

The *Xiphophorus* Genetic Stock Center

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Introduction

Genetic stock centers are priceless resources in scientific research. Genetic experiments often require that special strains of genetically identical animals or plants be used to assure that results can be repeated in any laboratory and that differences are not due to environmental factors or to random variation found in almost any population of animals. Among vertebrates, genetically identical animals most often are produced by inbreeding for many generations between brothers and sisters; in each generation, about one-half of the genetic differences between the parents are lost. It comes as a surprise even to most scientists that one of the oldest and best defined groups of genetic strains consists of livebearing fishes of the genus *Xiphophorus*, the platyfishes and swordtails familiar to the tropical fish hobbyist.

In the 1920s, the American biologist Dr. Myron Gordon and German biologists Hausler and Kosswig independently discovered that hybrids of a particular strain of the platyfish *Xiphophorus maculatus* and the swordtail *Xiphophorus helleri* developed cancers virtually identical to malignant melanomas in man. They traced the origin of these tumors to pigment cells of a platyfish color pattern consisting of black spots on the dorsal fin. Genetic studies demonstrated that melanomas developed only in hybrids which had replaced both copies of a platyfish regulatory gene with swordtail forms which could not control proliferation of the platyfish pigment cells. This animal model was one of the first to prove that some cancers were inherited diseases; after 65 years, these fish still are used in cancer research in the United States, Germany, Canada, and Japan.

Dr. Gordon realized that to identify precisely the genes responsible for development of cancer, genetically identical platyfish and swordtails would be



needed. Therefore, in 1939, he established the *Xiphophorus* Genetic Stock Center, housed at the American Museum of Natural History and the New York Aquarium until 1993, when transfer of the stock center to Southwest Texas State University in San Marcos was completed. During its 55+ years, the stock center has been directed by Dr. Gordon and Dr. Klaus D. Kallman in New York, and currently by Dr. Ronald Walter (Southwest Texas State University).

Several of the original genetic strains of platyfish and swordtails developed by Dr. Gordon in the 1930s still are available today; they are virtual genetic clones, the products in some cases of more than 80 generations of brother-to-sister matings.

When Dr. Gordon began his genetic studies and field work in Mexico and Central America, only a half dozen species of *Xiphophorus* fishes were known to science. Today some 23 species have been described; representatives of all but one are maintained at the stock center. Ongoing field studies by Drs. Kallman and Morizot continue to discover new species, and are critical in future preservation of the increasingly valuable genetic resources of the genus. No fewer than eight species are confined to extremely small geographic areas and are potentially threatened by human habitat destruction; one species already has been listed as endangered and another until recently was thought to be extinct. The *Xiphophorus* Genetic Stock Center, by providing fish to the international scientific community for study, at the very least reduces collecting pressure on wild populations, and could in the future preserve the only living representatives of some species. As the science of conservation genetics has evolved, so have the breeding strategies of the stock center, away from generation of new inbred strains to maintenance of maximal natural variability in newly originated genetic stocks.

Services of the Stock Center

Genetic Stock Center provides fish from more than 70 genetic strains to scientists and aquarists around the world. Scientists in more than 30 laboratories in the United States, Canada, Mexico, Japan, and Germany work on *Xiphophorus* genetics and depend on strains available from the stock center. In addition to supplying strains and consultation on husbandry and genetic questions, the stock center makes custom hybrids for a variety of projects, producing hundreds of such fish each year at very affordable costs. Unlike most mammals, where fertile hybrids between species are difficult or often impossible to produce, *Xiphophorus* hybrids are almost always fertile and are extremely valuable for their genetic variability and their very specific susceptibilities for many different cancers. Extensive use of these hybrids for gene mapping has made the *Xiphophorus* gene map the fifth largest among vertebrates, exceeded only by maps of man, mouse, rat, and cow in numbers of genes assigned.

The beauty of many *Xiphophorus* strains has attracted tropical fish fanciers for decades. The demand among cogniscenti for extraordinary fish like X.

montezumae with a sword longer than its body, far exceeds the production capabilities of the stock center, but surplus fish are made available to aquarists when possible. The present stock center facilities hold some 1200 aquaria, balanced between 900 tanks for genetic stock perpetuation and 300 for hybrids for research projects. While this number may seem large, each new species or newly identified genetic strain necessitates some redesign of the overall management plan.

Quality control at the stock center must be impeccable to maintain integrity of the large numbers of genetic strains (even fish manage to escape, and a "jumper" can mean disaster). Most strains have been purposely bred to carry diagnostic morphological traits such as red and black pigment patterns. Each strain possesses a unique genetic "signature" which can be checked for assurance of stock purity. Individual broods are never mixed, and males and females are separated prior to sexual maturity. All parents of broods are preserved for later reference in the event of later questions. All these precautions take a great deal of time, but have been essential in maintaining stock integrity sometimes for 50+ years.

