below 11 °C have caused extensive mortalities in shallow ponds. Increased cold tolerance should therefore be included in the breeding goal, in particular the ability to survive short periods (1-2 weeks) of low temperature. During the initial generations, all families should be tested in both fresh and brackish water in both Northern and Southern Vietnam, as well as in a cold water challenge test. The importance of genotype by environment interactions (the correlation of the performance of the families under different environmental conditions) may then be evaluated. If substantial genotype by environment interaction is found between important target environments (negative correlations or correlations close to zero), it should be considered to split the breeding program in two or more programs with different breeding goals. This may be separate breeding programs for Northern and Southern Vietnam or for freshwater and brackish water culture.

SELECTION METHOD

The breeding method should be a combination of individual and family selection. This will require tagging of all test fish. Family selection is required for improvement of frequency of early maturing females, for parallel testing in brackish water ponds and for challenge testing at low temperatures. The breeding values of the broodstock will be computed based on the growth performance of the individual and it's full sibs and half sibs, and the frequency of early maturing females, the survival rate in a low temperature challenge test and the growth performance and survival in a brackish water

field test of the full and half sibs of the breeding candidates. The relative weighting of the different traits and sources of information will be determined by the economic importance of the traits for the fish farmers.

START OF BREEDING PROGRAM

The breeding program should be started by random mating of breeders transferred from the GIFT project, avoiding mating of full or half sibs. All full sib families should be represented among the breeders. The production of the progeny generation of full sib families should follow the procedure described below.

PRODUCTION OF FAMILIES

The production of families will follow the design developed in the GIFT project (Figure 1). A training program for staff members from RIA1 and RIA 2 should be requested from the GIFT staff. Before mating, the breeders will be conditioned. One male will then be stocked with 2 females in a 1x1x1 m breeding hapa. A total number of 100 breeding hapas will be installed in a pond. All hapas will be inspected once every week for swim-up fry. Swim-up fry will be collected separately from each hapa and transferred at a standardised stocking density to 1x1x1 m rearing hapas, one hapa for each full sib group. The date of collection of swim up fry should be recorded. The spent females will be removed from the breeding hapas. Totally, this should result in some 150-200 full sib groups. After 3-4 weeks in the rearing hapas, the fry will be transferred at a reduced stocking density to B-net hapas for further rearing until an average body weight of 5 grams. The fingerlings will then be individually tagged, following the method developed by the GIFT project. A total of 130 fingerlings will be tagged per full sib family, amounting to 20-25 000 tagged fingerlings per generation. Of these, 50 fingerlings per full sib family will be communally stocked in a pond at RIA 1, 40 fingerlings per full sib family will be sent to the Research Institute for Aquaculture No. 2 in Ho Chi Minh City (RIA 2) for testing in fresh water (20) and brackish water (20). Furthermore, 20 fingerlings per family should be sent to the Cua Lo station of RIA 1 for brackish water testing and 20 fingerlings per full sib group will be kept for low temperature challenge testing at RIA 1 (Fig 2).

TESTING

Low temperature challenge test: Experiments will have to be carried out at RIA 1 to establish a suitable method for low temperature challenge testing. Preferably, a single communal test should be carried out with 20 tagged fish from each test family at a small size. Alternatively, if larger fish has to be used in the test, the test fish may be split in e.g. two groups. All full sib families should then be equally represented in each group. The number of fish from each full sib family should be recorded at the start of the challenge test. The suitable size of the test fish and the rate of the decrease of the temperature in the water will have to be determined experimentally. Water may be cooled by ice or by an electrical cooling system. At about 50 percent mortality, the family identity of all dead fish should be recorded. The surviving fish may then be kept at a low temperature (temperature to be determined) to record the survival time of each individual.

