The American Killifish Association

Killifish Conservation Program

The Killifish Conservation Program - Revision A. 1998

The following revision to the Killifish Conservation Program was undertaken to clarify certain aspects of the original program, provide a more formal administrative and operating structure, and introduce motivational, publicity and related elements. These changes are designed to further the progress of the Killifish Conservation Committee and to make it more accessible to the members of the American Killifish Association. The essentials of the original program remain unchanged, as does the objectives formulated by the founder of the KCC, Roger Langton.

Original Issue: Roger Langton, et. al 1992
Revision A: Charles A. Nunziata, et. al. 1998

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Introduction:

The Killifish Conservation Committee (KCC) consists of a cooperative effort on the part of members of the American Killifish Association to preserve a representative example of killifish fauna for future generations. Given limited resources, it is impractical to try to include all killifish species in this program. Because of this, a core group of species, representing several genera, will be chosen for breeding. The core list is under constant review and will be enlarged or shortened as knowledge and experience is accumulated. All members of the AKA are asked to join in this effort and enjoy the companionship of others devoted to this special project.

As the months and years go by it will become increasingly apparent that the tropical fish and related hobby industries will survive only to the extent that species are being successfully bred in captivity. If this is to be a long term success, it will be necessary for the aquarists and commercial establishments to breed fish in a manner that will maintain genetic diversity over decades and centuries, and this necessity will remain the ultimate goal of our breeding programs.

There are about 24,000 fish species that have been named. It has been estimated that from 20% to 40% of these species are in danger of becoming extinct by the year 2050. Since most of the captive breeding efforts are currently focused on saving endangered mammals, the amateur aquarist will find opportunities to take the lead in preserving for posterity fishes that can be successfully bred in captivity. Conservation resources are very limited and fish are likely to be neglected, with many species going extinct unnoticed. A likely outcome of working to save the hobby will be that more and more fish that are extinct in nature will be found only in the tanks of aquarists. The amateur will thus be performing the important conservation goal of helping to preserve the earth's biodiversity. It is hoped that the current and future conservation aquarists will earn respect by becoming an important part of the legal process that acts to ensure the survival of endangered species.

Every local, national and international aquarium society is urged to initiate a program to encourage conservation. No doubt only the most dedicated will manage to do the job and you are encouraged to be among them. The purpose of this program is to assist conservation aquarists who are committed to achieving these goals, and to provide a coherent program to the members of the American Killifish Association to achieve that goal.

General Information:

The following program was designed to facilitate the organization, administration and the conservation methodologies necessary to preserve a representative example of killifish fauna for future generations.

The KCC program provides a general framework within which specific teams of volunteer's function to protect specifically selected killifish species. A Species

Coordinator coordinates the activities of each team. The activities of each Species Coordinator within a genus are, in turn, coordinated by a Genus Coordinator, and that of the various Genus Coordinators by the Chairman of the Conservation Committee.

This program includes criteria and methodologies by which core species, representative of their respective genera, are selected, specifies the duties and requirements of coordinators and volunteers, outlines operating methods, and provides appropriate reference information.

In addition, the program provides for a special fast reaction team to address emergency situations. This subprogram, known as the Emergency Survival Program (ESP) has its own set of objectives, procedures and criteria. This program and its subcommittee is organized to identify species that are endangered or already extinct in the wild, and to organize captive breeding programs to conserve them.

This document is organized as follows:

Section 1: The Conservation Program
Section 2: Organization and Administration
Section 3: References and General Information

Section 1:
The Killifish Conservation Program

The Core Species Program
The Core Species propagation activity is the central activity of the KCC at large, and represents the primary mission of this effort. Ultimately, each genus, or group of closely related genera should be represented by one or more core species. Since it is unrealistic to attempt to conserve every species, the judicious selection of a few which express the essential characteristic of the genus will leverage limited resources to their maximum benefit.

The Chairman and coordinators will conduct and evaluate research to determine the status of a potential target species. From this evaluation, one or more candidates are submitted to a Core Species Selection Board for approval. This selection board consists of volunteers from both within and outside the A.K.A. who possess the expertise necessary to an effective selection process.

The program is initiated with the following target genera: Aphyosemion, Fundulopanchax, Cynolebias and related genera, Epiplatys, Nothobranchius and Rivulus.

Objectives:

1. The mission of the KCC is to promote, stimulate, motivate, and otherwise educate AKA members about conservation and how it can become an interesting part of the hobby.

2. The KCC will establish captive breeding populations of killifishes to preserve them for the next generation.

3. The KCC will organize and administer captive breeding populations of a manageable number of species that are representative of the killifish fauna as a whole. A database will be developed to track the status of these "core species" in the hobby.

4. The KCC will design and implement a model for a breeding program that will have a high probability of conserving the genetic diversity of captive killifish populations. Methods for both individual and group efforts will be developed. Guidelines will be written in a handbook that will be made available to all participants in the KCC program.

5. The KCC will develop an Emergency Survival Program (ESP) and a supporting subcommittee to identify species that are endangered or already extinct in the wild, and to organize captive breeding programs to conserve them.

6. The KCC will inform the AKA membership of the status of killifish habitats, giving special attention to areas that are most threatened by human activities. These reports will

be published as appropriate in JAKA, the BNL, or in a KCC Newsletter to be inserted in either of these publications.

7. The KCC will work with AKA Affiliate Clubs to help them establish breeding programs and encourage them to participate in breeding the selected core and ESP species.

8. The KCC will work closely with the Aquatic Conservation Network and other conservation organizations, institutions, or groups to disseminate information and develop joint breeding programs.

9. The KCC will develop incentives or awards to acknowledge and reward participants in the breeding program.

Core Species Team
The establishment of each core species is implemented by a Species Coordinator, also known as Stud Book Keepers who, together with the Genus Coordinator, will assemble a team of breeders who will propagate the species in accordance with the conservation requirements and established procedures.

Breeding stock is secured and distributed among the team members. Additional stocks are periodically obtained through breeders outside the program, collectors or other sources to accomplish the goal of maintaining genetic diversity to the greatest extent possible.

In addition, individual aquarists may not have the tank space required to breed fish in the manner suggested to preserve genetic diversity and as shown in the model presented in Section 3. Nonetheless, a group of aquarists, working in concert, can make progress toward fulfilling that model by exchanging stocks at least annually, and by spreading the progeny of new stock among the older stocks in the program. This periodic exchange activity as well as the timely introduction of fresh stocks from sources outside the group will tend to preserve genetic diversity of the core species to the degree possible under aquarium conditions.

The KCC Breeding and Maintenance Program
The KCC breeding program is founded on the goal of propagating the core or ESP species and preserving its genetic diversity. The character and complexity of the breeding program is determined by the resources and number of participants in each breeder team as well as the availability and propagation difficulties of the target species. Although the Genus and Species Coordinators are guided by the methodologies discussed in Section 3, they will determine the best mix of procedures to be employed for each Core and ESP selected species.

Stages in Establishing a Core Species:
In order to determine the degree of progress being made with a particular species, it is useful to break down the process into a series of stages. In this way the Species Coordinator will be able to more easily communicate the degree of progress being made.

Stage One: A species has been identified as a core species but no progress has been made in identifying founders or people willing to do the breeding.

Stage Two: At least 6 unrelated pairs have been located and are identified as founders of the captive breeding population. A Breeder Team has agreed to participate in the breeding program and is in possession of the founders.

Stage Three: A least six pairs have spawned and fry, representing each of the found pairs, are being raised. Plans are being made about how to spawn the next generation in order to maintain genetic diversity and actions implemented to swap fish among team members to assure the widest dispersal of the available gene pool.