"Stars" of the Genetic Stock Center

Each of the 70+ strains of swordtails and platyfishes has some distinctive attribute, whether it is the only representative of a species, carries genes for susceptibility to a particular cancer, or produces all male or female offspring in certain matings. Only a few can be illustrated here to illustrate the amazing scope of *Xiphophorus* genetic research and the fascinating variety of its subjects.



Xiphophorus maculatus, from the Rio Jamapa, Veracruz, Mexico. Several of the Rio Jamapa (designated Jp) platyfish strains are direct descendants of fish collected by Dr. Gordon in Mexico in 1939. Two sublines, Jp 163 A and Jp 163 B, were derived from offspring of a single female and

have been inbred for 85 or more generations. Females carry spotted dorsal, spotted side, dorsal red, and shoulder spot pigment pattern genes on their X chromosomes, while males additionally carry striped side and anal red genes on their Y chromosomes. Both strains develop malignant melanomas in hybrids with swordtails; the melanoma from Jp 163 A spotted dorsal pigment cells is spontaneous, while the melanoma from Jp 163 B spotted side cells develops very rapidly only after irradiation with ultraviolet light. Several other strains, including a recently collected wild Jp strain without red or black pigment patterns but with a beautiful blue iridescence, have been developed at the center. These strains have been central in genetic studies of cancer for more than 50 years.



Southern *X. helleri* strain Cd, from Rio Jamapa, Mexico. The magnificent Cd swordtail is the oldest stock of the center, derived from fish collected in Mexico as early as 1930.

Because swordtails usually mature much more slowly than platyfish and reach much larger sizes, Cd now is nearing only its 50th generation of inbreeding. The genetics of its remarkable red, yellow, and green color patterns still are unknown, but in closely related strains orange or green sword coloration is controlled by a single gene on the Y chromosome. A peculiarity of the Cd strain is the occurrence every few generations of almost all-male or all-female broods, a source of constant anxiety in its keepers. No cause for this deviation from normal sex ratios in this genetically uniform fish has yet been identified.



Pygmy swordtail, *X. multilineatus*, Rio Coy, San Luis Potosi, Mexico. Many notable discoveries in ecological and behavioral genetics have resulted from studies of the pygmy swordtails. A sex-linked polymorphism at a sex hormone-related gene produces four sizes of males maturing at different ages, from 6-9 months old for the smallest gold males to more than one year old for the largest blue males. Behavioral studies have shown that females prefer the large males which exhibit elaborate courtship displays, rather than the small males which do not court but mate by sneak attacks upon females. This complex polymorphism also occurs in other swordtail and platyfish species. Several northern swordtail species, including *X. multilineatus*, are found only in one short river system and could easily become endangered through habitat destruction.



Montezuma swordtail, *X. montezumae*, Rascon strain, Rio Gallinas, San Luis Potosi, Mexico. For many years, the Montezuma swordtail of the aquarium hobby was actually a sister species, *X. nezahualcoyotl*, with a much shorter sword and body. The "true" Montezuma swordtail was rediscovered by stock center directors in Mexico in 1980, and has become a favorite among aquarists because of its spectacularly long sword. The black spotting of *X. montezumae*, unlike that of its sister species, is not due to a sex-linked gene and does not lead to pigment cell cancers in hybrids.

The Future of the Genetic Stock Center

Though *Xiphophorus* fishes are among the best studied vertebrates genetically, largely due to availability of well characterized genetic stocks, maintenance of large numbers of genetic stocks requires constant effort and substantial funding. Southwest Texas State University is providing excellent facilities and support for the stock center, but State funds for this institution are inadequate to insure maintenance of the center. Federal grants have helped support the stock center through purchase of fish for research, but an increasing share of the budget must be generated from tax-exempt donations. Operating a genetic stock center is a continuing program; lack of funding for a year would result in the loss of more than six decades of carefully controlled breeding. For security of these priceless genetic resources, the goal of the center is to raise three million dollars of

endowed funds to support stock center maintenance for many years into the future. This endowment would support all day-to-day operations and provide funds for gradual expansion to include newly discovered species and construction and maintenance of new strains. Only such a liberation from year-to-year funding crises can assure continued availability of these fascinating fish to scientists and aquarists of the future.

Donations

Contributions to the XGSC are always welcome and appreciated. Such funding helps insure that the center will continue to maintain a high standard of excellence in stock purity and species/strain preservation. Such contributions can be made by submitting checks to "The *Xiphophorus* Genetic Stock Center". The director of the XGSC can be directly contacted regarding such donations (see below). A formal receipt is promptly provided to the contributor(s) for tax purposes.

Contact Information

Requests for live *Xiphophorus* fish or questions regarding the *Xiphophorus* Genetic Stock Center, its operation and services should be forwarded to

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