Frequency of early maturing females: Fifty tagged fingerlings from all families will be communally stocked in one large pond at RIA 1. The pond should be continuously inspected for occurrence of swim-up fry. The pond should be drained about three weeks after the first occurrence of swim-up fry, and all females should be scored and recorded as sexually mature or non-mature according to the method developed in the GIFT project. All fish should then be restocked in a neighbouring pond.

Brackish water field tests, north and south: In both field test stations (RIA 1 and RIA 2), 20 tagged fingerlings from each family should be communally stocked in one brackish water pond. Because of possible problems with entangling of tags, ponds without mangrove vegetation may have to be used. Body weight and survival of all test fish should be recorded in the first week of November, and the records should be forwarded to RIA 1 immediately. The test fish may then be slaughtered or restocked for further grow-out. At RIA 2, the test fish should be kept for later use as broodstok for mass production of progeny that may be disseminated as broodstock to collaborating hatchery operators (see the chapter about dissemination below).

Fresh water field test, south: At RIA 2, 20 tagged fingerlings from each family should be communally stocked in a fresh water pond. Body weight of all test fish should be recorded in the first week of November, and the records should be forwarded to RIA 1 immediately. The test fish should be kept for later use as broodstock for mass production of progeny that may be disseminated as broodstock (see the chapter about dissemination below). If the genotype by environment interaction (see above) between fresh water pond culture in the north and the south is found to be insignificant during the initial generations, the focus of the fresh water test at RIA 2 may be shifted to other freshwater target farm environments of importance (cage culture, low pH).

Fresh water test of the breeding nucleus: In early December, the body weight of all fish in the pond at RIA 1 should be recorded and pre-selection may be carried out (see below).

SELECTION OF BROODSTOCK

In late November, full sib and half sib family records of low temperature tolerance, frequency of early maturing females, body weight in brackish water at RIA 1 and RIA 2 and in fresh water at RIA 2 will be available. The families may then be preliminary ranked according to their combined breeding values (full sib family selection index developed by AKVAFORSK). At final recording of body weights in the pond at RIA 1, a pre-selection may then be performed based on the breeding values of the full sib families. All fish from the 50 top ranked full sib families should be pre-selected and restocked, each sex separately, until final breeding values have been computed. The best of the remaining breeders should be kept for mass production of broodstock for hatchery operators.

Final selection of broodstock to produce the next generation in the breeding program will be based on a selection index developed and initially computed at AKVAFORSK, including the following traits (Figures 2 and 3):

Body weight of the individual and its full and half sibs recorded at RIA 1
Low temperature tolerance of full and half sibs in challenge test at RIA 1
Frequency of early maturing females in the full and half sib families at RIA 1
Body weight and survival of full and half sibs in brackish water test Cua Lo Station of RIA 1
Body weight of full an half sibs in freshwater pond at RIA 2
Body weight and survival of full and half sibs in brackish water test at RIA 2

The non-selected breeders should be kept for mass production of broodstock for hatchery operators.

The routines for production of the next generation of 150-200 full sib families will then be repeated as described earlier (Figure 1).

DISSEMINATION OF IMPROVED SEED TO THE FISH FARMERS

Because of the relatively low fecundity of the tilapia, dissemination of improved seed will have to be based on distribution of improved broodstock to hatchery operators (Figure 3). After the production of the full sib families for the breeding program have been completed, the selected parents should be used for mass production of broodstock for hatchery operators. The progeny of the selected parents will be top genetic quality broodstock, followed by the progeny of the discarded breeders during the final selection (see above) and the discarded breeders during the pre-selection (see above). RIA 2 will serve as the center for dissemination in South Vietnam. This may be done by keeping the test fish until the full sib family breeding values have been computed (see above). Fish from the best 50 % of the full sib families may then be stocked in a breeding pond for mass production of fingerlings that may be disseminated as broodstock to collaborating hatchery operators.

