Written by Russell McAndrews
Monday, 22 June 2015 19:19 -

ABSTRACT
Habitat preservation, the preferred means of conservation, is not an option for Lake Victoria at this time. The only clear course of action is faunal rescue and captive maintenance of a representative slice of this unique biodiversity.
With a few exceptions, these opportunistic and precocious little fishes adapt quickly and easily to captive propagation. Once established, their phenomenal fecundity can quickly overcrowd a site. Their high rate of reproduction is especially important for maintaining optimal genetic diversity by overcoming bottlenecks to reach a minimum viable population within a single generation.
Haplochromini is the term used by E. Trewavas to denote the “tribes”, or species flocks of haplochromine cichlids, recognizing the uniqueness of the Lake Victorian ichthyofauna. Indeed, none would argue against the scientific value of this chaotic ecosystem. As animals go, these relatively small, prolific fishes would seem to be tailor make for captive propagation. Allowing for the behavioral requirements of individual species, **the most significant obstacle to gene pool maintenance is networking** .

INTRODUCTION
Haplochromines and their ancestors are the most radiant example of explosive speciation in fishes (Kaufman.1988). Each species flock evolved within one lake basin creating an intriguing and diverse set of species-rich endemic flocks (Greenwood, 1981). These large latchstring species flocks contrast sharply with the relatively poor diversity found in riverine fauna. Relative levels of endemism are comparable but the diversity of the East African lakes are unparalleled. In short, cichlids have adapted to an incredibly wide range of conditions, and are generally considered to be among those species least vulnerable to extinction.
How can such a successful, adaptable and aggressive animal be so susceptive to extinction? A major focal point of research into the L. Victoria mass extinction is the study of behavior as it pertains to the dynamics of the situation. The answer seems to be that the same qualities which proved so successful in the past are now hindrances to survival in the face of the Nile perch. Most haplochromines exhibit low fecundity, they put a lot of energy and care into relatively few eggs. Most exhibit a strong attachment to a particular site and compared to pelagic fishes, they wander very little. These two factors make haplochromines sitting ducks for the perch.
In the first ever listing of an entire ecosystem, the World Conservation Union Redbook of Endangered Species lists the hundreds of endemic fishes of Lake Victoria under the single heading of “**ENDANGERED**”. Lake fisheries, once based upon 300 endemic species now rely on three, two of these are alien introductions. The Nile perch, Late s niloticus , a giant predator whose population explosion inversely coincided with the decline of the haplochromines, is the primary species caught in the lake. The Nile tilapia, Oreochromis niloticus , which evolved sympatric with the perch and grows very quickly is believed to have hybridized and/or displaced the two endemic tilapiines, O. esculentus and O. variabilis . The single endemic success story is a small schooling pelagic sardine-like species, Rastrineobola argentea

.

RESEARCH

Amid the growing tide of global extinction, Lake Victoria and its fishes provide a tragically unique subject for study. The lake's formation, colonization, explosive speciation, on-going ecological collapse and proposed reconstruction are all areas of intriguing research but little understanding. Underlying all these points is behavior, a better understanding of the haplochromines and their behavioral traits are necessary to facilitate further understanding of the overall problem, the big picture if you will. Logistically, behavioral study lake-side is impossible presently; lack of facilities, the ever present schistosome parasite and turbid water which has become four times worse since the onset of disaster completely rule out meaningful, long term under water study. Observations have been made with a remotely operated submarine equipped with a camera, and although this was successful, it is only practical for specific tasks of short duration (e.g., verification of sediment cores; spot inspections at different points, depths and habitats around the lake.) The only solution to the multi-faceted problem of behavioral study is long term captive maintenance, it could also be considered the simplest, even the stewardship and housing must be directed toward that end. Stewardship itself can be an ongoing kaleidoscope of problems and is, off and on, in dire need of some research, particularly veteranarial assistance.

Research topics include the effect of phenotypic plasticity in captive breeding programs due to genetic drift; the effect of isolated sub-population versus panamixia on over all conservation of genetic diversity; the impact of captive breeding on age specific fecundity. Suggested markers for monitoring phenotypic plasticity are: feeding adaptations/jaw and tooth morphology; growth rate; brain morphology; and male spawning coloration.

EDUCATION

A display of these fishes and their history make and excellent educational tool to bring conservation biology to the public. Predictable and interactive behaviors allow for the manufacture of placards to focus the public's attention. The Victorian disaster is an excellent example because of the breadth and scope of the conservation issues which are pertinent.

In addition to universities, lower schools can be valuable participants while providing, first hand, an example of conservation biology.

STEWARDSHIP

Maintenance of breeding and social structures found in nature may be more important to overall success in maintaining a species than the priorities of a captive breeding program designed to retain maximum heterozygosity. Reliable information about natural population structure is an important prerequisite for developing a biologically sound breeding plan.