Stage Four: Excess pairs are distributed to reliable breeders. Including the six pairs chosen to produce the next generation, at least 20 pairs exist among participating aquarists. In addition, new blood from unrelated sources are introduced into the group.

When a species reaches stage four, it is considered to be established. Ideally, once a species has reached the final stage, it will stay in that position indefinitely. In reality, some species will probably fall back to earlier stages for any number of reasons. The fewer individuals with the fish, the more likely the species will be in trouble if an individual drops out or an "accident" occurs, e.g. disease or natural disaster. Therefore, the size of the breeder team will be maintained so that the usual forms of life's events will not erode the status of the core or ESP species.

Core Species Selection Criteria:
The core species are selected by either of two procedures: By a Core Species Selection Board, appointed by the KCC Chairman, as provided in Section 2., or in response to a petition by an individual or group for the inclusion of a particular species, the Chairman may issue a directed decision to include the species, or submit it to the Core Species Selection Board for recommendation. The Core Species Selection Board will conduct investigations, research and similar activities for the purpose of constructing a preliminary shortlist of Core Species candidates. All species selected, regardless of the selection method, must satisfy the KCC Core Species selection criteria defined below.

Candidates should fulfill <u>one or more</u> of the following equally valid criteria.

> The species is considered a representative phenotype of a larger group of similar or closely related killifish.
>
> The species is unique, showing little or no relationship to other killifish species or

groups (e.g., the only species of a genus, such as Adamas formosus or Lamprichthys tanganicanus.

The species is vulnerable to extinction because of a small natural range.

Candidates must meet all of the following criteria:

The collection locality or region should be known to avoid crossbreeding with genetically different and possibly incompatible lineages.

There is an expectation that the maintenance requirements of the fish are feasible with current aquarium technology, and that the fish can be bred under aquarium conditions.

The fish is or will soon be available in the hobby, and is not highly inbred.

The Emergency Survival Program (ESP)
The ESP Species propagation activity is an ancillary activity of the KCC whose sole purpose is to respond to emergency situations where killifish species are in immediate danger of extinction. As in the Core Species Program, one or more candidate species are submitted to a similarly appointed ESP Selection Board for approval.

The ESP selection program is designed to facilitate the organization, administration and the conservation methodologies necessary to respond quickly and effectively to an emergency situation, and to establish stopgap maintenance and breeding activities to preserve the loss of the target species.

Based on available information, the ESP Chairman will recommend candidates to a Selection Board for approval, upon which a series of activities are initiated to acquire and establish a breeding population. At the appropriate time, the target species will be transferred to the appropriate Genus Coordinator for establishment as a Core Species.

Objectives

1. Determine which species of killifish are at greatest risk of extinction.

2. Compile a list of candidates of endangered killifish, which are best suited for a captive breeding program.

3. Identify sources for the selected fish, and secure founding stock for the ESP program.

4. Establish a breeding group for each endangered species.

5. Gather and disseminate available maintenance and breeding information to aid in the propagation of the target species.

6. Provide timely reports on the status of the ESP species and its habitats.

ESP Species Team
The ESP breeding team is a volunteer group of expert killifish breeders who are organized as a standby unit ready to provide resources and breeding expertise immediately upon receipt of ESP target species. The team members are appointed by the ESP Coordinator, and are charged with the task of establishing a stable population of the ESP target species as quickly as possible.

The ESP Breeding and Maintenance Program
The ESP KCC breeding program is founded on the goal of establishing a breeding population of the endangered killifish as quickly as possible to both forestall the extinction, and to provide a sufficient number of breeders so that the Core Species process can be initiated.

The character and complexity of the rescue program is determined by the resources and number of participants available. The endangered fish acquired are distributed to those members of the ESP team with the most experience and skill in handling the particular species. Operationally, this team thereafter acts in the same manner as the Core Species teams noted above. Breeding stock is secured and distributed among team members, and additional stocks will be periodically obtained through breeders outside the program, collectors or other sources to accomplish the goal of maintaining genetic diversity.

Stages in Establishing an ESP Species:

Stage One: A species has been identified as in immediate danger of extinction, but no breeding pairs have been secured.

Stage Two: At least 6 pairs have been located and acquired, and a member or members of the ESP Breeding Team are successfully maintaining and breeding the fish under aquarium conditions.

Stage Three: At least six pairs have spawned and fry, representing each of the founding pairs, are being raised.

Stage Four: Firm schedules have been established for the transfer of the species to the appropriate Core Species Coordinator.

ESP Species Selection Criteria:

1. The species is in imminent danger of extinction or is already extinct in the wild.

2. The collection locality or region is known to avoid crossbreeding with genetically different and possibly incompatible lineages.

3. There is an expectation that the maintenance requirements of the fish are feasible with current aquarium technology, and that the fish can be bred under aquarium conditions.

4. The fish is available in the hobby at this time or will soon be in sufficient numbers and is not highly inbred.

Support Programs
The following set of provisions are designed to support the success of the KCC, to enhance its communications with the membership at large, and to further the cause of killifish conservation. In general, provisions are made for volunteer incentives, and the promotion of support among the general membership.

Publications
The primary purpose of KCC published material is to educate the general membership in the necessity for killifish conservation, to recruit active participants for Core and ESP Breeder Teams, and to report on the status of the various species. The following types of communications will be published in the BNL or JAKA.

Genus or species committee reports.
Conservation articles written by Coordinators
Core species breeding and maintenance articles – successes and failures
Rescue Reports - the Proceedings of the ESP Subcommittee
Field reports and the results of research conducted as part of the Core or ESP Species selection process.
Endangered Species Alerts
Literature reviews

In addition to the above, a recruitment brochure, essentially a summarized version of the program will be made available for distribution at the annual convention and regional shows.

The generation of the above referenced materials is included as a function of the individual genus and species coordinators as is part of their normal and ongoing efforts to broaden the participation in the KCC program. See Section 2. For operational details.

Motivational Program
The purpose of the KCC motivational program is to enhance the interest among volunteers and potential volunteers in the necessity for killifish conservation, and the belief that a "greater good" can be achieved through the success of this program. The Chairman may institute, implement or otherwise arrange to provide member oriented motivational programs to further the educational imperative.

Some motivational vehicles which may be implemented include the following:

A.K.A. Conservationist of the Year Award.
A general award for the person who most effectively represents the idea of killifish conservation, and furthers the effort of killifish conservation in general. This award can be bestowed on anyone, and is not limited to members of the KCC or the A.K.A.

KCC Member of the Year Award:
An award to the member of the Killifish Conservation Committee who most effectively furthered the effort of killifish conservation in general, and the effectiveness of the Killifish Conservation Committee in particular.

Membership cards, certificates or other identification paraphernalia.

A Quarterly Newsletter:
A communication vehicle for KCC members summarizing the activities of the committee. To encourage interest, the newsletter should be distributed to the general membership via the BNL or JAKA.

Semi-annual publication of the names of all participants in the BNL

Public recognition of specific achievements

Integration with the American Killifish Association

Affiliate Clubs of the A.K.A.
The Affiliate Clubs will be recruited to adopt one or two Core Species as a club project. A publicity package shall be provided and promoted via mailings and personal contact with Affiliate Club officials outlining how the Affiliate Club can participate as a member of a Core or ESP Species conversation program. In addition, the Affiliate Club will be urged to recruit individual members to participate, and to promote killifish conservation as part of its ongoing functions.

AKA Programs and Committees:
The KCC Chairman will work with the Killie Hobbyist of the Year Program and the Killifish Award Program to integrate the principles of killifish conservation into their award structure.

Relationship to other conservation organizations

The KCC will establish contact and maintain relations with other conservation organizations. This relationship may include membership, subscription and other appropriate associations, or may take the form of general communication.

