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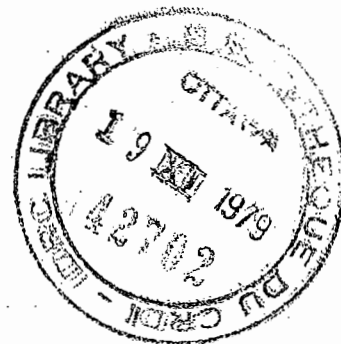
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FAO TECHNICAL CONFERENCE ON AQUACULTURE
CONFERENCE TECHNIQUE DE LA FAO SUR L'AQUICULTURE
CONFERENCIA TECNICA DE LA FAO SOBRE ACUICULTURA

Kyoto, Japan 26 May - 2 June 1976

RECEIVED
- 6 AUG 1979
ILR - / ALRO

FIR:AQ/Conf/76/E.60



PROGRESS IN TROPICAL AQUACULTURE RESEARCH

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, ROME, ITALY
ORGANISATION DES NATIONS UNIES POUR L'ALIMENTATION ET L'AGRICULTURE, ROME, ITALIE
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PROGRESS IN TROPICAL AQUACULTURE RESEARCH

Abstract

Key problem areas in aquaculture in which long-term basic investigations require concerted experimentation are as follows:

- (i) Breeding and seed production
- (ii) Nutrition, food and feeds
- (iii) Genetic selection and hybridization
- (iv) Intensification of culture systems, including polyculture
- (v) Aquaculture engineering
- (vi) Aquafarm management
- (vii) Selection of new species for culture.

Each problem area is discussed and possible strategies for their solution described.

Some modest cooperative research programmes between the International Development Research Centre and certain developing countries are described to illustrate attempts to solve these problems.

PROGRES DE LA RECHERCHE EN AQUICULTURE TROPICALE

Résumé

Les secteurs clefs de l'aquiculture dans lesquels la recherche à long terme nécessite une action concertée en matière expérimentale sont les suivants:

- (i) Alevinage et production de géniteurs
- (ii) Nutrition, alimentation et produits de nourrissage
- (iii) Sélection génétique et hybridation
- (iv) Intensification des systèmes de culture, y compris la polyculture
- (v) Génie aquicole
- (vi) Gestion des exploitations aquicoles
- (vii) Sélection d'espèces nouvelles aux fins d'élevage.

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Le document examine ces divers problèmes et décrit les stratégies auxquelles il est possible de recourir pour les résoudre.

Suit la description de quelques programmes d'ampleur limitée auxquels ont coopéré le Centre de recherche pour le développement international et certains pays en voie de développement, comme illustration des efforts entrepris pour résoudre les problèmes susmentionnés.

PROGRESOS EN LAS INVESTIGACIONES SOBRE ACUICULTURA EN ZONAS TROPICALES

Extracto

Entre los problemas clave de la acuicultura sobre los que es necesario realizar investigaciones básicas a largo plazo con experimentos concertados figuran los siguientes:

- (i) Reproducción y producción de peces para semilla
- (ii) Nutrición, alimentos y piensos
- (iii) Selección genética e hibridación
- (iv) Intensificación de los sistemas de cultivo, incluido policultivo
- (v) Ingeniería acuícola
- (vi) Administración de explotaciones acuícolas
- (vii) Selección de nuevas especies para el cultivo.

Se examina cada uno de estos problemas y se presentan posibles estrategias para su solución.

Como ejemplo de los intentos hechos por resolver estos problemas se describen algunos programas modestos de investigación cooperativa del Centro Internacional de Investigaciones para el Desarrollo y de algunos países en desarrollo.