CONTROL TO ESTIMATE GENETIC GAIN

The PIT-tagged fish transferred from the GIFT project may be kept alive at RIA 1 for several years. This will secure the availability of the material for other INGA members in the future. In addition, these breeders may be used for repeated matings after 2-4 generations of selection in the Vietnamese breeding program. The genetic gain in the breeding program may then be estimated by fin clipping of e.g. 20 progeny from each of 50 pairs of random breeders from the originally transferred material with e.g. 20 fin clipped progeny from each of 50 random pairs from the latest reproduction of families in the breeding program. The production of these groups may be carried out after the completion of the production of the families in the breeding program. After fin clipping, the two groups may be communally stocked in one fresh water test pond at RIA 1 and, if feasible, in one brackish water test pond e.g. at RIA 2 for grow out. The frequency of early maturing females in the two groups may be determined in the pond at RIA 1 as described earlier. If desired, the number in each of the test groups may be increased to carry out a communal low temperature challenge test. The difference between the two test groups in the various traits recorded will represent an estimate of response to selection.

After some years, the original GIFT breeders will become too old to be successfully reproduced. Before that, it must be decided if a new generation of progeny of randomly mated original GIFT breeders (using all available breeders) should be produced to serve as a continued source of genetic control. Other methods of control of genetic gain should then be considered as well.