Relevant information that results from this relationship shall be made available to the members of the KCC and the general membership through the publication channels noted above.

Section 2:
Mission, Duties and Responsibilities of the KCC Chairman and Coordinators:

General Requirements, Duties and Responsibilities of the KCC Chairman and Coordinators:

The KCC Chairman and the Genus, Species and ESP Coordinators shall be A.K.A. members in good standing, and shall possess management, communication and leadership skills, have substantial experience in the killifish hobby, have a broad array of contacts within the hobby, and hold a position of respect and recognition among the general membership of the A.K.A. They shall have a working knowledge of the technical issues associated with the maintenance of fish species, genetic diversity, effective breeding programs and be capable of integrating those requirements with the available resources.

It is the responsibility of the Genus, Species and ESP Coordinators to contribute to the production of articles, reports, alerts or similar publications. Specifically:

> Provide semiannual reports to the Chairman of the KCC, and other parties authorized by the KCC Chairman on the progress and effectiveness of the Core and ESP species programs, and the status of each core species within the particular genus.
>
> Provide at least one article each year for publication by the AKA related to the KCC activities for the genus for which the coordinator is responsible.
>
> Provide emergency alerts as necessary when the maintenance of a core species is endangered, or otherwise in need of assistance to further the core species program.
>
> Agree to promote the KCC through writings, speaking engagements or other activities designed to aid publicity efforts.

The Coordinators shall keep and maintain records sufficient to review the activities of the Core and ESP Breeder Teams for the use of future administrators.

The Core and ESP Species Selection Boards:
The Chairman, together with the ESP or Genus Coordinators, shall appoint people from within and outside the A.K.A. to serve on the ESP and Core Species Selection Boards. The Selection Board must be chaired by an A.K.A. member in good standing. The board shall be constituted with as many members as the Chairman determines is appropriate for the task, but in no case shall more than 30% of those selected be non-A.K.A. members. Coordinators are required to serve on their associated ESP and Core Species Selection Boards, and may at the discretion of the Chairman, serve on any number of other Core Species Selection Boards.

The KCC Chairman:

Mission:
Manage the resources of the KCC for the purpose of implementing the KCC program, its goals and objectives, and to promote A.K.A. and member support of the KCC program

Duties and Responsibilities:

Appoint Genus Coordinators, and the ESP subcommittee Coordinator.

Together with the ESP or Genus Coordinators, appoint people from within and outside the A.K.A. to serve on the ESP and Core Species Selection Boards as provided

Approve the selection of Core and ESP species.

Coordinate the activities of the KCC Genus and ESP Coordinators, and various selection committees in the process of selecting Core Species and ESP target species, and assure that such selections are made in accordance with the provisions of the KCC program.

In conjunction with the Genus, Species and ESP Coordinators, facilitate securing breeding stock, the distribution of such stocks, and the establishment of relationships with breeders, collectors or other sources of breeding stock as necessary to accomplish the goal of maintaining genetic diversity.

Direct and monitor the ongoing operational activities of the Coordinators and assure that such activities are in accordance with KCC program provisions and the Coordinator's duties and responsibilities as herein defined.

Contribute to and/or arrange for the production and publication of articles, reports, alerts or similar publications utilizing KCC personnel or people outside the KCC willing to contribute to this effort. Specifically:

> Provide periodic reports to the A.K.A. BOT as directed and as necessary to support the KCC program.
>
> Assure that the Genus, Core Species and ESP Coordinators supply reports on the progress and status of the individual core species and ESP program.
>
> Provide at least one article each year for publication by the AKA related to the KCC activities.
>
> Provide emergency alerts as necessary when the maintenance of a core or ESP species is endangered, or otherwise in need of assistance to further the KCC program.

Agree to promote through writings, speaking engagements or other activities designed to aid publicity efforts on behalf of the KCC.

Keep and maintain records sufficient to review the history of the KCC efforts for the purpose of continuity, and for the use of future administrators.

Establish and maintain communications with the committees of the A.K.A.

Evaluate how the KCC program, the idea of species maintenance, and the preservation of genetic diversity can be expressed in the operations of other KCC committees.

Present specific proposals to the A.K.A. BOT and committee chairpersons on integrating the goals and objectives of the KCC in the operations of their committee.

Manage, implement and establish motivational vehicles as herein defined.

Establish communications with other fish conservation oriented organizations, and recommend actions in support of developing such relationships.

The Genus Coordinator:
In addition to the general requirements noted above, the Genus Coordinator shall possess particular knowledge and expertise in the characteristics, maintenance requirements, breeding techniques, nomenclatural relationships, history and status of the genus for which he or she is responsible.

Mission:
Manage the effort to conserve and maintain the characteristics of the selected Genus through the administration of the relevant Core Species Coordinators.

Duties and Responsibilities:
Together with the KCC Chairman, appoint people from within and outside the A.K.A. to serve on a Core Species Selection Board as provided.

Coordinate the activities of the Core Species Selection Board in selecting each core species and assure that such selections are made in accordance with the provisions of the KCC program.

Conduct investigations, research and similar activities for the purpose of constructing a list of Core Species candidates in accordance with the KCC Core Species selection criteria. From this evaluation, the Genus Coordinator will recommend one or more Core Species candidates to the KCC Chairman and the Core Species Selection Board for approval.

Appoint Species Coordinators, also known as Stud Book Keepers, one for each selected core species, and aid the Species Coordinator in establishing their Breeder team.

Direct and monitor the activity of the Species Coordinators and assure adherence to the requirements of the Species Coordinator as defined in the KCC program.

Facilitate securing breeding stock, the distribution of such stocks, and the establishment of relationships with breeders, collectors or other sources of breeding stock as necessary to accomplish the goal of maintaining genetic diversity.

The Species Coordinator or Stud Book Keeper:
In addition to the general requirements noted above, the Species Coordinator shall possess particular knowledge and expertise in the characteristics, maintenance requirements and breeding techniques of the species for which he or she is responsible.

Mission:
Manage the effort to conserve and maintain the selected core species through the administration of the Breeder Team.

Duties and Responsibilities:
Appoint and coordinate the activities of KCC members who volunteered to maintain, breed, and conserve the selected Core Species.

Direct a breeding program among the Breeder Team members in accordance with the Core Species breeding program requirements. Assign teams or make other arrangements among members so that in the aggregate the technical requirements of the Core Species breeding program are met to the greatest extant possible.

Monitor breeding activity, and arrange periodic trades to maximize genetic diversity to the greatest extent possible.

Facilitate securing breeding stock, the distribution of such stocks among the Breeder Team members, and aid the Genus Coordinator and KCC Chairman in establishing relationships with breeders, collectors or other sources of breeding stock as necessary to accomplish the goal of maintaining genetic diversity.

The ESP Coordinator:
In addition to the general requirements of the coordinators, the ESP Coordinator shall have the ability to react to an emergency, and to establish a rescue effort quickly and effectively.

Mission:
Manage the effort to provide an emergency resource by which identified species are acquired and populations established for the purpose of conservation and maintenance.

Duties and Responsibilities:
Together with the KCC Chairman, appoint people from within and outside the A.K.A. to serve on an ESP Selection Board, as provided

Coordinate the activities of the ESP Selection Board in selecting each ESP target species, and assure that such selections are made in accordance with the provisions of the KCC ESP program.

Conduct investigations, research and similar activities for the purpose of constructing a preliminary shortlist of ESP candidates in accordance with the KCC ESP selection criteria. From this evaluation, the ESP Chairman will recommend one or more ESP candidates to a Selection Board for approval.

