

Genetic and Genetic-related Research on Aquaculture Organisms in the U.S. and Related Subjects

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Proposed and Ongoing Research



A requirement of the U.S. Aquaculture Bill was the preparation of species plans for the various aquaculture organisms, as agreed upon by academic and government researchers and commercial interests. These plans have been formulated. Special breeding and genetic studies were implicated in the plans for all the following species: salmon, trout, oyster, the hard clam (Mercenaria), abalone, Macrobrachium, crayfish, and brine shrimp. In both trout and salmon, concern was expressed about adverse effects of released stocks on natural stocks. A need was noted for genetic counselors for salmonid commercial interests.

One of the recommendations to come out of a recent review of the U.S. Sea Grant Program was the need to develop long-term genetics and selective breeding programs of sufficient scope to produce special strains of salmon, shrimp, Malaysian prawns, and oysters. This came from a desire to move from the "green thumb" approach of aquaculture to more sophisticated operations of modern agribusinesses. The belief was expressed that continued reliance on wild stocks will severely limit opportunities to increase yields in aquaculture systems.

The U.S. research currently being supported on aquatic species extends from the quite fundamental to efforts at developing strains of restricted use in particular locales or environments. There seems to be an appreciation of the value of inbred lines in research, and the necessity for strain evaluation of species as trout and catfish. There is a growing interest in the genetics of food conversion efficiency in fish, difficult as such studies may be, and possibilities of effective selective breeding for such.

Current and Planned Genetic Studies Relevant to Mariculture in the U.S.

Various breeding and genetic projects, encompassing rather standard selection and hybridization approaches, stock evaluation, efforts at establishment of new stock, sex control, and more fundamental studies, are currently being supported or have recently been reported in a number of states and in a few federal laboratories. These are identified below as follows according to culture group. Because freshwater species will inevitably for some time be looked to for information of use in the breeding and genetics of marine species, relevant projects on these are included. Cryopreservation projects are noted because of the implications of successful gamete and zygote preservation for aquaculture breeding. Information was made available from the U.S. Sea Grant Program, the National Marine Fisheries Service, the U.S. Department of the Interior, and the U.S. Department of Agriculture. More specific information on these researches, and names of investigators are obtainable from the U.S. Mariculture Committee members.

Shellfish

Oyster

Demonstration of the value of genetics in molluscan culture studies (University of Washington).

Breed the fourth generation of American oysters selected for resistance to the MSX disease caused by Minchinia nelsoni infections (Rutgers University).

On the American oyster, 2-way selection experiment for post-setting growth rate; development and study of inbred lines; geographic and inter-species hybridizations (Northeast Fisheries Center, Milford, Conn., Laboratory).

Hard clam

Biochemical genetic and breeding structure of natural populations of hard clams (South Carolina Consortium, Virginia Institute of Marine Science, and University of Georgia).

Abalone

Assessment of sperm-egg interactions during fertilization and hybridization of the California abalone (University of California).

Crustaceans

Assess amount of biochemical genetic variation within and between wild-caught stocks of culturable marine crustaceans; develop lobster and shrimp broodstock in which the mating system can be demonstrated with biochemical genetic markers; estimate heritability of growth in laboratory-reared family groups (U. California).

In vitro fertilization and hybridization of the Malaysian prawn (South Carolina Sea Grant Consortium).

An evaluation of the nutritional value of three selected strains in finfish culture (U. Rhode Island).

Seaweeds

Application of genetic studies to production of the seaweed, Chondrus crispus (U. Maine and U. New Hampshire).

Salmonids

Salmon

Coho salmon stock development for marine pen culture (U. Washington).

Genetic interaction of Auke Creek, Alaska, hatchery pink salmon with natural spawning stocks (U. Alaska).

Stock development for pen culture and natural enhancement (U. Washington and Oregon State University).

Rainbow trout

Development of improved rainbow trout broodstock through strain hybridization; development of improved rainbow trout broodstock through hybridization of highly inbred lines; development and maintenance of a trout strain registry; thorough biochemical (electrophoretic) characterization of fish strains define relative amounts of inbreeding in tested populations, characterize the strains, and evaluate the degree of relatedness between strains. This strain characterization also includes lake trout, striped bass, Atlantic salmon, and channel catfish (U.S. Dept. Interior, Fish and Wildlife Service).

Brook trout

Development of strains suitable for survival in waters impacted by acid precipitation; estimation of heritability of tolerance to a challenge in acid brook water; extensive field testing of two wild x New York domestic strains (Cornell U.).

An investigation of the genetic impact of stocking a wild brook trout population using electrophoretic analyses (Iowa State U.).

Induced polyploidy in brook trout (U. Rhode Island).