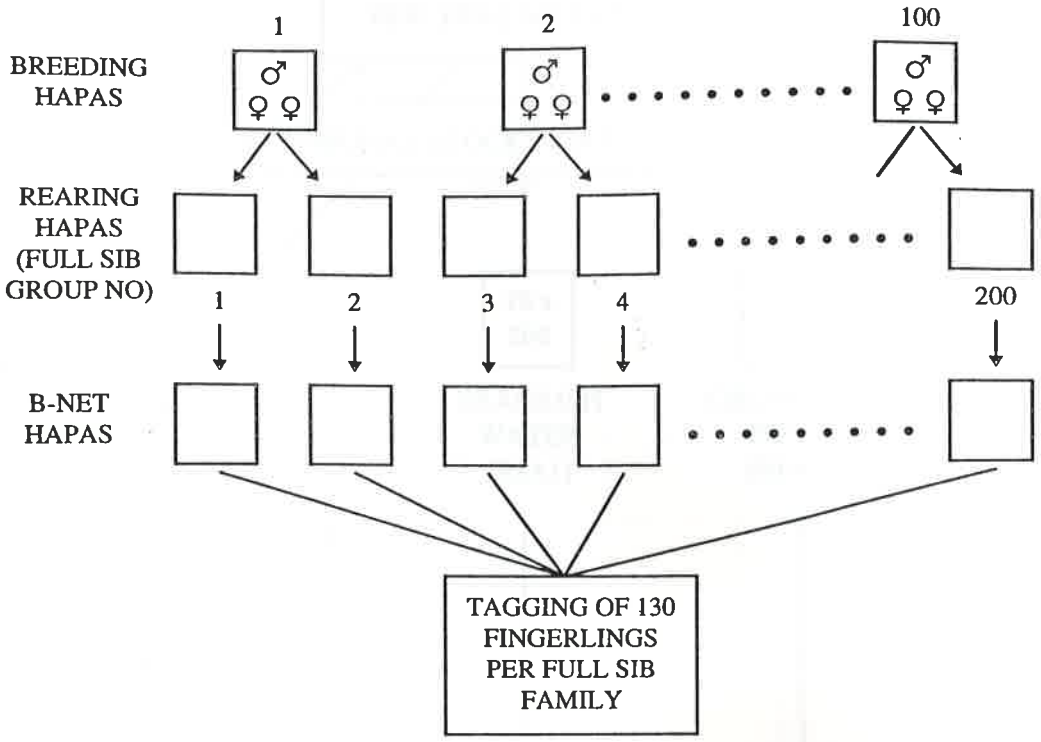

FIGURE 1. MATING AND REARING DESIGN

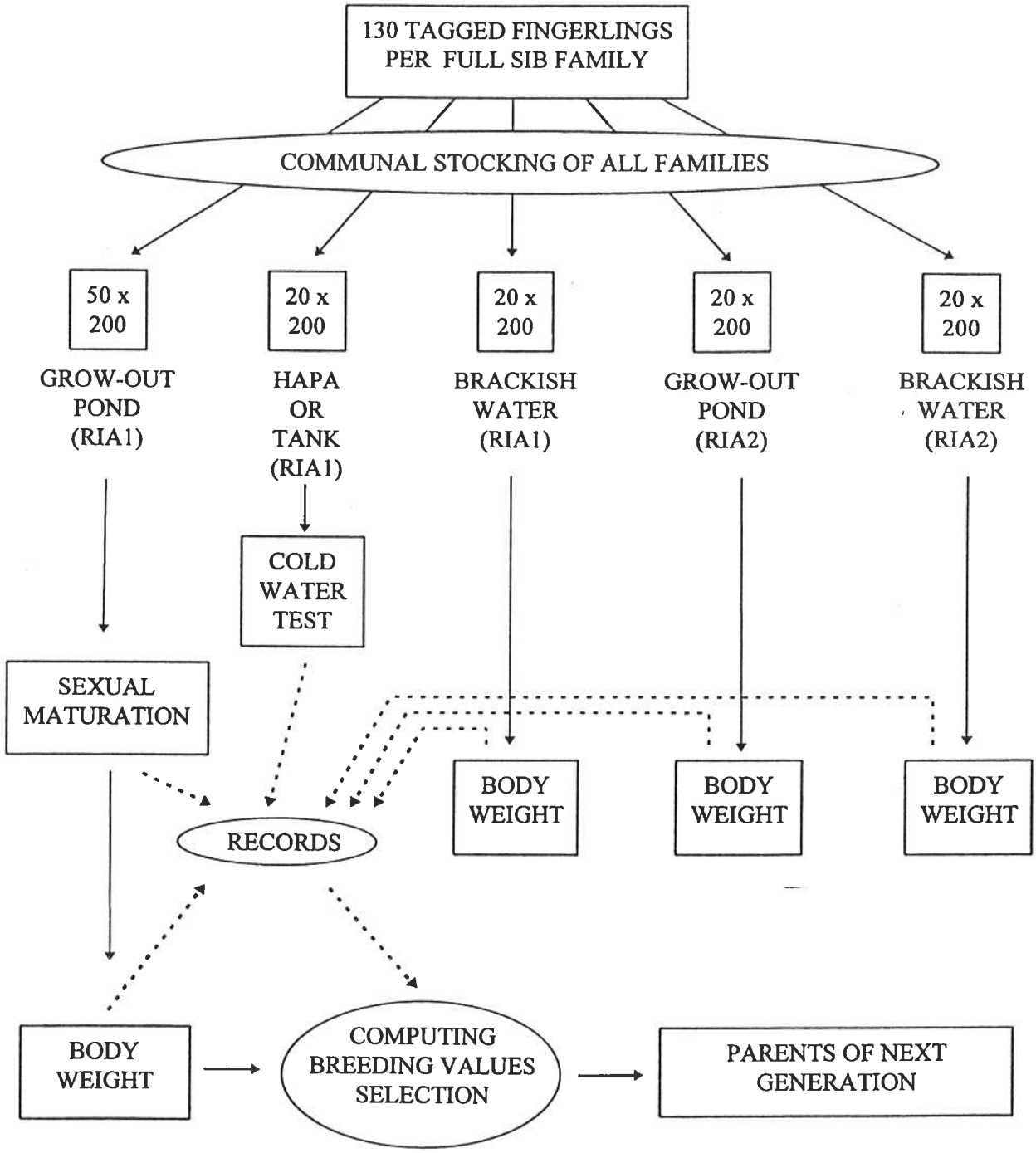

FIGURE 2. TESTING, RECORDING AND