Secure and appoint a team of ESP emergency maintenance volunteers as a standby resource for the purpose of establishing and stabilizing breeding stocks of the selected ESP species.

Together with the members of the ESP Subcommittee, locate sources for the selected ESP species, and secure starter stocks to initiate the "Rescue" stage of the ESP program.

After the target species is established, the ESP Coordinator shall facilitate the transfer of established ESP species to the cognizant KCC Genus coordinator for incorporation in the Core Species Program

The Member Volunteer:

General Notes on Member Participation:
The KCC program is designed so that anyone who wishes to participate can do so to whatever degree the individual's interest and resources allows. The member may effectively contribute to the KCC effort with just one tank because his or her contribution is merged with that of others into breeder teams, or groups of mutually supporting members whose efforts are managed by the Core Species Coordinator.

The individual member is asked to agree to the following:

1. Participants agree to adhere to, support and otherwise participate in achieving the objectives of the Killifish Conservation Program, to support the operations of the Killifish Conservation Committee, and to fulfill member responsibilities related to the Breeder Team to which they belong.

2. Individual participants agree to help locate core or ESP species, and to provide for or otherwise accept at least two pairs of genetically unrelated individuals to be used as founders for the core species program for which the member has volunteered.

3. Participants agree to provide the resources to maintain and breed the selected species for which he or she volunteered, and will make every effort to coordinate such activities with the other members of the species group, and with the Core Species or ESP Coordinator.

4. The member agrees to breed the fish in accordance with the general procedures and requirements presented in this program and the specific breeding instructions and resource requirements as determined between the Core Species or ESP Coordinator and the individual member, and other members of the Breeder Team.

5. The member agrees to offer the right of first refusal for excess core species fish to the Core Species or ESP Coordinator for an agreed upon price. These fish will be used exclusively to meet the needs of the KCC, and their distribution will be determined by the Core Species or ESP Coordinator.

6. The member agrees to keep accurate records and to complete and return data sheets provided by the Species, Genus or ESP Coordinator in the required time.

7. If the member cannot continue to keep the core species, the member agrees to offer the fish at an agreed upon price to the Species, Genus or ESP Coordinators for distribution.

8. The member agrees, if possible, to make provision for the care of the fish in the event of incapacity or death.

9. The member agrees to contribute to the greatest extent possible, articles, reports or other publications in support of the KCC program.

Section 3:
Reference Information

The material contained in this section is incorporated from the original KCC Handbook. This section provides background information, relevant theories, long term guidelines, breeding procedures, and discussion points regarding the purpose and necessity for a killifish conservation activity. It is a general treatment, and not necessarily representative of a preferred viewpoint. For our purposes, it provides a concise and readable introduction to the subject of conservation and the idea of preserving genetic diversity. A deeper study of the underlying issues is recommended to all members. The short bibliography provided is merely an introduction to the large body of published work that exists on the relevant issues.

Breeding for Genetic Diversity

General Information

Much of the research regarding genetic diversity has been done during the last 20 years. The author has drawn heavily upon the contents of two journals, Zoo *Biology* and *Conservation Biology.* Both of these journals contain research useful in planning a program for maintaining genetic diversity among captive bred animals. It should be kept in mind that most of the research has been done on mammals with little specific information about fish. Still, the principles are basically the same. It is not the intent of this article to present a comprehensive explanation of the science of genetics but a few general principles should be kept in mind.

When a male and female fish come together to spawn, both individuals makes a genetic contribution to the offspring. Both animals make different contributions. In other words, males carry different genetic material than females and vice versa. Breeding seven males with three females will pass on a smaller gene pool than would result from spawning five males with five females. Sutcliffe (1992) has shown that three males and seven females (or vice versa) will result in an effective breeding population equivalent to 8.4 individuals, while five males and five females will represent an effective population of 10. Effective population refers to the number of individuals that actually participate in breeding, not simply the total number in a particular population. This is an important consideration when beginning a breeding program designed for long-term maintenance.

Alleles is the term used to refer to the specific genetic variation that is exchanged from the genes. In other words, "each gene within each locus may exist in one of several variations- alleles". (Tudge, 1992.) Some alleles are fixed and will always produce the same result while others are variable and there may be several possible outcomes. One allele might give your fish tolerance to a certain disease or the capacity to adapt to cooler than normal water temperatures. Thus you will find genetic variation among fish that otherwise look identical. The more offspring a pair produces the more likely it is that all the genetic variation available in the two fish will be passed on to the next generation.

Alleles can be lost over time. This natural phenomenon is referred to as genetic drift. An allele may become rare in a natural population, and if by chance none of the fish possessing the rare allele get to breed, the genetic information is lost and will probably never be regained. Since most natural populations are genetically variable, genetic drift is likely to be countered by other forces acting on those populations.

Although this is a natural process, the loss is accelerated when inbreeding occurs. Siblings can only pass on what was given to them by their parents. Inbreeding changes combinations of alleles (genotype) resulting in diminished genetic diversity. A point will be reached when the species is probably doomed to extinction. Infertility, deformity and susceptibility to disease are among the possible consequences. Thus, if a captive species is to remain viable, a large gene pool is desirable. The longer the species is to be maintained, the greater the need to breed the species in such a way as to conserve a large percentage of the genetic diversity. Theory suggests (Ralls & Ballou 1986; Tudge 1992) that a population of 500 individuals of equal sex ratio is needed for indefinite survival.

If your goal is to keep fish for a long period of time, you need founders that are unrelated. Founders are the original parents of your captive generations. The more founders, the more genetic diversity will be available for future generations.

Hybrids (offspring resulting from the crossing of two different species) are to be avoided because they do not represent the fish as it exists in nature and are seldom viable for very long. For conservationists, producing hybrids is a waste of time except for scientific research in determining relationships among species. Hybrids should not take precious time, space and effort that could otherwise be used for conservation efforts. Obviously hybrids should never be mixed with pure populations but the danger exists if they are in the fishroom. It is prudent that hybrids not be allowed to exist in the same area if there is any danger of contaminating a valuable gene pool.

In addition, breeding between subspecies should be avoided because they are often adapted to different environmental conditions. This is especially true for fish that will eventually be returned to their natural habitat. Breeding between subspecies might be done as a last resort to save a species from extinction, but not as a general rule. One need only look at the confusion found among discus breeders as to the origin of their fish. The well-know discus breeder Schmidt-Focke (1990) has recently warned aquarists to stop mixing these fish and to get back to breeding pure species and subspecies. Otherwise this magnificent fish may be lost to the hobby.

Does this mean that if only one pair of fish is available that it is useless to try and conserve them? No, you should try because you might get lucky. For example, all of the hamsters currently kept by thousands of children and grownups came from one pregnant female. Just take a look at the variability found among them. Some of the desert pupfish, such as Cyprinodon diabolis, are genetically identical due to hundreds of years of inbreeding (Turner, 1974) and yet persist as a viable population. Because of this variation in tolerance to inbreeding, efforts should be made even when the founding population is small. Still, as a general rule, it is best to breed fish in a manner that will preserve as much genetic diversity as possible.

Ideally, preserving genetic diversity in a captive population means that you start with a founding group that carries within it most of the gene pool found in nature. Unfortunately this is not always easy to achieve. Part of the difficulty lies in the fact that most aquarists do not keep records regarding breeding lines. Even if you obtain fish from different hobbyists who live in various geographical areas, it is not unusual to find that all fish came from the same parents. In some cases, one pair has produced all captive fish of a certain species. In practice it means that you start out with fish that are available. Still, every effort should be made to obtain fish that are genetically unrelated. This will increase the odds that the gene pool will be larger than it would be if inbreeding has occurred.