INTRODUCTION

The needs and priorities for successful implementation of national and international aquaculture programmes have been reviewed by a number of groups including: the Food and Agriculture Organization (FAO) and the Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR). The report of the TAC subcommittee on aquaculture (1974) listed seven problem areas in which basic investigations of a long-term nature require concerted experimentation. These key problem areas were:

- (i) breeding and seed production;
- (ii) nutrition, food and feeds;
- (iii) genetic selection and hybridization;
- (iv) intensification of culture systems, including polyculture;
- (v) aquaculture engineering;
- (vi) aquafarm management;
- (vii) selection of new species for culture

These key research problems have been grouped in different ways by various authors but the above list covers most of the important areas. This paper will discuss each of these problems and describe possible strategies for their solution. The compatibility of the solution to these long-term research problems and the particular interests of national aquaculture research programmes will be emphasized. Some modest cooperative research programmes between the International Development Research Centre (IDRC) and developing countries are described to illustrate initial attempts in this direction. Most of these comments are slanted toward tropical aquaculture research since the IDRC supports applied research projects emphasizing food production in developing countries.

It should be emphasized that, although aquaculture operations are widespread in many countries of southeast Asia, these endeavours have been a relatively new introduction in Africa and Latin America. However, the developments which have taken place in Israel with carp and in the United States with channel catfish provide hope that rapid strides can be made in aquaculture through the introduction of industrialized practices. Accordingly, the efforts which have been concentrated on these two particular species groups should now be turned to other species groups in different countries.

2. MAJOR RESEARCH AREAS

2.1 Breeding and Seed Production

In many aquacultural practices a shortage of the desired fry or fish seed obtainable at reasonable cost is a major obstacle to further development. The cultivation of selected species often depends on the collection of fish seed from natural sources. In many areas, these sources are inadequate, often seasonal, and the collections may result in depletion of natural stocks and disturbance if not destruction of associated species and habitats.

The most promising method of artificially producing fry is through induced breeding via pituitary extracts (hypophysation). This method, introduced since 1937, has been applied to a variety of different species in different environments. However, the application of these techniques has not solved the shortage of fish seed supplies. It has not been possible to breed all desired species using this method. The reasons for this lack of success are not always evident, but important factors appear to be the selection and maintenance of desired broodstock, photoperiod and temperature interactions on the ripening process, and obtaining satisfactory pituitary extracts for large-scale use. Often those species that can be artificially reproduced are only bred at their normal breeding season in restricted geographical and climatic areas and at high cost. Selected combinations of external environmental manipulation and hormonal treatment should be established to allow economical production of fry in areas where fish cultivation is desired. Sources of required broodstock and pituitary extracts, either whole or as purified fractions, must be established. Methods of sperm preservation, in order to have them readily available when eggs are ripe or capable of being stripped, require refinement and development for the most important species.

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Additional advantages of being able to breed any species when and where needed will lead to increased use of genetic hybridization work now being examined for some species. Additionally, fry and juveniles can be used for replenishing decimated natural stocks after natural (e.g., drought) or man-induced calamities, such as industrial pollution discharges.

Since the climate of a given area and the ecological suitability of the fish are major determinants in successful breeding programmes, consideration should be given to the establishment of specialized seed banks at which high volume fry production of species, which are difficult to breed, can take place. Here, selected broodstock could be maintained and suitable hybrids developed to increase production. Dependence on catching wild broodstock each year would be unnecessary. Areas which can now breed some of their cultivable species must consider what agencies will service as fry production and distribution centres. It is unlikely that in tropical countries individual farmers will be readily capable of carrying out all the scientific procedures required for maintenance of broodstock for hybridization or production and rearing of fry, and some countries may have to depend upon the establishment of regional sources.

2.2 Nutrition, Food and Feeds

The need for adequate feed supplies is a priority problem in many countries. Organic and inorganic fertilizers are very important to promote production of natural foods. Standards of fertilizer application need to be studied. The exchange of case history experiences between countries with similar conditions is desirable.