There are two distinct phases of captive maintenance. First of these and far and away the most prevalent is propagation among siblings, while this is known to do damage, it is somewhat repairable, and is certainly preferable to no propagation at all. The second phase incorporates population intermixing and requires that populations be verified as a prerequisite to intermixing. In its most basic form, intermixing is the transfer, import and export, of males from one population to another or in both directions as a swap. After establishing populations, the next major reproductive goal for each species will be the elimination of inbreeding through the mixing of populations. This will effectively increase the size of the gene pool and hopefully counter genetic drift as well as some of the inbreeding damage from earlier generations. While it would probably be ideal to mix populations at every generation, due to time and budgetary constraints,

the more likely scenario would be to plan to mix populations every second or third generation. Captive maintenance of these animals is generally relatively easy, with a few exceptions, they are largely undemanding in their requirements. Slightly alkaline, moderately hard, warm, fresh water with a low salt concentration seems optimal. Some of the open and deep water species are less tolerant of poor water quality and some, possibly aligned with trophic preferences, are prohibitively aggressive toward con-specifics. Be advised that although some species have reproduced exceptionally well, others are proving quite challenging.
While aquaria and population sizes will vary from species to species and location to location, the following estimates of tank and population size should be considered a bare bones workable setup. Feel free to expand upon these aquaria and population sizes. Beware that there are a few hard to please species for which this bottom line approach would not be sufficient.
Two, 30-70 gallon aquaria are used for housing a colony, one for each of two generations. Adult breeders are to be housed in one while the other accumulates a cross section of fry for the next generation gene pool. One 30-40 gallon aquarium is used to house extra males and also, if isolable, double as a quarantine tank. Twelve small aquaria, 10-20 gallon will serve as cribs for six months worth of segregated batches from which the next generation gene pool has been selected. Selected fry are socially integrated into the up-coming colony tank. Disrupt cichlid territories by rearranging all structure in the aquarium whenever new animals are added to a populated tank. Those animals not selected would ideally be de-accessioned immediately to make room for future broods. Additionally, a half dozen small to medium size pails are useful for temporarily housing newly stripped broods which are not free swimming yet.
The type and amount of filtration required depends upon numerous variables; temperature, water chemistry, the number of fish, the size of the fish, the size of the tank, their diet and feeding regimen. With a few exceptions, the Victorian haplochromines are more tolerant of dissolved organics from the Tanganyikan cousins and about on par with the haplochromine derivatives from Lake Malawi. Similarly, they are hearty eaters and will, with few exceptions, readily accept most commercially prepared foods. Newly hatched fry should be given measured feedings of baby brine shrimp for the first 72 hours, as they will over feed on the shrimp. Powdered flake food should be offered after 48 hours and at the same time as the Arte mia
for dietary acclimation.

Damage control and common sense dictate some forethought with regard to these fishes. Due to the presence of pathogens too numerous to list, wild animals should provably never be housed in a centralized system. At least one species, Mycobacterium marinum has exhibited itself as organ and ovarian granulomas of autopsied wild fish. Known among fishermen as Mariner’s tuberculosis, it exhibits itself as lumps which typically spread through the lymphatic system in humans and can only exist in the extremities (Kator & Rhodes, 1992), due to the higher temperatures of the body core. In fish, it often does not exhibit itself at all and entire populations may never exhibit the disease given optimal conditions in Nitrogen cycle management and behavioral requirements. Stress is directly responsible for the majority of outbreaks and, depending on the form of stress, the outbreaks exhibit differing dynamics. Symptoms vary and only serve to confuse as they are only indicative of secondary infections and treatments of same will have little or no effect. This has proved itself to be a problem in the past and no affective treatment is known. Fortunately, this is only a problem with wild animals and exposure to wild animals.

MATURATION AND REPRODUCTION

Curiously enough, one of the anthropomorphic phenomena encountered in haplochromine husbandry is shared, and perhaps better studied, in fisheries research. Heavily fished stocks show quicker maturation. With haplochromines, the removal/absence of larger males will result in color maturation of males at a smaller size than would otherwise occur. Additionally, females in the same size range will begin to breed, not always successfully. Due to this early and continued diversion of growth energy into reproductive energy the growth of the fish slows dramatically. Some refer to this as “dwarfing”, alluding to the apparent shrinking in size of a given mature population. Many of these fishes, in the absence of a larger male, will begin to color up a just over 1”TL. In a population with the above characteristics generation time is reduced temporarily until the population has had a chance to re-mature. This can happen very quickly -- say within one year -- depending upon the population and the various pressures it is under at that time. Re-maturation of the population is a process akin to ontogenetic “leap frog”. The expense of early dominance is reduced growth. This allows the sub-dominant males to out grow and then displace the early, smaller male. If the size differential from early to normal maturation is large enough, several males may replace each other in succession with the initial small male becoming one of the largest.