Theory suggests (Ralls & Ballou 1986) that you need from 6-12 unrelated founder fish of an equal sex ratio to have a good chance for success over an extended period of time. Using this relatively small number of founders will likely mean they are not representative genetically of wild populations and the effects of inbreeding will lead to a fairly rapid loss of genetic diversity within a few generations. In addition, it may be unrealistic to believe aquarists can create an artificial environment that will provide the same selection pressures encountered in nature. The end result may be a species genetically very different from those found in the wild. The number of founders used to begin the captive breeding program will depend upon the specific goals of the program (e. g. returning a fish back into its natural range versus maintaining the fish for the aquarium trade) as well as the availability of breeding stock.

If your goal is to maintain a viable population during your lifetime as an aquarist, then here is a suggested procedure that should produce good results for at least a 40 year period. This example starts with a founding population of eight individuals, four males and four females. If all goes well a core breeding population of 32 individuals (16 males and 16 females) will be the effective population that contributes to each subsequent generation. This model can be easily modified upwards or downwards depending upon the goal to be achieved. Perhaps an effective breeding group of 500 individuals is necessary for a population to be maintained indefinitely while fewer than eight founders would work well for aquarists with more modest goals. Working with a group of aquarists is advisable when the tank space each person can contribute is limited. Cooperating groups can exchange fish from time to time to expand the gene pool. Space, time, commitment and life's circumstances will eventually determine what is accomplished.

For the purpose of going through the proposed breeding process, Fundulopanchax gardneri nigerianus, a well known killifish, will be used as the species being maintained. Some species will be much more difficult to maintain than others but many fish can be successfully maintained using this method. This model will be a combination of random and manipulated breeding procedures designed to insure genetic diversity for a 40 year period.

The set up requires 20 tanks and several small containers for egg incubation and for housing fry during the first few days after hatching. Fp. gardneri nigerianus will require eight 21/2--gallon, four 20-gallon and eight 10-gallon tanks. For most purposes it is better to err on the side of larger rather than smaller tanks. (See figure 1.)

The first step is to set up four 21/2-gallon tanks for the founding breeders. Each tank will contain a spawning mop and a sponge filter. Tanks are labeled A, B, C and D. The breeding pairs from the eight founding individuals are chosen randomly. No effort should be made to make judgements about which are the most desirable specimens etc. It is assumed the fish are healthy and in prime condition. Obviously, all eight founding fish are used in the breeding program. Keeping in mind the data required to fill out the studbook (brood numbers etc.) will make the record keeping requirements easier.

Eggs are picked from the spawning mops and water incubated in petri dishes or other appropriate containers. Each container is labeled A, B, C, or D to keep the source of the eggs accurate. It is important to pay attention when putting eggs in containers or eggs from more than one breeding line can accidentally get mixed. When the eggs hatch, in about 14 days, the fry are placed in appropriate containers until they are eating well and ready to be transferred to larger quarters. Again, the containers should be labeled accurately. It is desirable that at least 30 fish from each pair be produced. In the case of Fp. *gardneri nigerianus,* this should not prove to be difficult.

When the fry are ready, they are put in the appropriate 20-gallon tank and raised to breeding size. The rearing tanks should be labeled to keep track of breeding lines. The fry produced by breeders labeled A should be placed and reared separately in a rearing tank labeled A. Fry from tank B go into rearing tank B and so on for all four breeding lines. These fish will be considered the F1 generation relative to the founding individuals and will eventually become the parents of the F2 generation and so on.

Because genetic drift is likely to occur with each generation, it is important to have some patience and not breed the fish too early. The idea here is to produce no more than one new generation each year. If you breed fish at intervals of eight months, 60 generations will be produced in the 40 year period causing a greater loss of genetic diversity than would be the case if one generation is produced each year. Of course, some fish, such as South American annuals, will need to be bred more often if they are to reproduce during their prime. Other fish will be commonly bred every two years or even longer intervals. For *Fp. gardneri nigerianus,* one year seems appropriate. In addition, it is likely that some genetic information will be lost as a result of adapting to the aquarium environment, especially after several decades of breeding.

When the F1 offspring are near full maturity, four males and four females should be chosen randomly from the same breeding line and placed in a 10-gallon tank. The only selection to be used is to avoid deformed or diseased fish. This should be done for each of the four breeding lines with each tank being carefully labeled A, B, C, or D. When all four 10-gallon tanks have four males and four females from the four founding pairs, you will have a core of 32 fish. It is this core of breeders which will participate in producing the next generation, that will provide the genetic viability of your species. It is wise to keep the remaining fish in the 20-gallon tanks in the event that the fish chosen for breeding die or become diseased. Redundancy is an important aspect of this process and especially important if the fish is extinct in the wild. After the conservation requirements are met, the excess fish can be distributed to other aquarists.

At this point it is important to emphasize that fish used to produce the next generation be chosen randomly. Although selection may counter the effects of inbreeding to a certain extent, the question remains as to what you select for? Selection causes genetic change and there may be correlated responses that produce other, less desirable characteristics. Because of this risk, a random approach is recommended in this model.

After the core breeding stock has reached one year of age, the fish should be bred to produce the F2 generation. Remember that all 32 fish will be used to pass on their genes to the next generation. This may seem difficult to accomplish but with a little planning it can be done within the framework of a diverse and active life. The founding breeders are now held in reserve in case of serious problems with the offspring (redundancy). Otherwise they can be used to produce fish and eggs for distribution; this latter activity should be kept separate from the core program. By the time you are ready to spawn the F2 generation, the founding breeders may have died or be past their prime, i.e. *Fp. gardneri nigerianus* example.

The next step is to set up four additional 21/2-gallon tanks to house the F1 breeders. A suggested pattern would be as follows: A randomly chosen pair from the A and B lines (e.g. a male from tank A and a female from tank B or vice versa.) are set up in the new breeding tank which becomes the new tank labeled A. A pair from the B and A lines is set up in a tank labeled B. A pair from the C and D lines is set up in a tank labeled C and a pair from the D and C lines is set up in tank labeled D. It is important to keep track of which two lines are being bred in tanks A, B etc. These same patterns are repeated until each of the 32 core individuals has been used for breeding. Since breeding lines A X B and B X A (the same is true for C X D and D X C) use the same two sources to produce the new breeding lines, be sure to breed only four fish from each established line. Four fish will be used from line A and four from line B to produce the new Line A. The same is true when producing the new line B. Four fish from line C and four from line D will produce the new line C. The same is true for the new line D. (See figure 2.)

It is not necessary to breed fish in all possible combinations. It can be done, but is more than most aquarists can handle and is not required for the 40 year model being presented.

It's important to emphasize that males and females are to be chosen randomly for this second round and all subsequent rounds of core breeding. Once a given pair has produced four or five viable eggs, a second pair, using the same random procedure can be placed in the spawning tank. Keep this up until all fish in the 32 core program have spawned. This is where the final four tanks are used. After a given pair has spawned, say from strains A and B, it can be placed in the appropriate 10-gallon tank. A separate tank for each breeding line is needed to ensure the spawned fish's usefulness in the event of unforeseen problems. The unspawned fish will still be in the original 10-gallon tanks. This way you can keep track of which fish have spawned and which have not. (See figure 1.)

It is now time to remove any remaining fish in the 20-gallon tanks to make room for the F2 generation. It is important to clean the tanks thoroughly to ensure that no eggs or disease are present. After accurately labeling and preparing each tank, the offspring can be introduced and raised to maturity**.** Problems, of course, may arise relative to the number of fry that survive to adulthood, sex ratio etc. Much of your success will be due to consistent monitoring of water quality and general good maintenance practices. A dose of good luck wouldn't hurt either.