Supplementary feeds are increasingly important in many developing countries especially with intensification of culture operations. There is a need to develop economical standard feed mixtures which satisfy nutritional requirements. This necessitates understanding the basic nutritional requirements of the desired species under a variety of culture conditions. In addition, the nutritional requirements may be different for various growth stages. At present, the fry of most species are fed live food at least for the initial stages of growth. Examination of the requirements at fry, juvenile, marketable size, and broodstock stages is required. The feeds required for high-quality broodstock may be quite different from those necessary to provide rapid growth for the fish market. This type of research will necessarily be long term in nature and initially may have to be restricted to a few species. There appear to be many options for innovative research in this area. For instance, in some species of carp it has been suggested that microflora in the gut may make significant contributions to the nutrition of the fish. If correct, this approach may make the preparation of suitable feeds less time-consuming. To date, few experiments have been performed on food species in developing countries. Many studies have concentrated on the development of diets for best growth under given conditions. Diet development studies are needed in many species but eventually the underlying nutritional requirements will have to be examined before scientific advice can solve the problems of culture practices.

The source of supplementary feed materials will be an increasing problem as demands on all protein sources increase. Surveys of locally available inexpensive feed ingredients are, therefore, necessary. This will include detailed analyses of the adequacy of the different feed ingredients, and methods of processing, storage and dispensing.

In comparison to the seed production problem, much less basic knowledge seems to be available in the area of nutrition and feeds, and for future developments greater emphasis will have to be placed on fundamental studies.

2.3 Genetic Selection and Hybridization

Little work has been done in this area of research. Development of domesticated strains of fish for culture characteristics and consumer preferences involves decisions on the preferred characteristics. These include not only characters, such as fast growth and a good proportion of flesh to bones, but also the ability to utilize inexpensive feeds, adaptation to high density culture, disease resistance, etc. Unfortunately, a number of morphological and physiological characteristics are often associated with these characters making

selection experiments difficult. In addition, much is environmentally determined and very location-specific in field application thus making these experiments even more difficult. Greater examination of these problems is, therefore, required and, after obtaining suitable intraspecific and interspecific crosses, extensive laboratory and field trials will be required.

Much of the work in this area is dependent on successful induced breeding experiments described in section 2.1.

2.4 Intensification of Culture Systems, including Polyculture

Although much aquaculture, as now practised in the developing world, is extensive in nature, it seems inevitable that intensification will be required in the future. The use of polyculture (composite culture), in which a variety of species are cultivated in a single body of water, has shown excellent promise as a system to obtain optimum economic yields. Tests have been made of sizes, densities and species combinations but further testing is required especially under the conditions under which an individual farmer operates. Questions of water-quality maintenance and associated fish stress in combination with aquaculture engineering and management considerations require further research.

Application of chemicals and use of specialized equipment under differing economic and labour conditions requires close examination. Even with the extensive areas now available for aquaculture and the potential areas that might be used, optimization of production will be a necessity. In many areas, this will require industrialization of culture practices far in excess of present methods. Steps in this direction may, however, increase the incidence of disease, pests and competition, and research must concentrate on methods to deal with these problems.

2.5 Aquaculture Engineering

The objectives of this particular field of experimentation are to design aquaculture installations appropriate for different situations in tropical countries. Basic studies on soils, water and site characteristics and the assessment of constraints in systems of construction and operation are needed. Care must be taken in trying to adapt labour-saving but energy-consuming equipment to the socio-economic conditions of tropical countries.

2.6 Aquafarm Management

If aquaculture is to be established on an industrial basis, additional studies on diseases, parasites, predators, pests, and weeds will be necessary, and other adverse factors must be identified and quantified. An assessment must be made of the proper balance of fixed and variable cost factors especially energy demands to optimize economic returns. Studies on the minimum economic size of culture units and methods of sanitation in culture installations are also needed.

2.7 Selection of New Species for Culture

Concentrated efforts have been applied to many traditional species in Asia, Africa and Latin America. However, many other species have been identified in aquaculture which would meet consumer needs, but at the moment - owing to difficulty in breeding or feeding them - have not been widely used. They may be considered curiosities which have not been put to full tests for all the criteria which must be satisfied.