A consistent trait that seems to apply to most Victorian haplochromines is a general darkening of the male especially the pelvic fins which become black. The male’s first attempt at reproduction, although not always successful, will bring about, first spawning or courting coloration (very intense), and then, following the act, a less intense “dominant” color scheme. Typically, a female may not brood her first batch to term. Additionally, the first couple of spawns tend to produce few eggs by comparison with later spawns which are as much as ten times the number. An area for future research concern is, the identification of which selective effects are directly or indirectly related to the process of brood stripping and how will this change generation after generation.

Sexing individuals is usually a simple task. Sexual dimorphism, although present, is highly variable from species to species. Some species, seemingly correlating to deep and open water, when not actually spawning, display little or no color. The predominantly silver coloration, in conjunction with highly variable black overlay pattern, has been said to give these fish the appearance of wet newspaper, still, close inspection will reveal slightly darker fins (dorsal and ventral), on the male. Another key indicator, egg spots, are always present on the anal fin of the male and are extremely specific as far as size, color and arrangement. While some females often exhibit spots on the anal fin these are usually lesser in number and size, paler in color and not true ocelli but instead are called pseudo-ocelli. Complicating the situation, a haplochromine male in the process of maturation might display several different colorations or color patterns. On a day to day basis, the one constant character are the egg spots, although even they can change slightly through the years.

IDENTIFICATION

Foremost in one’s mind when handling these fish should be an awareness that they do not always have the same color pattern, or the same colors. While a male haplochromine is courting or spawning he will show very distinct, very intense coloration. A lesser male in the vicinity would have much subdued colors and any visible patterns are typically of a horizontal theme. Aggressive fish, both male and female, exhibit varying intensity on a standard vertical theme. Extremely frightened or stressed animals display both the horizontal and the vertical to produce a variation on a checkered theme. This has the affect of darkening and fragmenting the fishes outline. In short, these fish look different in a bag than they do in a tank; they look different over sand than they do over rock; and they look different in any one tank from one day to the next. Indeed, from one second to the next as a complete color change can take place that fast. An additional word of warning, many of these fishes, especially juveniles and fry, are quite proficient at mimicry. Presumably this mechanism allows females and fry to school together to limit predation.

Once these fish have settled in they are very communicative and do exhibit clearly identifiable markings and patterns which serve to identify the moods of the animal to the observer. Useful information can be had by simply watching the underlying pattern of bars and stripes. Each species as a repertoire of patterns and colors which allow them to communicate their moods and intentions to others of their kind.

Ocelli, egg spots, or egg dummies as they are sometimes known, are egg-shaped spots circled with a transparent outer border ring. They are located on the anal fin of many old-world mouth brooding cichlids. Although they are mainly to be found on males, sometimes exclusively, they do occur on some females and so therefore are not completely indicative of sex. Arrangement, size, number, and color are all highly variable from species to species but not especially variable within a species. Typically, egg spots are arranged in one or more rows. A familiarity with these arrangements as well as color and size differences, would provide a key indicator. Goldschmitt noted that definite correlations can be made between the fish and its habitat by extrapolating information from the variation between the specie's egg spot (color and size) and the egg. One such example would be egg spots which are larger or more brightly colored than the actual egg are indicative a deep or turbid water habitat.

Smaller spots indicating shallow water, closely alighted spots and eggs for an intermediate zone.

Sorting by stress pattern in an emergency measure which has proved useful in the past for separating inadvertently mixed species. Two species which did not resemble one another were both placed in the same tank due to space limitations. The next morning they could not be told apart until they were all placed in a white pail at which point the two species looked quite different once again.

GENE POOL MAINTENANCE

Effective gene pool maintenance, and our increased understanding of it, is absolutely critical and an integral part of any long-term captive propagation. Captive populations may have varying goals with regard to genetic heterogeneity depending upon their function, species, duration, out come and other factors. For instance, genetics usually play a small role with display animals, little or no attempt is made, or required, to track or manipulate blood lines. To a lesser degree, this is also true for research or aquaculture populations. Aquaculture research and any associated genetic manipulation would be oriented around productivity not preservation. The pending Lake Victoria Species Survival Plan outlines objectives for minimizing the loss of genetic diversity. There are three step-wise objectives associated with the VSSP. First on the list is the establishment of a minimum viable population (MVP). This step is a large one in that it is series of component tasks. Founder stock acquisition alone can be particularly difficult, even impossible. Successful species identification and isolation lead to reproduction and necessary dispersal. Fortunately, the fecundity of these fishes allows MVP to be reached within a single generation from the founder stock in most cases.

Minimize genetic loss and drift by equalizing founder representation and avoiding culling or other processes of domestication. All selections should be completely random.