Producing. The F3 generation comes about by crossing A & B lines with C & D lines. The recommended pattern can be seen in figure 3. After that you can repeat the same sequence used for the F1 and F2 generations with future generations. Following this pattern will insure that some of the genetic information from all eight founders will be represented in each of the four breeding lines.

Many aquarists will not have the tank space to breed fish in the manner suggested here. In such cases it is desirable to cooperate with another aquarist to accomplish the task. Figure 4 gives an example of how this might be accomplished. It is advisable to make this arrangement between aquarists who communicate regularly to ensure that each participant is operating with the same assumptions. This will increase the chances that both aquarists will have fish ready when it is time to exchange specimens for the next breeding sequence.

The preceding example is given to illustrate in a concrete way the principles involved when breeding fish to maintain genetic diversity. It is important to emphasize that many fish will have to be housed and bred in a very different manner. Cichlids, for example, do not spawn in synthetic mops, but lay their eggs in clusters on rocks, flowerpots and other solid objects; others are mouthbrooders. In these cases the fry will be chosen randomly, rather than a few eggs incubated and hatched separately for introduction into the next generations' core population. The Fp. *gardneri nigerianus* example is less complicated because the sexes are easily distinguished. For many cichlids this is not the case and fish will have to pair off before choices can be made. Obviously more work and patience will be required and the tank set up will be considerably different from the example given here. Needless to say, tetras, catfish and other groups of fish will require further refinements. It will be up to the conservation aquarist to make the innovations necessary to achieve the best results. When a successful approach is developed, it is hoped that those aquarists will write of their experiences and pass them on to others.

The importance of keeping accurate records should be clear at this point. A stud book form can be used to jot down the origins of each founding fish and keep aquarists on track regarding breeding procedures. (See figure 5.) Then, if they want to know if someone's fish are closely related to theirs, they might have the answer. If aquarists are fortunate enough to find people who will cooperate with them by exchanging fish and information, the task will be more pleasant. Also it is critical to be able to prove that your fish are captive bred in the event they are subsequently listed as threatened or endangered. A strong record will help avoid possible legal difficulties. Along with this, the demonstration that aquarists are dedicated to the task of conserving nature, will likely open the door for more participation by amateurs in the future.

In the meantime, many fish that are currently available to aquarists will become extinct in nature. The decision whether or not to take responsibility for their survival will be up to them. To quote Edward 0. Wilson . "every scrap of biological diversity is priceless, to be learned and cherished, and never to be surrendered without a struggle."

Other Breeding Strategies

Limited Tank Space:
The author has made a conscious effort to simplify the KCC program without sacrificing the need for a science-based protocol designed for long-term conservation. Despite this, there will be those who consider this project to be beyond the capacity and motivation of the vast majority of amateur aquarists. Nevertheless, the effort will go forward, slowly at first, with faith that an ever growing number of aquarists will come to realize that they have an important role to play in the preservation of the earth's biodiversity.

Many members of the AKA will agree with the objectives of the Species Maintenance and Conservation Committee but will not have the tank space to breed fish in the manner suggested in the handbook. This does not mean that the aquarist has to sit on the sidelines. It is possible to participate with just one pair of fish from the core breeding list. In fact, the committee organizers hope that every member of the association will join the KCC and participate in some way.

If you agree to spawn a species on the core list, all you need to do is inform the chairperson of the KCC that you are willing to spawn, for example, Aphyosemion aff. primigenium 88/10. We request that you fill out an information sheet that gives as much data as is available relative to the origins of your fish. In many cases all you will know is from whom or from where you received your fish. Ideally we would like to be able to trace every core species back to the original wild specimens, be able to name the collector and know when and exactly where the species was collected. Much of the time, this information will not be available. After you have filled out the form, send it to the chairperson and he/she will put your name and the fish you are spawning in a computer database. When you are successful spawning the fish, you are asked to offer a pair or two to the KCC which will buy them if there is a need at that time. Using this approach, there is a way for each and every interested person to participate even if he/she has only one pair of fish designated as part of the KCC program.

The computer database will contain a record of all people in the KCC and list the fish they are spawning. In addition, it will contain information derived from the Fish and Egg Listings and from the New & Rare Species offerings. Species Coordinators of the different genera will receive all information regarding the fish they are trying to breed and will contact people when there is a need for pairs of a particular species in the core breeding program. For example, an aquarist might lose breeders from a particular breeding line and will want to replace them. The Species Coordinator supervising that genus will look over the data and try to find fish that are not genetically related to the ones he/she already has in the breeding program. The names and addresses of those who have these fish will be given to that person and orders can be make to replace the needed fish. In other words, the Species Coordinator of a particular genus will help manage the breeding patterns for each species in order to ensure, that genetic diversity remains at its highest possible level.

Requests for fish will also be made through the KCC Newsletter and AKA members are asked to help by supplying these fish to the requesting members. As you can see, there is a way for everyone who wishes to do so to participate in the KCC. It is a serious project but that doesn't mean it can't be enjoyable and rewarding. Please come forward and let us know what you are willing to do. If successful, future generations will come to appreciate the efforts made by current conservation aquarists.

Breeding Group with Random Selection

Another breeding strategy that helps preserve genetic diversity consists of several pairs housed in an aquarium that has been divided into three compartments. This method is workable for aquarists with limited tank space. It is recommended that at least four unrelated pairs of the same species and location be used as founders. Depending upon the size and number of breeding pairs, a 10, 15, or 20 gallon tank can be used. A 20 gallon (long) tank has been found to be particularly useful and can accommodate up to ten pairs of the smaller killifish species. As mentioned, the tank is divided into three compartments. One section is smaller than the other two and is used for the breeding pair. The other two sections are larger and of equal size. The males are placed in one of the large sections and the females in the other. A sponge filter is placed in each of the large compartments with no filtration in the breeding section. (See diagram below.) After the fish are well conditioned, a pair is randomly selected and placed in the breeding compartment which has been prepared with the proper spawning medium (mop, peat moss etc). If conditions are right, the breeding pair will produce a large number of eggs in one day's time. The eggs are collected and put in an appropriate environment for incubation. The breeders are then removed and another pair, randomly chosen, is placed in the breeding compartment. Keep this up until all fish have spawned. There is no need to separate the eggs by spawning pair. When the eggs hatch and the fry raised to maturity, breeders for the next generation are randomly chosen. For most species, one large brood of fry per year (40+) will be adequate. Annuals will have to be bred more often. Participants are encouraged to offer excess fish to the KCC.

This method requires as few as three or four tanks. In addition to the tank for the breeders, it is useful to place the fish that have spawned in a separate tank in order to keep track of which fish have contributed to the gene pool and which have not. After all have spawned, they can be returned to the divided tank and the process repeated, if necessary. The remaining tanks can now be used to raise the offspring. In all of these methods, high standards of husbandry are essential.

A Proposed Study of the Effects of Inbreeding
One of the possible research projects for those involved with the Killifish Conservation Committee would be to study the effects of inbreeding on their fishes. This information can be particularly useful when conservation aquarists learn that they have captive populations that are extinct in nature. If the decision is made to take extra care to maintain these fish indefinitely, knowledge of how to breed fishes to maintain genetic diversity will be essential. In addition, it would be useful to have information about the degree of inbreeding already experienced by a species and the effect this might have upon subsequent generations.