Provided that they can be bred through the use of hormones, and studied under controlled experimental conditions, it should be possible to obtain pertinent information on food habits, spawning, growth, and adaptability to pond conditions; and then to test-rear juveniles (of wild as well as cultivated stock) to determine their suitability for aquaculture systems. Eventually this is going to be the aspect with greatest promise since it will then be possible to use indigenous species of fish rather than introduce exotic fish with the consequent dangers inherent in introduction. This is particularly significant for the wide faunistic speciation of rivers, such as the Amazon, Niger, Congo, Nile and Zambesi.

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An urgent need in every country is for scientists, extension workers, and other staff to attack these problems and transfer research recommendations to the aquaculturists. Most countries maintain a research staff for fisheries; however, many cannot afford the luxury of large training institutions for specialists in the various disciplines of aquaculture. Regional institutions and consortia of universities operating under international cooperative agreements of countries with similar problems and interests would seem a profitable way of overcoming this deficiency.

Such institutions could also lead in the examination of many of the research problems listed here. In addition, they could serve as regional clearing houses for aquacultural information, coordinating agencies and centres for out-reach programmes to national institutions.

It is hoped that many of the national institutions will see fit to carry out long range research on those problems which are in their national interest. However, national priorities will differ and the regional international research and training centres could maintain research programmes on the major problem areas. It is worthwhile to emphasize that, although national planning will follow national needs as a priority, elucidation of some of the long-term research factors listed above will also serve national needs since a well planned long-term research strategy will be most beneficial.

3. IDRC'S AQUACULTURE PROGRAMMES

IDRC's programme supporting aquaculture seeks to follow the above research priorities by cooperative projects in various countries.

In the area of fish breeding and seed production, the domestication of both exotic and indigenous carps in Malaysia, and the breeding of milkfish (Chanos chanos) in the Philippines are relevant. In Kenya, a programme on breeding and hybridizing Tilapia is being formulated, while in Brazil a similar project to breed indigenous species from the Amazon is being organized. In all projects, it is hoped eventually to establish industrialized breeding procedures under local conditions. In many areas, it has become evident that satisfactory amounts of pituitary materials are not always available. A pilot-scale operation has begun in Vancouver, Canada, to collect large numbers of Pacific salmon (Oncorhynchus) pituitaries. It is hoped that upwards of 1 million glands can be collected each year and that after bio-assay and field testing, suitable preparations can be developed to satisfy increasing needs for breeding of food fish species. This would permit a wide variety of applications leading to a domestication of desired fish in tropical countries where year-round temperatures permit faster growth and the greatest demand exists for animal protein consumption.

In the area of fish nutrition, nutritional requirements for Chinese carps are being studied in Malaysia. Economical and nutritionally-effective feeds for juvenile stages of fish are being developed for milkfish in the Philippines. In India, scientists of the Central Inland Fisheries Research Institute (CIFRI) will study nutritional requirements and feed formulations for Indian carps. A project to examine the nutritional requirements of native catfish is being formulated in Thailand.

Another programme in India is one of applied research in which results which have been obtained over the years by the CIFRI are applied under field conditions by the villagers themselves. At the same time, a seed bank proposal is under consideration in which Gangetic carps would be bred and cultivated under the differing climatic regions of the eastern, western and southern areas of the Indian subcontinent. Further, the work that has previously been done in the distribution of these Gangetic Indian carps to such countries as Burma, Fiji, Kenya, Mauritius, Nepal and Sri Lanka may permit the observation of their development and maturation processes under different climatic conditions thus contributing to a worldwide domestication study. A similar undertaking for other species which have been similarly distributed may also be profitable.

Studies on genetic selection and hybridization also need to be followed for indigenous species and work in Kenya may prove indicative for east and central African species.

The study of fish parasites in Indonesia will perhaps contribute an initial pilot study for more intensive studies in aquafarm management. Although there are gaps in aquaculture engineering and the search for new species, some efforts along these lines are being made in Sarawak and Brazil through programmes under consideration by the Centre.

Finally, an appeal is made for concerted action in collaborative and complementary research in aquaculture. The establishment of a permanent consultative advisory group on aquacultural research has been suggested to achieve this end. It is hoped that steps will be taken at the FAO Technical Conference on Aquaculture toward the planning and establishment of such a body.