INTERSPECIFIC HYBRIDIZATION

Naturally occurring hybridization, although rare, does take place and is possibly partially responsible for the diversity of the cichlid fauna of Africa. Inters-specific hybridization in Lake Victoria is directly responsible for the extirpation of the two endemic tilapiines. Although this is not strictly a "natural" incident, it is indicative of the process as it pertains to extinction and population dynamics.

Most species will hybridize and the bulk of the damage done by those hybrids, through the contamination of existing gene pools, will happen unintentionally. Unintentional hybridization can occur in a number of ways. Misidentification, especially female haplochromines, is probably the most common. Another means by which hybridization could occur is when two or more species are housed together, or even near each other. Evolution has developed a mechanism whereby, water-born pheromones precipitate cascading spawning behavior among groups. Typically, within the confines of an aquarium, a dominant male will spawn with any receptive females. Even more typically, a dominant male will try to not allow any other, similar, subdominant males to spawn. Any time one places two species in a tank where spawning activity occurs, one is faced with the risk of producing hybrids. It may not be known that two species are present as individuals chased out of one aquarium could wind up in another. Lastly, is fertilization across a divider. Males have been known to fertilize supposedly inaccessible eggs by simply discharging enough milt to saturate a localized spawning area of the aquarium. This can be a useful husbandry technique allowing for the propagation of overly aggressive species without a potentially murderous outcome. Granted, hybridization will not always occur under the above circumstances, but common sense and damage control dictate steps to minimize its probability.

INBREEDING, OUTBREEDING & GENETIC HETEROGENEITY

Klaus Kallman (1991), in reference to some live bearing fishes of the genus Xiphophorus, demonstrated that founders from large populations produce stocks which frequently are lost due to inbreeding depression, while founders from small populations produced stocks which consistently remain viable through tens of generations with no deleterious effects. This information does seem to fit with earlier difficulties experienced with
Yssichromis
, especially "pyrrocephalus" which was lost in-country apparently due to inbreeding depression. Pelagic or lake-wide species of cichlids would be, in effect, a large population as apposed to the habitat-specific cichlids with their territorial (I.e., localized), behavior and small pockets of isolated populations. Obviously, a direct correlation is impossible, and therefore undesirable, but it must be concluded that each species may have different genetic requirements simply based upon behavior, specifically, reproductive behavior.

In many lesser captive breeding efforts of fishes, sibling to sibling reproduction is the accepted norm. This is of course inbreeding, and while for a variety of reasons, it must be tolerated, it should be phased out as the mainstay of reproduction. As above, the quantitative impact of inbreeding on a particular gene pool is largely dependant upon behavioral and genetic factors of that population.

Inbreeding and gene concentration are processes. They are, in part, responsible for the intensely diverse cichlid fauna occurring throughout Africa. Without corrective action, isolation

will result in inbreeding. Thus varying races are formed, typically in distinct locations. A step-wise process, at each generation a percentage of the present genetic material is lost. This will result in a passive selection and an overall reduction of the genetic diversity. The layman's term "selection" is the appropriate one for the process in each individual case, however, the concentration best describes the process within a gene pool. An example would be a gene which concentrates via selection from 2% of the population to 50%.
Since inbreeding takes place in nature, why shouldn't we let it take place in aquaria? Isolation and variation are parts of the greater process of speciation, this is evolution at work. However, in the case of long-term captive maintenance of threatened or endangered species, gene concentration is to be avoided whenever possible. Inbreeding is not preservation.

CONCLUSIONS

A healthy gene pool could never have too many genes but could easily have too few. Equalize founder representation. Adapt management to meet the needs of all disciplines. Tameness and adaptations to captive environments are inevitable.

REFERENCES

Andrews, C. and L. Kaufman. (in press) Captive Breeding Programs and Their Role in Fish Conservation .

Greenwood, P.H. 1981. The Haplochromine Fishes of the East African Lakes. Cornell Univ. Press.

Kallman, K.D. 1991. Genetic Diversity in Small Isolated Breeding Populations. Proceedings from the Desert Fishes Council. P.32

Kator, H. and M. Rhodes. 1992. Mycobacterium marinum, the "Leisure-Time Pathogen". Marine Resource Advisory, No. 44

Kaufman, L.S. 1988. Caught Between a Reef and a Hard Place: Why Aquariums Must Invest in the Propagation of Endangered Species . 5th World Conference on Breeding Endangered Species in Captivity.

Witte, F., Goldschmidt, J.H. Wanink, M.J.P. van Oijen, P.C. Goudswaard, E.L.M. Witte-Maas, and N. Bouton. 1991.
The Destruction of the Endemic Species Flock: Quantitative Data on the Decline of the Haplochromine Species from the Mwanza Gulf of Lake Victoria
.