Aquarists, can participate in this proposed research by keeping accurate records. Each time a new species is obtained a record of the pedigree can be made. To be able to trace the origins of your fish to wild caught specimens would be ideal, but is not always possible. Still, even knowing from whom you obtained the fish might prove to be useful. In other words, it is important to know the degree of inbreeding that has occurred before you begin your own breeding efforts. (Clearly, a large number of wild caught fish would be the best way to start a long-term breeding program as these fish are likely to have a high degree of genetic diversity. The more founders of equal sex ratio the better.) After the initial gathering of information, keep track of the number of generations and degree of inbreeding that has taken place for each new batch of fry. A careful account of the number of fry, percentage of deformed or problem fish, and other observable factors should be noted for each generation in order to determine, if any, the visible effects of inbreeding.

After the degree of inbreeding has been documented for several generations, a few fish can be sent to a professional who is able to do DNA studies. The DNA results are then compared with data from wild specimens. The loss of genetic diversity due to genetic drift and inbreeding can then be determined. Theoretically, inbreeding increases the chances that subsequent generations will show symptoms such as infertility, deformities and lack of residence to disease. It is also possible, with a little luck, along with careful selection of breeders, to produce a line of fish that show no genetic diversity due to inbreeding but are viable generation after generation- perhaps indefinitely. When this latter result happens, it means that the lethal genes have been eliminated from the strain. Other breeding lines will eventually crash and have to be discarded. From this process, we may be able to learn which fish are more or less resistant to inbreeding and thereby give us information that will help us choose breeding practices that are likely to insure the survival of a species. In addition, DNA studies make a "fingerprint" for a species that can help determine if subsequent hybridization has taken place. Given the number of species threatened or about to go extinct in nature, the aquarist is in a position, if he has the proper knowledge, to help save a species both for the hobby and for purposes of conservation.

There are a couple of interesting examples of inbreeding that have been observed by the author. The first that comes to mind is a strain of what was then called Aphyosemion christyi (=A. schioetzi). Joe Ricco, a Charter Member of the AKA, inbred them for a ten year period. At the end of the ten years, all fish were deformed and the strain was discarded. Another example comes from twenty-one years of inbreeding of Profundulus punctatus. All of the latter coming from one male and one female caught in the wild in 1972. Despite this long period of inbreeding, P. punctatus continues to produce healthy offspring. The Blue Gularis (Fundulopanchax sjoestedti) is another fish that has experienced considerable inbreeding and could be included in this proposed research. These examples are useful in helping aquarists improve breeding practices and would be even more useful if DNA studies had been done before and after inbreeding had occurred.

What is needed for such a study is a proper protocol, including data gathering forms, which can be developed through the cooperative effort of hobbyists and professionals. Since there are several professionals in this group, perhaps they would be willing to offer guidance for such a study. The KCC chairpersons will make every effort to identify professional ichthyologists and biologists that are willing and able to assist conservation aquarists with these efforts.

In Defense of Captive Breeding of Endangered Fish:
The debate over the value of captive breeding as a means of preserving species from extinction will probably go on for decades to come. Conservation-minded people are divided as to the value of this approach to the long-term maintenance of biodiversity. The purpose of this article is to discuss the positive aspects of captive breeding by commenting on the points most frequently made by those who oppose or seriously question such efforts. Eight opposing statements will be examined in an effort to make the case that captive breeding efforts can and will make a valuable contribution to conservation.

1. Humans are part of nature and the extinctions caused by their dominance and superiority are natural.

It is obvious that this attitude works against conservation efforts. It reflects an anthropocentric perspective that places humans at the center of existence and assumes their superiority and the inherent inferiority of all other living things. This attitude is shared by many people, many of whom have not examined the assumptions by which they live their lives. This common attitude demonstrates a profound ignorance about how ecosystems work by failing to recognize the essential services that plants and animals provide in the maintenance of a viable environment. As a matter of fact, if these free services were to suddenly stop, Homo sapiens would become extinct in a very short time (Ehrlich, 1988; Wilson, 1992).

Another component of this position is the belief that humans cannot destroy the environment even if they wanted to and that nature will always be able to rapidly repair any damage that might be done. Along with this is an optimistic belief that technology will be able to solve any environmental problems that might arise. Many go so far as to say that those who wish to restrain human activity for the sake of the environment are perpetuating a hoax which represents the last vestiges of socialism or communism. In effect, environmentalists are seen as enemies of capitalism. Clearly, people who hold these attitudes do not offer much encouragement to those who wish to restrain or modify some human activities in order to protect the viability of the planet. The reality is that we are presently in one of the great extinction spasms of geological history. E. 0. Wilson estimates that currently 27,000 species of plants and animals go extinct every year. In the rainforest, due to human activity, this represents an extinction rate from 1,000 to 10,000 times faster than the normal rate over geological time (Wilson, 1992). Clearly, education is an important component of any conservation effort.

People with this view often fail to see that what sets humans apart from the rest of nature is their ability to understand the consequences of their behavior. Implied within this is the capacity to restrain behavior for the common good. It is this unique potential to be ethical that gives hope that a new value system will evolve which gives reverence for the miracle each species represents. Those who support measures that insure a high degree of biodiversity have faith that respect for all life and the consequent preservation of nature will eventually evolve to become the norm. This hope is based upon the increased realization that it is in the best interests of human survival to do so. At that point the extraordinary efforts of those involved in saving species from extinction will be more fully appreciated.

2. What good is the captive breeding of a species when its natural habitat is destroyed and there is no possibility of reintroduction?

One of the expectations of people involved in captive breeding is that some fish species will eventually be reintroduced into their natural habitat. It is true that many habitats will not be able to support aquatic life for many decades or perhaps forever. The conservation aquarist chooses to maintain the fish even if the future of its habitat looks bleak. The hope is that habitat reconstruction will become an important area of research in the next few decades and that eventually many species will be placed back into nature even if the habitat has to be engineered by humans. If the fish no longer exist, this will not be an option. In addition, the educational value of displaying fish that are threatened or extinct in nature should not be underestimated. It is hoped that such displays will help inform people of the value of biodiversity and may help bring about the conservation ethic mentioned earlier.

3. Long term captive breeding will eventually fail due to the inevitability of inbreeding and the subsequent loss of genetic diversity.

Perhaps the greatest challenge presented to persons breeding fish for conservation is to maintain genetic diversity in their captive specimens. Fortunately, conservation biologists have done considerable research in the last two decades relating to genetic management. Their findings will give guidance to those involved in long term captive breeding programs. Still, most of this research has been done on mammals that produce small broods over extended period of time; this research may or may not apply to many fish species. More research will be necessary to refine breeding procedures to achieve this goal and these processes may differ for individual species. It is likely that some species will prove to be more resistant to inbreeding than others. Some fish species living in small habitats have survived hundreds of years of inbreeding and are, for all practical purposes, genetically identical e. g. desert pupfishes. Aquarists have maintained viable populations for decades despite a high degree of inbreeding. Experience among amateurs suggests that it is possible to eliminate lethal genes through selective breeding practices. But, to be fair, aquarists have also learned that continuous inbreeding can lead to deformities, disease, and the loss of a breeding group.

Despite all of these potential difficulties, the serious conservation aquarist will make every effort to begin a breeding program with as many unrelated founders as are available and add unrelated specimens to the program when available. Theoretically, it is possible to maintain a high percentage of the genetic variability present in the founders through careful breeding management.

A high level of genetic diversity will be especially desirable, if not essential, when a species is to be reintroduced into a natural environment. The point of concern is well taken. Only time and experience will determine if these obstacles can be overcome. Not to try would be the greatest mistake. The opportunity to save a species seldom occurs more than once.

4. Animals bred in captivity lose their survival instincts and become easy prey when reintroduced into their natural habitat.