In brook trout and lake x brook hybrids determinations of soluble protein types, their genetic bases, genetic linkage and cytogenetic relations, and pleiotropic effects; also the banding pattern of chromosomes. Use of these genetic traits in differentiating strains of trout. Study of the chromosomes of normal and sex-reversed fish with the intention of relating findings to studies of the evolution of trout genomes (Pennsylvania State U.).

Freshwater Fish

Catfish

An evaluation of channel catfish strains from widely divergent areas (Texas A and M University).

Heritability estimates of growth in channel catfish (Mississippi State U.).

Two-way selection between and within families of channel catfish for 40-week body weight and growth uniformity; development of inbred lines in an evaluation of inbreeding depression (Georgia Coastal Plain Experiment Station).

Replicated experiments to test diets against growth rate in four strains of channel catfish (Kansas State U.).

Crossbreeding of strains and evaluation of the hybrid strains of channel catfish (Louisiana State U.).

Establishment of a northern Michigan ecotype broodstock of a warm water channel catfish with concomitant selection for disease resistance, rapid uniform growth, and efficient food conversion (Michigan State U.).

Heritability and correlation estimates in channel catfish for head width, head depth, fork length, total weight, and dress-out weight for 30, 60, 90, 120, 150, and 480 days (Mississippi State U.).

Crossbreeding of populations of channel catfish from geographically isolated sources, testing of crossbreds among blue, channel, and white catfish (Auburn U.).

Tilapia

Crossbreeding between species of Tilapia to produce all-male broods; heritability estimates by half-sib analysis for length and weight in Tilapia nilotica from Africa (Auburn U.).

Evaluation of various species and monosex hybrids (U. Puerto Rico).

Striped bass

An evaluation of striped bass-white perch hybrids (with a determination of food preference of hybrid larvae) for use in aquaculture (U. North Carolina).

Yellow perch

Selection of yellow perch and other cool water species for adaptation to hatchery operations (U. Wisconsin).

Control of sexual differentiation (U. Wisconsin).

Cryopreservation

Of pike, trout, salmon and muskellege sperm, eggs, and zygotes (U. Minnesota).

Of striped bass sperm (North Carolina State U.).

Of yellow perch sperm (U. Wisconsin).

U.S. Aquaculture Data Resource Bank

It has been recommended (Natl. Res. Council Rept., Role of the U.S. Department of Agriculture in Aquaculture, 1979) that a central data resource in the National Technical Information Systems of the Science and Education Administration collect, collate, and disseminate aquaculture data, and provide aquaculturists with information. This would be on production, research, marketing, supply and price data, regulations, and consumer information. As of May 1981, this recommendation was being acted on.

Major New Publications of Use in Aquaculture Genetics

Note is made of Sewall Wright's (Prof. Emeritus, U. Wisconsin and U. Chicago, U.S. National Academies Sciences and Arts and Sciences) encyclopedic treatise, *Evolution and the Genetics of Pollution*, Vol. 3, *Experimental Results and Evolutionary Deductions*, 1977. This volume could be highly useful to aquaculture breeders as it is devoted primarily to experimental studies of populations in the laboratory and critically and exhaustively reviews results of classic selection experiments, publication of which is scattered about decades of scientific literature. Five chapters deal with inbreeding and cross-breeding and three with artificial and natural selection in the laboratory. Finally, the patterns of breeding used in development of livestock breeds are used as an intermediate between laboratory and natural populations. In addition, such topics as weight gain in relation to rations, genetic fitness in mixed and single species stands, and selection for resistance to injurious substances are discussed for classic experiments on experimental or well-studied agricultural species.

Attention is also called to a recent comprehensive review of cytogenetics of fish with particular reference to the salmonids (J. R. Gold, Genetics Section, Texas A and M University). This was included in *Fish Physiology VIII, Bioenergetics and Growth*, eds. W. S. Hoar, D. J. Randall and J. R. Brett, Academic Press, 1979. Part V of the review deals briefly with cytogenetics and fish culture and makes note of the work on induced gynogenesis of Cherfas in USSR and Mariculture Committee member Purdom in the U.K. Also discussed under the subsection "General Use of Karyology" is the possibility that chromosome abnormalities may be contributing significantly to reproductive failure in commercial fish species commonly attributed to physiological stress.

A recent review, "Fish Cytogenetics" by Y. Ojima, Japan, puts some emphasis on chromosome engineering, induced parthenogenesis and polyploidy in fish. This

appears in Proceedings Special Symposium, Present Status of Fish Genetics and Future Prospects of Breed Improvement", Japanese Society Scientific Fisheries, Japan National Academy Science, Koseisha-Koseikaku Publ. Co., Tokyo. The Symposium was translated to English by NOAA, U.S. Dept. Commerce, at the request of the Northeast Fisheries Center. Copies are presently available through ICES Mariculture Committee members.

Polyploidy is further the subject of a new (1980) book edited by W. H. Lewis, Washington University - "Polyploidy, Biological Relevance."