COMPUTING OF BREEDING VALUES

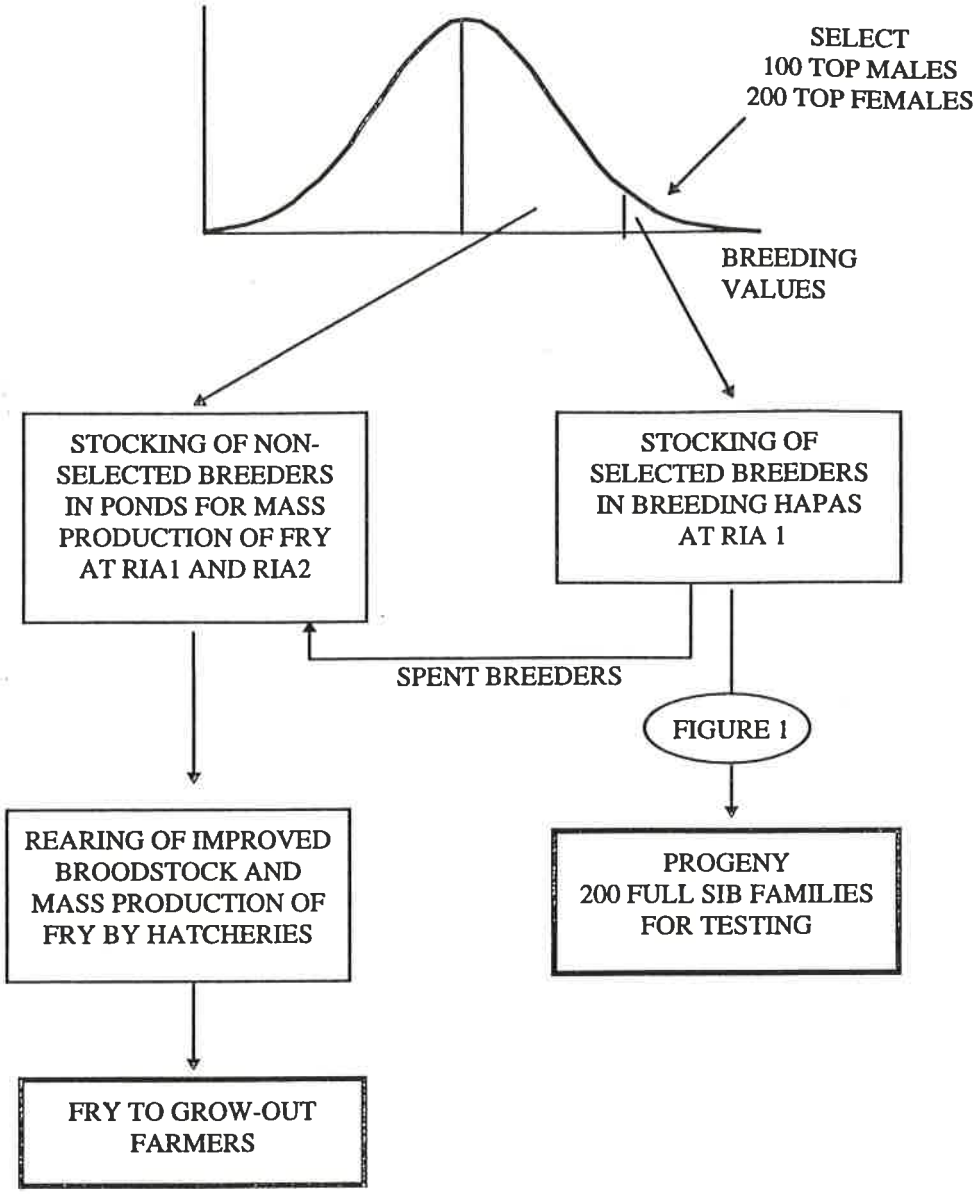

FIGURE 3. SELECTION OF BREEDERS AND DISSEMINATION OF GENETICALLY IMPROVED TILAPIA TO FARMERS