It is certainly true that captive bred fish learn some "unnatural" habits while living in aquariums. It is not unusual for fish to rush to the front of the tank in anticipation of being fed and to seemingly recognize the people who feed them. This behavior does not mean that the fish has lost the proper response to predators. The instincts are there, but have been compromised in the safe aquarium environment. If you drop a small fish into a tank containing large cichlids, there is often a wild chase with the small fish seeking and sometimes finding a safe hiding place. The panic shown in the behavior of the potential victim says a great deal about the existence of flight instincts in the face of danger, even in species that have been in captive environments for many generations. The question is, will the fish learn in time to revert to a more natural response? As biologists become more adept at the science of reintroduction, ways may be found to revive these survival mechanisms before fish are put back into nature.

5. Captive bred animals no longer participate in the process of evolution and, therefore, lose their importance to the natural world.

Conservation aquarists have respect for the wisdom of nature in creating a wide variety of species and wish to see the process of evolution continue; this is an important motivational factor in their efforts. It is true that the interaction that occurs in a natural habitat is temporarily lost or greatly compromised in captive populations. It is also true

that the adaptations that do occur are in response to an artificial environment and may not be useful in the wild. But the bottom line is clear, if the animal does not exist, the possibility
of future participation in the evolutionary process is lost forever. (Even in this context the potential for meaningful research exists, although this is a secondary consideration except in cases where research aids conservation efforts.)

6. The cost of keeping a species indefinitely in captivity is very high. Scarce funds should be used to protect habitat rather than maintain a species that is, for all practical purposes, extinct.

If the potential for captive breeding is used as an excuse for not protecting habitat, then the concept is being misused. Habitat protection is always the first priority. As a general rule, it is only when the habitat is in grave and imminent peril that captive breeding comes into play. The bulldozer and chain saw are very capable of turning a pristine environment into a wasteland within a matter of days or weeks. Still, these decisions are often difficult. Conservation aquarists want to be able to obtain enough founders when captive breeding is indicated but they don't want to endanger a habitat further if there is any possibility of it being saved. This is where knowledge and good judgement come into play.

Other conservationists advocate that captive breeding programs should begin long before a species is on the brink of extinction. Indeed, when one considers the number of countries that are currently experiencing political instability, many of which have critical fish habitats under their jurisdiction, it would seem prudent to have captive populations outside of those areas. This approach suggests that the wise thing to do is establish these populations in anticipation that habitat destruction is likely within a few years. Such action is especially appropriate in those areas where conservation efforts are highly problematical. By the time everyone agrees that a habitat is ruined, it may be too late to acquire a viable population for captive breeding. The rainforest species of Sierra Leone and Cameroon would be good examples of fish that will probably be in trouble within this decade and plans could be made now to save them. It is a tough wire to walk.
If human population doubles during the next century, as it surely will, it is likely that from 30 to 60% of all species on earth will disappear by the year 2050 (Wilson, 1992).

7. Saving fish for the hobby is wasting resources that could be used for more important human needs.

Certainly, much of the motivation for amateur aquarists to participate in captive breeding programs will be to save the fish for the enjoyment of the hobby. Given the extent of the challenge to save even a few species, all persons of good will should be invited to participate. If aquarists are willing to follow the rules insuring the integrity of the breeding program, they should be encouraged to take part. The potential is enormous. It is likely that the hobbyist will become, before long, a conservation aquarist who understands the full significance of the work. Yes, human needs are important, but the survival of biodiversity on this planet must be our highest priority if we are to avoid the collapse of civilization and what Paul Ehrlich describes as "the equivalent of a nuclear winter" (Ehrlich, 1988).

8. As a general rule, technological societies do not support the ethical principles necessary to sustain long term conservation efforts.

The number of people focusing on conservation issues is growing but, for the most part, there are few fundamental changes that put significantly less stress on the environment. We tinker around but cannot face the hard choices necessary to make the difference. We are an intelligent species, but history may yet record that we have a fatal flaw- our capacity to use nature exceeds the capacity of nature to sustain our activities. Put another way, we may demonstrate that our capacity to restrain ourselves for the sake of posterity is weaker than our desire to satisfy every imaginable appetite in the present. If this latter characteristic proves to be true, then there is little of significance that separates us from the proverbial beast. Many know that we are heading for difficult times but, as in the case with the U. S. national debt, the necessary adjustments to solve the problems are difficult to contemplate and politically unpopular.

We all know what has to be done: reduce human population, walk more gently on the earth, love nature as our mother and father, move from material growth to personal growth, stop this unhealthy obsession with our species (ourselves), make room for all life and learn to love, or at least appreciate, an of nature as we love and appreciate ourselves. In the interest of our survival, change in this direction is an historical necessity. Is it too late? Maybe, but we have to try to change or we will be in danger of losing those qualities essential to our humanity.

Cyprinodon alvarezi (El Potosi, Nuevo Leon, northern Mexico).

Final Thoughts

Originally published by the KCC founder, Roger Langton, in the original KCC Handbook.

Since the effort required to achieve success in preserving genetic diversity is considerable, it is useful to have an effective support system. Aquarium societies are a good place to start. Preserving species can become part of your society's work. Monthly meetings, newsletters and study groups are examples of what can be useful in helping the aquarist stick with the task. Eventually national and international networks will be formed. You are encouraged to join these groups or provide leadership in forming them.

Another consideration is the degree of support you have from your family or housemates. For example, if your spouse ridicules you and demonstrates little or no understanding for your conservation efforts, you will have more difficulties. The old story of the wife who felt that her husband loved his fish more than his family, comes to mind. Apparently one day while the husband was away she entered the fishroom with a hammer and smashed all the tanks. While one would not expect such a drastic consequence, it is important to sit down with your significant others and let them know what you want to accomplish and ask for their support. It would be desirable to get the whole family involved in a positive way. Frankly, if they are unwilling to support you, it might be better to participate in a very modest way or not to begin at all.

None of us live forever or remain true to all tasks forever. It is essential to have a plan to pass your fish and equipment on to someone who can carry on the work. This could be part of your will or part of the understanding you have with those who are close to you. Find someone who will agreed to take care of your fish in the event of an emergency. An entire fish population can be lost in a short period of time and quick action is essential when the principal caretaker is unable to care for them.

Ideally, most conservation efforts will eventually become part of well funded organizations Le public aquariums, universities, commercial hatcheries, aquarium societies etc. When this happens, the personal problems we all have will have less impact on the task.

It has been estimated that 74 species of plants and animals go extinct everyday, 3 an hour, 27,000 a year (Wilson, 1992). This rate of extinction is faster than that of any period since life began on earth. This unprecedented loss of millions of years of evolution weights heavily upon the conscience of many sensitive people. To prevent even a few species from extinction would give us hope for a future in which all living creatures are given consideration and respect for the miracle each one represents.

"Killifishes are ecologically bound to rainforests and the destruction of their habitats could lead to the extinction of species in the near future - above all the relic species with a small distribution area. Therefore, we should try to keep enough fish of the respective species in our tanks in order to preserve them for the next generation." (1987)

A. C. Radda & E. Purzl
Color Atlas of Cyprinodonts of the
Rainforests of Tropical Africa

"Killifish clearly need all the help they can get if more than a tiny minority are going to make it past the 21st century." (1993).

Paul Loiselle
Curator of Freshwater Fishes
The Aquarium for Wildlife Conservation
Brooklyn, New York

"Many kinds of undertakings in expansion in South America menace the habitats of Cynolebiatinae. Deforestation, river barriers, drainage systems, and embankments all destroy in an irreversible way the temporary environments, threatening the very existence of several of these species." (1995)

Wilson J. E. M. Costa Pearl Fishes "...every scrap of biological diversity is priceless, to be learned and cherished, and never to be surrendered without a struggle." (1992)

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Charles A. Nunziata
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Roger W. Langton
Founder, Killifish Conservation Committee

Section 3: Reference Figures: