Desert Fishes Council

"Dedicated to the Preservation of America's Desert Fishes"

Proceedings of the Desert Fishes Council

VOLUMES XXII AND XXIII

1990 AND 1991 ANNUAL SYMPOSIA

AND

INDEX FOR VOLUMES XVI THROUGH XXIII

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July 1992

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AGENCY REPORT FOR TEXAS PARKS AND WILDLIFE DEPARTMENT

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The commissioners of the Texas Parks and Wildlife Department (TPWD) have appointed a new Executive Director, Andy Sansom. Before coming to TPWD, Mr. Sansom was State Director for the Texas Nature Conservancy. In addition to retaining most of our current programs, Mr. Sansom plans to institute a program to educate and encourage private land owners to practice conservation. He will also develop methods to increase availability of public lands for non-consumptive use (e.g., hiking & photography).

Under Andy Sansom's guidance, the TPWD has been buying land that preserves unique ecosystems and hopefully this will continue. Some recent land acquisitions should benefit Texas desert fishes and some desert riparian systems. The TPWD has purchased the Big Bend Ranch State Natural Area which consists of 120,000 hectares (with mineral rights) west of Big Bend National Park. It borders the Rio Grande and contains several springs and most of the Alamito Creek drainage. Plans are to retain this as a natural area with limited tourist impact. This natural area should provide varying degrees of protection for several state threatened species: Campostoma ornatum (Mexican stoneroller), Notropis chihuahua (Chihuahua shiner), Cyprinodon eximius (Conchos pupfish), and Etheostoma grahami (Rio Grande darter).

Another recent acquisition by TPWD was the Devils River State Natural Area. It covers 8,000 hectares, contains several springs, including Dolan Springs and upper Dolan Creek, and 5 kilometers of the Devils River. The TPWD also plans to keep this a natural area with limited tourist impact. It should provide varying degrees of protection for several state threatened and endangered species: Dionda diaboli (Devils River minnow), Cyprinella proserpina (proserpine shiner), Cyprinodon eximius ssp., maybe Gambusia senilis (blotched gambusia) and Etheostoma grahami.

The Devils River State Natural Area contains one of the larger concentrations (sometimes) of D. diaboli. Dolan Creek is the location where Clark Hubbs and some others of us reestablished the Devils River subspecies of C. eximius and it now probably has the largest population of this subspecies. Although about half of their natural range is now gone, at least part of what is left is protected.

The Texas Nature Conservancy recently purchased Diamond Y Spring and part of Leon Creek. Their holding consists of 600 hectares, north of Fort Stockton and there will be very limited access to the public. This area is home to the once-thought-to-be-extinct Cyprinodon bovinus (Leon Springs pupfish). The preserve will also provide protection for Gambusia nobilis (Pecos gambusia). Both of these species are federally endangered. Additionally, the preserve will protect three rare snail species and the puzzle sunflower (Helianthus paradoxus).

A recent TPWD status review of Dionda diaboli suggests that their numbers have declined throughout what remains of their range. Reduction in water flow from human use and drought was probably a major contributing factor. The historically restricted range of this species has been reduced by inundation of the lower Devils River by Amistad Reservoir (1969), dewatering of the upper Devils River (the headwaters have moved about 20 km downstream) and extirpation of the Las Moras Creek population (late 70s).

Texas now lists Oncorhynchus clarki virginalis (Rio Grande cutthroat trout) as an extirpated native species. This decision was based on various historic accounts and descriptions of trout in West Texas. Although no specimens exist, for several reasons we feel O. c. virginalis was the species referenced. Texas is now exploring the possibility of reestablishing O. c. virginalis in a few appropriate sites.

The TPWD has begun a process of developing management plans for fishes of special concern. To date, management plans for two species, Polyodon spathula (paddlefish) and Micropterus treculi (Guadalupe bass), have been completed. Each plan has the following components: 1) objective of management plan (= preserve, conserve and protect natural resources); 2) historic perspective; 3) biological summary; 4) current problems; 5) proposed remedies. The TPWD intends to implement these plans and, in essence, they could serve as state-level recovery plans.

Finally and unfortunately, a series of intensive collections this past year has confirmed that Gambusia georgei (San Marcos gambusia) is now extinct.

ESTUDIO de HABITAT de los PECES NATIVÔS del RIO DOLORES, ESTADO de COLORADO

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Resumen

El Rio Dolores a una nez sosteniá numeros desconocidos de Colorado squawfish (*Ptychocheilus lucius*) y probablemente era como tributario de desove para este especie en el Rio Colorado. Seethaler (1978) reportó que T. M. Lynch capturó squawfish en el Valle Paradox en 1962. Otras colecciones de Colorado squawfish fueron reportados durante la época 1950 y 1960 por Lemons (1955), Nolting (1956, y Coon (1965). La colección mas reciente de Colorado squawfish en la cuenca del Rio Dolores fue por Horpestad en 1973, que reportó siete individos en el Rio San Miguel, aproximadomente 6 millas sobre la confluencia con el Rio Dolores. Sin embargo, no se capturaron Colorado squawfish durante una investigacion pisícola del Rio Dolores por Holden y Stalnaker (1973) durante 1971. Investigaciones recientes por el Servicio de Pesca y Animales Silvestres en la época 1980 tambien faltaron en hallar Colorado squawfish en el Rio Dolores (Valdez 1982). La operación de fábricas de uranio en los Rios San Miguel y Dolores durante la epoca 1950 se demonstró que era la causa de impactos severos a la vida aquática y probablemente contribuyó al fallecimiento local del Colorado squawfish en la cuenca Dolores. Observacione directos de impactos asociados con efluente y desperdicio "accidental" de fábricas de uranio en el Rio San Miguel fueron reportados por Sigler et al. (1966), y incluyeron matancia de peces, movimiento de peces, y cambios drásticos de pH (7.6 a 4.3).

Una orden de corte reciente bajo del Programa Superfund de la Agencia de Proteccion Ambiantal para remover el desperdicio de la fábrica de Uravan probablemente mejora la calidad de aqua en el Rio Dolores. Operaciones de limpiesa estan en progreso en la fábrica de Uravan. Remoción del desperdicio se completará en fases en 2 a 6 años. Tambien, construcción de la Represa McPhee en el Rio Dolores en 1986 ha cambiado signitivamente el flujo del Rio Dolores. Almacenaje de los flujos de la primavera en la Represa McPhee han reducido la magnitud y cambiado estos flujos bajo de la represa. Este efecto es atenuado bajo de la confluencia del Rio San Miguel, cual es un rio sin represa y con flujo normal. Flujos en el verano y otoño en el Rio Dolores han sido aumentados por flujos mas constantes de la represa durante estos períodos. Antes de construcción de Represa McPhee, en Marzo 1984, el Rio Dolores sobre la confluencia del Rio San Miguel, frequentemente estaba sin aqua por diversiones agricolas. Flujos aumentados durante el verano por la Represa McPhee representan cambio beneficial para los peces nativos de la cuenca del Rio Dolores.

El propósito de este investigación es para examinar los peces del Rio Dolores por 2 años para avaluar la posibilidad de introducir el Colorado squawfish en este sistema. Los objectivos son: (1) Examinar el Rio Dolores por la presencia de Colorado squawfish y la abundencia de otros peces nativos, (2) Avaluar para el Colorado squawfish los atributos químicos y físicos del Rio Dolores, (3) Evaluar la posibilidad de introducir Colorado squawfish al Rio Dolores para realzar recobro de los especies de la cuenca superior, (4) Hacer recomenadiciones a introducir el Colorado squawfish en el Rio Dolores. Se ha completadó un año de trabajo. No se han capturado Colorado squawfish durante este esfuerzo inicial, aunque otros especies nativos incluyendo flannelmouth sucker (*Catostomus latipinnis*), bluehead sucker (*Catostanus discobolus*), roundtail chub (*Gila robusta*) y speckled dace (*Rhinichthys osculus*) se hallaron abundante.

Morphological variation and status of Owens speckled dace, *Rhinichthys osculus*

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Morphology of Owens basin *Rhinichthys osculus* collections made since the 1930's is examined and compared with a population from the adjacent Lahontan basin. Differences between all populations were statistically significant for many mensural and meristic characteristics, indicating that Owens basin speckled dace are distinct from *R. o. robustus* of the Lahontan basin. This also suggests that isolated populations in the Owens basin are subspecifically distinct. However, differences between many mensural and meristic characters of individual collections from a population were also statistically significant. This temporal variation and principle component analysis show the morphology of Owens basin populations is highly variable, and that these data cannot accurately describe taxonomic differences between populations. Other methods such as genetic analysis are required to determine the distinctiveness of isolated populations.

The widespread historical distribution of speckled dace throughout the Owens Valley is indicated by museum collections. A field survey of 166 sites in the Owens basin from 1988-1990 found the species extirpated from most early localities, and existing at three sites not represented in early collections. The species is most widespread in the northern Owens Valley where five, low density demes persist in habitats that are distantly segregated by predatory fish populations. Two isolated populations in Long Valley, Mono County, and one population near Benton, Mono County, each occupy small springs and less than 1 km of stream. The species is extinct at Little Lake. The species has declined from its historic abundance and distribution because of the introduction of non-native fishes and habitat deterioration caused by diversion. Extant populations must be protected to prevent additional extinction of Owens speckled dace.

Variación y condición morfológica del dace moteado de Owens, *Rhinichthys osculus*

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La morfología de las colecciones de *Rhinichthys osculus* de la cuenca de Owens hechos desde los años 30's esta examinada y comparada con la población de la cuenca adyacente de Lahontan. Las diferencias entre todas las populaciones fueron estadísticamente significativos de muchas de las características de medidas proporcionales y de cuentas, el cual indica que el dace moteado de la cuenca de Owens es distinto del *R. o. robustus* de la cuenca de Lahontan. Este también sugiere que muchas populaciones isoladas en la cuenca de Owens son súbspecificamente distintos. Sin embargo, las diferencias entre muchos cáracteres de medidas proporcionales y de cuentas de colecciones individuales de una población fueron también estadísticamente significativos. Esta variacion del tiempo coleccionado y análisis del componente principal muestran que la morfología de las populaciones de la cuenca de Owens es súmamente variable, y que estos datos no pueden describir precisamente las diferencias taxonómicas entre las populaciones. Otros métodos como el análisis genético son requiridos para determinar la distintiridad de populaciones isoladas.

La extensiva distribución histórica del dace moteado por todas partes del Valle de Owens está indicado por las colecciones de los museos, hechos del 13 localidades. Un estudio de 166 sitios en la cuenca de Owens de 1988 a 1990 enseño que la especie ya no existe en nueve de estas localidades, y existe en tres sitios no representados en las primeras colecciones. La especie existe mas en el norte de Valle del Owens donde cinco demes de baja densidad persisten en habitaciones que son separadas de lejos a causa de populaciones de peces predatorios. Dos populaciones isoladas en Long Valley, Mono County, y una población cerca de Benton, Mono County, cada una de las tres ocupa pequenas manatiales y menos de 1 km de chorro. La especie es extincta de Little Lake. La especie ha declinado de su abundancia y distribución histórica a causa de la introducción de peces no nativos y el deterioro causada por la diversión de aguas. Las populaciones existentes tienen que ser protegidas para prevenir mas extinción del dace moteado.

Chemoreception, Imprinting, and Propagation of Colorado Squawfish and Razorback Sucker: a Plan of Study

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ABSTRACT

There is evidence that chemoreception is involved in spawning site selection and other life events in Colorado squawfish *Ptychocheilus lucius* and razorback sucker *Xyrauchen texanus*. The potential role of olfaction and imprinting in the recovery of extant populations of these endangered fishes is discussed and related to their reproduction. A work plan is proposed that would: 1) evaluate the roles of imprinting, learning, and genetic control on the reproductive ecology of Colorado squawfish and razorback sucker, 2) determine the mechanism by which adult fish locate suitable spawning areas, 3) assess the role of olfaction in habitat selection, and 4) develop plans for the establishment of new stocks of these fishes using information about their reproductive ecology.

RESUMEN

Existe evidencia de que la quimiorecepción participa en la selección del sitio de desove y en otros eventos durante el ciclo de vida del Colorado squawfish *Ptychocheilus lucius* y del razorback sucker *Xyrauchen texanus*. Este trabajo discute el papel potencial del olfato y la impronta en la recuperación de poblaciones existentes de estas especies en peligro de extinción, con relación a su reproducción. Se propone un plan de trabajo que incluye: 1)evaluar el papel de la impronta, el aprendizaje y el control genético en la ecologia reproductiva del Colorado squawfish y del razorback sucker; 2) determinar los mechanismos por medio de los cuales los peces adultos localizan las áreas de desove disponibles; 3) evaluar el papel del olfato en la selección del habitat; y 4) desarrollar planes para el establecimiento de nuevos stocks de estos peces utilizando información acerca de su ecología reproductiva.

INTRODUCTION

The Endangered Species Act (ESA) of 1973 provided new policy and funding to Federal and State agencies involved in protection and recovery of endangered animals and plants. However, little was known of the ecological requirements of many endangered species, and wildlife management concepts were more oriented toward sport hunting and fishing. In the American Southwest, progress toward recovery of endangered Colorado River fishes has been constrained by a paucity of information on their life history requirements, their rarity, and the harshness of the environments in which they live. In addition, current habitat use information may only reflect marginal use because the species have been in decline for many decades. Thus, caution must be used when interpreting current habitat use data.

Under the ESA, recovery must be accomplished within an ecosystem context. It is imperative that ecological aspects prevail in endangered species management, and an understanding of biotic and abiotic factors limiting the distribution and abundance of the target species be well understood and incorporated into any management attempt. Because remaining populations of endangered species are fully protected under the ESA, it is incumbent upon management agencies to demonstrate that proposed management or recovery actions will not further jeopardize the existence of a listed species.

This paper presents a recommended course of action for the study of chemoreception and imprinting in Colorado squawfish and razorback sucker in the upper Colorado River basin. We address the potential role of these mechanisms in the life cycle of these fishes, and the application of this knowledge to recovery plans. Study objectives include the following:

To determine the mechanism by which adult Colorado squawfish and razorback sucker locate suitable spawning areas, and to evaluate the role of olfaction in habitat selection.

To identify the roles of imprinting, learning, and genetic control on the reproductive cycles of Colorado squawfish and razorback sucker.
To explore means by which new populations of Colorado squawfish and razorback sucker may be established using innate behavioral mechanisms.

BACKGROUND:

Minnows and suckers belong to the Suborder Cyprinoidei. The fish family Cyprinidae, or minnows, consists of about 275 genera and over 1600 species and is the largest and most diverse in the world. The closely allied suckers, family Catostomidae, consists of 12 genera and 58 species. Spawning migrations occur in the Cyprinoidei and some of these are well-known in various parts of the world. In North America, potamodromous migrations of catostomids to specific spawning streams or reaches have been reported for many years (e.g., Dence et al. 1940, Dence 1948, Raney and Webster 1942). Similar migrations have also been reported in Asia for various minnows (Nikolskii 1961, Breder and Rosen 1966).

Several experiments have demonstrated that some minnows exhibit an exquisite sense of smell and can detect minute quantities of dissolved substances (Pfeiffer 1963, Kleerekoper 1969, Smith 1975). The use of chemical stimuli to orient to rearing areas has been extensively evaluated in salmonids and clupeids, but various minnow and sucker species also use olfaction to orient to natal streams (reviewed by McKeown 1984, Smith 1985). As an example, Werner (1979) found that migrating white suckers were impaired in their ability to detect their home stream when their nares were plugged; thus demonstrating an olfactory basis for homing in the fish.

Colorado squawfish and razorback sucker are presumably endangered, in part, because of complex life histories that are poorly suited to regulated environments. Recovery of both species requires a better understanding of their reproductive ecology. Considering that neither fish is secure, it is assumed that more intensive management/recovery options must be developed. Existing information about Colorado squawfish life history suggests some options. So little is known about the razorback sucker, that more basic information must be obtained before management tools can be developed. Because environmental conditions vary so greatly between upper basin rivers, it is assumed that recovery programs for both species must be determined and implemented on a site-specific basis. The following provides some review of the basic components of the life history of both species as a foundation for development of this work plan.

Migration

Much is written in the popular (e.g., Hay 1959) and scientific (reviewed by McKeown 1984, Smith 1985) literature about the migrations of fishes. Anadromous migrations of salmon, striped bass, and shad from the sea to spawning grounds in freshwater are well-known. Other fish migrations also occur, including catadromous movements of adults from freshwater to marine environments (e.g., eels); oceanadromous movements in the seas (e.g., herring and tuna); and potamodromous movements in freshwater (e.g., sturgeons, suckers, and minnows). Although migrations in freshwater include species that exhibit relatively short-distance movements, some eurasian species undertake long-distance movements of over 1,000 km.

Although migrations of commercially-valuable fishes have been intensively studied (reviewed by McKeown 1984), much has yet to be learned about causal mechanisms (Dodson 1988, Quinn and Tollman 1987), and very little is known about rare freshwater forms such as Colorado squawfish and razorback sucker. Spawning migrations of Colorado squawfish and razorback sucker have been reported for over 100 years (Jordan 1889), but environmental factors associated with migration are not well understood. It is assumed that, as in other species, environmental cues influence intrinsic biological mechanisms that result in spawning.Migrations of Colorado squawfish to spawning locations, presumably an adaptation to the fluctuating environment in which it evolved (Smith 1981, Tyus 1986), has been documented (Wick et al. 1983; Tyus and McAda 1984; Tyus 1985, in press). However, stimuli that cause the fish to migrate at the proper time and arrive at distant spawning locations have not been identified (Tyus and Karp 1989). In addition, return of young squawfish to natal areas as reproducing adults is suspected, but not documented. Less is known about the razorback sucker, but migration to spawning areas and repeated use of the same sites have been reported (Tyus and Karp 1990).

Early studies of fish migration were directed at understanding migratory patterns and factors affecting the control of fish migration. One outstanding contribution was the olfactory hypothesis for salmon homing proposed by Hasler and Wisby (1951). They suggested that young salmon imprint to the odor of their natal tributary, store this information in a long-term olfactory memory, and later use this memory to relocate the stream during spawning migrations. In the following 40 years, many other workers have tested and further refined this hypothesis. It is now recognized that fish imprint to a "home-site olfactory bouquet" which consists of environmental odors that may include both a geologic and species-specific component (Hasler and Scholz 1983, Foster 1985). However, our knowledge of the adaptive significance of migrations and reproductive cycles is poor for all but a few, commercially important species.

Migration patterns of adult Colorado squawfish are similar year to year. These movements are presumably an orientation to environmental conditions in the spawning reaches, and movements of fishes in up- and downstream directions is suggestive of an olfactory orientation mechanism (Harden-Jones 1968, Hasler and Scholz 1983). Some behaviors associated with olfactory orientation in salmonids were exhibited by Colorado squawfish, and the presence of spring-fed tributaries and other water inputs in spawning reaches may provide piloting cues. Tributary streams may provide gross cues for long-distance orientation, while more subtle cues, unique to specific sites, may be used for egg deposition (Tyus, In press). Reproductive by-products from previously-hatched young (Foster 1985) may also be included in a home-site olfactory bouquet. Colorado squawfish larvae may imprint such odors in the areas in which they develop, and later recognize these odors as migrating adults.

Recaptured and radiotagged adult Colorado squawfish have demonstrated a fidelity (repeated return) to the same spawning areas (Wick et al. 1983, Tyus 1985, in press). However, it has yet to be shown that these fish return to natal areas for spawning. The similarity of their behavior to that of many other fishes makes it probable that they do so, and this could lead to reproductive isolation and separate genetic stocks. It is noted that the maintenance of discreet stocks can be developed through spawning site imprinting and homing (Horrall 1981), and thus, specific migration routes and positive or negative rheotaxis in homing orientation suggests different genetic stocks (reviewed by Smith 1985). Some genetic interchange between stocks may occur from fish that "stray" from one area to another, and could be important for successful evolution of the species (Baker 1982; Leggett 1984). It is therefore important that the genetic identity of separate stocks of Colorado squawfish be identified and protected.

Knowledge of the reproductive ecology of the razorback sucker is poorly known, principally because successful recruitment is lacking throughout the Colorado River Basin (Lanigan and Tyus 1989, Marsh and Minckley 1989). However, razorback sucker migrations have been documented, and there is compelling evidence that homing behavior occurs as in the white sucker. The possibility of at least two separate spawning stocks of the razorback sucker in the Green River basin (Tyus and Karp 1990) suggests that imprinting and home site selection may be also be important considerations in the recovery of this fish.

STUDY METHODS AND APPROACH:

Because of the time required to do this work, and the critical need to demonstrate progress towards recovery of endangered Colorado River fishes, we plan to conduct basic ecological studies concurrently with developing recovery and management options. This would best serve the needs of the Recovery Implementation Program with respect to efficiency, timeliness, and cost. It is presumed that studies be designed and implemented with the combined efforts of Federal and State agencies, university researchers, and others.

We propose that the authors constitute a steering group for implementing the program. An advisory work group would consist of the following: (1) a representative from each of the non-game divisions of state wildlife conservation agencies from Arizona, Colorado, Utah, and New Mexico; (2) one representative from the Bureau of Reclamation; (3) one representative from the Western Area Power Administration; (4) an expert on artificial imprinting (A.T. Scholz); (5) an expert on chemosensory cues from reproductive by-products (N.R. Foster); and (6) a representative from the Biology Committee, Recovery Implementation Program. In addition, administrative and clerical support would be necessary, and this would presumably be available from the Fish and Wildlife Service.

Study initiatives and priorities would be developed jointly by the steering and advisory groups. It would then be incumbent on the steering group to implement annual work agendas by the most prudent and feasible means. Studies would presumably consist of laboratory and field activities, of which laboratory work would be solicited from competent researchers at large. Field studies would be conducted primarily by state and federal agencies.

Colorado squawfish

Work on Colorado squawfish would be primarily field-oriented, and directed toward evaluation and protection of some stocks, and augmentation of others. Recovery of Colorado squawfish may require provision of new spawning habitats in some areas and reestablishment of populations in areas where it is lost, or greatly diminished. Population augmentation or reintroduction may fail unless the reproductive behavior associated with the location of suitable spawning and nursery sites is understood.

Information about reproductive ecology of Colorado squawfish in the Green and Yampa rivers was used to outline studies evaluating olfaction and imprinting as a means for recovering or re-establishing populations of the fish. Further development of such studies would be accomplished jointly with assistance from knowledgeable researchers. A principal investigator has been identified to guide each major study section, and field personnel suggested for conducting the work. Locations selected for performing the work were based on criteria associated with operational costs and recovery potential.

Razorback sucker

Razorback sucker work would include an evaluation of existing stocks, but more emphasis would be placed on artificial imprinting as a stop-gap measure. Emphasis would be placed on stock evaluation and use of hatchery facilities to a greater extent than in the Colorado squawfish.

The Colorado River Fishes Propagation and Experiment Station at Ouray, Utah has been given a high priority for razorback sucker work because of its proximity to a large population of spawning adults and potential recovery areas, staff experience with propagation of the fish, and reduced costs associated with using an existing facility. Release of imprinted fish into the Green River would ostensibly provide the best existing habitat to insure high returns. However, the importance of this work dictates that more than one site be used if possible, and results compared. This study is restricted to the Upper Colorado River Basin, and it is noted that state regulations may not allow work on the endangered fishes outside the basin.

WORK ITEMS:

Genetic Assessment

Recent studies indicate that some Colorado squawfish and razorback suckers in the Green and Yampa rivers return to the same spawning sites for spawning (Wick et al 1983, 1986; Tyus 1985, In press; Tyus and Karp 1990). If return to these specific spawning sites is a general reproductive phenomenon for these species (i.e., the fish return to natal spawning areas as adults and spawn in the reach(a) or exact site(b) at which they were hatched), then genetic differentiation among disjunct spawning populations or stocks is suspected. The existence of genetically-distinct populations of Colorado squawfish and razorback suckers should be evaluated for these different spawning areas could be evaluated by collecting and analyzing genetics data. In addition, there may be a genetic basis for sub-stocks within a spawning area; in squawfish, the different rheotaxes (positive and negative) noted in migrating fish suggest the existence of these sub-stocks. These different movement patterns must also be considered in testing the following hypotheses:

H1:Breeding populations of Colorado squawfish and razorback suckers differ genetically.

Tasks: Determine if Colorado squawfish and razorback sucker are reproductively isolated between (a) reaches or (b) spawning sites:

Methods: Identify spawning sites in the upper Colorado River Basin. At each site during the spawning season, capture fish in breeding condition and mark them with a uniquely-numbered tag. Take superficial somatic tissues and gametes from each fish for genetic analyses. If possible, obtain tissues and sex products of fish known to use reaches(a) and sites(b) for spawning, or of fish emerging from such areas. Perform analyses (i.e. allozymes and mtDNA) to determine differentiation within and among breeding populations. In addition, emerging larvae should be taken from each spawning site and these fishes also subjected to genetic analyses. Use fish from Green, Yampa, and Colorado rivers, and use northern squawfish as the outgroup.

H2:Upstream and downstream migration (i.e. positive and negative rheotaxis) in Colorado squawfish is under genetic control.

Task: Determine if Colorado squawfish that migrate upstream and downstream to reach the same spawning grounds are genetically different.

Methods: Obtain tissues from both groups, evaluate genetic differences as above.

Imprinting

It is presumed that Colorado squawfish and razorback sucker return to natal areas by use of olfactory cues (i.e., memory of specific home-site odor bouquet). If the young fish are imprinted, it must occur at an early ontogenetic stage as in pink salmon and other fishes which emigrate immediately after emergence (Hasler and Scholz 1983). Although it is of interest to know when imprinting occurs (i.e., egg stage, swim-up, or as the young fish migrate downstream from spawning areas), some problems can be avoided if the fish can be imprinted to a synthetic chemical.

If artificial imprinting is successful, then maintenance of release sites would be necessary to provide release of the imprinting chemical in perpetuity. Therefore, it would also be important to learn if reproductive by-products in spawning areas could function to attract young in the absence of imprinting odors.

H3: Colorado squawfish and razorback sucker are imprinted to a specific home-site odor bouquet (HSOB) on spawning areas, and use this induced memory to return to those areas as spawning adults.

Task: Determine if fish learn a HSOB, subsequently use these as a cue to locate spawning sites.

Methods: Capture local spawners from two areas, fertilize eggs from those sites, split egg lots into two from each area and place one-half of each lot in baskets of media and return to parental spawning sites. After 1-2 weeks remove these to hatchery, rear them to about 300 mm (about 1 year before the males are expected to mature) and mark them with coded wire or PIT tags. Of these, stock all but 100 fish in areas upstream and downstream of the hatching sites. Of the remainder, radiotag 50 fish from each location and release them upstream (25) and downstream (25) of spawning areas in the summer or fall after they first reach sexual maturity. Monitor these fish and determine their behavior during the next spawning season.

Task: Determine if razorback suckers reared at the Ouray hatchery facility are imprinted to hatchery discharge water.

Methods: Place traps in hatchery discharge pipes and attempt to attract fish that were reared at Ouray and released into the Green River 3 to 5 years previously.

H4: Colorado squawfish and razorback sucker can be artificially-imprinted to a suitable synthetic substance.

Task: Test synthetic substances for imprinting effectiveness.

Methods: Obtain newly-fertilized eggs from a hatchery, mark them during incubation and early larval development, rear to sub-adult size, and release at a re-introduction site. Three groups would be marked: morpholine, phenethyl alcohol and a control group that would be hatched in hatchery water. The reintroduction site would be carefully chosen for its adequacy as a future spawning and rearing area, and the fish would be attracted as spawning adults by releasing imprinting chemicals (and control water) during the anticipated spawning period.

Response of the imprinted fish to suitability of the attractant and various habitats would be monitored by recaptures.

H5: Colorado squawfish and razorback suckers recognize odors from reproductive byproducts and use them to locate specific sites for egg deposition.

Task: Determine if reproductive by-products can be used to attract fish in lieu of using a synthetic chemical.

Methods: Obtain biological waste-products (egg cases, feces, etc) from hatchery-reared fish, and place these in selected spawning locations. Monitor the location by capturing fish during the spawning season. This could be done in the presence or absence of other cues (HSOB or synthetic compounds) depending on study design.

Morphology

It is important to determine temporal development of functional receptors used in olfaction to determine the timing associated with imprinting. Therefore it is necessary to determine the comparative functional morphology of sensory organ development and their function.

Also there are accessory organs involved with reproduction in both species: In the Colorado squawfish, breeding tubercles are hard, horny structures that may have a tactile function in breeding, and razorback sucker tubercles are soft and fleshy organs that may be involved with secretions of attractant odors.

H6: Functional receptors used in olfaction develop at an early stage in Colorado squawfish and razorback sucker

Task: Determine the development of olfactory sensory organs

Methods: Obtain a series of ontogenic stages for both species and determine structures microscopically.

Task: Determine neuroanatomy of sensory system: when do connections become functional (i.e. "turned on").

Methods: Obtain a series of ontogenic stages for both species and determine structures microscopically.

H7: Breeding tubercles are important reproductive organs that may be involved in attracting mates and influence the successful completion of spawning.

Task: Evaluate the role of tubercles in reproduction.

Methods: Obtain tissues from sexually-mature fish and examine these structures microscopically to determine possible function.

Population Augmentation or Re-establishment

Knowledge of genetic control and olfactory response to imprinted odors can assist in recovery of Colorado squawfish and razorback sucker by augmenting existing populations, or establishing new populations of the fishes. This will require incorporation of new ideas into fisheries management, and long-term field efforts to successfully augment or reestablish new populations.

We propose that the larger, and presumably more stable populations in the Yampa-Green system be evaluated and studied for population attributes, and to determine relationships between fish response and environmental conditions. Although some "natural" imprinting would be evaluated in Colorado squawfish and razorback sucker in the Green River, other locations would be more acceptable for augmentation and re-establishment. Population augmentation should be attempted in the Colorado River, by utilizing existing knowledge. Reestablishment and testing of synthetic substances might be best conducted in the San Juan River. Finally, an effort to reestablish the fishes in locations where they currently do not exist, perhaps in the lower basin, would ultimately test the effectiveness of the developed methods. Because of time required to test the previously mentioned hypotheses, it would be best to conduct all studies simultaneously, and to make adjustments in the program, as needed, when data become available.

Recommended Work for FY 1990-1991:

Because all parts of this project will require several years (5-7) to complete, we recommend that immediate steps be taken to implement appropriate parts. As examples, there are several projects that will be sampling target fish during this period, including razorback sucker and Colorado squawfish spawning, Gila, and others. Some of these projects will have the capability to obtain genetic material and to preserve this for use in evaluating stocks of Colorado squawfish and razorback sucker. PIs in those projects should be encouraged to cooperate by obtaining needed material. If extra funds are available, they could be provided to assist sampling during the spawning seasons. Objectives include:

-Develop final SOW after review and comments received from Technical Committee, select cooperators and study sites (i.e., spawning areas).

-Develop sampling protocols and identify sampling teams for various locations.

-Develop non-lethal tissue-sampling techniques and collect tissues and gametes, obtain larvae, tag fish.

-Contact field personnel involved in on-going work, provide them with guidelines and any needed equipment to tag breeding fish and to obtain genetic material from fish they may encounter.

-Begin work on RFP's for contractors, memoranda of agreement for cooperating agencies.

-Develop and finalize any needed MOU's between agencies, develop and award competitive contracts, and develop needed purchase orders or sole source contracts for assistance from identified experts.

-Initiate spawning basket experiments.

-Perform data analyses, integrate findings

-Develop FY 92 scope of work dependent on results of above studies.

Genetic assessments would determine if distinct populations exist among fish from different spawning sites, reaches, and those that exhibit differential rheotactic responses. Distinct populations would mean site specific spawning and this would require a mechanism in the fish that would allow identifications of the home site. Previous experience in other species suggests that imprinting may be the mechanism responsible if site-specific differences exist. If no distinct populations are found, a high degree of straying and genetic mixing would be indicated, and this would suggest that the spawning site fidelity previously reported is practiced only over a few spawning seasons. However, recognition of the spawning sites, as indicated by the return to them of the fish, would suggest that some environmental cue is available to the fish. Work with lake trout (Horrall 1981, Foster 1985) suggests that olfactory cues indicating an acceptable site, rather than a specific site, may operate in the latter case.

In populations of Colorado squawfish studied to date, certain river sections are used heavily for spawning, and there is a fidelity for these sites over several years. Certain genetic and environmental components may be involved in this site selection, and the genetic assessment will be helpful in evaluating which one of these components may be operating. In any event, the development of recovery plans may require imprinting or conditioning fish to certain sites, and fish will be needed for this work. Fertilized eggs must be obtained, subjected to environmental conditions, and the larvae should be reared in the hatchery. In this manner, fish will be available for necessary experiments to evaluate different spawning strategies. This can be best accomplished by obtaining gametes from fish on-site.

ACKNOWLEDGEMENTS

This paper was prepared with funds provided by the Recovery Implementation Program and U.S. Fish and Wildlife Service. P. B. Johnsen, J. H. Williamson, C. A. Karp, and others improved an earlier draft of the manuscript. F. Abarca rendered a spanish translation of the abstract.

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XXII SIMPOSIO ANUAL INTERNACIONAL SOBRE LOS PECES DE ZONAS ARIDAS

TITULO/TITLE: PECES DE UN DESIERTO TROPICAL

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RESUMEN/ABSTRACT

En el Estado de Oaxaca se presenta una región árida que muchos autores han clasificado como desértica, la Ictiofauna de esta zona presenta características peculiares en cuanto a su origen, ya que se han encontrado peces templados, así como tropicales. La Mixteca o desierto de Tehuacán actualmente sufre impactos debido a la ganadería y asentamientos humanos, siendo los cuerpos de agua escasos y muy explotados. En este trabajo se presenta un panorama de la diversidad de especies icticas, y se analiza los paramentros ambientales en que se encuentran actualmente, con el fin de recomendar medidas que lleven a su conservación.

DISTRIBUTION AND STATUS OF CHIHUAHUA CHUB, GILA NIGRESCENS; UNITED STATES AND MEXICO, 1990

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The precarious status of the Chihuahua chub, *Gila nigrescens*, in the United States, and concern that the species has declined in range and abundance in Mexico, prompted an inventory of the Bustillos and Guzman basins, Chihuahua, in March 1990. Ten sites in the Bustillos and 42 in the Guzman basins were sampled. *Gila nigrescens* was found at five sites in the Bustillos and 23 in the Guzman. At most locations, *G. nigrescens* was uncommon or rare; it was moderately abundant at 11. Generally, *G. nigrescens* was found where debris piles had accumulated, stream banks were undercut, or among submerged root wads. Such habitats were most common where human modification of the streams was limited. Where stream water was extensively diverted for irrigation and human settlement was rather dense, few or no specimens of *G. nigrescens* were collected. In the United States, *G. nigrescens* is restricted to about a 10 km reach of the Mimbres River in southwestern New Mexico. There the fish is moderately common only in a spring system associated with the river. Based upon information provided by previous workers and our work, *G. nigrescens* in the Bustillos and Guzman basins has declined in the past 15+ years and continued development of the water resources of New Mexico and Chihuahua will cause future losses in range and abundance.

LA DISTRIBUCION Y ESTADO POBLACIONAL DE *GILA NIGRESCENS* EN LOS ESTADOS UNIDOS DE AMERICA Y MEXICO, 1990

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El estado precario de *Gila nigrescens* en los Estados Unidos de América, y la preocupación que la especie ha declinado en su rango de distribución y abundancia en México, estimuló un inventario de las cuencas de Los Bustillos y Guzmán, Chihuahua, durante marzo de 1990. Diez sitios en la cuenca de Los Bustillos y 42 en la de Guzmán fueron muestreados. *G. nigrescens* fue hallado en cinco sitios en la cuenca de los Bustillos y en 23 sitios en la de Guzmán. En la mayoria de las localidades, *G. nigrescens* fue poco común o escaso; fue moderamente abundante en 11 localidades. Generalmente, *G. nigrescens* se encontró en sitios donde había acumulado montícolos de escombro, donde hubo solapas debajo de las orillas, o entre raices sumergidos. Tales habitats fueron más comunes donde la modificación de los arroyos por el hombre fue limitado. Donde el agua de los arroyos fue desviada extensivamente para riego y donde la colonización humana fue densa, pocos o ningunos ejemplares de *G. nigrescens* fueron recolectados. En los E.E.U.U., *G. nigrescens* es restringido a un tramo de 10 km del Río Mimbres en el suroeste del estado de New Mexico. Allí, el pez es moderamente común solamente en un sistema de nacimientos de agua asociados con el río. Según información proveida por investigadores previos y a éste trabajo, *G. nigrescens* en las cuencas de Los Bustillos y el Guzmán ha declinado en los ultimos 15+ años y el continuado sobreaprovechamiento de los recursos acuáticos de New Mexico y Chihuahua causará futuras pérdidas en el rango de distribución y la abundancia de esta especie.

XXII SIMPOSIO ANUAL INTERNACIONAL SOBRE LOS PECES DE ZONAS ARIDAS

TITULO/TITLE: LOS PECES DEL ARROYO SAN PEDRO-LA PRESA,

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RESUMEN/ABSTRACT

El arroyo de San Pedro-La Presa, se localiza a 80 Km. al Norte de la Ciudad de La Paz, B.C.S. en las estribaciones de la Sierra de la Giganta, en donde se han encontrado poblaciones de cinco especies de peces. Una de estas es Fundulus lima, endémica del Estado, a la que se creía extinta; las otras son Eleotris picta, - - - Agonostomus monticola, Dormitador latifrons y Poecilodos no identificados aun, introducidos en este sitio - por los pobladores del area como peces de ornato.

ICHTHYOFAUNISTIC REPORT OF THE ATOYAC AND MIXTECO RIVER BASIN IN THE MIXTECA REGION, PUEBLA-OAXACA, MEXICO

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During 1989, a series of collects were made in the Atoyac River Basin, including part of the Puebla and Oaxaca states. The collected material was donated to the Freshwater Fishes Collection of the Fishes Laboratory, Biology Department, in the Universidad Autonoma Metropolitana Unidad Iztapalapa. In this work, the obtained data in the Mixteca area during the realization of such collects, are reported in placard modality.

[Editor's note: this abstract was received only as a FAX transmission. An apparently small part of it, in the location of this note, was lost in transmission. The entire abstract was re-typed verbatim and re-printed by the editor for reproduction. Pagination of the FAX, from which the index was developed, is retained. The editor accepts responsibility for any errors in transcription from the FAX]

....the antecedents, the justification, and the utilized materials and methods.

A geologic and hydrographic map is presented, where it is indicated the study area. There are also included: temperature and annual precipitation distribution graphs and a brief description of the climate, according to the Köppen Classification (modified by Garcia).

Photographs of the six native species are shown, including pertinent data such as: scientific name, common name, locality, reported distribution for the species and its biogeographic origin, if the stream was rapid or not, and peculiar data such as the fact that Poeciliopsis gracilis populations consist, apparently during certain year's season, of females only. Finally it is mentioned the real and potential use for every species.

It also are included a discussion of the data and the conclusions that can be followed, giving emphasis in the biogeographic peculiarities of the region, which includes Neotropical and Neartic species and also, species tht belongs to the Pacific Slope and another one that belong to the Atlantic Slope.

With this placard we pretend to prove that, although a resources scarcity exist, basic Biology investigation has to be done, so it can contribute with important data of our species and ecosystems, as in this particular matter, to the knowledge of fishes of the arid zones.

This study was realized with the support of the Junta de Mejoramiento Moral, Civico y Material del Municipio de Puebla and the Association France Cichlid.

XXII SIMPOSIO ANUAL INTERNACIONAL SOBRE LOS PECES DE ZONAS ARIDAS

TITULO/TITLE: Potencial de Depredación de Algunos Insectoas Acuáticos (LIBELLULIDAE, COENAGRIONIDAE, HYDROPHILIDAE, NOTONECTIDAE AND CORIXIDAE).

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RESUMEN/ABSTRACT

Los insectos fueron divididos en trestallas y se observó que en las familias Libellulidae, Coenagrionidae y Notonectidae, la capacidad de depredación de alevines se incrementa con relación a la talla. Por el contrario, las larvas de la familia Hydrophilidae consumen más alevines cuando su propia talla es pequeña, mientras que las larvas en la talla mayor casi no presentan capacidad depredadora de alevines, aunque llegan a consumir alevines más grandes que su propia talla.

Se encontró que las ninfas de la familia Libellulidae son las que representan mayor peligro para los alevines, con un promedio de depredación diaria de 1.64 alevines por insecto por día; le siguen los insectos de la familia Notonectidae con un promedio de 1.50, la familia Coenogrionidae con 0.43 y las larvas de la familia Hydrophilidae con 0.35 alevines consumidos diariamente por cada insecto. También se determinaron los límites de la depredación con respecto al tamaño para cada una de las familias utilizadas en este estudio y se observó que mientras más grande es el insecto, mayor es el tamaño de los alevines que puede consumir.

Los insectos de la familia Corixidae no consumieron alevines en ninguno de sus tamaños, por lo tanto no se consideran como depredadores . La interación de tallas entre el depredador y su presa es en linea, entre mayor sea el insecto mayor sera su presa.

ABSTRACT

Predation potencial of some aquatic insect (LIBELLULIDAE, COENAGRIONIDAE, HYDROPHILIDAE, NOTONECTIDAE AND CORIXIDAE) upon fish fry.

The insects were divided by size into three ranfe class, Libellulidae, Coenagrionidae and Notonectidae increased the predation potencial with their increment in lenght, opposed to Hydrophilidae which ate more fry at the somller size, meanwhile the largest insect almost did not eat fry, but were capable of eating larger fry than it's own body lenght.

Libellulidae happened to be the most dangerous to the fry, eating an average of 1.64 fry daily, followed by Notonectidae, consuming 1.5 fry a day, then there is Coenagrionidae - with en uptake of. 0.43 fry, and at last the Hydrophillidae larvae with a daily consumption

Corixidae proved to be a nonpredator by not eating any size of fry by neither size of the insect.

Also it was tested the fry size-insect-size interaction observing straight relationship for all insects. that ins the bigger the insect the larger the fry it can capture up to 19 mm. either.

Conservation Genetics of Tui Chub (Gila bicolor)

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Conservation genetics involves application of genetic theory and methodology to both taxon identification and the quantification, maintenance, and enhancement of genetic "health" of managed populations. Ideally, diagnostic genetic characters define taxa and offer unambiguous identification of pure versus hybrid populations. Estimates of gene diversity, commonly measured as heterozygosity, yield insight into current levels of adaptive plasticity, an indication of a population's ability to cope with environmental fluctuation. A genetic study of the Owens tui chub (Gila bicolor snyderi) is ongoing to determine the status and geographic range of this Federally listed, Endangered species. Comparative data have been obtained from Lahontan creek tui chub (G. b. obesa), Goose lake tui chub (G. b. thalassina), Klamath River tui chub (G. b. bicolor), and two undescribed tui chub forms. Preliminary results indicate that the seven populations of Owens tui chub examined have moderate levels of gene diversity. This suggests that, at least from a genetic perspective, these populations are robust. Owens tui chubs are significantly differentiated from all reference tui chubs except the Lahontan creek form. Thus, potential hybridization between obesa and snyderi cannot be answered yet.

La Conservación Genética del Ciprínido (Gila bicolor)

La genética de la conservación implica la aplicación de la teoría y la práctica en genética tanto para la identificación de taxa como para la cuantificación, mantenimiento y mejoramiento del "bienestar" genético, de las poblaciones en cuestion. Idealmente, los caracteres genéticos diagnosticables definen una taxa y diferencian con certeza una población híbrida de una pura. Estimaciones de la diversidad genética, comunmente medidos como heterocigozidad, permiten una mejor apreciación de los niveles actuales de plasticidad adaptativa - una indicación de la habilidad de una población para sortear fluctuaciones en el medio ambiente. El estudio genético del ciprinido de Owens (Gila bicolor snyderi) esta encaminado a determinar el estado actual y el rango geográfico de esta especie catalogada como "bajo amenaza" según las regulaciones federales. Datos comparativos han sido obtenidos de ciprinidos de la quebrada Lahontan (Gila bicolor obesa), del lago Goose (Gila bicolor thalassina), del rio Klamath (Gila bicolor bicolor), y de otras dos subespecie no descritas. Resultados preliminares indican que las siete poblaciones de ciprínidos tienen niveles moderados de diversidad genética, lo cual sugiere que al menos desde el punto de vista genético dichas poblaciones se encuentran en un buen estado. Los ciprínidos de Owens se diferencian notablemente de las otras especies de ciprínidos anteriormente descritas, a excepcion de la variedad de Lahontan (Gila bicolor obesa). De esta manera la posibilidad de hibridización entre esta subespecie y el ciprinido de Owens (Gila bicolor snyderi) no ha sido aún determinada.

The Distribution and Abundance of the Fishes of Ash Meadows: A Preliminary Inventory

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As part of the effort to restore the Ash Meadows, Nevada, ecosystem to its original condition, a preliminary fish census was conducted during the summer and fall of 1990 in order to document the abundance and distribution of exotic and native fishes. Four native fish populations, all of which are endangered, were found to occupy a variety of habitats, including springpools, spring outflows, marshes, and reservoirs. A Peterson mark-recapture technique documented the presence of 15,600 Ash Meadows Amargosa pupfish (Cyprinodon nevadensis mionectes), 420 Warm Springs pupfish (Cyprinodon nevadensis pectoralis), and 590 Ash Meadows speckled dace (Rhinichthys osculus nevadensis) in the springheads on the Ash Meadow National Wildlife Refuge. The distribution of the Ash Meadows Amargosa pupfish was found to occur over a wide range in the spring outflows, marshes, and reservoirs, while Warm Springs pupfish and Ash Meadows speckled dace were restricted to much smaller areas. Devils Hole pupfish (Cyprinodon diabolis) were counted visually and were found to number 440 individuals in Devils Hole, and 118 fish in an artificial refugium. As a group, non-native mosquitofish (Gambusia affinis), sailfin mollies (Poecilia latipinna), largemouth bass (Micropterus salmoides), and black bullheads (Ictaluras melas) were found to be widely distributed over the entire refuge, and are continuing to expand their range.

Genetic Diversity in Small Isolated Breeding Populations

Klaus D. Kallman, New York Aquarium

Numerous species of poeciliid fishes are restricted to small springs or small sections of rivers in the arid parts of the southwestern United States and adjacent parts of Mexico, whereas elsewhere poeciliid species may be distributed over thousand of square miles. The isolated forms often have a small effective breeding populations. They are threatened with extinction, because of man-made habitat destruction, natural failure of springs due to increased aridity or perhaps due to inbreeding depression as the population size contracts. Limited biochemical data suggest that many small isolated populations exhibit reduced genetic variability. We have used a more sensitive method to assess genetic variability in small populations of Xiphophorus (platyfish and swordtails) by using the tissue transplantation technique. Transplants in platyfish, as in man, survive only if all the donor's transplantation antigens are also present in the recipient. Because these fish possess twelve or more histocompatibility genes each one of which can exist in two or more allelic states, a huge number of genotypes exist in large outbreeding populations and the chance that any two individuals, including siblings, share the same histocompatibility genotype is virtually nil. No graft survival is expected. This prediction was tested by making fin transplants among siblings of parents taken from large populations. Not one graft survived. However, when similar transplants were made among fish derived from small populations of geographically restricted species, up to 95% of the grafts survived. In the spike-tailed platyfish transplants were "takes" among members of an isolated population but were rejected when host and donor came from an abundant population. These data demonstrate that small isolated populations or species are naturally inbred but exhibit no deleterious effects. Fifty years of experience of maintaining stocks of platyfish and swordtails in the laboratory has shown that stocks derived from founders of large populations generally suffer from inbreeding depression and are eventually lost. Stocks that originated from founders taken from the periphery of a species' distribution or from a small isolated population can often be kept without difficulty. Some strains have been maintained for up to 70 - 80 generations.

RE-DISCOVERY OF *Gila intermedia* and *G. purpurea*

IN NORTHERN SONORA, MEXICO.

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Abstract

Gila chub, *Gila intermedia* was first collected in northern Sonora in the Rio Santa Cruz in 1851 by John H. Clark. Subsequent records in the Mexican portion of the basin are undocumented, and *G. intermedia* was considered probably extirpated from Sonora. In August 1990, 13 specimens of *G. intermedia* (45.5 mm to 98.7 mm SL) were collected in Ciénega Los Fresnos (31° 19' N and 110° 26' W), adjacent to the Arroyo Los Fresnos (tributary of the rio San Pedro) within two km of Arizona. Ciénega Los Fresnos is in a natural grassland used for livestock grazing. The Ciénega consist of a series of narrow, deep pools connected by shallow channels, and a main channel which joins the Ciénega with the Arroyo Los Fresnos. Abundant *G. intermedia* were observed in pools with dense aquatic vegetation. Additionally probable tiger salamander, *Ambystoma tigrinum stebbinsi*, and Huachuca springsnail, *Pyrgulopsis thompsoni*, both with restricted distribution, as well as the rare plant *Lilaeopsis schafferiana* var. *recurva*, were observed in the Ciénega. The record of at least four species of restricted distribution make Ciénega Los Fresnos important for the study and conservation of these species.

In addition, at Rio San Bernardino, a tributary of the Rio Yaqui, 23 Yaqui chub (*Gila purpurea*) specimens were collected in Sonora just below the boundary with Arizona. This is the first collection record of *G. purpurea* in Sonora since the species was split into *G. purpurea* and a presently undescribed *Gila* sp. Historically, all *Gila* in the rios Sonora, Màtape, Moctezuma and San Bernardino in Sonora were considered to be *Gila purpurea*. But recent analysis suggest that *Gila* in the rios Sonora, Màtape and Moctezuma are a distinct, undescribed species, leaving the Rio San Bernardino as the only site for which *G. purpurea* is presently know in Sonora. Questions remain about the distribution and taxonomic relationships of these two species that can only be answered by additional survey and collection.

REDESCUBRIMIENTO DE *Gila intermedia* Y *Gila purpurea* EN EL NORTE DE SONORA, MEXICO

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Resumen

El charalito del Gila, *Gila intermedia* fué originalmente colectado en el norte de Sonora en el Río Santa Cruz en 1851 por John H. Clark. Los registros siguientes en la porción Mexicana de la cuenca del Gila son inciertos y *G. intermedia* fue considerada probablemente extirpada de Sonora. En Agosto de 1990, 13 especímenes de *G. intermedia* (45.5 mm a 98.7 mm de Lp) fueron colectados en la Ciénega Los Fresnos (31° 19' N y 110° 26' O) adyacentes al Arroyo Los Fresnos (tributario del Río San Pedro) a 2 km de Arizona. La Ciénega Los Fresnos está en un pastizal natural utilizado como terreno de agostadero. La Ciénega consiste de series de tanques estrechos y profundos conectados por canales someros, y un canal principal que une a la Ciénega con el Arroyo Los Fresnos. *G. intermedia* fué observada abundante en los tanques, asociada a coberturas de plantas acuáticas. Adicionalmente se observaron en la Ciénega probables Salamandras Tigre *Ambystoma tigrinum stebbinsi*, caracoles de Ciénega Huachuca *Pyrgulopsis thompsoni*, ambas de distribución restringida a la región del Río San Pedro, así como la planta rara *Lilaeopsis schafferiana* var. *recurva*. El registro de al menos cuatro especies de distribución restringida, proporciona a la Ciénega Los Fresnos una condición importante para el estudio y conservación de estas especies.

Adicionalmente, en el Río San Bernardino, tributario del Río Yaqui, 23 ejemplares del charalito Yaqui (*Gila purpurea*) fueron colectados en Sonora justo en la frontera con Arizona. Este es la primer colecta de *G. purpurea* en Sonora desde que la especie se separó en *Gila purpurea* y una *Gila* aún no descrita. Historicamente, todos los *Gila* de los Ríos Sonora, Mátape, Moctezuma y San Bernardino en Sonora eran considerados como *Gila purpurea*. Pero, análisis recientes sugieren que *Gila* en los Ríos Sonora, Mátape y Moctezuma son una especie distinta aún no descrita, dejando al Río San Bernardino como el único lugar donde *G. purpurea* es conocida actualmente en Sonora. Existen interrogantes acerca de la distribución y relación taxonómica de estas dos especies que sólo pueden ser resueltas con investigaciones y colectas adicionales.

OBSERVED GROWTH AND MOVEMENT IN INDIVIDUALS OF THE LITTLE COLORADO POPULATION OF THE HUMPBACK CHUB (Gila cypha)

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The following information was collected during May (1987-1989) and April-May (1990). Data were examined for between year and within year trends. During this research 358 humpback chubs, were collected more than once in a given year. Within year analysis revealed a difference of 8.35mm in total lengths between the initial capture and recapture. An error in sex determination was made every 6.6 fish (16%). The average number of days between recaptures was 3.55 days. The average distance between the initial capture/recapture sites was 427m.

The 73 humpback chubs used in the between year analysis were found to grow 0.037mm/day, 1.1mm/month and 13.5mm/year when considering the total population across all age and size classes. The observed mean growth was 19.0mm. The average days at large was 497 (entre 337-1080 days). The average distance between capture and recapture was 1700m (range 0-10459m) between years.

Observed growth in fish less than 200mm in total length was 23mm (N=11); fish between 200-250mm grew 22mm (N=15); fish between 250-300mm grew 18mm (N=6); fish between 300-350mm grew 7mm (N=13); fish between 350-400mm grew 8mm (N=22); while fish over 400mm grew 2mm (N=6). Smaller fish grew considerably faster than older larger fish. Growth slowed considerably once fish reached 360mm in total length.

EL CRECIMIENTO Y MIGRACIÓN DE LA ESPECIE ICTICOLA "HUMPBACK CHUB" (Gila cypha), EN EL CHIQUITO COLORADO RIO.

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La siguiente informacioń fué obtenida durante Mayo (1987-1989) y durante April-Mayo (1990). Esta informacion fué analizada por tendencias y direccioń durante y entre los años que compredió este estudio. 358 Gila cypha fueron coleccionados más de una vez durante el mismo año. Esto reveló una total diferencia de más or menos 8.35mm de longitud total entre la primera y segunda captura. El margen de error sobre los sexos comprende approximadamente 6.6 peces o sea el 16%. El termino medio de tiempo entre la primera y segunda captura fue de 3.55 dias. El termino medio de distancia entre los sitios de captura primaria y secondaria fue de 427 metros.

De los 73 epecimes de Gila cypha reconocidos entre los años de este estudio reveló un índice de crecimiento de 0.037mm por dia, or sea 1.1mm por mes y 13.5mm por año considerando la poblacioń total incluyendo todas las edades y tamaños de los peces. El termino medio de crecimiento observado fue de 19mm por año. Es aproximadamente un promedio de 497 dias (entre 337 a 1080 dias). El termino medio de distancia entre captura primaria y secundaria fue de 1700 metros (entre 0-10, 459 metros).

El termino medio de crecimiento de peces de menos de 200mm de longitud fue de 23mm (N=11): peces entre 200-250mm crecieron 22mm (N=15); peces entre 250-300mm crecieron 18mm (N=6); peces entre 300-350mm crecieron 7mm (N=13); peces entre 350-400mm crecieron 8mm (N=22); mientras peces mas de 400mm crecieron 2mm (N=6). Peces mas pequenos crecieron considerablemente mas rápido que peces mayores y mas grandes. Crecimiento retardo considerable cuando los peces obtuvieron 360mm en medida de longitud.

RELACION DE FACTORES BIOTICOS Y ABIOTICOS EN LA AMPLITUD DEL RANGO CASERO DE LA TRUCHA ARCOIRIS *ONCORHYNCHUS MYKISS NELSONI*, DEL ARROYO SAN RAFAEL, SIERRA SAN PEDRO MARTIR, B.C., MEXICO.

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RESUMEN--La influencia de los factores bióticos y abióticos en la amplitud del rango casero de la trucha arcoiris, *O. mykiss nelsoni*, fue estudiada durante un ciclo anual (Oct. 1988 a Dic. 1989) a través de una sección de 1 km del Arroyo San Rafael, Noroeste de Sierra San Pedro Mártir, B.C. Un total de 151 truchas adultas (> 1 año) fueron marcadas y liberadas en sus sitios originales de captura, de las cuales 41 (27 %) fueron recapturadas. Las truchas recapturadas demostraron un patrón general de permanencia en sitios específicos del arroyo, tipicamente en pozas con sustrato arenoso, y registraron un promedio de amplitud de rango casero de 4.6 m (Min = 3 m y Max = 70 m). La amplitud del rango casero registró una significativa correlación ($p < 0.05$) con la profundidad y descarga del arroyo, asimismo, registró una baja correlación ($p > 0.05$) con la densidad y diversidad de presas (bentónicas y deriva), temperatura y sustrato. El tamaño del rango casero fue similar entre las clases talla de la trucha. La mayoría de las truchas exhibieron mayor desplazamiento durante el período de reproducción (Enero a Marzo), probablemente debido a la búsqueda de sitios adecuados de desove.

ABSTRACT--The influence of abiotic and biotic factors on the homing range amplitude of San Pedro Martir rainbow trout, *O. mykiss nelsoni*, was studied during one year (Oct. 1988 to Dec. 1989) throughout 1 km section of Arroyo San Rafael, Sierra San Pedro Martir, B.C. A number of 151 adult trouts (> 1 year) were tagged and released in their capture original sites, being 41 (27 %) specimens recovered. The displacement of tagged trout along stream showed a tendency to permanence in stream specific sites, typically in pools with sandy bottom, as well as an average range size of 4.6 m (Min = 3 m and Max = 70 m). Homing range obtained a significant correlation ($p < 0.05$) with the stream depth and discharge, however, registered a poor correlation ($p > 0.05$) with the prey density and diversity (benthic and drift), temperature and sediment type. We did not find significant differences in the homing range size among trout size classes. Most trout registered large movements during their breeding period (January to March), probably due to their searching behaviour for selection of spawning suitable sites.

DETERMINACION DE LA TALLA-EDAD DE PRIMERA MADUREZ SEXUAL Y FECUNDIDAD DE LA TRUCHA ARCOIRIS (*ONCORHYNCHUS MYKISS NELSONI*) DE LA SIERRA SAN PEDRO MARTIR, BAJA CALIFORNIA, MEXICO.

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RESUMEN--Las gonadas de 128 truchas colectadas durante un año (Feb. 1988 a Ene. 1989) en el Arroyo San Rafael, Sierra San Pedro Mártir, B.C., fueron analizadas histológicamente con la técnica Hematoxilina-Eosina, para determinar la talla y edad de primera madurez sexual. La talla y edad de primera madurez se registró en especímenes de 105-115 mm LP y 1 año de edad, respectivamente. El período de desove ocurre de Enero a Marzo, con una mayor frecuencia en Febrero. La fecundiad total y por gonada fue determinada en 24 hembras grávidas por conteo directo. La fecundidad total *per capita* fue de 192 ± 77 ovocitos, y registró una correlación significativa ($p < 0.05$) con la talla, peso y edad. La fecundidad de la gonada izquierda presentó un promedio de 79 ± 44 ovocitos, en cambio la derecha, registró 113 ± 54 ovocitos. El tamaño promedio de ovocitos maduros fue de 2.65 ± 0.41 mm, y es independiente de la talla y peso.

ABSTRACT--The gonads of 128 trouts captured during one year (Feb. 1988 to January 1989) were analized with the Hematoxylin-Eosin histological technique, in order to

determine the size and age of sexual maturation early. Both sex begin to maturity at the 105-115 mm SL and one year, respectively. Spawning period occured between January to March, with high frecuency in February. The total fecundity (both gonads combined) and per gonad (left and right) was determined on 24 trouts taken prior to spawning, using the actual count method. Individual total fecundity was 192 ± 77 ovarian eggs and showed a significant relationship ($p < 0.05$) with the length, weight and age of trout. Left gonad fecundity obtained an average of 79 ± 44 ovarian eggs, however, the right gonad registered an average number of 152 ± 57 eggs. The average mature-egg size was of 2.65 ± 0.41 mm, being similar or independent with the trout length and weight.

ANALISIS CUALITATIVO Y CUANTITATIVO DE MACROPARASITOS DEL SISTEMA DIGESTIVO DE LA TRUCHA, *ONCORHYNCHUS MYKISS NELSONI*, DE LA SIERRA SAN PEDRO MARTIR, B.C., MEXICO.

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RESUMEN--La parasitofauna del sistema digestivo de la trucha de San Pedro Mártir, *O. mykiss nelsoni*, fue analizada en 175 especímenes colectados durante un ciclo anual en el Arroyo San Rafael. Los tremátodos Digeneos (Familia Allocreadiidae, género *Crepidostomum*) fueron los parásitos más abundantes (87.9 %), seguido en menor número por nemátodos (11.9 %) y tremátodos Monogeneos (0.2 %). Los órganos más afectados por parásitos fueron los ciegos pilóricos e intestino, principalmente por tremátodos Digeneos, con una frecuencia de infestación de 97.7 % y 83.9 %, respectivamente. Los nemátodos fueron los parásitos dominantes en estómago (72 %). La composición y número de parásitos fue similar para ambos sexos, excepto en juveniles-del-año. Solamente los tremátodos Digeneos registraron una correlación significativa ($p < 0.05$) entre su número y la talla de la trucha.

ABSTRACT--The parasitofauna of the digestive tract of San Pedro Martir rainbow trout, *O. mykiss nelsoni*, was examined on 175 trouts collected along one year from Arroyo San Rafael.

Digenea trematodes (Family Allocreadiidae, Genus *Crepidostomum*) were the most abundant parasites (87.9 %) for all trouts examined, and less percent by Nematodes (11.9 %) and Monogenea trematodes (0.2 %). The organs mostly infested by parasites were pyloric caeca (97.7 %) and intestine (83.9 %), principally by the Digenea trematodes. In the same manner, the Nematodes were the parasites more abundants in stomach (72 %). The parasite number and composition was similar between sex, excepte in young-of-the-year. Only the Digenea trematodes showed a significant correlation ($p < 0.05$) between the their abundance and the size of trout.

Geographic Variation in Cannibalism of Congeneric Young by *Gambusia* Adults

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ABSTRACT

Predation on congeneric young by *Gambusia* adults is moderate with about 50% survival of young for a month. The vast majority of the predation is by females, with males seldom eating young. Predation on species with small young (*G. affinis*, *G. speciosa*, and *G. geiseri*) is more extensive than on species with large young (*G. nobilis*, *G. heterochir*, and *G. gaigei*). Conversely, predation on large young of *Poecilia* tends to be greater than congeneric predation. Additionally, adults producing large young tend to prey more extensively on similar sized young than adults producing small young. *G. affinis* predation varies extensively with some populations (Junction, Toe Nail, Fairy, Arizona) being highly predaceous and others (Pecos, Big Bend) scarcely eating any young. The geographic variation in predation does not correlate with geographic patterns or known environmental variables. It does suggest that mosquito consumption may well vary extensively dependent upon the population used.

INTRODUCTION

An extensive literature reports that adult *Gambusia* eat their own young (Seale, 1917; Koster, 1957; Krumholz, 1948; Axelrod and Schultz, 1971, 1983; Minckley, 1973; Walters and Legner, 1980; Schoenherr, 1981; Harrington and Harrington, 1982; Meffe and Snelson, 1989; Smith and Reay, 1991). Meffe and Crump (1987) reported that *Gambusia holbrooki* grew better on prepared diets supplemented with *G. holbrooki* protein than on comparable other supplemented diets. Dionne (1985) showed that *Gambusia* adults ate their own young but could not ascertain a selective advantage to the cannibalism; her paper was severely criticized by Meffe (1986) who felt she did not adequately test for cannibalism. In contrast, Hubbs (1991) showed that about half of the young *Gambusia* exposed to congeneric adults survived a month. That report also showed that young in aquaria with adult females had lower survival than those with adult males, that some species were more predatory than others, and that geographic variation occurred in predation by adults. This paper expands on those data by showing at least four levels of predation by *Gambusia affinis* adults.

MATERIALS AND METHODS

Predation on young congenerics by *Gambusia* adults was tested in aquaria measuring 49 by 15 by 17 (deep) cm. Each aquarium could be divided into two relatively equal regions by a glass plate. Approximately 10 newborn *Gambusia* were placed in one region and an adult was placed on

TABLE 1. Comparison of experiments with predator present or absent at end of experiment in percent

# young introduced	no predators	predator present
3	1	3
4	2	4
5	1	5
6	4	6
7	7	7
8	11	7
9	6	7
10	67	59
11	0	2
12+	1	1
Total experiments	95	2352 = 4% no predator

the other side. The partition was removed after one day, and the survivors counted after 30 more days. The partition only served as an optional refugium as some young *Gambusia* usually were on the adult side when the partition was removed. The only other object in the aquarium was an airstone and at the start of each experiment the aquarium was filled with fresh water. Consequently, the young could not hide from the adult predator and predation potential was maximal. Young produced by *Poecilia* adults from San Marcos were used to supplement the *Gambusia* data. Ninety-five experiments that lacked an adult at the end of the 31 day experimental interval were excluded from the experimental results. No difference was apparent in the survival of adults dependent upon the number of young introduced (Table 1), but the young survival commonly was very high.

The statistical treatment has been to contrast survivorship of young via Chi-square. I consider the results to be significant at the 0.001 level (= Chi-square value of 10 or higher) because the adult present may be the significant item. If the adult is the variable the significance levels would be altered by an order of magnitude.

Fish for experiments were obtained from 28 Texas localities and one in Arizona (Table 2). Isolated females were checked daily (or more often) and newborn young used for experiments. Young that appeared malformed were excluded from the experiments. Adult predators had been maintained in aquaria for more than a week.

The feeding regime was that followed in the Hubbs (1992) experiments. Adult and larval *Drosophila* and Tetramin dried foods were fed all fish at about 20% of biomass daily. Numerous snails ate the excess foods and in turn served as food for the fish (Hubbs, 1990).

TABLE 2. Localities from which *Gambusia* stocks were obtained and the number of young used in experiments. The localities are arranged from southwest to northeast within species and shown on Map 1. Except for the Arizona population, all localities are in Texas.

		Number of Young Used
Gambusia affinis		
1	Bog Hole, Santa Cruz Co., Arizona	552
2	Alamito Creek, Presidio Co.	120
3	Big Bend Refugium, Brewster Co.	1674
4	Balmorhea, Reeves Co.	1598
5	Diamond Y Refugium, Pecos Co.	657
6	John's Marina (Rio Grande south of Dryden), Terrell Co.	683
7	Lazy Pond (Independence Creek near conjunction with Pecos River), Terrell Co.	233
8	Pecos River at conjunction with Independence Creek, Terrell Co.	65
9	Egg Creek at Fairy, Hamilton Co.	511
10	Toe Nail Trail at Christoval, Tom Green Co.	27
11	Ft. McKavett, Menard Co.	70
12	Clear Creek, Menard Co.	583
13	San Saba River at Dry Creek, Menard Co.	110
14	700 Springs at Telegraph, Edwards Co.	233
15	Junction, Kimble Co.	1001
16	James River Bat Cave, Mason Co.	1075
17	Fessenden Spring, Kerr Co.	742
18	Heart of the Hills Research Station, Kerr Co.	461
19	Cow Creek, Travis Co.	1008
20	San Marcos, Hays Co.	688
21	Woman Hollering Creek, Bexar Co.	278
22	Cost (Guadalupe River), Gonzales Co.	224
23	Big Brown Reservoir, Freestone Cr.	581
24	Cut 'n Shoot (Crystal Cr.), Montgomery Co.	248
25	Village Creek, Hardin Co.	828
26	Eggnog Branch, Nacogdoches Co.	154
Gambusia speciosa		
27	Devil's River Natural Area, Val Verde Co.	2031
Gambusia geiseri		
	Balmorhea, Reeves Co.	452
	Diamond Y Refugium, Pecos Co.	107
	Lazy Pond, Terrell Co.	7
28	Chandler Springs, Terrell Co.	107
	Toe Nail Trail at Christoval, Tom Green Co.	14
29	Anson Spring, Tom Green Co.	1229
	San Marcos, Hays Co.	434
Gambusia nobilis		
	Balmorhea, Reeves Co.	348
	Diamond Y Refugium, Pecos Co.	164
Gambusia heterochir		
	Clear Creek, Menard Co.	514
Gambusia gaigei		
	Big Bend Refugium, Brewster Co.	837

RESULTS

Approximately one half (50%) of the young survived the experimental interval (Table 3). Presumably some young died from other causes but that fraction would be relatively small. For example, 4% of the adults were absent at the end of the experimental period (Table 1) which may reflect young mortality as well.

TABLE 3. Survivorship of poeciliid young exposed to predation by *Gambusia* adults for 30 days

	# survived	# introduced	% survival	chi square value
total	10398	20757	50	
female predator	3546	10983	32	3027
male predator	6830	9678	70	

Chi square numbers for sex differences in individual tests using both sexes as predator

	higher survival with female				higher surival with males				
chi square values	10+	1 - 9.9	1 - 1	1- 9.9	10 - 19.9	20 - 29.9	30 - 39.9	40 - 49.9	50+
number of comparisons	1	13	66	130	80	37	23	8	10

Sexual differences - Survivorship of young exposed to potential male predation was about twice that of young with adult females (Table 3). The Chi-square value for that difference was very significant. Three hundred and sixty-eight individual population predation experimental series used adults of both sexes. Fourteen of them had higher survival of young with females and 288 had higher survival with males (66 were nearly identical or identical) (Table 3). One hundred and fifty-nine of those favoring males were significant whereas one favoring females was. Forty-one combinations favoring males had significant values less than 0.000001.

Male predation - Adult males ate young *G. affinis* at 3 distinctly different levels (Table 4). Three species (*G. affinis*, *G. speciosa*, and *G. geiseri*) had about 75% survivorship, two (*G. heterochir* and *G. gaigei*) had about 50% survivorship and one (*G. nobilis*) had less than 25% survivorship. Those groupings are highly significant statistically. *G. nobilis* seem to be more predaceous than the other 5 species as young survivorship was lowest in all of the six test series despite the small sample sizes in most tests. Similarly, *G. affinis* males were relatively nonpredaceous with survivorship among the highest of the comparisons. The three species (*G. nobilis*, *G. heterochir*, and *G. gaigei*) that prey extensively on *G. affinis* young have substantially higher survivorship when young of those species were used. The lowest young survival in *G. gaigei* male tests was for *Poecilia* young suggesting that predation, not cannibalism, applies.

TABLE 4. Survivorship percentages of poeciliid young exposed to male predators

Young

predator	*affinis*	*speciosa*	*geiseri*	*nobilis*	*heterochir*	*gaigei*	*Poecilia*
affinis	**74**^{45}	**84**^{6}	**84**^{7}	**86**	86	**79**	
speciosa	**75**^{3}	88	62	89	85	75	
geiseri	**71**^{6}	**79**	**74**	77	68	92	
nobilis	**23**^{4}	5	50	69	53	61	
heterochir	**50**^{2}	64	88	93	61	89	
gaigei	**52**^{3}	52	59	75	73	65	44

bold face = > 100 young

Romans = 50-100 young

small type = < 50 young

The superscript number indicates the number of hundreds when over 200.

TABLE 5. Survivorship of percentage poeciliid young exposed to female predators

Young

predator	*affinis*	*speciosa*	*geiseri*	*nobilis*	*heterochir*	*gaigei*	*Poecilia*
affinis	**31**^{55}	**35**^{6}	**46**^{6}	57	90	**72**	0
speciosa	**29**^{3}	**69**	53	71	24	74	
geiseri	**16**^{6}	**25**	**34**	61	26	55	
nobilis	**14**^{4}	0	42	40	0	31	
heterochir	**35**^{4}	32	65	29	25	33	
gaigei	**17**^{3}	0	40	0	42	20	

bold face = > 100 young

Romans = 50-100 young

small type = < 50 young

The superscript number indicates the number of hundreds when over 200.

Female predation - Adult females ate young *G. affinis* at two distinctly different levels (Table 5). Three species (*G. affinis, G. speciosa,* and *G. heterochir*) had survivorship in the 30s but the other three (*G. geiseri, G. nobilis,* and *G. gaigei*) had about half that survival rate. *G. affinis* females ate many more conspecifics and *G. speciosa* than they ate the other 4 species (*G. geiseri, G. nobilis, G. heterochir,* and *G. gaigei*). *G. speciosa* ate many more *G. affinis* than *G. speciosa* or *G. geiseri*. *G. geiseri* females ate relatively few *G. nobilis* and *G. gaigei* but many *G. affinis* and *G. speciosa*. *G. nobilis* ate most young rather extensively, the partial exceptions *G. geiseri* and *G. nobilis*. *G. heterochir* females ate most young except for *G. geiseri* young. The lowest survival percentage was with conspecifics. *G. gaigei* ate three species (*G. affinis, G. speciosa* and *G. gaigei*) more than they ate two other (*G. geiseri* and *G. heterochir*). The low survival of conspecific young of *G. heterochir* and *G. gaigei* females suggests cannibalism. This potential is converse to the low survival of *Poecilia* young with *G. affinis* females.

Interpopulation variation - Intraspecific predation by *G. affinis* had a sufficient data base to show variations. Too few *G. nobilis* young were available and the *G. geiseri* predation rates were similar among the seven populations used. Conspecific predation by *G. affinis* females had at least four levels (Table 6). Predation by Big Bend females was quite low (68% survival) but that by Junction females very high (4% survival). Five populations (Pecos River, Clear Cr., Fessenden Spring, Eggnog Branch and Big Brown Reservoir) preyed at a relatively low level (41-57% survival) and Balmorhea, Diamond-Y, Bat Cave, Cow Creek, San Marcos, Woman Hollering, and Village Creek seem to be relatively predaceous (22-36% survival). Arizona, Fairy, Toe Nail, Dry Creek, and Cost also have quite predaceous females (2 - 15% survival). Male predation seems to be parallel with two of the five localities with low female predation having 83 and 88% young survivorship with males and only one of the other 24 have survival above 80%.

Predation on *G. speciosa* and *G. geiseri* shows a parallel pattern but the sample sizes were small. In each comparison young with Big Bend females survived at a relatively high rate (61 and 82%) and those with Junction females had a very low survival rate (18 and 7).

DISCUSSION

The data from these experiments affirm and expand on the conclusions of Hubbs (1991). *Gambusia* predation on young congenerics is substantially less than that reported in much of the previous literature. These observations agree well with stomach analyses of wild-caught adults (Hubbs, 1971; Hubbs et al., 1978; Crivelli and Boy, 1987). I believe that adult *Gambusia* recognize young *Gambusia* as relatively large zooplankters. An adult that failed to attempt to feed would have a selective disadvantage and much of the survival is based on efficient escape reactions by the young. Survivorship of young is size dependent with the small *G. affinis* (mean=1.50 micrograms) and *G. speciosa* (mean=1.60) young having a lower survival rate than the large *G. gaigei* (mean=3.70), *G. nobilis* (mean=3.66) and *G. heterochir* (mean=3.23) with *G. geisei* being intermediate (mean=1.98). This interaction is most likely predation, and cannibalism plays at most a minor role. This is best demonstrated by the low survivorship of large and apparently slow moving *Poecilia* young.

TABLE 6. Survivorship percentages of young exposed to *Gambusia affinis* adults from various populations southwest to northeast

Young

	G. affinis		*G. speciosa*		*G. geiseri*	
predator	female	male	female	male	female	male
Arizona	**10**^{2}	**56**				
Alamito Creek	**32**	**66**				
Big Bend	**69**^{4}	**88**^{3}	**61**	**89**	**82**	**89**
Balmorhea	**25**	**78**			51	78
Diamond-Y	**26**	**60**	12	81	33	81
John's Marina	**15**^{2}	**67**				
Lazy Pond	**14**	**82**				
Pecos	**58**	**78**				
Fairy	**2**^{2}	60				
Toe Nail	**15**	45				
Ft. McKavett	**17**	**78**				
Clear Creek	**46**	**83**^{2}			68	85
Dry Creek	**13**	76				
700 Springs	**23**	**75**				
Junction	**4**^{2}	**64**	**18**	**92**	**7**	**82**
Bat Cave	**25**	**76**			37	95
Fessenden	**41**	**77**^{2}	20	77	33	90
Heart of the Hills	**32**^{2}	**57**^{2}				
Cow Creek	**33**^{2}	**78**			51	81
San Marcos	**30**^{2}	**76**^{2}	32	77	55	80
Woman Hollering	**33**^{2}	**77**^{3}			39	66
Cost	**15**	**67**				
Big Brown	**51**^{2}	**76**^{2}	**59**	77	70	90
Cut n' Shoot	**24**^{2}	**72**				
Village Creek	**36**^{3}	**71**^{2}	41	88	31	88
Eggnog Branch	**41**^{2}	**79**^{2}				

bold face = > 100 young

Romans = 50-100 young

small type = < 50 young

The superscript number indicates the number of hundreds when over 200.

The well documented higher predation (Hubbs, 1991) by females than males is affirmed. Most of the comparisons (Table 3) that do not show statistically higher survival with males as predators are based on small sample-sizes, *G. nobilis* (high male predation) or Big Bend *G. affinis* (low female predation) adults. Those species whose adults prey extensively on young *Gambusia* have young with relatively high survival in predation experiments.

Gambusia affinis has been shown to replace *G. gaigei* in nature (Johnson and Hubbs, 1989). This replacement has contributed to the scarcity of *G. gaigei* and its listing as an Endangered Species. Predation on young and competition have been considered as major contributors to this replacement. Predation now seems unlikely as a species that eats about 28% (female) and 21% (male) replaced a species that eats about 83% (female) and 48% (male) of the young of the other species. The difference is actually greater than those figures because the *G. affinis* population that replaced *G. gaigei* is the least predaceous of the 26 populations tested. These data make competition the most likely reason for the replacement. Fortunately, the location where the replacement has been documented dried temporarily and when again flooded the location was invaded by *G. gaigei*.

Female *G. gaigei* and *G. heterochir* may prey more extensively on conspecifics than on other congenerics. If these data are confirmed by additional experiments a level of cannibalism will be demonstrated.

Intraspecific variation occurs in predation rates by *G. affinis* adults. The differences are highly significant statistically. This variation does not have a geographic or environmental pattern. The predator populations in Table 6 are arranged in a southwest-northeast pattern and the predation levels are geographically intermingled. The six relatively nonpredaceous populations have no consistent ecologic patterns: Big Bend is from the outflow of a warm spring; Clear Creek and Fessenden Spring from the outflow of ambient level springs; and Big Brown is a power plant reservoir (= elevated temperatures). Eggnog Branch is a tiny creek and the Pecos River is a major stream. The twelve relatively predaceous populations vary widely ecologically; Balmorhea, and San Marcos from the outflow of ambient level springs; Diamond-Y from the outflow of an ambient temperature high salinity spring; Toe Nail, Dry Creek, Junction, and Bat Cave from spring-fed rivers; John's Marina, Woman Hollering, and Village Creek from streams. Fairy is a tiny creek, and Cow Creek is an interrupted creek near (and perhaps repopulated from) a reservoir. The Pecos River population (low predation) is from its conjunction with Independence Creek; the Lazy Pond population (high predation) is from Independence Creek 1 km from that conjunction. The natural occurrence of the *G. affinis* populations may well have been distorted by public health organizations that release *G. affinis* for mosquito control. The absence of an obvious environmental or geographic pattern in the localities from which the *Gambusia* stocks were obtained is enigmatic. The best explanation is that the present (or past) availability of other food may have impacted the evolution of feeding behavior. This hypothesis is untestable.

The Arizona population has been introduced from Texas. Minckley (1973) and his collaborators have demonstrated that predation by *G. affinis* has had a substantial negative impact on the native *Peociliopsis* in Arizona. It is problematic what would have prevailed if a nonpredaceous population such as Big Bend had been the source of the introduction. The predation has substantially contributed to the listing of the Arizona *Poeciliopsis* is endangered. Presumably the introduction was from a predaceous population, such as Junction. Perhaps, *Poeciliopsis* would have remained abundant in Arizona if a less predaceous population had been used.

Gambusia affinis has been used extensively for mosquito control (= predation) without regard to population of origin. These data demonstrate that this species varies extensively in predation on congeneric young. It is likely that this species has equivalent predatory variability on mosquito larvae.

ACKNOWLEDGEMENTS

The field work to capture stocks benefitted from the assistance of numerous individuals including: Francisco Abarca, Pat Connor, David Edds, Robert J. Edwards, Linda Fuselier, Noeleonel Garcia, Cole and Gary Garrett, Lawrence Gilbert, Tom Hayes, Dean, Garrett and Jacob Hendrickson, Ereckson and David Hillis, Anson and A. Ryland Howard, Catherine S. Hubbs, William Matthews, James Peoples, Amy and A. Lee Pfluger, Andy Price, Hoven Riley, Glen A. Sachtleben, John Tilton and David C. Wilson. The laboratory work involved the assistance of Cathy Marler, Molly R. Morris, and Tanya Peterson.

Map 1. Map of collection localities listed in Table 2.

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THE EFFECT OF A FLASH FLOOD ON THE SALT CREEK, RIVERSIDE COUNTY, POPULATION OF THE ENDANGERED DESERT PUPFISH, *Cyprinodon macularius*.

by

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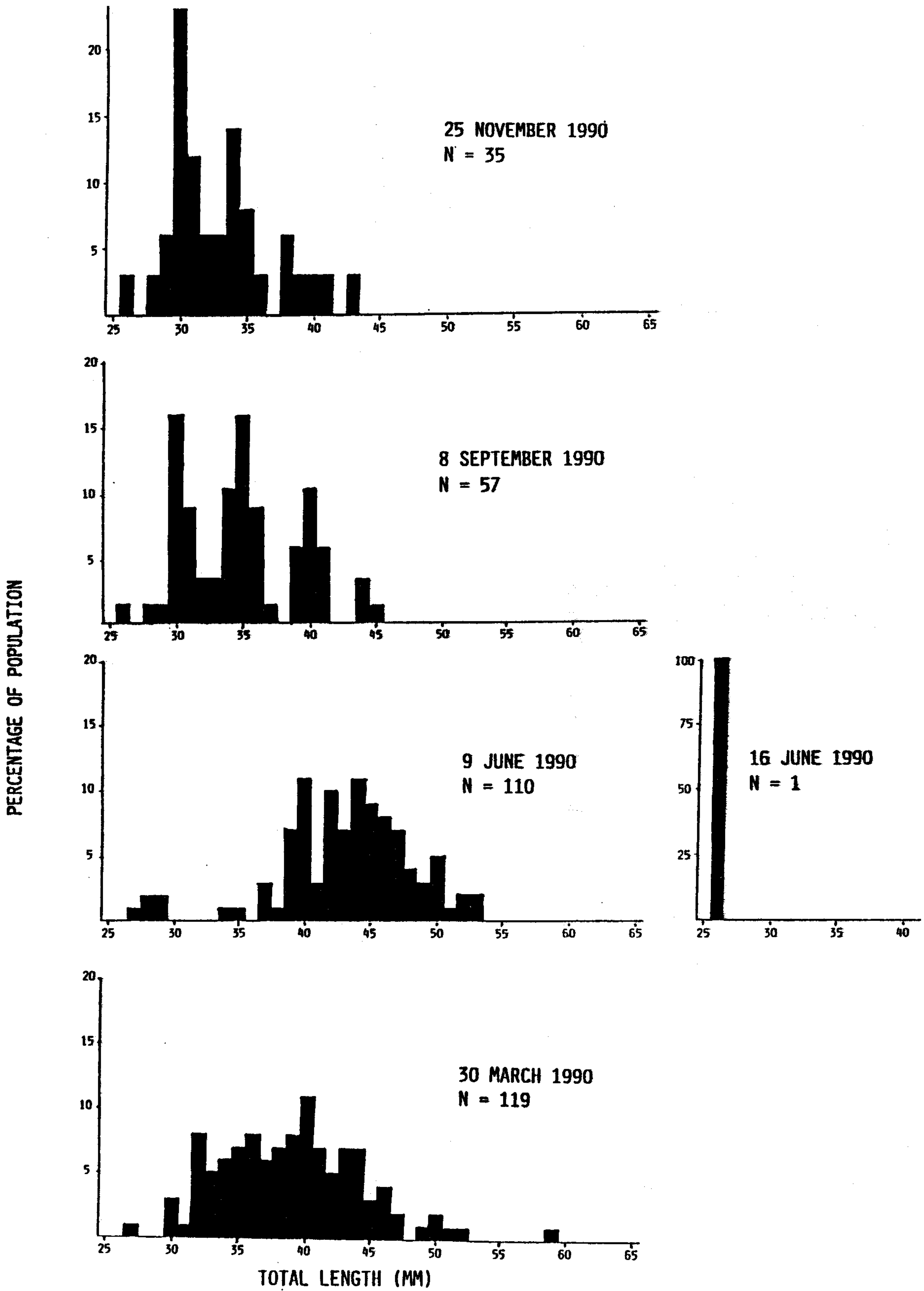
During the 1990 fiscal year, quarterly visits to Salt Creek, Riverside County, were undertaken for the purpose of trapping and analyzing the populations of Desert Pupfish. In order to analyze population structure and breeding characteristics, length-frequency analysis of fish from each habitat was conducted. Aquatic animals collected in traps along with the pupfish also were recorded.

The most interesting information to arise from this study to date was the consequence of a flash flood on the population. On 9 June 1990, within a few hours of completing a survey, a flash flood occurred. Provisional data on stream flow for 9 June 1990 obtained from the Water Resources Division of the U.S. Geologic Survey office in San Diego indicated that on that day the flow at the mouth of Salt Creek went from a base of 0.9 cubic feet per second (CFS) at 1700 hrs. to 1,080 CFS by 2100 hrs. The flow did not return to normal until 13 June 1990, four days later. I returned to the area on 16 June 1990 to assess the effect of the flood. Only one pupfish was collected and the area had been stripped of submerged aquatic vegetation.

Figures 1 and 2 illustrate that two bits of "dogma" about

Figure 1. Length-frequency distribution for Desert Pupfish from Salt Creek during 1990.



floods seemed to be contradicted; that floods wash out small fishes, and that floods tend to wash out non-native species in favor of the native species.

Examination of the histograms for Salt Creek (Figure 1) reveal one of the outcomes or consequences of the flash flood. On 16 June, a week after the flood, only one small pupfish was trapped. In apparent contradiction to what flash floods have done in other desert situations, subsequent sampling revealed that the flood apparently had cleared larger pupfish from the habitat. John (1963, 1964) documented the outwash of small fishes due to flash floods and Harvey (1987) has noted that fish smaller than 10 mm TL are susceptible to downstream displacement. Furthermore, with respect to the Salt Creek Pupfish, *Cyprinodon salinus*, in Death Valley, Williams and Bolster (1989) by measuring dead fish stranded after a flash flood documented that no large fish were apparently washed out and no small fish remained in the area of permanent flow.

Secondly, by 16 June most of the non-native species and nearly all submerged vegetation had been cleared from the habitat. The next two samples, however, revealed a large number of non-native fishes that apparently had washed down from upstream near the Nature Conservancy's facility at Dos Palmas. Flooding is more likely to eradicate non-native fishes, while leaving native forms to prosper in the aftermath (Meffee, 1984; Minckley, 1973; Schoenherr, 1979). I know of no natural situation where a population of pupfish was eliminated by flooding, but the possibility cannot be ignored. Figure 2

Figure 2. Animals trapped in Salt Creek during 1990

NUMBERS OF INDIVIDUALS TRAPPED
(12 traps for 24 hours)

SPECIES	30 MARCH	9 JUNE	16 JUNE	8 SEPT.	24 Nov.
Cyprinodon macularius	119	110	1	57	35
Gambusia affinis	73	152		71	2
Poecilia latipinna		13	1	42	149
Tilapia zillii				7	3
Ictalurus natalis	2				
Procambarus sp.	36	13			
Macrobrachium sp.				1	

clearly shows that pupfish did not return to former numbers, but it also shows that a large number of non-native species had appeared, including three documented "enemies" of pupfish; Mosquitofish (*Gambusia affinis*), Sailfin Mollies (*Poecilia latipinna*), and Zill's Cichlids (*Tilapia zillii*). The latter species has been most seriously implicated in the demise of the Desert Pupfish (Schoenherr, 1981a; 1981b; 1988) and this is the first time that it has been discovered in this part of Salt Creek.

The result if the influx of non-native species will bear watching. It is possible that non-native fishes could be eliminated by low concentrations of dissolved oxygen during hot weather, or that low water temperatures during winter might particularly select against Zill's Cichlid. On 25 November, when the water temperature dropped to 10° C, large adult Zill's Cichlids were nearly moribund. I was able to reach into the water and pick one up in my hand. It was obviously in distress. Hopefully future samples will reveal that non-native fishes are diminishing in number.

The effect of the flood on submerged vegetation may have been devastating to the preferred habitat for the Desert Pupfish at Salt Creek. Prior to the flood the most favorable trapping sites were in association with mats of the filamentous pond weed (*Zannichellia palustris*). The nearly complete washout of that plant doubtless removed cover and spawning substrate from the habitat, the loss of which by itself would have a profound effect on the pupfish. Coupled with the introduction of all the non-native species, loss of this important component of the habitat compounded the problem. After the flood, the Cyanobacterium (*Lygbya sp.*) became abundant. This photosynthetic organism forms thick mats intermingled with muddy substrate. In many locations this material becomes elevated, forming layers under which the pupfish could retreat. This habitat became a refuge in certain areas, but it is no protection from juvenile cichlids that also seem to seek the same cover.

The apparent similarity in the distribution of pupfish sizes after the flood is puzzling. There is no apparent indication of growth. It is possible that the small number of fish sampled caused a bias in the data. The appearance of small fish in both samples indicated that reproduction was occurring, but it is possible that the fish in the two samples were the offspring of a small number of breeding adults and recruitment had been relatively constant since the flood. Again, future sampling should reveal what becomes of the pupfish in Salt Creek.

Conclusion. The effect of a flash flood on the Salt Creek population showed that large fish were washed out and small fish repopulated thereafter. This observation contradicts previous observations indicating that floods wash out the small fish. It also became apparent that non-native fish were more common after the flood. In this case it appears that the fish were washed down from the upper parts of the Salt Creek drainage where the non-native species are known to occur. The appearance of Zill's Cichlid, *Tilapia zillii*, in pupfish habitat where it has not been reported before could be a serious threat to one of only two "natural" populations of Desert Pupfish in California. This threat plus the specter of a toxic spill from the proposed "trash train" that would pass upstream within a few hundred meters of its habitat makes the Salt Creek population of Desert Pupfish worthy of constant monitoring.

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EL EFECTO DE UNA AVENIDA EN EL ARROYO SALT, CONDADO DE RIVERSIDE: LA POBLACION EN PELIGRO DE EXTINCION DE EL PEZ DEL DESIERTO "PUPFISH" (Cyprinodon macularius).

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Durante 1990 se realizaron visitas trimestrales al arroyo Salt, Condado de Riverside con el propósito de capturar y analizar las poblaciones del pez del desierto "Pupfish". Para analizar la estructura de la población y las características reproductivas se realizó un análisis de frecuencia de la longitud de los peces para cada hábitat. Los animales acuáticos colectados en las trampas para los "Pupfish" también se registraron.

Hasta ahora, la información más interesante que surge de este estudio es el efecto de una avenida en la población. El 9 de junio de 1990, unas horas antes de completar uno de los registros, ocurrió una avenida. Datos provisionales de el flujo del arroyo el 9 de junio de 1990 obtenidos de la oficina de Monitoreo Geológico de la División de Recursos de Agua de los Estados Unidos indicaron que en ese día el flujo en la boca del arroyo salt fué desde una línea base de 0.9 pies cúbicos por segundo (PCS) a las 17:00 hrs. hasta 1,080 PCS a las 21:00 hrs. El flujo no regresó a su nivel normal hasta el 13 de junio de 1990, esto es, cuatro días después. Yo regresé a esta área el 16 de junio de 1990 para evaluar el efecto de esta avenida. Solamente se colectó un "Pupfish" y la vegetación acúatica sumergida había sido acanalada en esta área.

En la figura 1 y 2 se muestra como dos fragmentos del "dogma" acerca de las avenidas parece ser contradictorio; la avenida arrastró pequeños peces y esta tendió a arrastrar especies no nativas favoreciendo a las especies nativas. La evaluación de los histogramas en el arroyo salt (Fig. 1) revela una de las posibles consecuencias de la avenida. El 19 de junio, una semana después de la avenida, solo se atrapó un "Pupfish" pequeño. En aparente contradicción al efecto de las avenidas en otras condiciones desérticas, un muestreo subsecuente reveló que la avenida aparentemente eliminó a los "pupfish" más grandes de el hábitat. John (1963, 1964) documentó el arrastre de peces pequeños debido a las avenidas y Harvey (1987) notó que los peces menores a 10 mm de longitud total fueron suceptibles a el desplazamiento aguas abajo. Ademas, Williams y Bolster (1989) midieron a los "pupfish" muertos (Cyprinodon salinus) en el arroyo salt en el valle de la muerte; ellos encontraron que los peces grandes aparentemente no fueron arrastrados, sin embargo ningun pez pequeño permaneció en la área de flujo permanente.

Adicionalmente, el 16 de junio la mayoria de las especies no nativas y casi toda la vegetacion sumergida fue eliminada de el habitat. Sin embargo, los siguientes dos muestreos revelaron un gran número de peces no nativos que aparentemente habían sido arrastrados de aguas arriba cerca de la estación de Nature Conservancy en Dos Palmas. Probablemente, las avenidas eliminaron a los peces no nativos pero dejan prosperar a las formas nativas (Meffee, 1984; Minckley, 1973; Schoenherr, 1979). Yo no conozco ninguna situación natural en donde una población de "Pupfish"

Figura 1. Distribucion de frecuencia de la longitud para el "Pupfish" del desierto del arroyo salt durante 1990.

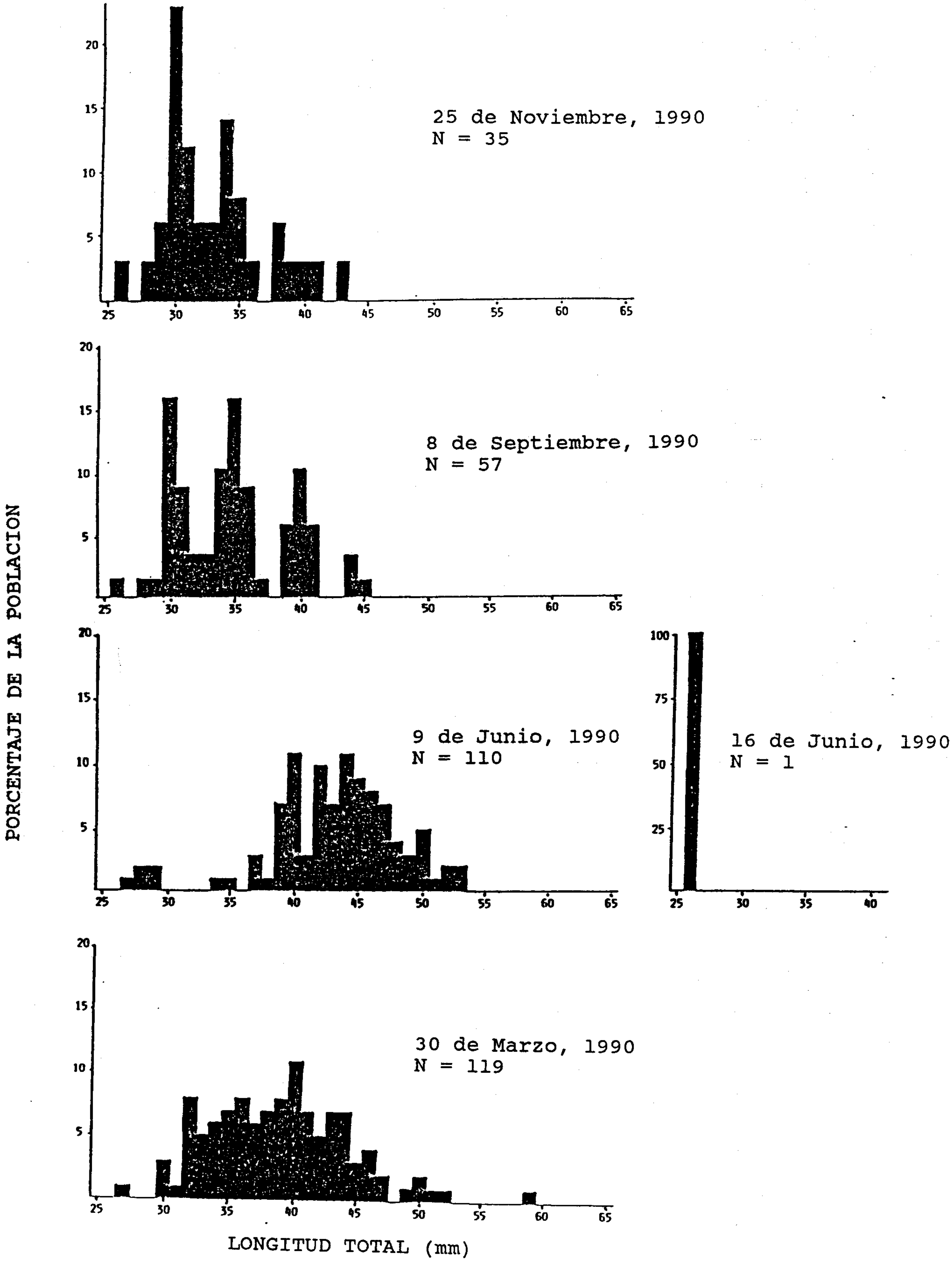

Figura 2. Animales atrapados en el arroyo salt durante 1990

NUMERO DE INDIVIDUOS ATRAPADOS
(12 trampas por 24 horas)

ESPECIE	MARZO 30	JUNIO 9	JUNIO 16	SEPT. 8	NOV. 24
Cyprinodon macularius	119	110	1	57	35
Gambusia affinis	73	152		71	2
Poecilia latipinna		13	1	42	149
Tilapia zillii				7	3
Ictalurus natalis	2				
Procambarus sp.	36	13			
Macrobrachium sp.				1	

haya sido eliminada por una avenida pero esta posibilidad no puede ser ignorada. La figura 2 claramente muestra que los "Pupfish" no regresaron a sus tamaños de población original, pero también muestra que un gran número de especies no nativas habían aparecido, incluyendo tres especies que se ha documentado son enemigas del "Pupfish": Mosquitofish (Gambusia affinis), Sailfin Mollies (Poecilia latipinna), y la carpa de Zill (Tilapia zillii). Esta última especie ha sido seriamente implicada en la reducción del "pupfish" del desierto (Schoenherr, 1981a; 1981b; 1988) y esta es la primera vez que se ha descubierto en esta parte de el arroyo salt.

El resultado de la entrada de especies no nativas se vera. Es posible que los peces no nativos pudieron ser eliminados por una baja concentración de oxígeno disuelto durante estados de tiempo caliente o que las bajas temperaturas del agua durante las noches invernales pudieron haber seleccionado particularmente en contra de la carpa de Zill. El 25 de noviembre cuando la temperatura de el agua disminuyó a 10^{o} C, adultos grandes de la carpa de Zill estaban casi moribundos. Yo fuí capaz de meterme al agua y levantar un pez con la mano. Obviamente estaba estresado. Esperemos que subsecuentes muestreos revelen que especies no nativas estan disminuyendo en número.

El efecto de la avenida en la vegetación sumergida pudo haber sido devastador para el hábitat preferido por el "Pupfish" del desierto en el arroyo salt. Antes de la avenida el sitio más favorable para atrapar peces estuvo asociaciado con las carpetas que forma una planta filamentosa (Zsannichellia palustris). El casi completo arrastre de esta planta sin lugar a duda removió substrato de cobertura en el hábitat, la pérdida del cual tendrá un profundo efecto en el "Pupfish". La pérdida de este importante componente en el hábitat complica el problema. Después de la avenida la cianobacteria, Lygbya sp., fue abundante. Este organismo fotosintético forma gruesas carpetas entremezcladas con substrato lodoso. En muchas localidades este material se eleva formando capas debajo de las cuales el "Pupfish" se puede refugiar. Este hábitat es un refugio en ciertas áreas pero no es protección contra las carpas juveniles que aparentemente buscan la misma cobertura.

La similitud aparante entre la distribución de los tamaños de "Pupfish" posterior a la avenida es enigmático. No existe evidencia aparente de crecimiento. Es posible que un pequeño número de peces muestreados causó una desviación en los datos. La presencia de pequeños peces en ambas muestras indicaron que los peces se estaban reproduciendo, pero es posible que los peces en las dos muestras fueron la progenie de un pequeño número de adultos reproductivos, y que el reclutamiento había sido relativamente constante desde la avenida. De nuevo, subsecuentes muestreos, deberán revelar el desarrollo del "Pupfish" en el arroyo salt.

Conclusión. El efecto de una avenida en las poblaciones de el arroyo salt muestra que peces grandes fueron arrastrados y peces pequeños posteriormente repoblaron. Esta observacion contradice previas observaciones indicando que las avenidas arrastran a los peces pequeños. También es aparente que los peces no nativos fueron más comunes después de la avenida. En este caso, parece que los peces fueron acarreados hacía abajo de las partes más altas del cause del arroyo salt donde se sabe que estas especies no nativas existen. Anteriormente no se había reportado la presencia de la carpa de Zill (*Tilapia* ~~zillihii~~ zillii) en el hábitat del "Pupfish" y esta podría ser una seria amenaza para una de las dos poblaciones "naturales" de el "Pupfish" del desierto en California. Esta amenaza aunada al esperado derrame tóxico de el propuesto "tren de basura" que pasará pocos cientos de metros aguas arriba de su hábitat, hace interesante el constante monitoreo de las poblaciones del "Pupfish" del desierto en el arroto de sált.

LITERATURA CITADA

TITULO/TITLE: LOS PECES DULCEACUICOLAS DE SONORA

AUTOR (ES)/AUTHOR (S): VARELA-ROMERO ALEJANDRO, JUAREZ-ROMERO LOURDES Y CAMPOY-FAVELA JOSE

INSTITUCION/INSTITUTION: AREA DE ECOLOGIA ACUATICA, CENTRO ECOLOGICO DE SONORA.

DIRECCION/ADDRESS: A.P. 1497, HERMOSILLO, SONORA, MEXICO 83000

RESUMEN/ABSTRACT

R E S U M E N

La ictiofauna dulceacuícola de Sonora fue estudiada en base a 176 colectas realizadas en las 12 cuencas hidrológicas de Sonora de Octubre de 1986 a Agosto de 1990. Un total de 59 peces se registran como la ictiofauna actual referidos a 57 especies, 31 géneros y 12 familias. Existen 36 especies nativas referidas a 22 géneros y 11 familias. Se reconocen cuatro subespecies referidas a dos especies. Hasta el momento se consideran cuatro especies en Peligro de Extinción y siete amenazadas. Seis especies nativas han sido extirpadas de territorio Sonorense y habitan las cabeceras de los ríos en Estados Unidos. Se reconocen cuatro especies endémicas, dos a la cuenca del Río de la Concepción (Gila ditaenia y Poeciliopsis n. sp.), una a la cuenca del Sonora (Catostomus wigginsi y la última a la subcuenca del Bavispe (C. leopoldi). La familia Cypinidae es la más diversa con 18 especies y 11 géneros. Las especies nativas tienen afinidades Neárticas y Neotropicales, compuestas por 22 especies primarias, ocho secundarias y ocho vicarias. Se registran 19 especies introducidas referidas a 15 géneros y siete familias. La situación actual de la ictiofauna nativa en general es favorable sólo para pocas especies. Se observa un significativo aumento en los factores que afectan la estabilidad y permanencia de las poblaciones nativas, entre las más importantes se cuentan, el uso indiscriminado del agua en apoyo a actividades agrícolas y mineras, contaminación, alteraciones directas de habitats naturales y la introducción de especies exóticas. Se sugieren áreas específicas de manejo y reserva en las cuencas hidrológicas que aseguren la continuidad del estudio y la conservación de estas importantes y frágiles comunidades.

TITULO/TITLE: THE FRESHWATER FISHES OF SONORA

AUTOR (ES)/AUTHOR (S): VARELA-ROMERO ALEJANDRO, JUAREZ-ROMERO LOURDES CAMPOY-FAVELA JOSE

INSTITUCION/INSTITUTION: AREA DE ECOLOGIA ACUATICA, CENTRO ECOLOGICO DE SONORA.

DIRECCION/ADDRESS: A.P. 1497, HERMOSILLO, SONORA, MEXICO, 83000

RESUMEN/ABSTRACT

A B S T R A C T

The freshwater ichthyofauna of Sonora was studied on 176 colects maked in 12 Sonoran Basins from October 1986 to Agost 1990. A total of 59 fishes were record as the present ichthyofauna referable to 57 species, 31 genera, and 12 families. Exist 36 native species referable to 22 genera, and 11 families. We recognize four subspecies referable to two species. At this moment, we consider four Endangered species and seven threatened. Six native species are extirpated of Sonoran territory and they are living in the upper streams in United States. We recognize four endemic species, two into the Río de la Concepción Basin (Gila ditaenia and Poeciliopsis n. sp.), one in the Río Sonora Basin (Catostomus wigginsi) and the last to the Bavispe sub-basin (C. leopoldi). Cyprinidae is the family most diverse with 18 species and 11 genera. The native species have neartic and neotropical affinities, composed by 22 primary species, eigth secondary and eigth vicarious. We record 19 introduced species referable to 15 genera, and seven families. The status of native ichythyofauna in general is favorable only for scarce species. We observed an significative increase in factors that may affect permanency and stability of native populations, among whitch are, the indiscriminate use of water to agricultural and mine activities, contamination, habitat alterations and the introduction of exotics. We suggest management and reserve specific areas in the basins that assure the study continuation and conservation.

XXI Annual Desert Fishes Council Meeting
Albuquerque, New Mexico, November 16-18, 1989.

FISHES OF THE RIOS MAYO AND FUERTE BASINS, SONORA AND SINALOA, MEXICO.

ALEJANDRO VARELA-ROMERO
JOSE CAMPOY-FAVELA
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Area de Ecología Acuática, Centro Ecológico de Sonora
Apdo. Postal 1497, Hermosillo, Sonora, 83000, México.

ABSTRACT

The Ichthyofauna from rios Mayo and Fuerte Basins, Sonora and Sinaloa is presented based on 19 and 11 collections made at low and medium elevation streams during November 1988 and March of 1989. A total of 22 speciesm were found in Río Mayo, ten were native species (65% in abundance), represented mainly by Poeciliopsis occidentalis, P. monacha, its unisexual form and Agosia chrysogaster. 25 species were found in Río Fuerte, of the 12 native (86.3% in abundance), P. latidens and Poecilia butleri were the most common. The native species, Ictalurus pricei, Cichlasoma beani, Poeciliopsis prolifica and Gila robusta were scarce in the collections at both basins, as well as Poeciliopsis lucida at R. Fuerte. Five species have been documented previously for these basins, but were not collected in this survey. Exotic species were captured in streams occupied by native. Gambusia affinis was collected associated with Poeciliopsis spp. at both basins and Tilapia sp. shared habitat aboundantly with native Sinaloan Cichlid, C. beani at Arroyo Cuchujaqui, Sonora.

A significative increase in factors that may affect permanency and stability of native populations in most localities visited was observed, considering the indiscriminated use of water and habitat alterations resulting from the high agricultural development of the area and the presence of exotics.

XXI Simposio Anual, Consejo de los Peces del Desierto
Albuquerque, New Mexico. Noviembre 16-18,1989.

LOS PECES DE LAS CUENCAS DE LOS RIOS MAYO Y FUERTE, SONORA Y SINALOA, MEXICO

ALEJANDRO VARELA-ROMERO
JOSE CAMPOY-FAVELA
LOURDES JUAREZ-ROMERO

Area de Ecología Acuática, Centro Ecológico de Sonora
Apdo. Postal 1497, Hermosillo, Sonora, 83000, México.

RESUMEN

Se presenta la ictiofauna de los Ríos Mayo y Fuerte en Sonora y Sinaloa, en base a 19 y 11 colectas realizadas en zonas de baja y media elevación durante noviembre de 1988 y marzo de 1989. Un total de 22 especies fueron colectadas en el Río Mayo encontrando 10 especies nativas (65% en abundancia) principalmente representadas por Poeciliopsis occidentalis, P. monacha y su forma unisexual, y Agosia chrysogaster. En el Río Fuerte se registraron 25 especies, de las 12 especies nativas (86.3% en abundancia) P. latidens y Poecilia butleri fueron las más comunes. Las especies nativas Ictalurus pricei, Cichlasoma beani, P. prolifica y Gila robusta resultaron escasas en las colectas de ambos cauces, así como P. lucida en el Río Fuerte. Cinco especies han sido documentadas anteriormente para estas cuencas sin colectarse actualmente. Las especies exóticas se capturaron en los cauces ocupados por las nativas. Gambusia affinis se colectó asociado a Poeciliopsis spp. en ambas cuencas y Tilapia compartió, con mayor abundancia, los hábitats de C. beani en el Arroyo Cuchujaqui en Sonora. Se observa un significativo aumento en los factores que afectan la estabilidad y permanencia de las poblaciones de peces nativos en las áreas visitadas, considerándose entre los mas importantes el uso indiscriminado del agua y alteraciones de hábitat ocasionado por el desarrollo agrícola y la presencia de especies exóticas.

Desert Fishes Council

"Dedicated to the Preservation of America's Desert Fishes"

P.O. Box 337
Bishop, California 93514
(619) 872-8751

January 4, 1991

RESOLUTION 90-1

RELATIVE TO THE PROPOSED LISTING OF FIVE SPECIES OF AQUATIC SNAILS IN IDAHO AS ENDANGERED

WHEREAS the best scientific evidence and status reviews have substantiated petitions to list five freshwater snails as endangered, and

WHEREAS a continuing series of proposed hydroelectric projects on the Snake River and its tributaries, a deterioration of water quality from existing dams, aquaculture facilities, agricultural and other non-point sources, and the presence of a prolific non-native snail pose on-going and increasing threats to these species, now therefore be it

RESOLVED that the Desert Fishes Council, an organization numbering in excess of 500 persons and comprising a nationwide and international representation of federal, state, and university scientists and resource specialists, members of conservation organizations, and individuals concerned with long-term environmental values, meeting at its 22nd Annual Symposium in Ensenada, Baja California, Mexico, does hereby request that the U.S. Fish and Wildlife Service immediately list the Idaho Spring Snail (*Fontelicella* or *Pyrgulopsis idahoensis*), the Snake River Physa Snail (*Physa natricina*), the Bliss Rapids Snail (an undescribed hydrobiid snail), an undescribed limpet-like species in the genus *Lanx*, and the Utah Valvata Snail (*Valvata utahensis*) as Endangered, and provide these species with the full protection afforded by the Endangered Species Act; and be it further

RESOLVED that copies of this Resolution be forwarded to the Director of the U.S. Fish and Wildlife Service, to the appropriate Regional Directors of the U.S. Fish and Wildlife Service, to the Governor of Idaho, to the Secretary of the Interior, and to the Director of the Idaho Fish and Game Department.

PASSED WITHOUT DISSENTING VOTE

ATTEST:

Edwin P. Pister
Executive Secretary

Desert Fishes Council

"Dedicated to the Preservation of America's Desert Fishes"

P.O. Box 337
Bishop, California 93514
(619) 872-8751
January 3, 1991

RESOLUTION 90-2

RELATIVE TO THE KANSAS NONGAME AND ENDANGERED SPECIES CONSERVATION ACT

WHEREAS the State of Kansas had the foresight to enact the Kansas Nongame and Endangered Species Conservation Act, and

WHEREAS the Kansas Department of Wildlife and Parks, as steward of all Kansas wildlife including rare fishes and their aquatic habitats, administers the Endangered Species Program including a Threatened Endangered Species Permit System, and

WHEREAS the Act and its associated regulations is a model law because it not only protects rare wildlife species from taking or willful destruction, but also protects their critical habitats and provides for mitigation, when appropriate, now therefore be it

RESOLVED that the Desert Fishes Council, meeting for its 22nd annual symposium in Ensenada, Baja California, Mexico, does therefore congratulate the State of Kansas and the Kansas Department of Wildlife and Parks on the 15th anniversary of their important conservation law, and be it further

RESOLVED that they be urged to continue wise use of the law and permit system in their preservation of Kansas fauna and ecosystems, and be it further

RESOLVED that copies of this resolution be forwarded to the Governor of Kansas; the Secretary of the Kansas Department of Wildlife and Parks; the Speaker of the House, Kansas House of Representatives; and to the Senate Majority Leader, Kansas Senate.

PASSED WITHOUT DISSENTING VOTE

ATTEST:

Edwin P. Pister
Executive Secretary

Desert Fishes Council

"Dedicated to the Preservation of America's Desert Fishes"

P.O. Box 337
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January 3, 1991

RESOLUTION 90-3

RELATIVE TO THE INTEGRITY OF THE ARAVAIPA CREEK ECOSYSTEM

WHEREAS Aravaipa Canyon, as of 1984, is included in the National Wilderness Preservation System, and

WHEREAS Aravaipa Creek harbors an unique assemblage of seven indigenous Gila River basin fishes, two of which, spikedace (Meda fulgida) and loachminnow (Tiaroga cobitis), are Federally listed as Threatened, and

WHEREAS there is a long history of valuable scientific research from Aravaipa Creek, and

WHEREAS the establishment of exotic red shiner has been implicated in the decline of native fish faunas of the Southwest, and

WHEREAS red shiner has invaded Aravaipa Creek, now therefore be it

RESOLVED that the Desert Fishes Council, assembled at its 22nd Annual Symposium on November 14-17 in Ensenada, Baja California, Mexico, does hereby recommend that immediate action be taken to determine the most acceptable means of restoring and maintaining the integrity of the natural ecosystem of Aravaipa Creek, and be it further

RESOLVED that these actions be made part of a larger plan that includes genetic studies, artificial propagation, prevention of invasion of other native fish habitats, and re-establishment of the native fish community in the San Pedro River, and be it further

RESOLVED that copies of this resolution be forwarded to the Director of the Arizona Game and Fish Department, the Regional Director of the U.S. Fish and Wildlife Service, the Director of the U.S. Fish and Wildlife Service, the Arizona State Director of the Bureau of Land Management, the Safford District Manager of the Bureau of Land Management, the Fisheries Program Manager of the Bureau of Land Management, and to other parties as appropriate.

PASSED WITH DISSENTING VOTE

ATTEST:

Edwin P. Pister
Executive Secretary

Desert Fishes Council

"Dedicated to the Preservation of America's Desert Fishes"

P.O. Box 337
Bishop, California 93514
(619) 872-8751

January 4, 1991

RESOLUTION 90-4

RELATIVE TO THE ESTABLISHMENT OF THE
NATIONAL INSTITUTES FOR THE ENVIRONMENT

WHEREAS the Desert Fishes Council is an organization numbering in excess of 500 persons and comprising an international representation of federal, state, and university scientists and resource specialists, members of conservation organizations, and individuals concerned with long-term values of aquatic ecosystems and their related biotas in western North America, and

WHEREAS the purpose of the Desert Fishes Council is to promote the conservation of our desert fisheries resources and habitats, and

WHEREAS the quality and quantity of these fisheries resources have been declining because of pollution, invasion by non-native species, and destruction of aquatic habitats, and

WHEREAS this decline has accelerated dramatically during the past decade despite considerable efforts to conserve this resource, and

WHEREAS our collective research efforts have not grown sufficiently to meet the increasing challenges posed by the increasingly complex and pervasive problems facing our environment, now therefore be it

RESOLVED that the Desert Fishes Council, assembled at its 22nd Annual Symposium on November 14-17, 1990 in Ensenada, Baja California, Mexico, wholly supports the concept of creating a National Institutes for the Environment and requests to participate in the planning and development of such an organization.

PASSED WITHOUT DISSENTING VOTE

ATTEST:

Edwin P. Pister
Executive Secretary

Desert Fishes Council

"Dedicated to the Preservation of America's Desert Fishes"

P.O. Box 337
Bishop, California 93514
(619) 872-8751

January 4, 1991

RESOLUTION 90-5

RELATIVE TO INTERNATIONAL COLLABORATION WITH THE DESERT FISHES COUNCIL

WHEREAS there are other countries in the world with similar desert (arid) ecosystems to those of Canada, the United States, and Mexico, and which have species in need of attention, and

WHEREAS such countries are found in the Middle East, Africa, Australia, South America, etc., and

WHEREAS scientists in other countries such as Australia are already conducting valuable work on threatened species, now therefore be it

RESOLVED that researchers from other countries be invited to Desert Fishes Council meetings in the future to encourage and promote the exchange of information and experience on desert habitats and species from around the world, and be it further

RESOLVED that copies of this resolution be distributed to representatives of the above nations as appropriate.

PASSED WITHOUT DISSENTING VOTE

ATTEST:

Edwin P. Pister
Executive Secretary

Desert Fishes Council

"Dedicated to the Preservation of America's Desert Fishes"

P.O. Box 337
Bishop, California 93514
(619) 872-8751
January 4, 1991

RESOLUTION 90-6

RELATIVE TO BIOSPHERE RESERVE STATUS FOR THE SIERRA SAN PEDRO MARTIR

WHEREAS the Sierra San Pedro Martir contains landscapes of great natural beauty that form the habitat of many species worthy of preservation, and

WHEREAS the Desert Fishes Council is deeply concerned over the preservation of the endemic trout (Oncorhynchus mykiss nelsoni) and its habitat, and

WHEREAS the Desert Fishes Council shares this same concern over all aquatic habitats and their related life forms in the Sierra San Pedro Martir, and

WHEREAS the United Nations Man and the Biosphere Program provides for the creation of Biosphere Reserves to promote research, education, and the rational use of natural resources, and

WHEREAS the Sierra San Pedro Martir is unquestionably one of the most remarkable and fragile mountain ranges in the Western Hemisphere, now therefore be it

RESOLVED that the Desert Fishes Council, an international organization numbering in excess of 500 university and agency research scientists and resource specialists, private conservationists, and other individuals concerned with the long-term integrity of North America's desert ecosystems, assembled at its 22nd Annual Symposium in Ensenada, Baja California, Mexico, does hereby support the incorporation of the Sierra San Pedro Martir into the Biosphere Reserve System, and be it further

RESOLVED that the Council supports research and conservation work in the Sierra San Pedro Martir and urges the people and governments of the State of Baja California and Mexico to recognize the natural value and importance of the Sierra San Pedro Martir by petitioning the Man and Biosphere Program to declare it a Biosphere Reserve, and be it further

RESOLVED that copies of this resolution be forwarded to the President of Mexico, to the Governor of the State of Baja California, to the Commission of the Californias, and to other officials and parties as appropriate.

PASSED WITH ONE DISSENTING VOTE

ATTEST:

Edwin P. Pister
Executive Secretary

Desert Fishes Council

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January 3, 1991

RESOLUTION 90-7

RELATIVE TO THE INTEGRITY OF THE VIRGIN RIVER ECOSYSTEM

WHEREAS the Virgin River has long been recognized as a unique ecosystem that supports a distinctive fauna including two fish taxa, the woundfin (Plagopterus argentissimus) and the Virgin River roundtail chub (Gila robusta seminuda), listed as endangered by the U.S. Department of the Interior, and

WHEREAS management toward recovery of these fishes and their ecosystem, including construction of barriers against invading exotics, chemical removal of exotic fishes, artificial propagation toward maintenance of stocks and reintroduction, negotiation for maintenance of river flow, and other programs and projects, have not succeeded, and the ecosystem and its fauna continue to deteriorate, and

WHEREAS the ecosystem comprises an interstate and interregional resource of great importance, now therefore be it

RESOLVED that the Desert Fishes Council, assembled at its 22nd Annual Symposium on November 14-17, 1990 in Ensenada, Baja California, Mexico, strongly recommends immediate formation of a Task Force at the Department of the Interior level to implement immediate and forceful emergency action toward:

1) Securing flows in the Virgin River mainstem compatible with the requirements of the listed species and the remainder of the system's indigenous fauna,

2) Attaining successful artificial propagation of woundfin and Virgin chub to insure their survival upon reintroduction,

3) Fulfilling the goal of removing red shiner from the system and preventing their reinvasion, and

4) Achieving other scientific and political actions as necessary to secure the Virgin River ecosystem from further perturbation and insure its maintenance as a viable and continuing ecosystem, and be it further

RESOLVED that copies of this resolution be forwarded to the Secretary of the Interior; the Director of the U.S. Fish and Wildlife Service; the Director of the Bureau of Land Management; the Regional Directors of U.S. Fish and Wildlife Service Regions 1, 2, and 6; the Director of the Utah Division of Wildlife Resources; the Director of the Nevada Department of Wildlife; and the Director of the Arizona Game and Fish Department.

PASSED WITHOUT DISSENTING VOTE

ATTEST:

Edwin P. Pister
Executive Secretary

Desert Fishes Council

"Dedicated to the Preservation of America's Desert Fishes"
P.O. Box 337
Bishop, California 93514
(619) 872-8751
December 15, 1990

A RESOLUTION CONCERNING THE TWENTY-SECOND ANNUAL SYMPOSIUM

WHEREAS the Twenty-second Annual Symposium of the Desert Fishes Council was held in Ensenada, Baja California on November 14-17, 1990 and was hosted by the Facultad de Ciencias Biológicas of the Universidad Autónoma de Baja California, and

WHEREAS the arrangements made by M.C. Gorgonio Ruiz-Campos and Oc. Carlos Yruretagoyena-Ugalde permitted an unusually well organized, informative, and enjoyable meeting, and

WHEREAS the students, faculty members, and administrators of the Universidad Autónoma de Baja California made special and extraordinary efforts to welcome the Desert Fishes Council to Ensenada and to the University, and

WHEREAS the student papers presented by those individuals affiliated with the Facultad de Ciencias Biológicas were of exceptional quality, covered a broad spectrum of basic and applied aquatic science, and demonstrated an unusually vigorous program of research, and

WHEREAS the Carl L. Hubbs award for the best student paper was won by Isabel Montes-Pérez and the Frances Hubbs Miller award for the best paper presented by a Mexican student was won by Manuel M. Villalobos-Ramírez, both students within the Facultad de Ciencias Biológicas, and

WHEREAS the members of the Desert Fishes Council were individually and collectively impressed and pleased with the arrangements, the quality of the meeting, and the opportunity to learn about the exceptional programs in biological sciences at the Universidad Autónoma de Baja California, now therefore be it

RESOLVED that the Desert Fishes Council, an organization numbering in excess of 500 members and comprising a nationwide and international representation of scientists and resource specialists, members of conservation organizations, and individuals concerned with long-term environmental values, does hereby express its profound and heartfelt gratitude to M.C. Ruiz-Campos, to Oc. Yruretagoyena, to the students and staff associated with the Facultad de Ciencias Biológicas, to the administration of the University, and to the entire University for providing us with such a memorable meeting, and be it further

RESOLVED that copies of this Resolution be forwarded to Dr. Alfredo F. Buenrostro-Cevallos, Rector of the University, to Dr. Conrado Noriega Martínez, Vicerrector, and to M.C. Faustino Camarena Rosales, Director of La Universidad Autónoma de Baja California y la Facultad de Ciencias.

PASSED BY UNANIMOUS VOTE

ATTEST: [signature]
E.P. PISTER, EXEC. SECTY.

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VOLUME XXIII (1991)

Desert Fishes Council

"Dedicated to the Preservation of America's Desert Fishes"

TWENTY-THIRD ANNUAL SYMPOSIUM

Death Valley National Monument Headquarters

Furnace Creek, California

November 21-23, 1991

AGENDA, 23rd ANNUAL SYMPOSIUM

Wednesday, November 20.

1900-2200 Pre-registration at Visitor Center

Thursday, November 21.

0800-1700 Registration at Visitor Center.

0900- Welcome to Death Valley - Superintendent Ed Rothfuss.

Announcements and introductions - Phil Pister, Executive Secretary.

SESSION I - AGENCY REPORTS AND MISCELLANEOUS PRESENTATIONS.

Chair: Jack Williams, Chairman, Desert Fishes Council.

MEXICO

CANADA

UNITED STATES

Bureau of Land Management	Arizona
National Park Service	California
Bureau of Reclamation	Colorado
Forest Service	Kansas
Fish and Wildlife Service	Nevada
Agency overview	New Mexico
Colorado River	Texas
Indian tribes	Utah

MISCELLANEOUS PRESENTATIONS

The Nature Conservancy.

Gila taxonomy project - Wayne Starnes, Smithsonian Institution.

SESSION II - RESEARCH AND MANAGEMENT PAPERS 1-19. 1320.

Chair: David L. Soltz, California State University, Long Beach.

SESSION III - BARBECUE. 1900.

Friday, November 22.

SESSION IV - RESEARCH AND MANAGEMENT PAPERS 20-35. 0800.

Chair: James La Bounty, U.S. Bureau of Reclamation, Denver.

SESSION V - RESEARCH AND MANAGEMENT PAPERS 36-53. 1320.

Chair: Steven P. Platania, University of New Mexico, Albuquerque.

SESSION VI - BUSINESS MEETING. 2000.

Chairs: Jack Williams and Phil Pister.

Saturday, November 23.

SESSION VII - FIELD TRIP. 0800.

Chair: Doug Threloff, U.S. Fish & Wildlife Service, Ash Meadows National Wildlife Refuge.

Desert Fishes Council
P.O. Box 337
Bishop, CA 93515
(619) 872-8751

31 October 1991

PAPERS, DESERT FISHES COUNCIL SYMPOSIUM XXIII

1. *Gambusia* birth weights. Clark Hubbs, University of Texas, Austin.

*2. Spawning behavior in a marked population of Owens pupfish, *Cyprinodon radiosus*. June Mire, University of California, Berkeley.

3. Big Bend National Park: refuge for rare Rio Grande fishes. Steven P. Platania, University of New Mexico, Albuquerque.

4. Bonytail and razorback sucker from the Salton Basin of California? Kenneth W. Gobalet, California State University, Bakersfield.

5. Conservation genetics of bull trout, *Salvelinus confluentus*. Fred W. Allendorf, University of Montana, Missoula.

*6. Influence of predation on the distribution of the Little Colorado spinedace, *Lepidomeda vittata*. Clay Runck and Dean W. Blinn, Northern Arizona University; and Tom Cain, Coconino National Forest, Flagstaff.

7. Status of the "Californian" minnow, *Ceratichthys cummingii*. Robert Rush Miller, University of Michigan, Ann Arbor.

8. Status of the Virgin spinedace (*Lepidomeda mollispinis mollispinis*) in the Virgin River drainage, Utah. R. A. Valdez and W.J. Masslich, Bio/West, Logan, UT; and Randy Radant, Utah Division of Wildlife Resources, Salt Lake City.

9. Investigations of the life history and ecology of the humpback chub (*Gila cypha*) in the Grand Canyon. R.A. Valdez, W.J. Masslich, L. Crist, and W.Leibfried, Bio/West, Logan, Utah.

10. The Dolores River as a reintroduction site for Colorado squawfish (*Ptychocheilus lucius*). W.J. Masslich and R.A. Valdez, Bio/West, Logan, Utah.

11. Morphological variation in pupfish. Gene Wilde, Texas Parks and Wildlife Department, Austin.

12. Back-calculated spawning dates for the humpback chub population of Grand Canyon as related to river flow. Chuck Minckley, Northern Arizona University, Flagstaff.

13. Unusual catostomid morphologies: introgressive hybridization or convergent adaptations? Allozymes to the rescue?? Bill Berg, University of California, Davis.

14. Predator recognition and avoidance by larval razorback sucker (*Xyrauchen texanus*) and northern hog sucker (*Hypentelium nigricans*). J.E. Johnson, M. Lyttle, and M. Pardew, University of Arkansas, Fayetteville.

15. Summertime movements of humpback chub, *Gila cypha*, in the Little Colorado River, Arizona. M.E. Douglas, P.C. Marsh, and B.E. Bagley, Arizona State University; Pat Ryan, Navajo Natural Heritage Program; and C.O. Minckley, Northern Arizona University.

16. Status of bonytail (*Gila elegans*) and razorback sucker (*Xyrauchen texanus*) in Lake Mohave, Arizona-Nevada. Paul C. Marsh and W.L. Minckley, Arizona State University, Tempe.

17. Genetic diversity in the razorback sucker (*Xyrauchen texanus*) as determined by analysis of mitochondrial DNA. Tom Dowling and W.L. Minckley, Arizona State University, Tempe.

*18. Mitochondrial DNA variation in spikedace and loach minnow. Alana Tibbets and Tom Dowling, Arizona State University, Tempe.

*19. Mitochondrial DNA variation in *Rhinichthys osculus* of the lower Colorado River. D.D Oakey and M.E. Douglas, Arizona State University, Tempe.

20. Habitat preferences and population structure of razorback suckers (*Xyrauchen texanus*) in Fossil Creek, Arizona. P.J. Barrett and O.E. Maughan, University of Arizona, Tucson.

21. An overview of water transfer proposals in Nevada. Paul J. Barrett, U.S. Fish and Wildlife Service, Reno, NV.

*22. Status of endemic fishes in two Nevada Bonneville drainages. M.E. Anderson and J.E. Deacon, University of Nevada, Las Vegas.

23. Introduced molluscs in the middle Snake River. P. Bowler and T. Frest, University of California, Irvine, and

The ecology, distribution and status of relict Lake Idaho molluscs and other endemics in the middle Snake River. T. Frest and P.A. Bowler, University of California, Irvine; and R. Hershler, Smithsonian Institution, Washington, D.C. (two-part presentation).

24. Thermal tolerance studies on remnant populations of desert pupfish (*Cyprinodon macularius*) from the Salton Sea area. Allan Schoenherr, Fullerton College, California.

25. Use of antimycin for removal of rainbow trout from White Creek, New Mexico. Jerome A. Stefferud, USDA Forest Service, Phoenix, AZ; D. L. Propst, New Mexico Game and Fish Department, Santa Fe; and G.L. Burton, U.S. Fish and Wildlife Service, Albuquerque, NM.

26. Mitochondrial DNA diversity within and among populations of endangered Sonoran topminnows. Joe Quattro, Hopkins Marine Station, Stanford University, Pacific Grove, CA.

27. Mosaic evolution of a new sexual species of *Poeciliopsis*. R.C. Vrijenhoek, Margaret Schenk, and Paul LeBerg, Center for Theoretical and Applied Genetics, Rutgers University, New Brunswick, NJ.

28. Is there Federal interest in curbing introductions? W.R. Courtenay, Jr., Florida Atlantic University, Boca Raton.

29. The Native Fish Work Group - a multiagency endeavor to improve the status of the razorback sucker in Lake Mohave, AZ-NV. Gordon Mueller, Bureau of Reclamation, Denver.

30. Cutthroat trout (*Oncorhynchus clarki*) subspecies relationships: mtDNA D-loop and ribosomal DNA sequences. Paul Evans, Brigham Young University, Provo, UT.

31. Arizona stockings of razorbacks and squawfish: history and future research and management challenges. Dean A. Hendrickson, University of Texas, Austin.

32. River management and habitat restoration strategy: recovery program for the endangered fishes of the upper Colorado. E.J. Wick, Colorado State University, Fort Collins.

33. Apache trout habitat use in the presence of brown trout. Lorena Wada, U.S. Fish and Wildlife Service, Albuquerque, NM; and O.E. Maughan, University of Arizona, Tucson.

34. Environmental characteristics of small springs in northern Nevada. D.W. Sada, Smithsonian Institution, Washington, D.C.; and G.L. Vinyard, University of Nevada, Reno.

*35. Summer microhabitat use by Sonora chub (*Gila ditaenia*) in Sycamore Canyon, Arizona. Jeanette Carpenter, U.S. Fish and Wildlife Service, Fort Collins, CO.

36. Duplicate gene expression and allozyme divergence diagnostic for *Catostomus tahoensis* and the endangered *Chasmistes cujus* in Pyramid Lake, Nevada. D.G. Buth and T.R. Haglund, University of California, Los Angeles; and W.L. Minckley, Arizona State University, Tempe.

37. A survey of relictual herpetofauna associated with the oases of central Baja California. L.L. Grismer and J.A. McGuire, San Diego State University.

38. Evolution of Death Valley pupfishes. A.A. Echelle and A.F. Echelle, Oklahoma State University, Stillwater; and T. Dowling, Arizona State University, Tempe.

39. Regulation of flows in the Pecos River, New Mexico, for the bluntnose minnow (*Notropis simus pecosensis*). G.L. Burton, U.S. Fish and Wildlife Service, Albuquerque, NM.

*40. Limnological characterization of the habitat of San Pedro Mârtir rainbow trout (*Oncorhynchus mykiss nelsoni*). Gorgonio Ruiz-Campos, Universidad Autõnoma de Baja California Norte, Ensenada, B.C.

*41. Conservation genetics of desert pupfish (*Cyprinodon macularius*). Jason Dunham, Arizona State University, Tempe.

*42. The Warner sucker: biology, salvage, and recovery efforts. Rollie White, University of California, Davis.

43. Limnological aspects of the lower Rio Santo Domingo (San Antonio) with special reference to an endemic turtle. Carlos Yruretagoyena, Patronato Para la Protección y Reforestación de los Bosques de Baja California, A.C.

44. The Devils River minnow, *Dionda diaboli*, part of the imperiled fish fauna of West Texas. Gary Garrett, Texas Parks and Wildlife Department, Ingram; R.J. Edwards, University of Texas, Pan American; and A.H. Price, Texas Parks and Wildlife Department, Austin.

45. Pupfish use of a restored marsh on the Ash Meadows National Wildlife Refuge. Doug Threloff, U.S. Fish and Wildlife Service, Pahrump, NV.

*46. Fish movement relative to physical environment in a Sonoran Desert stream. Caryl Williams, U.S. Fish and Wildlife Service, Dexter, NM.

47. Rediscovery of *Gila robusta* in the Little Colorado River drainage. M.R. Brown, Arizona Game and Fish Department, Phoenix.

48. Desert habitats in Canada. E.D. Lane, Malaspina College, Nanaimo, B.C., Canada.

49. A recently discovered *Cottus* from the White River system, Nevada. G.G. Scoppettone, U.S. Fish and Wildlife Service, Reno, NV; and Carl Bond, Oregon State University, Corvallis.

50. What constitutes high quality habitat for Gila topminnow (*Poeciliopsis o. occidentalis*)? An overview of habitat parameters supporting a robust topminnow population at Cienega Creek, Santa Cruz County, Arizona. J.R. Simms and K.M. Simms, U.S. Bureau of Land Management, Safford, AZ.

*51. Direct and indirect impacts of Tahoe suckers (*Catostomus tahoensis*) in artificial streams. Yingchuan Yu and G.L. Vinyard, University of Nevada, Reno.

52. New forms, and records on new introductions of fishes in Mexico - a word of caution. Salvador Contreras-Balderas, Universidad Autónoma de Nuevo León, México.

53. Endangered fishes, water resources, and development planning in northern Mexico. Salvador Contreras-Balderas and Lourdes Lozano-Vilano, Universidad Autónoma de Nuevo León, México.

*Student papers competing for Carl L. Hubbs and/or Frances Hubbs Miller awards.

**American Association of Zoological Parks and Aquariums/
International Union for the Conservation of Nature
Desert Fishes Species Survival Program
1991 Status Report**

1. As of 15 November 1991, fourteen AAZPA member institutions have agreed to participate in the Desert Fishes Species Survival Program. They are:

New York Aquarium*
New England Aquarium*
Niagara Falls Aquarium
National Aquarium in Baltimore
Belle Isle Aquarium*
Shedd Aquarium*
Columbus Zoo Aquarium*
Indianapolis Zoo*
St. Louis Zoo*
Dallas Aquarium*
Fort Worth Zoo Aquarium*
San Antonio Zoo Aquarium*
Arizona/Sonora Desert Museum*
Steinhart Aquarium*

* denotes institutions presently displaying or maintaining populations of species extinct in nature, officially designated as endangered or of special concern.

2. The Dallas Aquarium has joined the New York Aquarium in providing support for the Autonomous University of Nuevo Leon's Desert Fishes Breeding Center in Monterrey. Python Products of Milwaukee, WI has joined Tetra Sales (U.S.A.) as a corporate benefactor of the DFBC.

3. A formal proposal of collaboration in desert fish conservation efforts between the New York Aquarium and the Autonomous University of Nuevo Leon has been signed. The first shipment of endangered Mexican fishes to foreign participants in the desert fishes SSP was received in March 1991, logistics having been managed with the invaluable assistance the Dallas Aquarium. The New York Aquarium is presently maintaining the two El Potosi endemics, Cyprinodon alvarezi and Megupsilon aporus and has produced an F_1 of the latter. The Dallas Aquarium concurrently received stocks of C. nazas and Cyprinodon sp./Charco Azul. Dallas has subsequently acquired stocks of C. fonticola, and Cyprinodon sp./Charco Palma. All four species have bred successfully and efforts are underway to place the resulting progeny with other participating institutions.

4. In collaboration with the Texas Department of Parks and Wildlife, the Dallas Aquarium has undertaken the captive husbandry of Cyprinodon eximius collected from Alamito Creek. As the flourishing F_1 that has rewarded this breeding program is descended from a single founder pair, efforts will be made so secure additional wild breeders to broaden the genetic base of this captive population.

5. A preliminary survey of current holdings of Cyprinodon macularius, reveals that with two exceptions, all extant aquarium stocks of this pupfish are descended from limited founder stock of uncertain provenance bred successfully at the Belle Isle Aquarium. The New England Aquarium is maintaining C. m. macularius descended from founder stock held under culture at the U.S.F.W.S. facility at Dexter, NM, while the Arizona/Sonora Desert Museum exhibits and breeds the Quitobaquito pupfish, C. m. eremius. After consulting with Dr. Anthony Echelle, I have recommended the following steps be taken with regard to aquarium management of this species:

a. All pupfish descended from the Bell Isle population of C. macularius should be dropped from the Desert Fishes SSP. Extant stocks have substantial value as research material and should be held until final arrangements are made for their disposition.

b. Only C. m. macularius derived from the Dexter stock of this subspecies or C. m. eremius should be maintained under the Desert Fishes SSP.

c. Eleven institutions are currently holding or displaying C. m. macularius. Given the resources already committed to its management by federal and state agencies, this pupfish hardly warrants so much attention from public aquaria. I have therefore strongly recommended that no more than two populations of C. m. macularius be maintained by participating institutions and that otiose aquarium populations be replaced by Mexican Cyprinodon species, whose survival in nature is more seriously threatened than that of C. m. macularius.

6. All Cyprinodon species to date studied have the demonstrated ability to produce viable, fertile hybrids. Male pupfish will court and spawn with any congeneric female, while correctly identifying female pupfish is difficult due to the overall similarity of their coloration, Given the risk of genetic contamination of captive pupfish stocks posed by these biological peculiarities, it is the consensus of the Desert Fishes SSP participants that no more than one Cyprinodon species be maintained by any given institution on a long-term basis. This limitation need not be extended to the genera Cualac, Megupsilon or Lucania, whose females differ sufficiently from those of Cyprinodon to preclude the possibility of accidental miscegenation.

7. After consulting with Dr. Michael Smith of the American Museum of Natural History, Mr. Douglas Sweet (Belle Isle Aquarium) has proposed the following goodeids for inclusion in the Desert Fishes SSP. Species listed in decreasing order of endangerment in nature.

a. Allotoca maculata*
b. Hubbsina turneri*
c. Characodon lateralis*
d. Characodon audax*
e. Skiffia francesae**
f. Ataeniobus toweri**
g. Girardinichthys viviparus*
h. Xenoophorus captivus**
i. Allotoca goslinei
j. Allodontichthys polylepis

Species designated by a single asterisk (*) are represented by small populations. Those designated by a double asterisk (**) have produced sufficient surplus progeny to permit dispersal of founder stocks to other institutions.

8. The New York Aquarium is managing three Xiphophorus species as part of the Desert Fishes SSP. The Monterrey platyfish, X. couchianus, is extinct in nature. Xiphophorus gordoni and X. meyeri are of special concern because of their very restricted ranges and the susceptibility of their habitats to anthropogenic degradation. Breeding stock of X. couchianus was sent to the UANL's Desert Fishes Breeding Center in Monterrey in the fall of 1990 and to the Columbus Zoo Aquarium in summer of 1991. Steinhart Aquarium has expressed a desire to maintain and display this species and will be sent founder stock as soon as weather conditions permit. Efforts are underway to place at least one other population of the remaining two species under institutional management.

Maternal Size Does Not Determine Size of Eggs or Fry in the Owens Pupfish, *Cyprinodon radiosus.*

June B. Mire* and Leslie Millett, Dept. Integrative Biology *and Museum of Vertebrate Zoology, University of California, Berkeley

ABSTRACT

In discussions of mating systems and sexual selection, one question that invariably surfaces is that of the relative contribution of each parent to the production of offspring. In pupfish, the material contribution of the female consists solely of the egg. Since female pupfish spawn almost daily with many males for a period of several months, egg number is probably not a primary variable upon which male pupfish choose mates. If egg size varied, however, female "value" to a male might vary similarly, because larger eggs are expected to produce larger fry. We asked whether egg size is an important variable affecting the value of a female to a potential mate.

We collected ripe eggs from females every two weeks for one year. Two populations in Owens Valley, CA, were compared: Warm Springs and BLM Spring. Eggs collected at BLM Spring were significantly larger than those from Warm Springs, even though females at BLM were significantly smaller than those at Warm Springs. Although the relationship between female size and mean egg size is statistically significant ($F_{(1,67)}$=9.714, p<0.01), the correlation (r=-0.35) is so small as to be unimportant, and, counterintuitively, it is negative.

We obtained the first eggs at Warm Springs in early January, 1990, and at BLM in mid-February, 1991. This sequence of egg production mirrors the temperature differences between the habitats. Conversely, by mid-June, egg production at Warm Springs had almost finished, while at BLM Spring it continued until August.

In order to investigate the functional significance of egg size, we reared individual eggs to the fry stage in the lab. Eggs from a total of 30 females, ranging in size from 35 to 49.5mm total length (TL), were obtained in this way. Neither egg size nor fry size were strongly influenced by the size of the mother. A linear regression of mean egg diameter on female TL was non-significant (r=0.20, $F_{(1,24)}$=1.12, p>0.25). Similarly, a linear regression of mean egg diameter on mean fry TL for each female was non-significant (r=0.22, $F_{(1,24)}$=1.31, p>0.25).

We asked whether size of individual eggs was correlated with the size of fry they produced, without regard to maternal size. This correlation was non-significant as well (r=0.028, $F_{(1,146)}$=0.13, p>0.25). Neither did the size of an egg predict time to hatching or to yolk resorption.

Because egg size varies as much within an individual female as it does among all females, we conclude that it is unlikely that male pupfish use female size as a predictor of size of eggs or offspring when assessing potential mates. Even if males had some way of increasing their odds of fertilizing the largest eggs, it is uncertain whether the theoretically expected benefit it fitness would result.

CONSERVATION GENETICS OF BULL TROUT IN THE COLUMBIA AND KLAMATH RIVER DRAINAGES

Robb F. Leary

Fred W. Allendorf

Stephen H. Forbes

Division of Biological Sciences
University of Montana
Missoula, Montana 59812

ABSTRACT

We used electrophoretic analysis of proteins encoded by 51 loci to determine the population genetic structure of bull trout (Salvelinus confluentus) in the Columbia and Klamath River drainages. The sampled populations have little genetic variation within them and substantial genetic differences among them. Preserving the genetic diversity of bull trout will require the continued existence of many populations throughout this region. Bull trout from the Columbia and Klamath drainages are reproductively isolated and are evolutionarily distinct. These two groups of bull trout therefore would qualify as separate "species" under the United States Endangered Species Act according to criteria established for anadromous salmonid fishes.

Genotype frequencies at the four variable loci in a group of bull trout used for artificial supplementation indicate an extremely small number of effective parents. The release of such fish into the wild could have harmful effects on native fish populations.

Non-native brook trout (Salvelinus fontinalis) have been introduced throughout the range of bull trout, and hybridization between these species is increasingly reported. Protein and mitochondrial DNA genotypes collected from one stream over an eight year period indicate the displacement of bull trout by brook trout. This displacement was rapid and accompanied by extensive production of nearly sterile interspecific hybrids by both reciprocal crosses.

INFLUENCE OF PREDATION ON THE DISTRIBUTION OF THE LITTLE COLORADO SPINEDACE, LEPIDOMEDA VITTATA.

Clay Runck (Northern Arizona University, Flagstaff, AZ), Dean W. Blinn (NAU), and Tom Cain (Coconino National Forest Service, Flagstaff, AZ).

The Little Colorado spinedace, *Lepidomeda vittata* (Cyprinidae), occurs only in Arizona in disjunct populations in the Little Colorado River and several of its tributaries. The number of spinedace has been declining and it is listed as a Federally Threatened species. Electrofishing and seining data indicate an inverse relationship between the presence of rainbow trout and spinedace in Nutrioso Creek, Arizona. Spinedace and green sunfish occuppied the same habitats in Chevelon Creek, Arizona. Laboratory and field predation experiments support these field observations. In laboratory aquaria with one rainbow trout and four spinedace, the presence of rock refuges did not significantly reduce the average rates of capture of spinedace by rainbow trout (0.4 spinedace/hr) compared to aquaria without rock refuges (0.3 spinedace/hr). In aquaria with one green sunfish and six spinedace, the average rates of capture of spinedace by green sunfish were significantly less in tanks with rock (0.2 spinedace/hr) and vegetation (0.2 spinedace/hr) refuges than in tanks without rock (0.6 spinedace/hr) or vegetation (0.4 spinedace/hr) refuges. In field experiments, 18-30 spinedace were added to 3 X 2 m *in situ* stream enclosures; enclosures either received 2-3 trout or no trout. Significantly more spinedace disappeared from enclosures with trout (10 spinedace/trial) than from enclosures without trout (0.8 spinedace/trial). Our results suggest predation by rainbow trout could be a major factor contributing to the decline of the Little Colorado spinedace throughout the Little Colorado River drainage.

STATUS OF THE VIRGIN SPINEDACE
(Lepidomeda mollispinis mollispinis)
IN THE VIRGIN RIVER DRAINAGE, UTAH

Richard A. Valdez, William J. Masslich
BIO/WEST, Inc.
1063 West 1400 North
Logan, Utah 84321

and

Randy Radant
Utah Division of Wildlife Resources
1596 West North Temple
Salt Lake City, Utah 84116

ABSTRACT

The distribution, abundance and status of the endemic Virgin spinedace (Lepidomeda mollispinis mollispinis) in the Virgin River Drainage of southwestern Utah are described. The original range of the Virgin spinedace in Utah has been reduced by 40%, from 233 to 141 km of stream. Virgin spinedace are presently found in the mainstem Virgin River above La Verkin and in portions of seven principal tributaries including Beaver Dam Wash, Santa Clara River, Ash Creek, La Verkin Creek, North Creek, North Fork Virgin River, and East Fork Virgin River. They occur incidentally in the lower mainstem at tributary inflows from La Verkin, Utah, to Mesquite, Nevada. Of 13 distinct Utah populations, none is considered secure and free of threats; five are stable with existing threats, seven are showing evidence of decline with persistent threats, and one (lower Santa Clara River) is in danger of extirpation. The populations in Magotsu Creek, Quail Creek, and Leeds Creek are extirpated. Existing and impending water developments, water degradation and proliferation of non-native species further threaten the Virgin spinedace. A monitoring program, protection of inhabited areas, improved water quality, and reductions of non-native species are recommended to prevent further decline of habitats and populations. Since all Utah populations are threatened and the species exists in only one area outside of Utah (Virgin River near Mesquite, Nevada), development of a listing package is recommended to propose the Virgin spinedace as a "threatened species" under the Endangered Species Act of 1973, as amended.

INVESTIGATIONS OF THE LIFE HISTORY AND ECOLOGY OF THE HUMPBACK CHUB (Gila cypha) IN THE GRAND CANYON

Richard A. Valdez, William J. Masslich, Larry Crist
BIO/WEST, Inc.
Logan, Utah 84321

and

William Leibfried
Leibfried Environmental Services
Flagstaff, Arizona 86001

ABSTRACT

Investigations were initiated in September 1990 to characterize the life history and ecology of the endangered humpback chub (Gila cypha) in the Colorado River of Grand Canyon. These studies are part of the Glen Canyon Environmental Studies to evaluate the operation of Glen Canyon Dam. Several new and innovative techniques for sampling and monitoring fish in whitewater riverine habitat are described and evaluated. Small research boats from established base camps have allowed increased access to many previously unsampled habitats both up and downstream, but they have increased inherent risks to personnel and equipment and demand skilled handlers. Gill and trammel nets set for less than 2 hours have reduced stress to fish and practically eliminated mortality of chubs at the cost of increased labor for net maintenance and cleaning. Small maneuverable electrofishing boats have increased access to shallow shorelines but reduced the number of netters to capture fish. Radiotelemetry has become a valuable tool for monitoring fish movement and habitat use, but signal strength is restricted by water depth, conductance, and canyon geologic features. Greater access to sample areas and increased efficiency in capturing and monitoring humpback chub in the Grand Canyon will lead to a better understanding of the life history and ecology of this endangered species as impacted by Glen Canyon Dam.

THE DOLORES RIVER AS A REINTRODUCTION SITE FOR COLORADO SQUAWFISH (Ptychocheilus lucius)

W.J. Masslich and R.A. Valdez
BIO/WEST, Inc.
Logan, Utah 84321

ABSTRACT

The Dolores River in Colorado and Utah was investigated in 1990-91 to determine its suitability for the endangered Colorado squawfish (Ptychocheilus lucius), humpback chub (Gila cypha), bonytail (Gila elegans), and razorback sucker (Xyrauchen texanus). The Dolores River is the only major tributary in the Upper Colorado River Basin not presently occupied by these species. Colorado squawfish were historically reported from the system but were extirpated by uranium mill tailings spills in the early 1960's in the lower San Miguel River, a tributary of the Dolores River. Only one 400 mm long Colorado squawfish was captured during this investigation, about 1.5 km from the confluence of the Colorado River. The other endangered species were not encountered. This investigation determined that the Dolores River in its present condition is marginally suited for Colorado squawfish. This marginality is based on low flows controlled by McPhee Dam, poor water quality from continued seepage of uranium wastes and mining activity throughout the drainage, and increased sedimentation. Nevertheless, the Dolores River is showing signs of recovery since investigations in the early 1980's, as indicated by increased composition of native species and lower numbers of non-native channel catfish. We determined that the Dolores River can be a suitable tributary for wild and hatchery-reared Colorado squawfish with restoration of flows, improved water quality, and cessation of stocking of channel catfish.

PREDATOR RECOGNITION AND AVOIDANCE BY LARVAL RAZORBACK SUCKER AND NORTHERN HOGSUCKER

by J.E. Johnson, M. Lyttle, and M. Pardew

U.S. Fish and Wildlife Service
Arkansas Cooperative Fish and Wildlife Research Unit
University of Arkansas
Fayetteville, Arkansas 72701

ABSTRACT

Razorback suckers are endemic to the mainstream Colorado River that originally supported only one native piscivorous species, Colorado squawfish. Recent attempts to reintroduce razorback suckers into native habitats have not been very successful, perhaps due to predation by non-native fishes. Two hypotheses were tested: 1) larval razorback suckers will not recognize fish predators as rapidly as larvae of a similar species from a predator-rich environment, and 2) groups of larvae will recognize predators more rapidly than individual larvae. Over a period of 2 months after hatching, untested single razorback sucker larvae improved their predator recognition rate from random (50%) to greater than 80%. Similar avoidance patterns were observed in 1990 and 1991. Another catosotmid, northern hogsucker, recognized a predator earlier than did razorback sucker, and improved avoidance to 100% within 30 days after hatching. Five untested larval razorback suckers placed in the test chamber simultaneously, initially demonstrated predator recognition and avoidance similar to single larvae, but failed to improve as rapidly or as extensively as did single larvae. More surprising, groups of 5 previously tested and untested northern hogsucker larvae demonstrated little better predator recognition that did razorback suckers. Management implications are that razorback suckers should be at least 45 days old before stocking into the wild, and should be spread extensively throughout the stocking sites.

Status of bonytail (*Gila elegans*) and razorback sucker (*Xyrauchen texanus*) in Lake Mohave, Arizona-Nevada

Paul C. Marsh and W.L. Minckley
Center for Environmental Studies and Department of Zoology
Arizona State University
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INTRODUCTION

The largest known populations of two endemic Colorado River fishes, bonytail (*Gila elegans*) and razorback sucker (*Xyrauchen texanus*), are found in Lake Mohave, Arizona and Nevada. The lake is the only habitat where razorback sucker can be reliably captured at virtually any time of year, and during the winter-early spring spawning season literally hundreds of adults can be handled in only a few days. Bonytail is far less abundant, but in spring (March to May) there is a high probability of encountering the species. Although arguably the most critically imperiled western fish species, bonytail is not extinct, and by some measures it is doing comparatively well in Lake Mohave.

Lake Mohave is an artificial impoundment on the Colorado River mainstream, created in the early 1950s by closure of Davis Dam (Allan and Roden 1978). Bonytail and razorback sucker are among the imperiled "large-river" fish fauna of the Colorado River basin, and both are federally listed as endangered (U.S. Fish and Wildlife Service [USFWS] 1983, 1991). Background on bonytail is in the species' recovery plan (USFWS 1990), and for razorback sucker is in Minckley (1983) and Minckley et al. (1991). This paper provides a summary update on status of the two species in Lake Mohave, based upon collections over the past decade (see also Minckley 1983, Marsh and Minckley 1989a, and Minckley et al. 1989).

RAZORBACK SUCKER

Minckley (1983) reported data from 1974 to 1981, and comparisons with collections from 1981 to the present indicate that razorback sucker individual and population characteristics are not detectably different between the two time periods.

Abundance. We examined abundance in two ways: trammel net catch per unit effort (CPE) and mark-recapture population estimates. CPE gives information on trends in abundance, and is especially useful with long-term data sets. Razorback sucker CPE varies seasonally (lower in summer), but overall has remained relatively constant near 2.5 fish per $100m^2$ of netting per 24-hours. Based on consistent use of trammel nets deployed in similar habitat over the past 18 years, there is no evidence of change in CPE. It is to be noted that CPE data have closely tracked changes in relative abundance of other species in the lake, for example, an increase in striped bass (Morone saxatilis) and decrease in rainbow trout (Oncorhynchus mykiss).

Absolute abundance estimates are based upon mark-recapture data. Approximately 4,400 adult razorback sucker in Lake Mohave have been marked since 1981 (most since 1988). Multiple census techniques estimate that approximately 60,000 fish occupy the reservoir, and annual estimates over the past 5 years are indistinguishable from one another.

Although mark-recapture data provide quantitative population abundance estimates and associated confidence limits, we do not consider the technique useful for short-term assessment because there may be a significant delay before even a substantial change in abundance is detected by this estimator. Instead, we suggest that CPE be used as the standard barometer for status assessment, since abundance changes should be immediately reflected by this parameter.

Characteristics of Individuals. An increase in average total length (TL) of both adult males and females was evident from data collected from the 1960s into the early 1980s (Minckley 1983). Since then, a plot of TL vs time has been unchanged with males averaging approximately 55 cm and females about 62 cm TL, based upon measurements of nearly 10,000 fish. Weight data, plus information on anomalies, injury, disease, parasites, and eye condition (blindness, cataracts, bulging) similarly have shown no detectable change over the past decade.

Reproduction and Recruitment. Razorback sucker spawning activity in Lake Mohave has been documented repeatedly (Minckley 1983, Bozek et al. 1991), and we have observed such behavior annually since the 1970s. Although timing of peak activity varies in response to weather and lake conditions, we have detected no overall change in the intensity of such activity in the past 20 years. Eggs are deposited and fertilized, embryos hatch and grow to swim-up, and larvae are abundant for a time in spring (Marsh and Langhorst 1988).

With exception of 4 juveniles captured in 1987 by Arizona Game and Fish Department (AZGFD) personnel (Marsh and Minckley 1989b), there is no evidence of successful recruitment beyond the larval stage in Lake Mohave. Adults occupying the lake all are large, old individuals (McCarthy and Minckley 1987); there apparently are no fish between post-larval and adult life stages. This status is unchanged in our collective experience over the past two decades. Several explanations have been forwarded to explain the lack of recruitment by razorback sucker (see Minckley et al. 1991), and other native Colorado River fishes, including predation by non-native fishes, nutritional constraints, and drift from the system. Unless remedied, this situation likely will result in loss of the Lake Mohave population of razorback sucker by the end of this decade.

BONYTAIL

Quantitative abundance estimates for bonytail are lacking. No such estimates were attempted before the species became rare, and fish are now too uncommon to acquire either CPE or mark-recapture data that are meaningful. Reproduction, at least in Lake Mohave, is unobserved. However, recruitment there has been documented by capture of at least one, relatively young, wild bonytail (Minckley et al. 1989).

Basin-wide, bonytail is considered so rare that the immediate goal of the recovery plan (USFWS 1990) is to prevent the species' extinction. Toward that end, 7 of 9 "priority 1" tasks itemized in the plan's implementation schedule pertain to acquisition of wild bonytail, sequestering in refugia, and subsequent propagation, rearing, and stocking. One of these 9 tasks deals directly with obtaining wild fish, specifies attempts be made in Lake Mohave (and elsewhere), designates USFWS and the states as responsible parties, and estimates annual costs of $50,000 to carry out the task.

Between 1974 and 1991, we have captured a total of 57 bonytail in Lake Mohave; additional fish have been taken there by Arizona Game and Fish Department and by anglers (see also Minckley 1983 and Minckley et al. 1989). None was captured in 1975, 77-78, 82, 84, or 87. Largest single samples were of 8 fish (March 1981 and May 1988) and 9 fish (May 1990).

Since USFWS sent out a request in 1988 for acquisition of brood fish, we have captured a total of 34 bonytail from Lake Mohave. Of these, 6 were collected during March, 27 during May, and a single fish was captured in November. Based on size and/or age, 23 of the 34 fish were wild adults and 11 were considered sub-adults. The 23 adult fish were transferred to USFWS to augment existing brood stock, 7 sub-adults were released back to the lake, and 4 others died in the field.

Assessment of bonytail population status in Lake Mohave is complicated by augmentation stockings. Since 1981, more than 130,000 fish (including larvae and young adults to 16.5 cm TL) have been stocked (Minckley et al. 1989; AZGFD, California Department of Fish and Game, and USFWS files). Fish in the first (1981) stocking were marked with tetracycline, and juveniles stocked in 1990 were marked by fin clip; however, other bonytail were unmarked and may thus be indistinguishable (except on the basis of size or age determination) from wild fish. To the best of our knowledge, 11 of 39 bonytail captured since 1981 have been stocked fish (4 that were fin clipped, 3 on the basis of relatively small size, and 4 mortalities that were aged by otoliths as 1981 year class). Compared with the handful of Colorado squawfish (Ptychocheilus lucius) and razorback sucker that have been recaptured among the millions re-introduced to the Gila River system of Arizona, the rate of return of bonytail from Lake Mohave is remarkable. Resource agencies responsible for management and recovery of bonytail should take note of these data.

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STATUS OF ENDEMIC FISHES IN TWO NEVADA BONNEVILLE DRAINAGES

Matthew E. Andersen and James E. Deacon

ABSTRACT

The status of endemic fishes was examined in Big Springs Creek and Thousand Springs Creek of eastern Nevada's limited pluvial Lake Bonneville drainage in the spring and summer of 1991. United States Geological Survey maps indicate that as recently as the 1960s, perennial stream flow in these areas was greater than at present. In both watersheds there is widespread evidence of damage to vegetative cover, stream siltation, bank erosion along streams, and organic pollution from cattle waste deposited along and in springs, streams and reservoirs. Drought, the introduction of non-native species, environmental degradation by humans and their cattle, as well as application of piscicide, have had severe negative impacts on fish habitats.

The native ichthyofauna of Big Springs Creek historically included *Catostomus ardens*, Utah sucker, *Gila atraria*, Utah chub, *Rhinichthys osculus*, speckled dace, *Richardsonius balteatus hydrophlox*, redside shiner, and *Cottus bairdi*, mottled sculpin. The Thousand Springs Creek drainage historically included all of the preceding but *C. ardens*, the native sucker in this drainage being *C. (Pantosteus) platyrhynchus*, mountain sucker. In Big Springs Creek, Nevada Department of Wildlife (NDOW) piscicide

applications have accomplished their stated goal of eradicating C. ardens and Gila atraria. No record exists of Thousand Springs Creek being poisoned.

Today Big Springs Creek contains only R. osculus, R. balteatus, and C. bairdi. The modern Thousand Springs Creek drainage contains these three and introduced Salvelinus fontinalis, brown trout. Apparently drought, road construction for mining, introduction of sportfish and heavy cattle grazing in the Thousand Springs drainage have had similar effects on fish diversity as piscicide application in Big Springs Creek.

It is likely that good management practices could improve both the terrestrial and aquatic habitats of these isolated drainages. Restoration of the exact native ichthyofauna may be impossible, since original stocks of some populations may no longer exist. Attempts should be made to determine the best candidate populations for use in restoration efforts in the event good sustainable management practices restore these drainages to a condition compatible with survival of native fishes.

La Condición de Pescas Endémicas en Dos de los Desagües de Bonneville Nevada

Matthew E. Andersen y James E. Deacon

RESUMEN:

La condición de pescas endémicas fue examinada en el este de Nevada, especialmente en Big Springs Creek and Thousand Springs Creek. Estas áreas son las únicas secciones de Nevada en el antigüo desagüe de Lake Bonneville. Los mapas topográficos de los Estados Unidos indica en los años sesenta la abundancia de arroyos era mayor que en la actualidad.

En ambas cuencas hay evidencia de daños extensos a la vegetación, enarenamiento, erosión en las orillas de los arroyos y contaminación orgánica del desperdicio del ganado depositada en los manatiales, arroyos y represas. La sequía, la introducción de especies extranjeras, la degradación ambiental causada por el hombre y su ganado, así como la aplicación del veneno han impactado severamente el hábitat de la pesca y el número de habitantes.

El ichthyofauna nativo de Big Springs Creek históricamente incluía: *Catostomus ardens, Rhinichthys osculus, Richardsonius balteatus hydrophlox, Gila atraria,* y*Cottus bairdi.* El desagüe Thousand Springs Creek históricamente incluía todo lo ya mencionado a excepción de *C. ardens*, siendo el pez chupón nativo de esta región *C. (Pantosteus) platyrhynchus.* En Big Springs Creek las aplicaciones de veneno hechas por el Departamento de la Fauna de Nevada (NDOW) han consumado la meta de la erradicación del *G.*

atraria. El pastoreo de ganado ha impactado severamente el hábitat tambíen. Solamente a un pequeño desagüe en el area de Thousand Springs Creek se le ha aplicado veneno. *C. (P.) platyrhynchus* no se encuentra actualmente en el desagüe de Thousand Springs Creek, y*C. bairdi* y *G. atraria* tienen una presencia muy limitada allí.

Actualmente, Big Springs Creek solamente contiene *R. osculus, R. balteatus, C. bairdi,* y poco*C. ardens.* El desagüe moderno de Thousand Springs Creek contiene éstos e introdujo las truchas *Salvelinus fontinalis, Salmo trutta* y *Onchorhynchus mykiss.* Por lo visto la sequía, la construcción de carreteras para la minería, la introducción de pesca de recreo y el pastoreo de ganado en Thousand Springs Creek han tenido los efectos similares a los de la aplicación de veneno y el pastoreo de ganado en Big Springs Creek.

The Non-Native Snail Fauna of the Middle Snake River, Southern Idaho

La Fauna de Caracoles no Nativos a la Mitad del Rio Snake en el Sur de Idaho

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Abstract. In addition to the 38 species of native molluscs in the Middle Snake River, *Radix auricularia* (Linn.), *Corbicula fluminea* (Müller), and *Potamopyrgus antipodarum* (Gray) also have established naturalized populations. *Radix* is infrequent in the river, but is more common in warmer ponds and ditches, as well as being present in pool areas of a few cold spring tributaries. *Corbicula* occurs in the vicinity of Indian Cove Bridge (River Mile 525.4), where it has been known to occur for decades without substantially extending its distribution. *Potamopyrgus,* which invaded the Middle Snake River less than a decade ago, is the dominant species with vast populations. It occurs in all of the tributaries and has expanded its local range out of the Snake River canyon to streams and ditches on the lava plains of the right bank, but it has not yet appeared in Silver Creek, Wood River above Magic Dam, or other montane tributaries. Tropical Fish Farms using geothermal water on the left (south) bank of the Snake River between Twin Falls and Hagerman rear over a hundred species of tropical fish, as well as *Tilapia* sp. and catfish. The water in these hatcheries is kept below 25.6°C. Several *Pomacea* sp. color variants and *Marisa cornuarietis* (Linne) are raised by some hatcheries for sale to pet shops. Besides *Pomacea* and *Marisa* , *Biomphalaria glabrata* (Say), *B. havanensis* (Pfeiffer), *Tarebia granifera* (Lamarck), a non-native *Physella,* and *Potamopyrgus antipodarum* (uncommon in the thermal hatcheries; only in the coolest, most shaded areas of vegetation covered ponds) occur in the tropical fish farms. With the exception of *P. antipodarum,* all of these species were found in local pet shops. *Pomacea* and *Marisa* are sold, *Tarebia* and *Physella* had feral "populations" within several pet shops, and *Biomphalaria* were often given customers with the purchase of tropical fish. *Pomacea, Biomphalaria, Tarebia* (the most abundant species present), and *Potamopyrgus* (rare; probably vagrant from coldwater river populations) occurred in the thermal plumes in the mainstem Snake River. Our study was unable to confirm reports by fishermen of *Pomacea* spreading in the Snake River from the plumes. However, reproduction was evidenced in the plumes by egg masses on fallen trees within the thermally influenced area. At present there are no legal restrictions for culturing or possessing live freshwater molluscs of any species in Idaho, and the Desert Fishes Council is urged to prepare a list of potentially invasive mollusc and tropical fish species, as the Idaho Department of Fish and Game can deny aquacultural permitting for species considered to pose a threat to fish or wildlife in the wild.

Resumen. Ademas de las 38 especies de moluscos nativos a la mitad del rio Snake, *Radix auricularia* (Linn.), *Corbicula fluminea* (Müller) y *Potamopyrgus antipodarum* (Gray) tambien se han establecido poblaciones naturalizadas. *Radix* es poco frecuente en el rio, pero es mas comun en charcos y canales templados y tambien esta presente en pozas de algunos manantiales frios tributarios. *Corbicula* existe en las inmediaciones del puente Indian Cove (milla 525.4 del rio), donde se sabe ha existido durante decadas sin extender substancialmente su distribución. *Potamopyrgus,* quien invadio la mitad del rio Snake hace menos de una decada, es la especie dominante con vastas poblaciones. Este existe en todos los tributarios y ha expandido su distribución local fuera de el cañon del rio Snake a los arroyos y canales en las planicies de lava en el banco derecho, pero aun no ha aparecido en el arroyo Silver, rio Wood arriba del dique Magic u otros tributarios de las montañas. Granjas de peces tropicales que utilizan agua geotermal en el banco izquierdo (sur) de el rio Snake, entre las cascadas Twin y Hagerman, crian cientos de especies de peces tropicales asi como *Tilapia* sp. y catfish. El color de el agua en estos criaderos es de varias tonalidades de *Pomacea* sp. y *Marisa cornuarietis* (Linne) es criada en algunos criaderos para la venta en tiendas de mascotas. Ademas de *Pomacea* y *Marisa,* tambien existen en las granjas de peces tropicales: *Biomphalaria glabrata* (Say), *B. havanensis* (Pfeiffer), *Tarebia granifera* (Lamarck), un no nativo *Physella* y *Potamopyrgus antipodarum* (no comun en criaderos termales, solo en las pozas mas frias y con mas areas sombreadas por vegetacion). Con la excepción de *P. antipodarum,* todas estas especies fueron encontradas en tiendas de mascotas locales. *Pomacea* y *Marisa* se venden, *Tarebia* y *Physella* forman "poblaciones" silvestres dentro de varias tiendas de mascotas y *Biomphalaria* se da frecuentemente a los clientes que compran peces tropicales. *Pomacea, Biomphalaria, Tarebia* (la especie mas abundante) y *Potamopyrgus* (rara; probablemente erratica de poblaciones de rios frios) existen en plumas termales en el cauce principal del rio Snake. Nuestro estudio no fue capaz de confirmar los reportes de pescadores de *Pomacea,* quienes dicen que se dispersa de las plumas en el rio Snake, sin embargo la reproducción se evidencio en las plumas por masas de huevos en árboles caidos dentro de el area influenciada termalmente. Hasta la fecha, no hay restricciones legales para cultivar o procesar moluscos vivos de agua dulce de ninguna especie en Idaho y se le ha pedido a el Consejo de Peces del Desierto que prepare una lista de especies moluscos potencialmente invasores y especies de peces tropicales, ya que el Departamento de Pesca y Fauna Silvestre puede negar el permiso de acuacultura de especies consideradas como una amenaza para peces y fauna silvestre.

INTRODUCTION

Like many other plant and animal groups, the Mollusca include many species which have established naturalized, feral populations in parts of the world distant from their biological origins. Recent examples of exotic molluscan invasions which are well known because of their economic impact are the zebra mussel (*Dreissena polymorphia*), a Caspian Sea-Mediterranean basin species now a plague in the Great Lakes; the Asian clam (*Potamocorbula amurensis*), originally from China but which has established strong populations in San Francisco Bay that appear to be influencing the food chain (Dietel, 1991); and *Corbicula fluminea*, another Asian species which is a notorious ditch and canal clogger that is established in most large river systems in North America. One of the most successful hydrobiid snail invaders is the New Zealand mud snail (*Potamopyrgus antipodarum*), native to New Zealand but now well distributed in Tasmania, Australia, England, Europe, and more recently the Middle Snake River in southern Idaho (Bowler, 1990; Langenstein and Bowler, 1990). In many cases the source of introduction is speculative or unknown. Transplantation may have occurred many times (see, for example, Table I) because of the numerous potential means by which invasive species can be transported (Bowler, 1990). Inter-basin water diversions have also acted as conduits, transporting species from basins to which they are native into new drainages where they did not naturally occur. For example, the Erie Canal allowed several snails to invade numerous new drainages as within-continent exotics. Using the Erie Canal as a dispseral conduit *Elimia livescens livescens* invaded the Hudson River drainage [Goodrich, 1940; 1945] and *Elimia virginica* expanded its range from rivers with drainage systems terminating in the Atlantic Ocean into the Great Lakes basin [Goodrich, 1942].

Not all introductions result in large populations, and some exotics are more or less benign additions to the native fauna. Prior to the establishment and the extraordinary population building of *Potamopyrgus antipodarum*, Taylor (1985) observed that in western North America, "Exotic species due to human importation have had little effect on natives, as they mostly fill niches left vacant by Tertiary extinctions." Taylor first presented this observation in 1970 at an American Malacological Union symposium on rare and endangered molluscs, though in discussion Murray (1970) observed that at a site 30 miles north of San Antonio, Texas, *Melanoides tuberculatus* and *M. (=Tarebia) graniferus* "had invaded the type locality of *Goniobasis (= Elimia) comalensis* Pilsbry 1866 to the extent that *G. (Elimia) comalensis* is now extremely difficult to find where it was once common. Furthermore, several other habitats where *G. (Elimia) comalensis* was once common are now predominantly occupied by one or both of the above introduced species. It is possible that either...or both, could find their way to some of the localities of endemic native species to which he (Taylor) refers and have serious effects."

The Middle Snake River sub-basin drains much of the former watershed of Blancan (late Pliocene) Lake Idaho, which lost through extinction 70 or more mollusc species when it drained during the Pleistocene (Taylor, 1985; see also Malde, 1972, pp. D15-D16). Lake Idaho covered most of southern Idaho from approximately 3.5 million years before present to 600,000 YBP. At this time the Snake River drainage was captured by the Columbia River (see Taylor, 1985, among others), and much of former Lake Idaho ceased to be lacustrine (see Malde [1991] for a review of the Snake River Plain Geography). The Glenns Ferry Formation lakebed deposits of Lake Idaho are up to 1,200 feet deep.

Fossils indicate that subsequent smaller Pleistocene lakes formed by lava dams (the Bruneau Formation assemblage) sustained only the modern fauna, depauperate by comparison to the species-rich fauna of Lake Idaho (Taylor, 1985). As Malde (1965, p. 259) summarized, "The molluscan fossils from the Bruneau Formation represent almost entirely living species. Dwight W. Taylor (*in* Malde and Powers, 1962, p. 1211) reports that 'only one of the species is extinct, and most of the others are living in southwestern Idaho. The abundant species of the Snake River today, such as *Gonidea angulata* (Lea), *Valvata utahensis* (Call), *Lithoglyphus fuscus* (Haldeman) [= *Fluminicola hindsi*], and *Vorticifex effusus* (Lea), appear first in the Bruneau Formation'" [it is now known that *Valvata utahensis* is also present in the Glenns Ferry Formation] (see also Malde, 1982, p. 624). It is a sad parenthetic note that *Valvata utahensis*, which Taylor characterized as one of the "abundant species" of the Snake River in 1962, is Proposed for Listing as a federal Endangered Species.

The few Lake Idaho endemics which persisted (including two endemic hydrobiid species: the Bliss Rapids Snail [a new taxon in an undescribed hydrobiid genus], and *Pyrgulopsis idahoensis* [= *Fontelicella idahoensis sensu* Gregg and Taylor, 1965]) are restricted in distribution and habitat. Vermeij (1991) noted that in cases of natural biotic interchange, "biotas providing the bulk of the invading species in asymmetrical interchanges contain species that have evolved high competitive, defensive, and reproductive performance in comparison with native species in the recipient biotas" and "biotas in which the magnitude of extinction before the onset of interchange was high are especially vulnerable to invasion." In the face of the extraordinary scale of Pleistocene extinctions as a result of the draining of Lake Idaho, it is not surprising that there are "vacant" niches in the Middle Snake River, though it evolved as a habitat in the vacuum following the Lake Idaho extinction episode. The steep gradient of the Middle Snake River, dropping 1,680 ft. from Milner Dam (River Mile 639.1, elevation 4,135 ft.) to the C.J. Strike Reservoir (River Mile 517.6, normal pool elevation 2,455 ft.), provides fast water habitat analogous to the surf zones of Lake Idaho, especially in the segment from Shoshone Falls (River Mile 614.8; elevation 3,362-3,148 ft.) to Clover Creek (River Mile 547.7; elevation 2,503 ft.). In general the modern freshwater mollusc faunas of western North America are species poor in comparison with the more humid areas of the eastern U.S. (Taylor, 1985).

PREVIOUSLY REPORTED NON-NATIVE SPECIES

Taylor (1981; 1985; adapted from Table 4) and Bowler, 1990) cited the following freshwater species as exotics with naturalized, feral populations in western North America (Middle Snake River species in bold):

Introduced Species	Native Biological Origin
Bellamya japonica	Japan
Cipangopaludina chinensis malleata	Japan
Bithynia tentaculata	Europe
Battillaria attramentaria	E. Asia
Tarebia granifera mauiensis	Hawaii
Tarebia tuberculata	E. Asia
Psuedosuccinea columella	E. U.S.
Planorbella duryi	Florida
Anodonta corpulenta	E. U.S.
Corbicula fluminea	E. Asia
Potamopyrgus antipodarum	New Zealand
Radix auricularia	Europe

Burch (1989) cites *Marisa cornuarietis* as another introduction occurring in western North America.

Bowler (1990) reported thirty species of native freshwater molluscs from the Middle Snake River, and three non-native species: *Potamopyrgus antipodarum* (Hydrobiidae), *Radix auricularia* (Lymnaeidae), and the clam *Corbicula fluminea* (Corbiculidae). Frest and Johannes (1991) increased and refined the list of species native to the Middle Snake River, raising the total to 37 taxa. In terms of its unusual parthenogenic reproductive abilities, *Potamopyrgus anitpodarum* has distinct reproductive advantages over the native species, which, coupled with its comparatively broad ecological tolerance, has contributed to vast population building in the Middle Snake River and in many of its tributaries. In this regard it fulfills Vermeij's prediction of a successful invader. *Potamopyrgus antipodarum* occurs in the mainstem Snake River, nearly all of its tributaries, and is now found in many springs and irrigation systems above the rimrock on the north bank and lakebeds to the south. It has not yet appeared in Silver Creek, Wood River above Magic Dam, or other montane habitats. It is probable that this species is contributing to the marked decline of the native fauna.

Since its detection by Taylor (pers. comm.) decades ago, *Corbicula fluminea,* common in Lower Snake River impoundments, has not extended its distribution significantly above the Indian Cove Bridge (Snake River mile 525.4) area near Hammet. This is the most upstream site in the Snake River from which this species has been observed or reported. Transport to this area may have occurred from the use of *Corbicula* as fishing bait.

Radix auricularia, an Old World species, intriguingly inhabits a diversity of habitats ranging from the "Sculpin Pool" in Box Canyon, a cold spring habitat (14.23°C) to far warmer ditches and ponds (19.4 - 21.1°C) in the Hagerman Valley. It is infrequent in Malad River, and is rare in drift deposits in the mainstem Snake River. Nowhere has it built large populations *sensu Potamopyrgus* or proven to be a detriment to the local mollusc fauna (see Table 1 for a summary of early records and means of repeated introductions). *Radix auricularia* was first reported from Idaho at Homedale by Henderson in 1931. As is documented in Table 1, early introductions of *Radix* occurred many times and appear to have been linked with importations of lilies or azealas from Europe, as well as the aquarium trade. Within the Hagerman Valley irrigation and "miners ditches" have contributed to its local distribution.

POTENTIAL SOURCES OF INTRODUCTIONS INVESTIGATED

In considering potential sources for the introduction of exotic molluscs to the Middle Snake River area, one of the obvious possibilities is tropical fish farms, which often raise aquarium snails commercially and which harbor an inadvertant feral fauna of non-native species. Thermal springs and wells on the south (left) bank of the river provide hot water which is diluted with colder spring water to below 26.7°C at several tropical fish farms near Twin Falls and Buhl (Luntey,1985). Tropical fish farms culture well over a hundred fish species and several aquarium snail species in this area (see Table 2). Courtney et al. (1987) summarizes the records of exotic fishes from Idaho, including the Middle Snake River (see Table 3 for additions).

Pet shops which sell tropical fish, aquarium supplies, vegetation, and snails for aquaria are a second potential source of exotics. In addition to molluscs purposely obtained for aquarium use, there are many which "come along" with aquarium vegetation.

A third possible route of introduction is the stocking of fish from sites outside the state or from sub-basins which have been invaded by an exotic (Table 3). Although the Johnny Appleseed approach was diligently pursued by Ridenbaugh and others near the end of the last century, there is no documented case of a mollusc being transplanted along with fish into the Middle Snake River (though a number of accidental occurrences introducing exotic fish through inadvertently mixed or impure plantings have been reported; Table 3). The occurrence of *Potamopyrgus* in the Snake River makes planting trout or other species outside the sub-basin risky, as even a single individual of this tiny snail can found a population. This is a serious concern since the present distribution of *Potamopyrgus* in Idaho is limited to the Middle Snake River sub-basin system.

This study examines the mollusc fauna, both commercial and inadvertant, of two tropical fish farms and surveys most of the pet shops in southern Idaho.

RESULTS

The first hatchery site examined was adjacent to the Canyon Springs Golf Course (Snake River Mile 609.9) and the Twin Falls sewage treatment plant. Interestingly, the ponds were excavated through a layer of *Gonidea angulata* shells (apparently an enormous Native American midden, now buried over a meter beneath the present soil surface). This hatchery abandoned raising aquarium snails and tropical fish in 1990, though it had been most recently commercially licensed to do so between 1986 and 1990, and had raised both for many years before that. This facility currently rears *Tilapia* sp. and koi, as well as rainbow trout. At this aquaculture facility thermal water is obtained from a well and is mixed with cooler springwater to approximately 25.6°C (hatchery ponds are kept below 26.7°C, if possible). There are four cold water concrete raceways in which rainbow trout are raised. Sediment cleanings from this line of raceways not surprisingly contained dead shells of *Potamopyrgus antipodarum, Physella gyrina, Gyraulus cf. parvus* and a lymnaeid, all species present in the adjacent Snake River and its coldwater tributaries. Eight warmwater concrete raceways in which *Tilapia* and a few coy are cultured empty into a large unlined pond - effectively a settling pond - which has an outfall directly into the Snake River. This pond was inhabited by schools of numerous species of vagrant tropical fish, a number of catfish, an abundant population of *Tarebia granifera,* and lesser numbers of *Pomacea* sp., a non-native *Physella,* and *Biomphalaria.* The bottom of the settling pond was whitish due to deposits of dead *Tarebia,* and the underlying substratum was mud, layered with fish manure. It was clear that fish or snails could easily escape at the outfall into the thermal plume and the river.

The tropical fish and snails at this site had been cultured in wood-lined boxes, of which there were around sixteen roughly six feet by three feet, and twenty-six which were four feet by three feet; water in these boxes, when filled, was eighteen inches deep. The ponds were overgrown with vegetation, and the shading caused the temperature to be somewhat lower (22.2°C) than in the *Tilapia* (concrete) raceways. Water was trickled into the boxes. The boxes had abundant feral populations of *Pomacea, Biomphalaria glabrata, B. havanensis, Tarebia granifera, Physella* (non-native), and a few *Potamopyrgus.* It should be noted that *Potamopyrgus* was present only on the undersides of pond vegetation in the coolest areas of the rearing ponds; this species is not characteristic of thermal situations, and is absent, for example, in the sterile Banbury Natatorium outfall pool (30°C), though *Potamopyrgus* occurs in the adjacent Snake River. In New Zealand*P. antipodarum* Winterbourn (1969) found the species in thermal waters only at temperatures below 28°C. It is of anecdotal interest to note that *Biomphalaria glabrata* has been found recently in the outflow from a thermal well in the Bruneau area (P. Olmstead, pers. comm., 1991). This well, which became dry in 1990, also was host to various species of tropical fish, presumably former aquarium tenants.

Interestingly, there were no native species in any of the warm-water facilities, though some natives did occur in the coldwater trout raceways. In addition to the feral snails in these boxes, there were numerous species of tropical fish which were "wild" and untended. According to an employee, "We used to raise those snails, but now they just raise themselves." Egg masses were conspicuous on nearly every box that had water in it, and the amphibious *Pomacea* was common on vegetation, in the bottom of the boxes, and scaling the vertical walls of the boxes.

The temperature of the water forming the thermal plume at the outfall was 27.2°C. Live *Tarebia granifera* specimens of all age classes were abundant in a population that was clearly thriving. Shells from *Pomacea* were present, but no live animals were actually found within this plume. A local fisherman (Burton Perrine, pers. comm.) stated that *Pomacea* occurred in the Snake River outside the thermal plume area, but no living animals were collected in this study. This does not necessarily mean that the snails might not be present. During the summer the Snake River reaches 19.4°C at this site. However, visibility was poor and the river was higher than usual during the three visits to the site. The thermal plumes could act as refugia for thermophilic non-native taxa, especially when winter river temperatures are cooler.

There were several earthen ponds (not lined with concrete) for *Tilapia* and coy culture which were part of this operation, but were located perhaps a quarter of a mile upstream near the Canyon Springs Golf Shop. This site was similarly burgeoning with *Tarebia,* which were abundant in the depressions formed by *Tilapia* nests. *Pomacea* was also common and egg masses were present on the concrete headworks leading to the effluent pipe. The influent thermal water from this site was used several hours a day for sprinkling the Canyon Springs Golf Course, during which time the thermal plume area was dewatered and the level of the *Tilapia* ponds would drop. *Pomacea* egg masses were present on a fallen tree in the thermal plume, indicating successful reproduction. Carp were present at all outfalls, and food pellets were observed floating in the river at the plumes. *Tarebia* shells were abundant and the species survived the periods of dewatering by moving to wetted areas.

The second tropical fish farm examined (Geothermal Tropicals) obtains its water (31.96°C, pH 8.6) from a well. The pond temperatures are regulated by cold spring water and are kept below 26.7°C. This active aquaculture operation has 90 ponds of varying sizes, shapes and depths, and commercially raises over 100 species of tropical fish as well as the aquarium snails *Pomacea* and *Marisa* (Luntey, 1985). Pond sizes range from three by five feet (two feet deep) to four by 12 feet (three feet deep). The ponds used to culture snails are lined with wood because *Pomacea* grazing erodes the banks if they are earthen. Several settling ponds six by 50 feet (two feet deep) sequentially capture suspended solids and serve to cool the water so that its temperature approaches that of Deep Creek, a Snake River tributary into which the effluent eventually spills. The settling ponds freeze during the winter providing a strong thermal barrier before hatchery effluent enters the natural environment (Deep Creek; with incredibly dense *Potamopyrgus* populations in this reach).

One of the reasons it is remarkable that these species can survive in this area is the variation in temperature between summer and winter (Luntey, 1985). For example, Luntey (1985) published photographs of his ponds during the summer when the temperature was 100 degrees or more F (37.78°C), and in the winter when it is often extremely cold: "...Several days before Christmas of 1983 a blizzard swept into southern Idaho, dropping temperatures to -10 degrees F (-23.33°C) at our fish farm....high winds persisted along with the cold for several days and chill factors ranged from -45 to nearly -70 degrees F (-42.78 to -56.67°C)." During this period pond temperature dropped only to 65 degrees F (18.33°C), and a few tropical fish perished. The adjacent Snake River is warmer than this in the summer. Unlike most other facilities, the Luntey operation passes through several settling ponds, an open ditch and a pipe before plunging into a rapids on Deep Creek ; the chances of escape are minimal, and no escapees from the hatchery were observed downstream of the outflow.

Though most area pet shops don't sell aquarium snails or tropical fish, a survey of five pet shops which do sell tropical fish and/or aquarium snails (The Fish Bowl, Noah's Ark Pet Shop, Fifth Street Aquarium, Pets and Plants, Inc., and Green Acres Pet Shop) in Burley, Twin Falls and Ketchum, Idaho, indicated that the following species were marketed (common names; see below): Apple Snails, Golden Mystery Snails, Mystery Snails (*Pomacea*), Columbia Ramshorn (*Marisa*) and "very small snails" (*Tarebia* and *Biomphalaria*). Feral *Tarebia* and a non-native *Physella* species occurred in several of the shops in tropical fish tanks. According to one shop, purchased vegetation is sometimes so covered with snails and eggs when obtained from suppliers that it has to be soaked in alum (thus eliminating the snails) prior to placing on display for sale. The pet shops recommended keeping the snails in tanks at 22.2 - 24.4°C, which is only a few degrees less than the summer temperatures of the Snake River adjacent.

Exotic Species in Tropical Fish Farms and/or Pet Shops in Southern Idaho

	Farms	Plumes	Shops
Pomacea sp. (several color forms)	+	+	+
Physella sp. (not native)	+		+
Biomphalaria glabrata (Say, 1818)	+	+	+
Biomphalaria havanesis (Pfeiffer, 1839)	+	+	+
Marisa cornuarietis (Linne, 1758)	+		+
Tarebia granifera (Lamarck, 1852)	+	+	+
Potamopyrgus antipodarum (Gray, 1843)	+	+	

CONCLUSIONS AND RECOMMENDATIONS

There are no legal restrictions for possessing or for aquaculturally raising any species of non-native freshwater mollusc in Idaho. Similarly, for that matter, there are no regulations regarding possession or culturing freshwater molluscs in California. In Idaho the Fish and Game Commission reviews applications for aquaculture permits, thus there is the opportunity to deny an applicant permission to commercially raise species which are known to be invasive in the natural environment. The wording allowing this discretionary denial (prior to which tropical fish operations were exempt from Fish and Game jurisdiction entirely) was only instated in the past year or so reads as follows: Idaho Code 36-702 sub. "Wildlife held captive without license or permit unlawful - Exceptions. 2. Except for the provisions of paragraph (d) below and section 36-709 (Reasonable inspection - Notice of violation - Required records), Idaho Code, relating to inspection and records of same, nothing in this chapter shall be so construed as to apply to any exotic wildlife, or domestic fur farm operated under the provisions of title 25, Idaho Code, or any tropical fish or other aquaria or ornamental fish which the commission (believes does) not pose a threat to native fish if released into the public waters of the state. (d) It is a misdemeanor for any person to import into this state or release in the wild any species of wildlife except by permit issued by the director." California, similarly, has no restrictions upon possession or culture of freshwater molluscs, though possession of live exotic landsnails is regulated (see Title 14, 671, p. 52.72.9, i).

Under the auspice of this directive, the Fish and Game Commission has the authority to identify and deny culture of invasive species. However, in Idaho there is no list of either freshwater snails or tropical fish which would be unacceptable. The rule of thumb is a judgement call about whether the "thermal barrier" would preclude the establishment of feral, persisent naturalized populations. Yet in reality, the lower thermal tolerances for many species or their ability to form thermally tolerant ecotypes is not known. It could be argued that any species which could survive in the natural environment should be denied, but at the least those species which are known to form naturalized populations in temperate zone rivers, streams, or lakes should be identified. Professional conservation societies such as the Desert Fishes Council would serve a great public interest function by compiling a list of potentially invasive tropical fishes and freshwater molluscs for submission to the various western state Fish and Game departments. At present, discretionary denial is limited to species with which reviewing personnel are familiar. There is also a problem in agencies attempting to maintain a policy of consistency in denial or approval of a particular species - even though past approval may have been clearly an oversight. For example, in a recent aquaculture application in southern Idaho golden shiners and redclaw crayfish were denied, but the Fish and Game reviewer approved culturing fathead minnows: "Fatheads are permitted for other operators already and have been found in the wild - I see no threat....Even though we will permit the fatheads, goldfish, etc., the facility needs to be designed to prevent escapement of fish."

The compilation of a list of potentially invasive freshwater molluscs and exotic fishes, preferably annotated with published documentation, by the Desert Fishes Council would be an invaluable public interest service which the Idaho Department of Fish and Game would welcome (probably all western Fish and Game departments would utilize such a compilation). On a number of occasions senior fisheries biologists have inquired about the potential of various species to naturalize if they escape, and it would be of great benefit to deny aquaculture permits, and ideally possession of live animals of such species. Because of the diversity of alternative, commercially saleable species which would not survive in natural settings, there would likely be little economic impact.

It should be obvious that this is not the last word on the species pool of exotics in Idaho fish farms or aquarium supply shops because both regularly import stocks from sources scattered throughout the United States. Thus, it is likely that other species will turn up in both situations.

Acknowledgements

We gratefully acknowledge the assistance of Fred Partridge (Idaho Department of Fish and Game) and Al Cordoni (California Fish and Game Deptartment), who provided information about the regulation of tropical fish farms in Idaho and California. Robert Luntey kindly allowed access to and a guided tour of his facilities, as well as donating a number of snail specimens without charge and loaning slides for duplication. This study was undertaken because Trudi Bowler displayed attractive examples of *Pomacea* shells her brother, Burton Perrine, had collected in the Snake River near Twin Falls. Burton kindly provided detailed information about the localities from which these snails had "escaped" and the thermal plumes they inhabited. Without his help, these sites would not have been found. Luis Mota-Bravo translated the abstract. We also thank the students in the Fall, 1991 "Environmental Ethics" class at UCI and Robert Hershler (National Museum of Natural History, Smithsonian Institution) for constructive comments on the manuscript.

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Table 1. A selected chronology for *Radix auricularia* in North America, with observations about introduction sources.

Reference	Locality	Observations

Baker (1901) — Lincoln Park, Chicago, Illinois

"...an inquiry of the park gardener brought to light the fact that certain plants had been recently imported from Belgium. This information at once removed the mystery surrounding the sudden appearance of this shell in the park, and shows how easy it is at the present time to transport a species from one continent to another, especially if it be a pulmonate....the following introduced species have been found in the greenhouse or in the lily ponds: *Testacella haliotoidea, Limax maximus* and *L. flavus, Vitrea draparnaldi* and *Limnaea aurciularia*."

Allen (1911) — Lake Erie at Kingsville, Ontario Canada (Site record only)

Goodrich (1911) — Toledo,Ohio

"On March 21st last I found *Radix auricularia* L. in numbers in a marshy stream forming the northeast border of Toledo, Ohio...Dead shells of *auricularia* were found also on the marshy borders of a bayou farther to the north. Near this bayou are several greenhouses and I am informed that it is the custom of the florists to import potted azaleas from Holland and Belgium. In this way eggs may have been brought here and reached the open water through drains."

Henderson (1912) — Colorado Springs and Dotson Reservoir near Fowler, Colorado

"'We went to the pond in Monument Park for them, only to find it recently cleaned. As a result we took only one specimen. There is no reason to doubt that the species has been accidentally introduced there, and it will be interesting to note how it withstands the climatic conditions of Colorado, at an altitude of nearly 6,000 feet."

Long (1912) — Philadelphia, Pennsylvania

"...I am rather at a loss to account for the occurrence of this European species at this station. In both the localities previously reported, that of Mr. H.E. Walker at Lincoln Park, Chicago, reported by Mr. F.C. Baker, and that of Mr. R.E. Call, at Flatbush, Brooklyn, N.Y., the introduction of the species seems to be satisfactorily traced to European plants cultivated in either green-houses or ponds....at this locality...the common use of these snails in aquariums, and the pond being on private property...it is very possible that the contents of an aquarium may have been transferred to the pond at some time or other....I...am told that the pond has contained gold fish for many years and they are at present still frequent there."

Clapp (1913) — Charles River (impoundment), Boston, Massachusetts

"There are numerous explanations for the sudden appearance of exotic species in unexpected localities. A very popular, and probably in many cases a true one, is that they have escaped from some nearby greenhouse. In support of this theory, I will admit that there are several greenhouses in Cambridge, and that from some of them to the river would be but a short walk, but a comparatively long crawl."

Johnson (1913) Charles River, Boston, Massachusetts

"Since Mr. W.F. Clapp recorded the occurrence of this species in the Charles River, it seems to have greatly increased. My young friend, P.S. Remington, has found it in numbers on the Boston (Allston) side near the speedway."

Gregg (1923) So. California

"I have taken *Lymnaea columella* Say and *Lymnaea auricularia* (Linn) from a pond in Exposition Park, Los Angeles, also from a park at Beverly Hills, Cal. Mr. Allen, a local dealer in aquatic plants and goldfish, states that the latter occurs in a number of aquaria and ornamental ponds in this vicinity. They have doubtless been introduced and distributed with lily bulbs. Mr. Allen informs me that *L. auricularia* occurred in his ponds about three years ago and has been a common occupant since. These two species first came to my notice over a year ago."

Hanna and Clark (1925) California

"The finding...in 1924 extends the range...several hundred miles to the westward. Its first occurrence in the state was noted in a pool in the Japanese tea garden, in Golden Gate Park, San Francisco (H.W.C.). Later it was found in abundance in the fountain pool at the resort known as Byron Hot Springs, Contra Costa County, California (G.D.H.). Both of these localities are such to indicate that the mollusks were 'planted' in some manner but there is no way to trace positively the source of the original stock. A clue to the manner of introduction may be found in the fact that it is one of the favorite aquarium snails, and is sold in considerable numbers by dealers in aquariums and aquarium supplies under the name of 'African or Paper-shelled Snail.' The same people supply aquatic plants, and snail eggs might be easily distributed by these."

Henderson (1931) Snake River at Homedale, Idaho

"...How it arrived there is not yet explained, but it seems to add another state to those into which the species has been introduced."

Henderson (1935) Boulder, Colorado

"It has recently appeared in a a small lily pond at D.M.N. Andrew's Nursery, near Boulder. It is almost certain that the mollusks were introduced with pond lilies obtained from the Woodlake Water Gardens, at Woodlake, California....The *Lymnaea* has been found at several localities in California. As it is likely to spread in Colorado and become a permanent member of the fauna, a record of its appearance at Boulder is made for the benefit of future investigators."

Eyerdam (1941) Near Seattle, Washington

"I conclude that the introductions by accident of *Lymnaea auricularia* with aquarium specimens to western Washington have come from various countries in Europe, especially from England and Germany;" however, see Baker's (1942) comments on Eyerdam's taxonomic analysis.

McCoy (1964) Boulder and Fort Collins, Colorado

"Recent collections have it from Varsity Pond in Boulder, and City Park Lake in Fort Collins, extending the range in Colorado northward along the east face of the Rocky Mountains. The location of 3 of the 4 Colorado colonies in city parks would indicate that each probably results from a separate introduction."

Metcalf and Smartt (1972)

Lake Roberts on the Gila River; ranch pond near Deming, New Meixco (Site records only)

Table 2. Species lists for several "warm water" hatcheries along the Middle Snake River near Twin Falls and Buhl, Idaho. Sources for hatchery stock include rearing facilities in Buhl, Idaho; Lonoke, Arizona; Madera, California; Caldwell, Idaho; Granada Hills, California; and Draper, Utah, among others. With sources as geographically diverse as these, potential exists for new mollusc importations. The application sited indicates that there are proposals to significantly expand the list of species presently cultured. If approved, other aquaculturalists could insist that for consistency, they too should be allowed to add these species to those they are presently permitted to culture.

Canyon Springs (Twin Falls, Idaho)
Rainbow trout
Catfish
Tilapia sp.
Tropical fish (cultured from 1986-1990, perhaps longer; terminated 1990)

Fish Breeders of Idaho (Buhl, Idaho)
Catfish
Grass carp (supposed to be sterile)
White Sturgeon (not a native genotype)
Tilapia sp.
Alligators

Steven R. Davis (Application for Commercial Fish Rearing License)[Buhl, Idaho]
Channel catfish
Blue catfish
Rainbow trout
Tilapia sp.
Flathead minnow
Goldfish
Freshwater prawn (*Macrobrachium rosenbergii*)
Asian Arowana
Common Arowana
Black Arowana
Silver Needlefish
Rainbowfish
Discus
Discus Heckel
Peacock Pike Cichlid
Red Breasted Cichlid
Blue-Lipped Haplo
Severum
Convict Cichlid
Blue-Eyed Cichlid
Orange Chromide
Apple Snail
Green "Shark"
(and all species on the following page)

Table 3. A selected history of the introduction of fish species to the Middle Snake River (based upon personal communication with Dr. Herb Pollard and Fred Partridge [Idaho Department of Fish and Game], Simpson and Wallace [1980], and personal observations). Courtney, et. al. (1987) reports introduction data for other species (see also Bowler and Olmstead, 1990).

Salmo trutta – The original introduction is unknown, but was probably carried out by the U.S. Fish Commission (USFC) before 1937. *Salmo trutta* has been stocked by the Idaho Department of Fish and Game (IDFG) or the U.S. Fish and Wildlife Service (USFWS) in Palisades Reservoir, South Fork Snake River, Snake River at American Falls, Portneuf River, Sublett Reservoir, Salmon Falls Creek Reservoir, Billingsley Creek, Little Wood, Boise and Payette Rivers. Some scattered populations occur in small streams and in suitable habitat (mostly dam trailraces) throughout the Snake River Plain. It is locally abundant. In the Hagerman Valley it occurs in Billingsley Creek, Malad (Big Wood) River, Lower Salmon Falls impoundment, and the Hagerman Reach (Lower Salmon Dam tailwaters) of the Snake River.

Oncorhynchus kisutch – This species was stocked by IDFG in numerous reservoirs including Island Park, Blackfoot, Sublett, Salmon Falls Creek, Anderson Ranch, Arrowrock, Lucky Peak and Cascade since 1967. It is presently stocked only in Island Park, Ririe, and Cascade on a regular basis. Coho salmon may occur in any downstream waters because of its propensity to immigrate. It is locally abundant, and has occasionally been caught in the Hagerman Reach of the Snake River. Coho salmon bones have been identified in Indian fishing camps (Plew, 1981), including the Bliss Bridge site, thus a race adapted to long migration may have occurred in the Hagerman Valley prior to dams. In 1987 a race which formerly ascended the Snake River to the Grande Ronde became extinct.

O. nerka – *Oncorhynchus nerka* is native in the Payette River system, and has been widely introduced in reservoirs by IDFG. Strong populations have developed in the Boise River reservoirs and Island Park, and it is rarely seen in streams except during spawning migrations. The species is locally abundant, but sockeye salmon do not occur in the Hagerman Valley as an introduction and did not inhabit this area prior to dams.

Salvelinus fontinalis – Brook trout were widely distributed by the U.S. Fish Commission, probably starting before 1900. Brook trout were propagated and distributed by private sportsmen's clubs, state game wardens and USFWS in the 1920's and 1930's. Upper Henry's Fork, Big Lost River, Big Wood River, alpine lakes and small streams throughout the system have residual populations. IDFG stocked a few waters, most notably Henry's Lake, which produced a 7.14 pound brook trout in 1978. Brook trout are locally abundant, but do not occur in the Hagerman Valley area.

Cyprinus carpio – Carp were first stocked in Snake and Boise by the U.S. Fish Commission in 1888-90, and have since become widely distributed by minnow-bucket plants throughout the Snake River. Carp are abundant throughout the Snake River drainage. Carp were present in the Snake River as far upriver as Glenns Ferry by the mid-1890's.

Gila bicolor – The presence of *Gila bicolor* is probably due to a minnow-bucket plant in 1950's reported from Snake River, Lucky Peak Reservoir, and the Boise River. The only known population is Indian Creek near Nampa. *Gila bicolor* is uncommon except in Indian Creek.

Pomoxis nigromaculatus – This species was stocked by Ridenbaugh ca. 1895 in the Boise River but probably was also stocked by USFC at about the same period. It is distributed throughout the Snake River Plain from American Falls Reservoir downstream plus reservoirs in the area by IDFG and private individuals. The species is locally abundant and historically had spawning populations in the King hill reach of the Snake River.

Perca flavescens – The introduction of yellow perch is also credited to Ridenbaugh ca. 1985. Ridenbaugh and his friends stocked perch in numerous lakes and streams in the Boise and Payette River drainages. They are now found in nearly every water in the state. Yellow perch are locally abundant throughout the drainage, and are rare in the Hagerman Valley.

Aplodinotus grunniens – This species was included in a load of channel catfish from the Council Bluff National Fish Hatchery in 1973; only a few small drum were seen, and they were not detected until the load of 100,000 three-inch channel catfish had been planted. Two or three specimens were collected the following year near the planting site, so they may be acclimated in the Snake River below Bliss dam.

Tilapia zilli – *Tilapia* are commercially cultured in warm well-water near Buhl, and have escaped and acclimated in warm springs entering the Snake River between Buhl and Hagerman. Schools of *Tilapia* can be seen in the thermal plumes where warmwater hatchery effluent enters the Snake River. They seem reluctant to take a fly.

Gambusia affinis – Mosquito fish are distributed every summer by health districts in Elmore, Ada and Canyon counties, and may be overwintering in warm springs.

Stizostedion vitreum – Walleye Pike were stocked in Salmon Falls Creek Reservoir by IDFG in 1973-1978 and have no access to Snake River. Reportedly this species is invading the lower Snake River from Columbia river populations. An unanticipated overflow (spill) from the Salmon Falls Creek Reservoir may have allowed this species to enter Salmon Falls Creek below the dam and then the Snake River, though none have yet been reported below the dam. Several walleye have been caught in the Twin Falls power plant pool, probably the result of a bucket plant by fishing enthusiasts.

Ictalurus nebulosus and *I. melas* – The introduction of bullheads probably originated from mixed salvage from Illinois River which was widely distributed by USFC between 1888–1900. The brown bullhead is most common in suitable waters throughout the state. *Ictalurus melas* has been reported from Lucky Peak and Deer Flat reservoirs and the Snake River. Both species are common.

Ictalurus punctatus – This species has been planted in the Snake River, with a recent plant below Bliss dam.

Noturus gyrinus – Madtom probably reached the Snake River drainage the same way *Ichtalurus nubulosus.* The USFC had a salvage station at Meredosia, Morgan County, Illinois where they seined overflow sloughs and backwaters, loaded the fish on a tank car and headed west; Johnny Appleseeding the fish at every spot the railroad crossed the water. It was from this source, ca. 1892, that *Pylodictus olivaris, Lepomis gibbosus, L. gulosus, L. macrochirus,* and *L. cyannellus* first reached Idaho. Since then, private persons as well as IDFG personnel have distributed these species widely. *Ictalurus catus* has also been reliably reported, but not confirmed, from the Snake River near Marsing and may have come from this source. Madtom are common, but seldom noticed.

Pylodictus olivaris – Source above. Distribution: Snake River below Swan Falls. Common.

Lepomis gibbosus – Source above. Distribution: Snake River, and major tributaries and ponds downstream from Twin Falls. At least one author has reported *L. microlophus* from this reach but this could be a misidentification of *L. gibbosus*. Common.

L. gulosus – Source above. The distribution of this species includes C.J. Strike and Brownlee Reservoirs, Snake River and tributaries in Elmore, Ada, Canyon, Payette and Washington counties. This species is scattered, but common.

L. macrochirus – Source above. Widely distributed in reservoirs, pons an larger rivers throughout Snake River Plain. This species is abundant.

L. cyannellus – This species in common only in Bear River drainage but may occur in ponds in Snake River drainage in southeast Idaho.

Micropterus dolomieu – Smallmouth bass probably moved into the Snake River from the Yakima River by way of the Columbia River ca. 1940. Since 1960, they have been stocked in lower Big Wood River, Snake River to Twin Falls, Salmon Falls Creek Reservoir, Anderson Ranch Reservoir and Lucky Peak Reservoir. The Yakima stock originated from the northern midwest about 1925. Recent introductions have been from USFWS hatcheries in Montana and Nebraska. Smallmouth bass are occasionally caught in Malad (Big Wood) River and the Hagerman Reach of the Snake River.

Micropterus salmoides – Originally largemouth bass were stocked by William H. Ridenbaugh of Boise in 1887. The fish came from St. Joseph, Missouri by way of Salt Lake City and Wells Fargo. Ridenbaugh released 2,240 largemouth bass into the Boise River at Boise in 1892. The USFC planted the Boise and Snake Rivers ca. 1893. Largemouth bass occur throughout southern Idaho. This is a common species, and is best known from the Hagerman Wildlife Refuge bass ponds and other ponds along the Snake River near Buhl locally.

The Ecology, Distribution and Status of Relict Lake Idaho Mollusks and other Endemics in the Middle Snake River

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Abstract. The U.S. Fish and Wildlife Service has proposed to list five taxa of freshwater snails from the Middle Snake River as Endangered. Two of these species (Family Hydrobiidae), *Pyrgulopsis idahoensis* (Pilsbry 1933) and the "Bliss Rapids Snail," are species which are known in fossil form only from Blancan "Lake Idaho," a late Pliocene freshwater lake which covered much of southern Idaho. The Bliss Rapids Snail occurs in fast-water settings and in a few springs and alcoves, and has two color variants (currently under taxonomic study for publication in the near future). Its present range extends from around King Hill to Blue Lakes, with possible reported localities at isolated sites up gradient. *Pyrgulopsis idahoensis,* in contrast, occurs in sediments and beneath rocks in the flatter area of the gradient presently restricted to the reach from the Bliss Dam to C.J. Strike Reservoir, though its modern range formerly extended as far downriver as Homedale. *Valvata utahensis* also occurs in fossil form in the Glenns Ferry Formation (Lake Idaho sediments), but has both a fossil and modern distribution exceeding Lake Idaho's boundaries. The modern localities have been eliminated, with the exception of a few sites in the reach from Lower Salmon Dam to around Empire Rapids with another living locality below American Falls Dam. In the Middle Snake River area the historic modern range extended as far downstream as Grandview. *Physa natricina* has a fossil distribution in Pleistocene lakes and rivers, but is a rare mollusk known only from the mainstem Snake River at a few localities. At present this taxon occurs at a few sites in the Bliss Dam and Lower Salmon Dam tailwaters, with a possible record near Murtaugh, and had an historic modern range at least as far downriver as Grandview. An endemic *Lanx* inhabits a few of the Snake River Plain tributaries in small, isolated populations. *Valvata utahensis, Physa natricina,* and *Pyrgulopsis idahoensis* all have modern living ranges

which extended to Grandview in the Snake River. They have been eliminated below C.J. Strike Dam, however, and now persist as small populations. All of these species are currently in precarious situations and warrant listing as endangered species. *Fisherola nuttalli, Fluminicola columbiana* and *Anodonta californiensis* are other candidate species which qualify for listing as endangered species in the Middle Snake River. Other species such as *Vorticifex effusus* may become threatened in the future, as there appears to be decline in most of the lotic species. A major faunal turnover is occurring with pollution tolerant taxa characteristic of warm, shallow lakes replacing the coldwater, lotic assemblage. Taxa such as *Stagnicola caperata, Sphaerium patella, Physella gyrina, Physella integra* and the exotic *Potamopyrgus antipodarum,* for example, are increasing their presence, while native lotic species such as *Fluminicola hindsi, Vorticifex effusus, Pisidium nitidum, Sphaerium striatinum, Valvata humeralis* and *Pisidium pauperculum* are declining.

La Ecología, Distribución y Estatus de los Moluscos Relictos del Lago Idaho y otros Endémicos en la Parte Media del Rio Snake.

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Resumen. El Departamento de Pesca y Fauna Silvestre de los Estados Unidos ha propuesto listar 5 taxa de caracoles de agua dulce en peligro de extinción de la parte media del rio Snake. Dos de esas especies, Pyrgulopsis idahoensis (Polsbry 1933) y el caracol "Bliss Rapids" son conocidos como fosiles de el lago Idaho "Blancan", un lago de agua dulce perteneciente al Pleoceno tardío que cubría gran parte del Sur de Idaho. El caracol "Bliss Rapids", una especie de hydróbido no descrita, dentro de un nuevo género, existe en corrientes, algunos manantiales y alcobas. Esta especie tiene dos variantes en color (actualmente en estudio taxonómico que será publicado en un futuro próximo). Su rango actual de distribución se extiende desde la colina King hasta los lagos Blue con posibles localidades reportadas en sitios aislados en un gradiente. Pyrgulopsis idahoensis, en contraste, existe en sedimentos y debajo de las rocas en las áreas mas planas de el gradiente, actualmente restringido a el alcance que va desde el dique Bliss hasta el reservorio C.J. Strike, no obstante su rango moderno originalmente se extendía tan lejos como Homedale aguas abajo. Valvata utahensis (Call 1884) es también un fosil en la formación Glenns Ferry (sedimentos del lago Idaho), pero tiene distribución fosil y moderna que se extiende mas alla de los límites del lago Idaho. Las localidades modernas han sido eliminadas con la excepción de pocos sitios en los alcances que van desde la parte baja de el dique Salmon hasta los alrededores de los rápidos de Empire con otra localidad viviente debajo de las cascadas del dique American. En el área de la parte media del rio Snake el rango histórico moderno se extiende tan lejos como Grandview aguas abajo. Physa natricina (Taylor 1988) tuvo una distribución fosil en los lagos y rios del Pleistoceno pero en su distribución moderna es un molusco raro conocido solamente en el cause del rio Snake en pocas localidades. Actualmente, este taxón existe en pocos sitios en el dique Bliss y la parte baja de el dique Salmon con un posible registro cerca de Murtaugh. Esta

especie tuvo un rango histórico moderno hasta al menos Grandview, aguas abajo. Lanx, un endémico, habita algunos tributarios planos del rio Snake en poblaciones pequeñas y aisladas. Valvata utahensis, Physa natricina y Phyrgulopsis idahoensis tienen rangos vivos modernos que se extienden hasta Grandview en el rio Snake. Estas especies han sido eliminadas debajo del dique C.J. Strike, sin embargo actualmente persisten en pequenas poblaciones localizadas. Todas estas especies se encuentran actualmente en situaciones precarias y garantizan ser listadas como especies en peligro de extinción. Fisherola nuttalli (Haldeman 1841), Fluminocola columbiana Hemphill (in Pilsbry 1899), Anodonta californiensis (Lea 1852) y otras especies candidatas califican para ser listadas como especies en peligro en la parte media del rio Snake. Un gran cambio en la fauna esta ocurriendo con los taxas tolerantes a la contaminación característicos de lagos poco profundos y templados reemplazando el ensamblaje de especies de aguas frias. Taxas como Stagnicola caperata, Sphaerium patella, Physella gyrina, Physella integra y la forma exótica Potamopyrgus antipodarum, por ejemplo, estan incrementando su presencia, mientras especies nativas como Fluminicola hindsi, Vorticifex effusus, Pisidium nitidum, Sphaerium striatinum, Valvata humeralis y Pisidium pauperculum estan declinando.

THERMAL TOLERANCES FOR RELICT POPULATIONS OF DESERT PUPFISH, *Cyprinodon macularius*

by

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Abstract. Thermal tolerances of Desert Pupfish, *Cyprinodon macularius*, are legendary. Published data for critical thermal maxima and minima indicate a range of extremes from 7°C to 44.6°C (Lowe and Heath 1969, Deacon and Minckley 1974, Schoenherr, 1988). Furthermore, based on experiments with various species of pupfish the following generalizations may be made:

1. Thermal tolerances vary with acclimation temperature and season (Lowe and Heath 1969; Feldmeth, Stone, and Brown 1974).
2. Species from constant temperature habitats have narrower ranges of thermal tolerances, and those tolerances are inherited (Hirshfield and Feldmeth 1980).

We asked the question, "How long do pupfish populations have to be isolated in order to change their inherited thermal tolerances?" Preliminary data for pupfish populations from Chihuahua, Mexico showed the most significant differences in critical thermal maxima for populations that have been separated about a million years (Soltz and Feldmeth personal communication). Working with *Cyprinodon nevadensis* from Ash

meadows and the Amargosa River, Hirshfield and Feldmeth (1980) showed significant differences for populations that were separated from each other for several thousand years.

In the case of the Desert Pupfish, the population of *Cyprinodon macularius eremus*, from Quitobaquito Spring in Organ Pipe Cactus National Monument has been separated from the Colorado River and Salton Sea populations of *C. m. macularius* for a minimum of 100,000 years (Miller and Fuiman 1987). The critical thermal maximum of 44.6°C reported by Lowe and Heath (1969) for *C. m. eremus* is significantly higher than the 42.7°C our experiments showed for *C. m. macularius* for Salton Sea populations (Table 1). While we found no significant differences in critical thermal maxima for 3 populations of Salton Sea fish, we did find significant differences in critical thermal minima. We tested fish from Oasis Spring that lived at a constant 28°C for 13 generations and compared them to fish from Salt Creek where the seasonal temperature varied from 10°C to 31°C. The critical thermal minimum of 4.4°C is the lowest recorded for the species. Furthermore, we found no significant differences in critical thermal maxima and minima between fish from Salt Creek and fish transferred from Salt Creek to Thousand Palms where they lived in a similar variable temperature environment for 4 generations. These data imply that genetic thermal tolerances, particularly critical thermal minima, are able to evolve rapidly. In order to avoid genetic bottlenecks, refugia should provide the greatest amount of environmental heterogeneity possible.

TABLE 1. A SUMMARY OF THERMAL TOLERANCES FOR PUPFISH FROM OASIS SPRING AND SALT CREEK, RIVERSIDE COUNTY, CALIFORNIA

	Oasis Spring	Oasis Spring	Thsnd Palms	Salt Creek
CTMax (°C)	42.7	42.6	42.4	41.9
CTMin (°C)	5.3	6.3	4.4	4.6
Thermal Scope	37.4	36.3	38.0	37.3

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TOLERANCIAS TERMICAS EN LAS POBLACIONES RELICTAS DEL PEZ DEL DESIERTO "PUPFISH" *Cyprinodon macularius*.

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Resumen. Las tolerancias térmicas del pez del desierto "pupfish", *Cyprinodon macularius* son legendarias. Datos publicados, muestran que el rango crítico de temperaturas es de 7° C a 44.6° C (Lowe and Heath 1969, Deacon and Minckley 1974, Schoenherr 1988). Basándose en experimentos con varias especies de "pupfish" se pueden hacer las siguientes generalizaciones:

1. Las tolerancias térmicas varían con la temperatura de aclimatación y la estación (Lowe and Heath 1969, Feldmeth, Stone and Brown 1974).
2. Las especies que viven en hábitats con temperatura constante tienen rangos reducidos de tolerancia térmica y estas tolerancias son heredables (Hirshfield and Feldmeth 1980).

Nuestra pregunta es la siguiente, "Cuanto tiempo tienen que aislarse las poblaciones de pupfish para cambiar la heredabilidad de sus tolerancias térmicas"? Datos preeliminares de las poblaciones de "pupfish" de Chihuahua, México mostraron diferencias significativas en la temperatura crítica máxima en poblaciones que han estado separadas durante un millon de años (Soltz y Feldmeth, Comunicación personal). Trabajando con *Cyprinodon nevadensis* que vive en las praderas de Ash y en el

rio Amargosa, Hirshfield y Feldmeth (1980) mostraron diferencias significativas entre poblaciones que se separaron desde hace cientos de años.

En el caso del pez del desierto "pupfish", la población de *Cyprinodon macularius eremus*, del manantial de Quitobaquito en el monumento nacional de Organ Pipe Catcus se ha separado de las poblaciones de *C. m. macularius* del rio Colorado y el mar de Salton desde hace al menos 100,000 años (Miller and Fuiman 1987). La temperatura crítica máxima de 44.6^{o} C reportada por Lowe y Heath (1969) para *C. m. eremus* es significativamente más alta que los 42.7^{o} C obtenidos en nuestros experimentos con *C. m. macularius* de las poblaciones del mar de Salton (Tabla 1). A pesar de que nosotros no encontramos diferencias significativas en la temperatura crítica máxima para las tres poblaciones de peces del mar de Salton, nosotros encontramos diferencias significativas en la temperatura crítica mínima. Nosotros observamos peces de el manantial de Oasis que vivieron en una temperatura constante de 28^{o} C durante 13 generaciones y los comparamos con peces de el arroyo Salt donde la temperatura estacional varía de 10^{o} C a 31^{o} C. La temperatura crítica mínima de 4.4^{o} C es la mas baja registrada para la especie. Ademas, nosotros no encontramos diferencias significativas en la temperatura crítica máxima y mínima entre los peces del arroyo Salt y los peces transferidos del arroyo Salt a Thousand Palms donde estos vivieron en un ambiente similar de temperatura variable durante 4 generaciones. Estos datos implican que las tolerancias térmicas genéticas, particularmente la temperatura crítica mínima, son capaces de evolucionar rapidamente. Con objeto de evitar el efecto de cuellos de botella genéticos, los refugios deberían proover la máxima heterogeneidad ambiental.

TABLE 1. RESUMEN DE LAS TOLERANCIAS TERMICAS PARA EL PEZ PUPFISH DE EL MANANTIAL OASIS Y DEL ARROYO SALT, RIVERSIDE COUNTY, CALIFORNIA.

	Manantial Oasis	Manantial Oasis	Thousand Palms	Arroyo Salt
CTMax(^{o} C)	42.7	42.6	42.4	41.9
CTMin(^{o} C)	5.3	6.3	4.4	4.6
Rango Térmico	37.4	36.3	38.0	37.3

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USE OF ANTIMYCIN TO REMOVE RAINBOW TROUT FROM WHITE CREEK, NEW MEXICO

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Abstract.--A major goal of recovery for the endangered Gila trout, *Oncorhynchus gilae*, is re-establishment of populations in streams within its native range. Six streams have been treated with the piscicide antimycin A to remove non-native rainbow trout, *O. mykiss*, and brown trout, *Salmo trutta*. Toxicant application and monitoring techniques have been refined with each treatment. White Creek, a tributary of West Fork Gila River, met criteria established by the Gila Trout Recovery Team for re-establishment of Gila trout but supported a population of rainbow trout. Data on the population of rainbow trout and the aquatic habitat were gathered in 1990, and used to develop the renovation plan for the stream. More than 10 km of stream above a 10-m high natural waterfall barrier were treated with antimycin A in June 1991. Post-treatment surveys are planned for summer 1992 to determine if the population of rainbow trout was removed. A second application of antimycin may be applied then. Methodologies used for survey and renovation are described.

Gila trout, *Oncorhynchus gilae*, an endangered species (U.S. Fish and Wildlife Service (USFWS) 1967), New Mexico Wildlife Conservation Act, 1974; Arizona Game and Fish Department (AZGF), 1988) is native to the Gila River drainage of southwestern New Mexico and Arizona, and has had an active recovery program during the past two decades. When federally listed, the species remained in five small headwater streams in the Gila National Forest, New Mexico (Mello and Turner, 1980; Propst et al. in press). Reasons for decline of Gila trout were similar to those given for other interior North American salmonids; predation by non-native brown trout, *Salmo trutta*, hybridization with non-native rainbow trout, *O. mykiss*, and cutthroat trout, *O. clarki*, habitat degradation and loss, and changes in water quality and quantity (Behnke, 1979; USFWS; 1979, 1984, in press; Propst et al. in press).

The goal for recovery of the species is to improve the status of Gila trout to the point that survival is secured and viable populations of all morphotypes are maintained in the wild. Recovery actions direct re-establishment of populations of Gila trout within the former range (USFWS, 1979; 1984). Downlisting of the species to threatened status could occur if each of the surviving populations is replicated (USFWS, in prep).

The Recovery Plan directed that streams within the historic range of Gila trout be surveyed to identify those with conditions suitable to support a population. Factors considered in selection of restoration streams included the physical, chemical and biological properties of the stream (including the extant trout population), access, and angler use. The feasibility of removing non-native fishes, the presence of a suitable barrier to invasion of non-native salmonids (or site for construction of a barrier) and its location were also determined. This information was necessary for the responsible management agencies to make appropriate planning decisions and present and explain such decisions to the public (USFWS; 1979, 1984, in prep.).

The piscicide antimycin A in liquid form (trade name, *Fintrol-Concentrate*) has been used in six streams (Table 1) in the Gila National Forest (Coman, 1981; Turner, 1986; Propst, et al., in press). Ten treatments have been necessary to remove non-native trouts. All renovated streams have received Gila trout except White Creek. Little and Mogollon creeks supported populations of native speckled dace, *Rhinichthys osculus*, Little Creek contained native Sonora sucker, *Catostomus insignis*, and desert sucker, *Pantosteus clarki*. McKnight Creek had a population of native Rio Grande sucker, *Pantosteus plebius*, eliminated by treatment with rotenone in 1973 (Bickle, 1973). Only Little Creek retains a population of speckled dace.

Techniques used in selecting and treating a stream have been refined with each renovation and will continue to do so as we evaluate each project. Our purpose is to describe the application of antimycin A in White Creek and factors that have influenced the success of other treatments.

Study Area--White Creek originates on Mogollon Baldy Peak in the Gila Wilderness, and flows easterly about 13 km before entering West Fork Gila River (Fig. 1). About 2.6 km above its confluence with West Fork Gila River, a 10-m high waterfall blocks all natural upstream movement of fish.

White Creek flows through a V-shaped valley with steep sides. Stream elevation ranges from 2100 m at the mouth to 3100 m at the source; between Halfmoon Park and the barrier the stream channel has a slope of 3.8 to 5.7%. Floodplain width is <20 m, active channel width is <8 m, and wetted width is 2 to 3 m. Depth averages 0.2 m, but pools to 1 m deep occur. Pool-to-riffle ratio is 23:77 and the most common habitat types are step-run and low-gradient riffle. Pools are primarily boulder-formed plunge pools; habitat types formed by wood (down trees or rootwads) are not common in the stream. Substrate composition is cobble to small boulder, and deposition of fine sediment is low. Log pool-building structures were constructed by the Civilian Conservation Corps in the upper reaches of the creek.

White Creek is a second-order stream and discharge does not increase appreciably once the headwater tributaries join. In June 1991, measured discharge was 35 L/sec at Halfmoon Park. Daytime water temperature in June 1990, was 12 to 18°C, pH 8.3 to 8.6, conductivity 83 to 102 µg/cm, and dissolved oxygen 6.6 to 7.6 mg/l.

Rainbow trout was the only fish species above the barrier in White Creek, below the barrier brown trout also occur. Genetic analysis of trout from upper White Creek

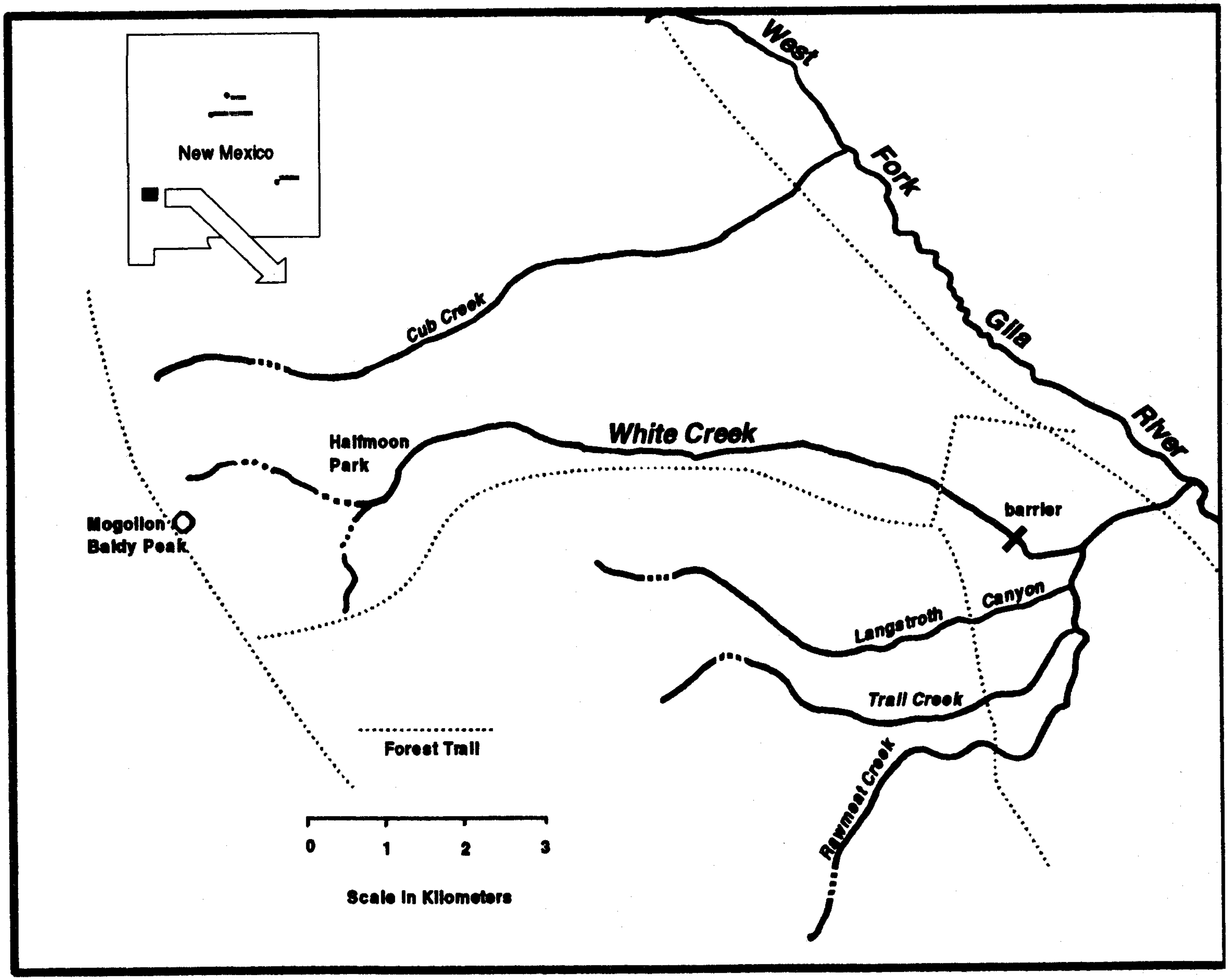

Figure 1. Map of White Creek, New Mexico, showing placenames used in text.

Table 1. Record of streams treated with antimycin A to remove non-native trout.

Stream	Target Species (trout)	Year of Treatment	Year Restocked
Iron Creek	Brown	1981	1981[1]
Little Creek	Brown/rainbow[2]	1982	1982
Dry Creek	Brown/rainbow	1984, 1985	1986
Trail Canyon	Rainbow	1986, 1987	1986, 1987
Mogollon Creek	Brown/rainbow[3]	1987, 1988, 1989	1989
White Creek	Rainbow	1991	

1. Unsuccessful treatment, brown trout still exist and are now being removed by electrofishing.

2. Sonora sucker, desert sucker and speckled dace also present.

3. Speckled dace also present.

showed Gila trout influence (Riddle et al., in review). Jenks Cabin Hatchery, operated by the New Mexico Department of Game and Fish from 1923 to 1939, was established at the confluence of White Creek and West Fork Gila River for propagation of Gila trout (Miller, 1950). Whether the Gila trout in White Creek occurred there naturally, or were stocked above the barrier is open to speculation.

Methods--During an extensive survey of White Creek and nearby drainages in July 1989, we found the aquatic habitat could support trout, a 10-m high waterfall isolated the upper 10+ km of stream from natural invasion by non-native trout, and reasonable stream access existed. We also found a population of trout that near Halfmoon Park visually appeared to be rainbow x Gila trout hybrids. Tissue samples were preserved for genetic analysis. Electrophoretic and mitochondrial DNA analyses found some influence of Gila trout in the specimens collected, but the fish were largely derived from rainbow trout (Riddle et al., in review). Accordingly, the Gila Trout Recovery Team recommended additional surveys of White Creek to evaluate its potential for re-establishment of Gila trout.

A protocol has been developed for renovation project planning for recovery of Gila trout (USFWS, in prep.). Surveys are done to determine the structure of the existing population of trout, which is then used as a template to identify when the translocated Gila trout population can be considered "established." Differences in response to physical habitat by rainbow or brown trout, versus Gila trout, are considered before a determination of "establishment" is made.

The physical, chemical and biological properties of the habitat are surveyed and these data then employed to determine the potential of a stream to support Gila trout, and whether significant differences in the population structure between Gila trout and the non-native population can be expected. Habitat surveys are used to develop the renovation plan, and whether any structural changes are necessary.

In June 1990, the aquatic habitat and trout population in White Creek was surveyed at ten sites (108 to 182 m long) equidistantly-spaced between the barrier and Halfmoon Park. At each site, a 24-volt backpack electroshocker was used to stun fish in a single pass. All trout captured were weighed, and measured for total (TL) and standard length (SL). Aquatic habitat was classified by habitat type (Bisson, et al., 1982; Hankin and Reeves, 1988). Length, width, average depth and dominant substrate type were quantified for each habitat type. Conductivity, pH, dissolved oxygen and water temperature were measured at each site.

Notes on human and livestock access to the stream, extent of recreational use, suitable camping sites for project personnel, potential landing sites for helicopter sling loads, and trail access were made. All items were considered in the decision to re-establish Gila trout in White Creek (USFS, 1991).

The liquid form of antimycin A was selected as the fish toxicant for White Creek. This choice was made because the piscicide is designed for use in running waters and because only a few µg/L of active ingredient are required for removal of trout. The toxicant does not repel fish, and its action is rapid and irreversible (Aquabiotics Corp, n.d.). Antimycin A is pH sensitive and rapidly degrades in pH's of 8.5 and over. It is deactivated quickly and easily with potassium permanganate (Lennon, et al., 1970). It has been a registered fish toxicant in the United States and Canada since 1966, but the U. S. Environmental Protection Agency has directed that it be reregistered (Schnick, 1991).

Monitoring of aquatic macroinvertebrates during treatments in Dry, Mogollon and Trail Canyon creeks showed that antimycin A had minimal long-term effects at dosages used to kill trout (Mangum, 1985; 1986; Jacobi, 1988). Short-term effects can be severe (Minckley and Mihalick, 1981). Aquatic macroinvertebrates were not monitored during this treatment.

Antimycin A was applied to White Creek in June 1991. Label instructions for antimycin A "roughly estimate" 7.5 µg/L active ingredient to kill trout when pH is <8.5, and water temperature is <15.5°C (Aquabiotics Corp., n.d.). Other workers have applied 10 µg/L to remove Apache trout, *O. apache*, and 8 µg/L to remove brook trout, *Salvelinus fontinalis*. In both cases, a second treatment was necessary for total removal (Rinne, et al., 1981; Gresswell, 1991). Our experience with antimycin A in other streams convinced us to apply 20 µg/L. We have found that such a dosage is necessary to cause a 95%+ kill of trout. In previous treatments, antimycin A was rapidly detoxified, either through biodegradation or dilution in the standing volume of water. Bioassays and observations of extent of fish kill in other streams showed that a concentration of 20 µg/L active ingredient of antimycin A should kill all trout for a distance of about 150 m.

Stream discharge was gaged by salt-dilution (Engstrom-Heg, 1971a) the morning of the treatment. Salt-dilution gaging has the advantages of high precision and of applicability to small, shallow and turbulent streams. A measured amount of salt in solution was introduced into the stream at a constant rate. Water temperature and concentration of total dissolved solids (TDS) were measured using a Hach Model 44600 Conductivity/TDS meter with a digital readout. The TDS concentration is nearly equivalent to the sodium chloride concentration (Hach Company, 1988), and was used to calculate stream discharge by the formula:

$$Q=\frac{S}{\Delta C}$$

where:

Q = stream discharge (m^3/min),
S = input of salt (g/min), and
ΔC = increase in TDS (mg/L).

Each unit of antimycin A consists of a bottle of active ingredient and one of acetone diluent, which when combined has a volume of 480 ml. The solution obtained by mixing the diluent with the active ingredient retains potency for up to 7 days. Once water has been added to this solution, it must be used within 8 hours to ensure potency. Label instructions state that 12.3 ml of the mixed solution will treat about 1,234 m^3 of water at a rate of 1 µg/L (Aquabiotics Corp., n.d.). The amount of the mixed solution of antimycin A needed to charge each drip station was calculated according to the formula:

$$A=\frac{Q\times T_h\times 12.3\times D}{1234}$$

where:

A = amount of antimycin A needed (ml),
Q = stream discharge (m^3/h),
T = dispensing time (h), and
D = desired dosage (µg/L).

Antimycin A was metered into the stream from Mariotte bottles (drip stations) that provided a constant flow and could be easily calibrated (Engstrom-Heg, 1971b). Each drip station was constructed from a 19-L plastic bucket with an airtight sealable lid, fitted with a 0.625-cm brass outlet valve 2 cm above the bottom, and a length of 0.625-cm copper tubing inserted through the lid that extended to 4 cm above the bottom. Drip stations were calibrated to dispense the contents at a constant rate (ml/min), that was calculated using the formula:

$$F=\frac{V}{T_{min}}$$

where:

F = flow rate (ml/min),
V = drip station volume (ml), and
T = dispensing time (min).

Flow from each drip station was adjusted until the required rate was reached.

Drip stations were charged sequentially beginning above Halfmoon Park and extending downstream to the barrier during a 3-day period. Drip stations were placed at regular intervals measured with a hipchain by a person walking the creek channel. Each drip station was filled with water from the stream, with care being taken to exclude debris and sediment that might clog the outlet valve. The calculated amount of antimycin A was added to the container and the solution mixed. The drip stations were sealed and flow rate calibrated. All drip stations were charged during midday (0900-1500 h) so the toxicant was in the stream when trout were most active.

Twenty drip stations at 150-m intervals were charged on 26 June, and 23 on 27 June. Eight drip stations at 300-m intervals were set up on June 28. The upper 43 drip stations were calibrated to run for

3 h and to provide a dosage of 20 µg/L active ingredient of antimycin A. The lower 8 drip stations ran for 2 h at a concentration of 30 µg/L active ingredient. This adjustment was made because we had miscalculated the amount of antimycin A needed for the treatment and were running short of the toxicant. Empty drip stations were either moved downstream for the next day's treatment or taken back to camp.

Backpack sprayers were used to treat small tributaries from above the uppermost drip stations to the spring sources. Each sprayer held 15 L of water and was charged with 50 ml of antimycin A, enough to treat about 250 m^3 of water at 20 µg/L. Nozzles of the sprayers were adjusted to produce an even spray across the water surface. Rubber-bladder fire sprayers were used in previous treatments, but not in White Creek because they leaked, were difficult to carry safely where footing was uncertain, and the spray pattern could not be adjusted.

Fish in distress appeared within 2 h of toxicant application. Individuals exhibited flared gills, lack of orientation, and did not respond to external stimuli. Dead fish were gathered from each of the ten sites that had been sampled in 1990, and weighed and measured. All other fish were left in the stream to decompose.

Signs advising the public of the project were placed at the trail crossing of White Creek above the barrier. This area is a popular destination for hikers and riders and is the only place in the renovation zone with trail access. During the project no recreationists were encountered. The signs were removed at the end of the project.

A detoxification station was set up at the waterfall to prevent fish from being affected by the toxicant outside the project area. A solution of potassium permanganate was metered into the stream at 1 mg/L using the same equipment used to dispense the toxicant. Although no detailed checks were made downstream from the barrier, riders from our camp crossed White Creek about 2 km below the barrier twice on the final day of treatment and saw no dead or distressed fish, nor was discoloration of the water due to the detoxicant noted.

Results and Discussion--The population of rainbow trout in White Creek is unexploited by anglers, except near the trail crossing. In 1990, average abundance of rainbow trout captured from 10 sites was 0.63 fish/m (0.30 to 0.81 fish/m, n=959). Specimens captured were 69 to 229 mm TL, and the size structure of the population was dominated by fish 80 to 110 mm TL, which we assumed were from the 1989 year-class (Fig. 2).

Population abundance was less in 1991 (n=403), although data were not taken in a manner that could provide a reliable estimate. Lengths were less (59 to 212 mm TL) than the previous year, but the 1989 year-class still dominated the population (Fig. 2). Whether the observed size distribution of the population in 1991 was correct, or an artifact of measuring only observed dead individuals, is not clear. It is common however, for year-classes to be absent or reduced in streams in the Southwest. Such absences are often attributed to weather conditions that affect stream discharge and are highly variable from year to year (P. R. Turner, pers. comm.).

Few fish <70 mm TL were taken in either year, but fish from the 1990 year-class were taken in 1991. The timing of our surveys (early-

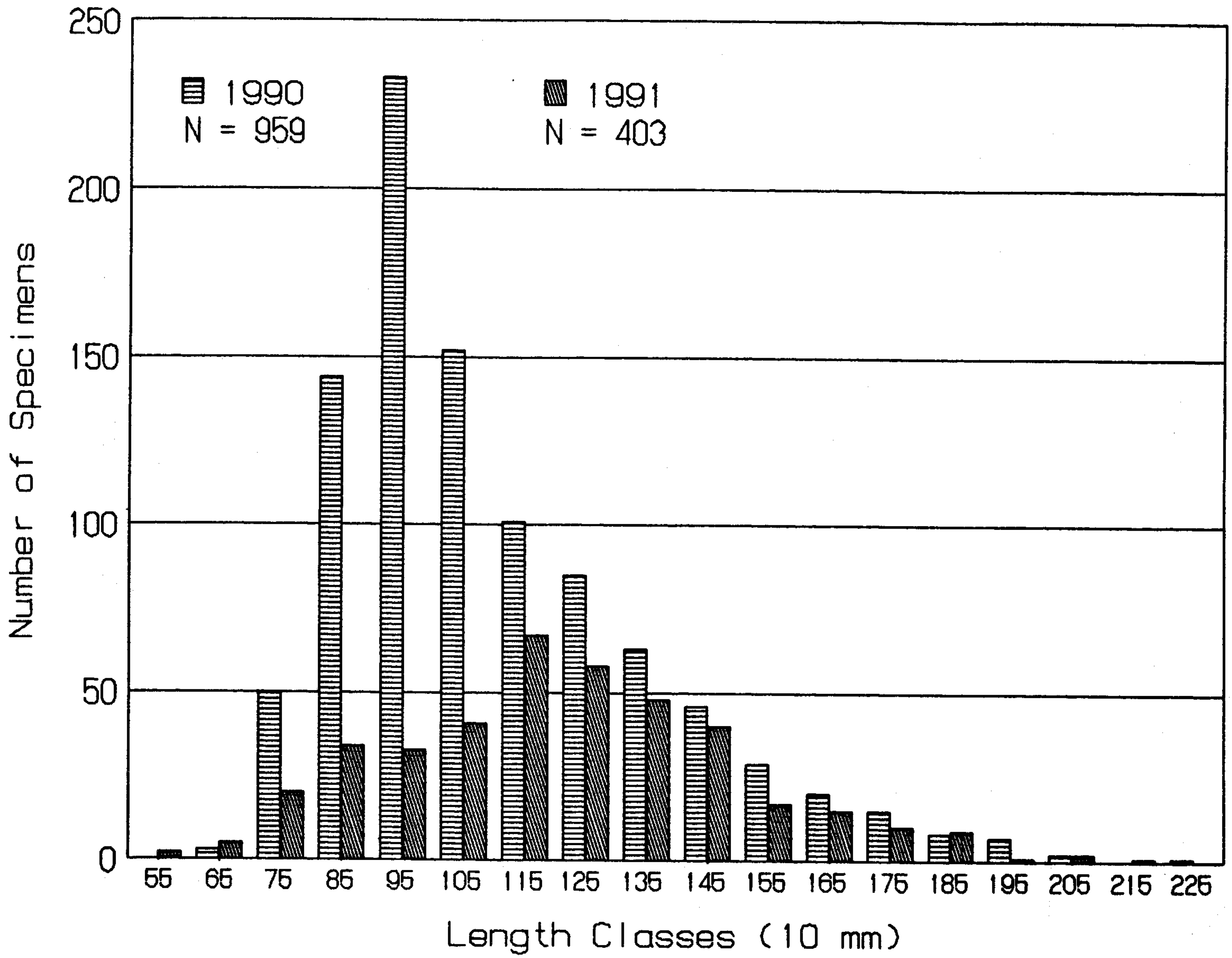

Figure 2. Population structure of rainbow trout in White Creek, New Mexico.

June) probably precluded capture of age 0 fish, most of which would still have not emerged into the water column.

Standing volume of water in White Creek was about 0.13 m^3/m, which reflected the dominance of shallow water habitat and lack of pools. In 1990, rainbow trout were commonly captured in the shallow riffles and runs, where they occupied small pockets of quiet water formed by the larger rocks. Rinne (1981) determined that in pools, depth and to lesser extent, volume of water influenced the total biomass and maximum length of Gila trout. In White Creek, pools make up <25% of the total length and surface area of the stream, and pool volume accounts for 40% of the total volume. Although low in abundance, the spacing and surface cover of the pools suggest that White Creek will support a reproducing population of Gila trout comparable in abundance and size range to the existing population of rainbow trout.

Post-treatment monitoring of White Creek will be done in 1992. Experience in other streams leads us to believe a second treatment, and perhaps a third, will be necessary to achieve complete removal of rainbow trout from the stream. To date, only Little Creek has been reclaimed with a single treatment. The virtual absence of age 0 fish found after the treatment suggests that larval fish had still not emerged from the redds. Examination of adult fish indicated that spawning had probably occurred earlier in the year, and there was nothing to show that redds had been destroyed by a flood or other natural occurrence.

Antimycin A is can kill eggs, and is purported to be effective against eggs in redds. But in Dry Creek, a few age 1 rainbow trout were found in 1985 following an early-July treatment in 1984. A thorough examination of the stream after the second toxicant application revealed no adult fish, thus we believe that it was eggs or larval fish in gravel in 1984 rather than adult fish that had survived the treatment. The issue of survival of eggs and larval fish still intragravel was a factor in our decision to treat White Creek at a dosage of 20 µg/L.

Several attributes of White Creek however, suggest that a second treatment may not be necessary. Stream flow is continuous from source to the barrier; there are no intermittent reaches where water flow is underground and subject to dilution or detoxification. The only tributaries to White Creek are the two headwater streams that join to form the main channel. There are no springs and few seeps where rainbow trout might find refuge from the toxicant except in the upper headwaters and these were intensely treated. Finally, the slope of White Creek is steep, pools are not abundant nor large, therefore dispersion and dilution of the toxicant is not considerable.

We encountered no unanticipated problems in the treatment of White Creek other than underestimating the amount of toxicant needed for application at the preferred concentration and duration. Despite this we were able to adjust the procedure so an adequate amount of antimycin A was applied to attain a nearly complete kill, if not total.

The equipment used has been field tested and modified as a result of experience gained during nine applications. Although there is always the need for additional modification and refinement, we believe that major problems with our techniques and methods have been surmounted. For example, a few drip stations were plugged by debris and did not empty completely; in the future, water will be filtered through a coarse sieve to remove stream debris.

We have found that detailed planning is vital to success of a treatment. Knowledge of the physical, chemical and biological properties of the stream system to be treated is essential for solving myriad unanticipated complexities of an ordinary treatment. Stream surveys to determine the length of stream, its discharge and standing volume, location of springs, seeps and intermittent areas, annual thermal regime, species present (fall or spring spawners), community structure, location of a barrier to exclude non-native trout, access and location of camping areas must be done early so alternative treatment scenarios can be devised. In renovations for recovery of Gila trout where the site is distant from the nearest road, and even further from a source of supply, all exigencies of the treatment must be considered before the treatment is begun.

Published accounts of field application of antimycin A are few. Rinne (1981) reported on removal of Apache trout, and Gresswell (1991) on removal of brook trout; Lennon, et al., (1971) provided an overview of stream renovations. Much of the material is in the form of field notes or project reports; descriptions of methods, formulas, equipment and other details are often anecdotal and vague. Most treatments have not been designed to accomplish a complete kill, thus the survival of few fish post-treatment is not considered a problem.

We have gained most of our knowledge through experience, and while the efforts we expend in treatments may seem tedious, sometimes arbitrary and perhaps superficial, they are the result of episodes and ordeals that have occurred during previous treatments. We fully expect that our methods and equipment will continue to be refined with additional treatments, and that our efforts will become more streamlined as our base of knowledge expands. But because our work occurs in remote areas, our technology will have to remain relatively unsophisticated and able to withstand the rigors of nature.

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MITOCHONDRIAL DNA DIVERISTY WITHIN AND AMONG POPULATIONS OF THE ENDANGERED SONORAN TOPMINNOW (*POECILIOPSIS OCCIDENTALIS*).

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Knowledge of genetical structure of remnant populations of an endangered species should play an integral role in any comprehensive recovery plan. Our goal is to characterize the distribution of genetic diversity within and among populations of the endangered Sonoran topminnow (*Poeciliopsis occidentalis*). Earlier studies, based on protein electrophoresis, identified low levels of genetic diversity in most Arizona populations of the Gila topminnow (*Poeciliopsis o. occidentalis*), as opposed to populations from Sonora, México, which exhibited considerable diversity. To complement this work, we assessed mitochondrial DNA (mtDNA) variation in this species. As in the allozyme study, considerable mtDNA variation was found within and among topminnow populations in Sonora, where the species remains locally abundant. We detected no mtDNA diversity within or among samples of the Gila topminnow from Arizona. However, a large degree of sequence divergence (which exceeds the differences observed among haplotypes from separate river drainages in México) was observed in contrasts between the Gila topminnow and *P. o. sonorensis*, a subspecies inhabiting the upper reaches of the Rio Yaqui in southeastern Arizona. Based on the current genetic information and additional morphological data showing that *P. o. sonorensis* is distinct from downstream Yaqui populations in México, we suggest elevation of *P. o. sonorensis* to species status, and comment on the tractability of the current topminnow recovery plan.

IS THERE FEDERAL INTEREST IN CURBING INTRODUCTIONS?

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Abstract

If the introduction of the zebra mussel (Dreissena polymorpha) into the North American Great Lakes has had any positive impact, it raised concern that species introductions are not inherently beneficial. This goes against the grain of what I term the "introduction paradigm" that has been a dominant factor in resource management here for at least two centuries. The Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 is now law, but fails to place restrictions on introductions. The Office of Technology Assessment (Congress of the United States) and the National Research Council are currently evaluating the extent and impacts of past introductions of nonindigenous species. Two items of federal legislation have been proposed, addressing conservation of biological diversity, both of which **could but do not** include introduced species as a matter of concern, and another bill (Species Introduction and Control Act of 1991) would require greater scrutiny of future introductions through so-called protocols. Perhaps the federal government may conduct introductions (i.e., new policies) that could actually be beneficial to native species.

The Native Fish Work Group - A multiagency endeavor to improve the status of the razorback sucker in Lake Mohave, AZ-NV.

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In 1989, the Bureau of Reclamation approached the Fish and Wildlife Service and National Park Service with a scheme to help the aging population of razorback suckers found in Lake Mohave, AZ-NV. Lake Mohave represents the specie's last strong hold where approximately 60,000 suckers still reside, the vast majority being over 25 years of age. The plan called for the use of permanent and temporary barriers to isolate reservoir backwaters. Once renovated, these refugia would allow razorback suckers areas to spawn and grow without being molested by nonnative fishes. Suckers reaching 30 cm would be released into the reservoir to supplement the adult population.

Arizona State University, Arizona Game and Fish Department and Nevada Department of Wildlife joined the Federal agencies in forming the Native Fish Work Group (NFWG). Since its inception in 1989, the NFWG has developed and implemented a research/management plan, constructed a spawning facility at Yuma Cove and is currently modifying Davis Cove for sucker grow-out. These activities are being accomplished through a cooperative effort utilizing the resources and expertise found in the six agencies. If this program proves successful on Lake Mohave, the effort could be expanded to include other native fishes and other locations.

ARIZONA STOCKINGS OF RAZORBACKS AND SQUAWFISH: HISTORY AND FUTURE RESEARCH AND MANAGEMENT CHALLENGES

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Between 1981 and 1990, > 10 million hatchery-produced razorback suckers (*Xyrauchen texanus*) and > 623,000 Colorado squawfish (*Ptychocheilus lucius*) were stocked to historic range in the Verde and Salt rivers from which natural populations had been extirpated. Efforts to date have focused on broad-scale stockings and general fish surveys to monitor success. Only 519 razorbacks, and 444 squawfish were taken in several years of intensive electrofishing and netting surveys during all seasons throughout large segments of both rivers. Survival of razorbacks appears better in the upper Verde River than in the Salt River, while squawfish appear to fare better in the Salt than do razorbacks. Most recaptures occurred within weeks of stockings; few had lived > a few months in the wild. While significant, large populations have not established in mainstreams, some populations of razorbacks have persisted in small, isolated, peripheral habitats prohibiting emigration. Despite growth to maturity in these populations, no evidence of wild reproduction has been found. The few squawfish known to have overwintered in the wild were also taken from a habitat closed to downstream emigration. Proximate impediments to large-scale successful recruitment of stocked individuals clearly include predation, principally by exotic flathead catfish and smallmouth bass, and inability of hatcheries to produce large numbers of individuals large enough to escape predation. Despite limited success, it is recommended that stockings of both species continue for two reasons. Large-scale field experiments easily accomplished under the "experimental, non-essential" designation with readily available hatchery fish can elucidate mechanisms of failure of recruitment of hatchery stock. These should emphasize experimental analyses of factors affecting mortality, movements and habitat use of stocked fish. Effects of fish condition, transport and stocking stress, size, stocking season, and parasite ecology are other variables which need research. Along with experiments, stockings now proven, at least in the case of razorbacks, to contribute to establishment of long-lived populations should continue with both species. These should be as extensive as possible, and focus on releases to closed, peripheral riverine and reservoir habitats (e.g. isolated backwaters), preferably with low or reduced predator populations. While direct stocking of larger individuals would likely increase survival rates in the wild, absolute numbers stocked would remain small given existing facilities. Stockings of far greater numbers of small individuals to such isolated, "wild" habitats and subsequent "wild" growth there prior to release, *via* either natural or artificial mechanisms, to larger, adjoining habitats, will likely prove to be the most economical and successful approach to establishing multiple, new populations of long-lived individuals. Recommendations for immediate habitat management actions for both species include manipulations of predator populations and maximization of availability of backwater habitats.

RIVER MANAGEMENT AND HABITAT RESTORATION STRATEGY;
An issue paper on habitat development
RECOVERY PROGRAM -ENDANGERED FISHES- UPPER COLORADO RIVER

by

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ABSTRACT

This issue paper addresses the habitat development element of the Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin. It is intended as a guide to the Biology and Management Committees to aid decision making regarding habitat restoration.

Literature was reviewed on life history requirements of the endangered fishes, fish population and habitat trends on the Colorado River System, and river restoration and mitigation procedures on rivers. In addition, biologists and hydrologists working on recovery efforts in each portion of the basin were consulted and habitat restoration strategies offering the greatest potential to reverse downward trends in fish populations and habitat were formulated. Field examination of extensive portions of the river system was conducted with biologists and water resource personnel working on habitat related projects to evaluate habitat conditions and potential restoration projects.

The Colorado River System is one of the most utilized and developed river systems in the world. Throughout the last 100 years complex changes in river morphology and aquatic fauna have occurred as a result of channelization, water diversion, introduction of non-native riparian vegetation, construction of large dams, introduction of non-native fishes, and other human induced impacts.

Changes in fish communities often serve as biological confirmation of degraded or changed habitat in a river system. The near extirpated status of several endangered species in several drainages in the Colorado River System clearly indicates the need to evaluate the value to the recovery effort of habitat restoration or development projects. Four federally listed endangered species (bonytail chub, _Gila elegans_, Colorado squawfish, _Ptychocheilus lucius_, and humpback chub, _Gila cypha_, and razorback sucker, _Xyrauchan texanus_) are among the 13 native, big river, fishes of the Upper Colorado River

basin that have suffered severe declines as a result of alterations to the Colorado River ecosystem.

Habitat management by flow regulation and nonnative species interactions are closely related topics that require integration into habitat restoration recommendations. Flow alterations affect other habitat components in complex ways. Future habitat restoration projects will depend on management of flow regimes. Proliferation of non-natives also affect the habitat components of food, cover, space, and water quality.

There is a conceptual difference between river restoration and habitat development. J. A. Gore in his book "The Restoration of Rivers and Streams, Theories and Experience" states that **river restoration** is the process of **recovery enhancement.** Recovery enhancement enables the river ecosystem to stabilize or reach trophic balance at a faster rate than through some types of habitat development. River restoration through recovery enhancement requires examination of unstressed or less stressed portions of the system and/or a return of a river ecosystem to a more historical condition.

S. Swales described the important steps in using instream habitat improvement methods in mitigating the adverse effects of river regulation on fisheries. He stated that "the overall aim of mitigation by instream habitat improvement is to enhance, recreate, or rehabilitate features of the river environment which may be limiting to aquatic communities. **The first stage in a habitat improvement program is, therefore, to identify the main limiting factors for the faunal groups under investigation. The next stage is to design and implement an improvement program aimed at modifying and recreating these factors."**

Literature review and field observations indicated that extensive habitat alteration of the Colorado River System occurred due to the timing of several major events. The initial invasion of tamarisk (salt cedar) in the early 1900,s coincided with a period of extensive erosion. This was followed by sediment supply reductions in the 1940's as river banks stabilized during alternating climatic cycles and changing land use practices. Subsequent construction of large storage reservoirs in the 1960's reduced both peak discharge and sediment. This sequence of events has resulted in the following habitat alterations and is hypothesized to negatively affect native fish populations:

1). reduction in channel widths (up to 50%) causing:
   a) reduction of low velocity shoreline and floodplain habitat
   b) increased main channel velocity
   c) increased downstream transport of fish larvae
   d) loss of native fish to nonnative predation in downstream reservoirs and remaining low-velocity habitat.

2) extensive levee formation ultimately leading to:

a) river confinement and channelization

b) infrequent interaction of the river with floodplain habitat

c) reduced nutrient cycling and food availability to fishes

d) recruitment failure of fish dependent on floodplain habitat

These problems were further complicated by direct channelization by man associated with irrigated farming and urbanization of the floodplain. Water diversion structures blocked or diverted natural fish distribution mechanisms interfering with reproduction and recruitment of migratory-dependent species. Wetland mitigation procedures associated with reservoir construction resulted in further diking along the river, reduced native fish access, and degraded water quality. The construction of reservoirs, floodplain gravel pits and wetland mitigation areas led to further introductions and proliferation of non-native species causing competition for food resources and predation on native species.

In spite of the magnitude of habitat loss, opportunities were found that could return to beneficial use considerable quantities of habitat to endangered fish on the Colorado, Gunnison, and Green rivers. A strategy for determining priority species and potential habitat restoration projects was formulated.

1). Evaluate trends in both endangered fish populations (all life stages) and habitat in each drainage. (Identify priority species and life stages based on declining trends in numbers and habitat.

2). Identify limiting factors threatening endangered fish populations in the river system. Identify habitat development projects that address key limiting factors of priority species in each river drainage.

3). Incorporate project attributes that could enhance utility and likelihood of success:

A. Recommend projects that can be expanded or are large enough in scope to make a notable improvement in habitat availability thereby increasing the likelihood of detecting a response by fish populations. Follow through with project evaluation and, if possible, treat projects as experiments.

B. Emphasize **first** the rehabilitation of existing riverine habitat that has been historically used by endangered fish but access has been denied by construction of levees and diversion structures. The highest likelihood of success will be restoration of natural river and riparian-wetland habitat (bottomland) that has recent documented fish use. Emphasize habitat improvements that can be maintained by natural hydrological processes thus reducing maintenance costs.

C. Locate projects where water availability will remain high and natural hydrographs can be maintained and/or restored to improve habitat for endangered fish.

D. Integrate several functions of habitat restoration and/or development projects.

1. Natural reproduction and recruitment
2. Life history studies
3. Exotic fish control
4. Population and habitat monitoring
5. Competitive interaction (resource sharing) studies
6. Population augmentation (including)
    a. Grow-out facilities
    b. Nutrient and food studies
    c. Imprinting studies
7. Incorporate hydrology and sediment factors

Razorback sucker was considered the priority species on the Green and Colorado rivers. Riparian wetland (bottomland) habitat restoration was considered the priority habitat for development to aid razorback. Opportunity to restore wetland habitat was found at Ouray National Wildlife Refuge and near Jensen, Utah on the Green River. Wetland restoration potential was found near Moab, Utah and between Rifle and Debeque, Colorado, on the Colorado River and on the Gunnison River near Delta, Colorado.

Restoration of access to upper main-stem Colorado and Gunnison rivers was considered critical to long-term maintenance and security Colorado squawfish and razorback sucker populations on these rivers. Area and depth of pool and eddy habitat during base flow on the upper Colorado and Gunnison rivers compared favorably with that available on the Yampa River. Water quantity, quality, and future maintenance of a natural hydrograph are important long-term considerations in recommending habitat restoration for these areas. Removal of diversions at Redlands on the lower Gunnison River and Price Stubs on the Colorado River near Palisade was recommended. Testing of a prototype fish passage structure was recommended for Government Highline Diversion on the main-stem Colorado River near Plateau Creek. Backwater habitat modifications which provide improved access for adult Colorado squawfish and control of nonnative northern pike were recommended for the upper Yampa River in Colorado.

Apache Trout Habitat Use in the Presence of Brown Trout

by Lorena L.L. Wada, S. Leon, and O.E. Maughan
Arizona Cooperative Fish and Wildlife Research Unit and
U.S. Fish and Wildlife Service,
Pinetop Fisheries Assistance Office, Arizona

Few Apache trout were found in pools occupied by brown trout; they appear to be displaced by brown trout of equal or larger size. There was no evidence that fry or juvenile apache trout survived in areas of co-occurrence with brown trout but ample evidence of recruitment in areas above the distribution of brown trout.

Brown trout occupied areas of lower currents ($\bar{x}$ 1.92 cm/sec) than did Apache trout ($\bar{x}$ 3.09 cm/sec). The regression model [-230.26 + 31.50(depth) + 0.16(instream cover) - 4.40(out-of-stream cover) - 538.84(height of out-of-stream cover) - 0.78(bankcut)] accounted for 76% of the variability in biomass of Apache trout.

Environmental characteristics of small springs in Northern Nevada

Donald W. Sada, Smithsonian Institution, Gary L. Vinyard, University of Nevada, Reno, Robert Hershler, Smithsonian Institution

Five hundred eleven springs between 1080 m and 2339 m elevation were surveyed in northern Nevada during 1991. Information collected at each spring included the occurrence of aquatic snails (particularly in the family Hydrobiidae), and characteristics of the aquatic environment.

Sample sites were categorized as rheocrenes (69.7%), heliocrenes (14.9%), limnocrenes (6.7%), and others (8.7%) (e.g. dry, springbrooks, creeks). Most sites were located on U.S. Bureau of Land Management (BLM) (47.5%), U.S. Forest Service (USFS) (8.0%), and private lands (42.6%). A few sites were on Tribal and military lands (1.9%). Springs were typically small (mean wetted perimeter width = 277 cm ±860, 1 S.D.; mean depth = 11.9 cm ±31, 1 S.D.). Mean water temperature was 18.6°C (±10.0, 1 S.D.), mean dissolved oxygen concentration was 7.0 mg/l (±5.8, 1 S.D.), and mean conductivity was 558 μmhos/l (±583, 1 S.D.).

The condition of each site was categorized according to the magnitude of disturbance. Highly disturbed sites had denuded, sloughing stream banks, and/or they were completely captured in a diversion structure. Lesser disturbance was categorized as moderate, slight, and undisturbed. Most springs on BLM land were highly disturbed (high = 53.8%, moderate = 22.2%, slight = 16.0%, undisturbed = 8.0%), and most springs on private lands were highly disturbed (high = 54.1%, moderate = 26.1%, slight = 16.7%, undisturbed = 3.0%). Springs on USFS land were in better condition (high = 31.6%, moderate = 26.3%, slight = 26.3%, undisturbed = 15.8%). Disturbance was mostly attributed to effects of livestock (53.4%) and diversion (35.1%). Many of the springs had been diverted for livestock use. Effects of residential use and recreation were comparatively small (6.7% and 4.7%, respectively).

The debilitated condition of springs reflects the intense use of aquatic resources in this arid region. Management programs must recognize springs as riparian ecosystems, and provide them with similar protection given to stream ecosystems. Additional studies are needed to determine the biota of these isolated habitats.

SUMMER MICROHABITAT USE BY SONORA CHUB IN SYCAMORE CREEK, ARIZONA

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Abstract: The Sonora chub (Gila ditaenia) is endemic to the Rio de la Concepcion Basin, and is a Federal Threatened and Arizona State Endangered species. Designated critical habitat is in Sycamore Creek watershed, but to date there has been no quantitative research on Sonora chub habitat. The main objectives of this study were to determine summer microhabitat use and selection by Sonora chub in Sycamore Creek, and to determine if microhabitat selection varies according to size class. Surface observations located fish at randomly assigned points in four different stream sections. Distributions of microhabitat use and availability differed significantly for variables related to substrate, water column depth, velocity, cover, and shade. Microhabitat use, availability and selection varied between some pools. However, microhabitat use by size class remained fairly constant between different pools.

USO DEL AMBIENTES EN EL VERANO POR EL CHARALITO SONORENSE EN SYCAMORE CREEK, ARIZONA

Resumen: El charalito sonorense (Gila ditaenia) es endémico a la Cuenca del Río de la Concepción, siendo considerado en la lista Federal de especies amenazadas y la lista del estado de Arizona de especies en peligro. Habitat crítico está indicado en la cuenca del Sycamore Creek, pero hasta hoy no se ha conducido ninguna investigación del habitat del charalito sonorense. Los principales propósitos de este estudio fueron determinar el uso del ambiente en el verano y selección del charalito sonorense en Sycamore Creek y, determinar si la selección del ambiente varia según clases de tamaño. Observaciones superficiales encontraron peces en localidades indicados al azar en cuatro secciones diferentes del río. Distribuciones del uso del ambiente y disponibilidad varían significativamente según factores variables relacionadas al substrato, profundidades del agua, velocidad, cobertera, y sombra. Uso del ambiente, disponibilidad y selección variaban entre algunas de las albercas.

REGULATION OF FLOWS IN THE PECOS RIVER NEW MEXICO, FOR THE PECOS BLUNTNOSE SHINER (Notropis simus pecosensis)

Gerald L. Burton
U.S. Fish and Wildlife Service
Albuquerque, New Mexico

Three dams control flow of water in the Pecos River, New Mexico. Santa Rosa Dam is the uppermost dam and is operated by the U.S. Army Corps of Engineers for flood control, irrigation, and sediment retention. Sumner Dam, located downstream from Santa Rosa Dam, is operated by the U.S. Bureau of Reclamation and is used primarily for irrigation storage. Brantley Dam, another Bureau facility, located approximately 203 miles (327 km) downstream of Sumner Dam, is also used primarily to store irrigation water. Operation of these three dams, but especially Sumner Dam, determine the quantity and quality of habitat available to the Federally threatened Pecos bluntnose shiner (Notropis simus pecosensis). Results of a formal Section 7(a)(2) consultation conducted between the Bureau and the U.S. Fish and Wildlife Service are discussed. The consultation resulted in formulation of conservation measures and reasonable and prudent alternatives which will, if successfully implemented, provide for conservation of the species and protection of its critical habitat.

Warner Sucker a Threatened (not Endangered) Species: Life History Notes and Refugium Populations

Rollie White
University of California
Davis, California

The Warner sucker, Catostomus warnerensis, is a Federally listed endemic sucker from south central Oregon's Warner Valley. In a four month study in spring of 1990, we caught 354 suckers and observed 2770 more in net sampling and visual observation, respectively. Though suckers were collected in nearly all habitats we sampled, length frequency distributions show that many of the larger lakes in the valley are populated with only large adult suckers. This is in spite of spawning activity observed in at least one lake that produced viable offspring. Irrigation diversions blocking migration corridors and heavy predation from piscivorous introduced gamefishes are likely to blame. Stream resident and lake resident adult form suckers were observed, suggesting refugia. The recovery of the sucker, and its ultimate down-listing are realistic goals but depend very heavily on continued cooperation with local landowner-irrigators, on protection of current sucker habitats, and on reestablishing migration corridors.

Reseña Historica Poblacional del Chupalodos de Warner: una Especie Endémica Amenazada

El chupadodos de Warner (Catostomus warnerensis) es una especie catalogada como endémica para la zona sur central del Valle de Warner, en el Estado de Oregon, EE UU. En un estudio de cuatro meses iniciado durante la primavera de 1990, se capturaron 354 ejemplares y además se observaron 2770 individuos capturados con red y registrados in situ. Aunque los chupalodos fueron colectados en la mayoría de las areas muestreadas, la frecuencia de distribución de tallas indica que la mayoria de los lagos en el valle están solamente habitados por adultos de talla grande. Esto a pesar que se han constatado desoves y producción de alevines en por lo menos uno de los lagos. Las causas aparentes pueden ser: la diversión por irrigación que ha bloqueado los corredores de migración y la predación intensiva por otras especies piscícolas introducidas en esos cuerpos de agua. La presencia de peces nativos en el arrollo y en el lago, sugieren que esta zonas son refugios. La recuperacion poblacional del chupalodos y su reclasificación fuera de las listas de especies en peligro, son metas posibles de lograr, pero dependerá enormemente de el establecimiento de un programa de cooperación continua con los dueños de tierras para que opten por nuevas formas de riego y reestablezcan corredores de migración que protejan a la especie y su habitat.

DESERT HABITATS IN CANADA

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V9R 5S5

Canadian desert habitats are restricted to three provinces and the Northwest Territories. In British Columbia, Alberta and Saskatchewan, there are several small desert areas, less than 1000 $mi.^2$ each, that can be characterized by hot summer and cold winter temperatures, while Canada's largest desert in the arctic has cool summers and very cold winters.

In terms of aquatic fauna, Canada's deserts differ from those in the southwest United States and Mexico, in that there is almost a total lack of endemism, except perhaps whitefish in the arctic. This is almost certainly due to two facts: 1) in most Canadian desert areas the glaciers retreated more recently than 10,000 years ago, therefore there has been insufficient time for much evolutionary change and 2) most Canadian desert areas are dominated by large rivers acting as a migratory pathway for organisms entering and leaving the desert areas. Native fish species have colonized from the south and a few glacial refugia. British Columbia desert native fish fauna is dominated by salmonids (strict sense), catostomids and cottids, while Alberta and Saskatchewan deserts are dominated by cyprinids, catostomids and percids. The most common forms in arctic Canada are the coregonids. There are warm (summer), high salinity ponds and lakes in the three provinces' deserts, but by and large, they are devoid of fish - there are no cyprinodonts in desert Canada.

Abstract of talk for Desert Fishes Council Meeting - 1991

Yu, Yingchuan and Gary L. Vinyard
Department of Biology
University of Nevada
Reno, Nevada 89557

Direct and indirect impacts of Tahoe suckers (*Catostomus tahoensis*) in artificial streams.

We examined the direct and indirect effects of Tahoe suckers on algae and water chemistry in artificial streams. Each stream was divided into two sections, one containing fish and one without fish but with connected water circulation. Direct and indirect fish impacts could be examined in separate sections.

Our findings from three 28-day experiments indicated that, relative to control tanks without fish, Tahoe suckers caused significant reductions in algal biomass and primary production while increasing chlorophyll specific productivity in the direct effects stream sections. In the indirect effects stream sections, algal biomass and total primary production was increased, while chlorophyll specific productivity was reduced. Dissolved nitrogen and phosphorus levels were increased in streams containing fish. Tahoe suckers caused short-term increases in sedimentation rates early in each experiment.

What constitutes high quality habitat for Gila Topmminow (Poeciliopsis o. occidentalis)? An overview of habitat parameters supporting a robust population at Cienega Creek, Pima County, Arizona. Jeffrey R. Simms and Karen M. Simms, U.S. Bureau of Land Management, Safford District, Arizona.

Abstract: We studied population and habitat characteristics for the endangered Gila topminnow (Poeciliopsis occidentalis occidentalis) in Cienega Creek, Pima County, Arizona. We sampled fish at 5 locations in the fall of 1989 and 9 locations in the winter of 1990. We depleted small creek segments with seines and estimated populations with linear regression techniques. We classified and measured aquatic habitats, recorded dominant substrates, measured or estimated cover, and made visual estimates of topminnow abundance for 16 km of perennial Cienega Creek. Using depletion data, we estimated a fall topminnow population of approximately 2.5 million (conservatively). Cienega Creek supports a very productive topminnow site with fish densities as high as 566/m2. Late winter depletion data showed a major decline in topminnow abundance from the fall except where a head water spring influenced thermal conditions. We classified 1006 habitats on Cienega Creek into 10 habitat types. Marsh was the dominant habitat type. Our preliminary data analysis suggests that Topminnow used habitats disproportionately to their availability (Chi Square, $P<0.01$). Topminnow were found more frequently in pool, glide, and backwater habitats and less frequently in marsh, riffle, chute, cascade, and fall habitats. Topminnow were associated with sand substrate more often than other substrates. At this point our data analysis indicates that a more detailed study examining specific microhabitat features within preferred macrohabitat types is necessary in order to define high quality habitat. A knowledge of basic habitat factors which are essential to maintenance of the topminnow population at Cienega Creek is necessary to guide future management actions.

Desert Fishes Council

"Dedicated to the Preservation of America's Desert Fishes"

P.O. BOX 337
BISHOP, CA 93514
(619) 872-8751

March 30, 1992

91-1

Relative to Water Levels in Devils Hole and Ash Meadows National Wildlife Refuge

WHEREAS excessive use of ground water resources is known to adversely affect water levels in Devils Hole, and causes the only natural population of Devils Hole pupfish, Cyprinodon diabolis, to decline; and

WHEREAS the U.S. Supreme Court in Cappaert vs. U.S. ruled that the water level in Devils Hole must be maintained above a minimum point; and

WHEREAS many other rare and federally listed threatened and endangered species in Ash Meadows wetlands adjacent to Devils Hole have also been affected by ground water pumping; and

WHEREAS the unique qualities of Ash Meadows are recognized by inclusion of most of these wetlands within Ash Meadows National Wildlife Refuge; and

WHEREAS the U.S. Fish and Wildlife Service has approved a recovery plan for listed species in Ash Meadows stating that recovery will occur when habitats are secured from threats and rehabilitated to natural conditions from effects of habitat disturbance caused by diversion, ground water pumping, land clearing for agriculture, and non-native terrestrial and aquatic species; and

WHEREAS the U.S. National Park Service has recorded a decline in the water level in Devils Hole since August 1989; and

WHEREAS the rate of decline in Devils Hole indicates that a water level below that mandated by the U.S. Supreme Court may occur within the next 10 years; therefore be it

RESOLVED that the Desert Fishes Council, an international professional organization dedicated to the preservation of America's desert fishes, requests the U.S. National Park Service and the U.S. Fish and Wildlife Service to initiate investigations and take actions necessary to prevent additional water level declines; and be it further

RESOLVED that the U.S. Fish and Wildlife Service should take additional steps to protect the deeded water rights to all springs discharging on Ash Meadows National Wildlife Refuge; and be it further

RESOLVED that copies of this resolution be sent to the Honorable Harry Reid; the Honorable Richard Bryan; Congressman James Bilbray; Congresswoman Barbara Vucanovich; Mr. Michael Turnipseed, Nevada State Engineer, Carson City, Nevada; the Regional Director of the U.S. Fish and Wildlife Service, Portland, Oregon; the State Director of the U.S. Bureau of Land Management; and the Regional Director of the U.S. National Park Service, San Francisco, California.

PASSED WITHOUT DISSENTING VOTE

Attest

Edwin P. Pister
Executive Secretary

Desert Fishes Council

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March 30, 1992

91-2

Relative to Road Construction between Pahrump and Amargosa Valley, Nye County, Nevada

WHEREAS Ash Meadows, Nye County, Nevada, includes a higher concentration of endemic species of plants and animals than any other area in the United States; and

WHEREAS the U.S. Fish and Wildlife Service lists 11 of these species as either threatened or endangered, Critical Habitat has been delineated for 9 of these species, and 15 additional species are candidates for future listing; and

WHEREAS unique qualities of Ash Meadows are further recognized by inclusion of much of the area within Ash Meadows National Wildlife Refuge; and

WHEREAS the U.S. Fish and Wildlife Service has completed a recovery plan for listed species in Ash Meadows stating that recovery will occur when habitats are secured from threats and rehabilitated to natural conditions from effects of habitat disturbance caused by diversion, ground water pumping, land clearing for agriculture, and non-native terrestrial and aquatic species; and

WHEREAS Nye County, Nevada, wishes to construct and pave a road through Ash Meadows National Wildlife Refuge to connect the communities of Pahrump and Amargosa Valley that will adversely modify Critical Habitats, prevent rehabilitation of disturbed habitats, and increase access to habitats where non-native species may be more easily introduced; and

WHEREAS Nye County, Nevada, has received funds and approval from the U.S. Fish and Wildlife Service to construct a road connecting these communities, but through a corridor lying south of the Refuge and outside of most habitats occupied by rare species; now therefore be it

RESOLVED that the Desert Fishes Council, an international professional organization dedicated to the preservation of America's desert fishes, requests the U.S. Fish and Wildlife Service to require use of the southern road corridor by denying permission for construction through the Refuge; and be it further

RESOLVED that copies of this resolution be sent to the Honorable Harry Reid; the Honorable Richard Bryan; Congressman James Bilbray; Congresswoman Barbara Vucanovich; Governor Robert Miller; the State Director of the U.S. Bureau of Land Management; and the Regional Director of the U.S. Fish and Wildlife Service, Portland, Oregon.

PASSED WITHOUT DISSENTING VOTE

Attest

Edwin P. Pister
Executive Secretary

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91-3

Relative to Restoration of the Marys River Watershed, Nevada

WHEREAS the U.S. Bureau of Land Management and the U.S. Forest Service have prepared and are implementing a restoration plan for the Marys River watershed in northeastern Nevada; and

WHEREAS restoration of the threatened Lahontan cutthroat trout, Oncorhynchus clarki henshawi, is an integral part of this effort; and

WHEREAS this is one of the first cooperative efforts by the U.S. Bureau of Land Management and the U.S. Forest Service to conserve and restore riverine and riparian habitats for an entire watershed; and

WHEREAS this is one of the pilot "Bring Back the Natives" projects which help implement valuable initiatives of both agencies, such as Fish and Wildlife 2000, Riparian-Wetland Initiative for the 1990s, Rise to the Future, Every Species Counts, and the Recreational Fisheries Policy; now therefore be it

RESOLVED that the Desert Fishes Council, an international professional organization dedicated to the preservation of America's desert fishes, enthusiastically supports the "Bring Back the Natives" concept, of which the Marys River project is a fine example; and be it further

RESOLVED that both agencies are encouraged to expand such efforts throughout the United States in conjunction with their principal national supporters, the National Fish and Wildlife Foundation and local partners; and be it further

RESOLVED that copies of this resolution be sent to Mr. Cy Jamison, Director, Bureau of Land Management, Washington, D.C.; Mr. F. Dale Robertson, Chief, U.S.D.A. Forest Service, Washington, D.C.; Mr. Billy Templeton, State Director, U.S. Bureau of Land Management, Reno, Nevada; Mr. Gray Reynolds, Regional Forester, U.S.D.A. Forest Service, Ogden, Utah; and Mr. Amos Eno, National Fish and Wildlife Foundation, Washington, D.C.

PASSED WITHOUT DISSENTING VOTE

Attest

Edwin P. Pister

Executive Secretary

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91-4

Relative to Protection of Phantom Lake Spring Fishes

WHEREAS the Comanche Springs pupfish, Cyprinodon elegans, listed as endangered under the Endangered Species Act of 1973, as amended, is known to have historically occurred in only two spring systems within the Pecos River drainage in southwestern Texas; and

WHEREAS the Pecos gambusia, Gambusia nobilis, listed as endangered under the Endangered Species Act of 1973, as amended, is known to have historically occurred in the Pecos River basin in southeastern New Mexico and western Texas; and

WHEREAS the Comanche Springs pupfish and Pecos gambusia have experienced reductions in range, abundance, and stability of habitat, and currently are existing tenuously; and

WHEREAS the Comanche Springs pupfish and Pecos gambusia exist in the Phantom Lake Spring head and irrigation canal within the U.S. Bureau of Reclamation's Phantom Lake Spring Property; and

WHEREAS the Bureau of Reclamation, as a federal agency, has certain requirements under the Endangered Species Act that necessitate consideration of endangered species at a higher priority than fulfillment of contractual obligations to water user groups; and

WHEREAS opportunities currently exist to maintain and enhance this important fish habitat through negotiations with Reeves County Water Improvement District, property fencing, habitat modification and enhancement, development of an endangered fish habitat management plan, and monitoring of enhanced habitat and native fish populations by qualified biological personnel; now therefore be it

RESOLVED that the Desert Fishes Council, an international professional organization dedicated to the preservation of America's desert fishes, supports efforts by the U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, Reeves County Water Improvement District, and Texas Parks and Wildlife Department to cooperatively protect and enhance Comanche Springs pupfish and Pecos gambusia habitat through flow maintenance, reduction of predaceous fish and non-native fish encroachment and introductions, and long-term management of the property as an endangered species refugium; and be it further

RESOLVED that copies of this resolution be sent to the Regional Director, Upper Colorado Region, U.S. Bureau of Reclamation; Regional Director of the U.S. Fish and Wildlife Service, Region 2; Governor Ann Richards; and the Director, Texas Parks and Wildlife Department.

PASSED WITHOUT DISSENTING VOTE

Attest

Edwin P. Pister
Executive Secretary

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91-5

Relative to Protection of the Rio Grande Silvery Minnow

WHEREAS the Rio Grande historically supported a diverse ichthyofauna, composed of as many as 154 species in 54 families, of which 18 are native to New Mexico; and

WHEREAS at least six of the native species of the Rio Grande in New Mexico are now probably extirpated; and

WHEREAS the Rio Grande silvery minnow, Hybognathus amarus, a cyprinid that was historically abundant in the mainstem Rio Grande and Pecos Rivers, and whose abundance and range have declined dramatically in the Rio Grande, and that has been extirpated from the Pecos River; and

WHEREAS the State of New Mexico, by Regulation 682 of November 30, 1990, lists the Rio Grande silvery minnow as endangered, Group 2; and

WHEREAS the U.S. Fish and Wildlife Service issued Notice of Proposal to List the Rio Grande silvery minnow as a federally endangered species on February 19, 1991; and

WHEREAS recent collections within the current range of the Rio Grande silvery minnow have resulted in an alarmingly low capture rate, indicating further reduced abundance and distribution; and

WHEREAS the Rio Grande silvery minnow is a short-lived species, achieving a maximum known age of three years, therefore further endangering its existence due to increased susceptibility to annual unpredictable events; and

WHEREAS disturbance and further degradation of habitat in the known range of the Rio Grande silvery minnow, including drying of extensive reaches of the Rio Grande, will continue to occur without full protection and remedial actions for the species by the State of New Mexico, the United States government, and other resource users within the basin; now therefore be it

RESOLVED that the Desert Fishes Council, an international professional organization dedicated to the preservation of America's desert fishes, requests immediate action by water management and resource protection agencies to begin recovery efforts, including habitat rehabilitation, conducting basic research on the species and more drastic removal, propagation, and potential reintroduction activities, to ensure long-term survival for the Rio Grande silvery minnow; and be it further

RESOLVED that the Desert Fishes Council requests the U.S. Fish and Wildlife Service to emergency list the Rio Grande silvery minnow immediately; and be it further

RESOLVED that the Desert Fishes Council requests the New Mexico Department of Game and Fish to upgrade the status of the Rio Grande silvery minnow to Endangered, Group 1; and be it further

RESOLVED that copies of this resolution be sent to the Regional Director, Upper Colorado Region, U.S. Bureau of Reclamation; the Regional Director of the U.S. Fish and Wildlife Service, Region 2; and the Director, New Mexico Department of Game and Fish.

PASSED WITHOUT DISSENTING VOTE

Attest

Edwin P. Pister
Executive Secretary

Desert Fishes Council

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91-6

Relative to Protection of Biodiversity

WHEREAS the number of species of animals and plants threatened with extinction continues to increase; and

WHEREAS endangerment of species often results from human activities, some of which probably exterminate species before scientists have had opportunity to study them or even become aware of their existence; and

WHEREAS extinction is a permanent, irretrievable loss of living resources that may have important benefits as food, medicine, or biological control of pests, as well as being part of the history of life on Earth; and

WHEREAS such human activities that cause extinction could, with proper planning, be modified to permit the continued existence of potentially impacted organisms; and

WHEREAS species other than Homo sapiens do not recognize political boundaries; and

WHEREAS the geographic distribution of a species often involves many nations as well as the air, water, and land connecting them; now therefore be it

RESOLVED that the Desert Fishes Council, an international professional organization dedicated to the preservation of America's desert fishes, supports both national and international efforts to immediately increase and improve research on biodiversity on a global scale; and be it further

RESOLVED that the Desert Fishes Council encourages immediate efforts by the United Nations, President Bush, and the leaders of all nations to cooperate on international efforts to preserve endangered species; and be it further

RESOLVED that two approaches to accomplish this are: (1) preservation of significant examples of all types of natural habitat, with emphasis on areas of high endemism; and (2) establishment and administration of International Biotic Preserves similar to the World Heritage Sites recognized by UNESCO (the United Nations Economical, Scientific, and Cultural Organization); and be it further

RESOLVED that copies of this resolution be sent to the United Nations; UNESCO; UNEP (United Nations Environmental Program); President George Bush; Mr. Barber B. Conable (President of the World Bank); the National Science Foundation of the United States; and other pertinent parties.

PASSED WITHOUT DISSENTING VOTE

Attest

Edwin P. Pister
Executive Secretary

Desert Fishes Council

"Dedicated to the Preservation of America's Desert Fishes"

P.O. BOX 337
BISHOP, CA 93514
(619) 872-8751

March 30, 1992

91-7

Relative to Minimizing Impacts of Timber Harvesting in the Sierra Madre Occidental Region of Mexico

WHEREAS the Sierra Madre Occidental region is a center of endemism which comprises a great variety of aquatic habitats that support a high level of biodiversity; and

WHEREAS the Government of Mexico with funding provided by the World Bank is about to undertake a large-scale initiative to exploit the forest resources of the Sierra Madre Occidental in the States of Sonora, Chihuahua, Durango, and Sinaloa; and

WHEREAS the multiple negative effects of poorly planned, uncontrolled timber harvesting on aquatic biotopes and their associated organisms in other parts of North America are well documented; and

WHEREAS current knowledge of the aquatic biota of the Sierra Madre Occidental is insufficient to either generate a baseline against which potential anthropogenic impacts can be evaluated or to permit the devising of appropriate measures to mitigate the effects of such impacts upon it; and

WHEREAS such environmental impact studies to date undertaken in the area to be exploited have focused preponderantly upon its terrestrial ecosystems; now therefore be it

RESOLVED that the Desert Fishes Council, an international professional organization dedicated to the preservation of America's desert fishes, encourages the Government of Mexico to immediately cause to be carried out a timely, thorough, and detailed environmental impact survey of those aquatic communities that fall within the boundaries of the zone wherein the project will be based; and be it further

RESOLVED that the Desert Fishes Council urges the World Bank to make available sufficient funds to carry out such a survey in a timely and efficient manner; and be it further

RESOLVED that the Desert Fishes Council encourages the Government of Mexico to collaborate with appropriately competent Mexican academic institutions and non-governmental conservation organizations in setting up a mechanism that allows the findings of such a survey to serve as the basis for an interactive process aimed at developing and implementing whatever measures are necessary to minimize the impacts of timber harvesting in the Sierra Madre Occidental upon its aquatic habitats and their associated biotas; and be it further

RESOLVED that the World Bank make available to the Government of Mexico sufficient funds to implement appropriate strategies to mitigate the environmental effects of this project by designating a portion of its projected loan for this purpose; and be it further

RESOLVED that copies of this resolution be immediately forwarded to the President of Mexico; the Secretary for Urban Development and Ecology; the Director-General of Conservation of Natural Resources; the Chairman of the World Bank; and the Directors of its Environmental and Agriculture Divisions.

PASSED WITHOUT DISSENTING VOTE

Attest

Edwin P. Pister
Executive Secretary

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RESOLUCION PRESENTADA ANTE LA REUNION ANUAL
DEL CONCEJO DE PECES DEL DESIERTO,
21-23 DE NOVIEMBRE 1991

En relación a la urgente necesidad de realizar un estudio profundo de impacto ambiental sobre habitats acuáticos en la Sierra Madre Occidental, preliminar a la implementación de una iniciativa forestal mayor en los estados de Chihuahua y Durango.

CONSIDERANDO que la Sierra Madre Occidental es un centro de endemismo que comprende una gran diversidad de habitats aquáticos que producen un alto nivel de biodiversidad, y

CONSIDERANDO que el Gobierno de México, con presupuesto complementado por el Banco Mundial, está por iniciar una iniciativa en gran escala para modernizar la explotación de los recursos forestales de la Sierra Madre Occidental en los estados de Chihuahua y Durango, y

CONSIDERANDO que el conocimiento actual de la bióta acuática de la Sierra Madre Occidental no es suficiente para generar ya sea una línea base contra los impactos antropogénicos potenciales, o para permitir el diseño de las medidas apropiadas para mitigar los efectos de tales impactos, y

CONSIDERANDO que se encuentra bien documentado el efecto negativo y múltiple que tienen las extracciones forestales pobremente planeadas, o sin controles ecológicos, sobre los biotopos acuáticos y sus organismos asociados en otras partes de Norte América, y

CONSIDERANDO que los estudios de impacto ambiental realizados hasta la fecha en el área por explotarse o modernizarse se han enfocado preponderantemente a ecosistemas terrestres, por lo tanto se aprobaron resoluciones;

RESUELTO, que el Concejo de Peces del Desierto, una organización profesional dedicada a la conservación de los peces y sus ecosistemas en los desiertos de Norte América, sugiere al Gobierno Mexicano que considere, y en su caso formule, proponga e incluya en sus planes la realización de un estudio modero de impacto ambiental, completo, detallado, y oportuno de las comunidades acuáticas que se encuentren dentro de los límites de la zona del proyecto, así como de su área de influencia ambiental, y

RESUELTO, que el Concejo de Peces del Desierto solicite al Banco Mundial que proporcione al Gobierno de México fondos suficientes para llevar a cabo los estudios de base e impacto de una manera eficiente y oportuna, y

RESUELTO, que el Concejo de Peces del Desierto sugiera al Gobierno de México que coopere con las Instituciones Académicas mexicanas mas apropriadas y competentes en el tema, así como entre las organizaciones conservacionistas no gubernamentales, para instituir un mecanismo que permita que los resultados de tal investigación sirvan como base para un proceso interactivo encaminado a desarrollar e implementar las medidas necesarias para minimizar los impactos de la extracción forestal en las Sierra Madre Occidental sobre sus habitats acuáticos y sus biotas asociadas, y

RESUELTO, que se solicite al Banco Mundial que provea al Gobierno de México también fondos suficientes para implementar las estrategias apropiadas para mitigar los efectos ambientales de este proyecto, designando una parte de su préstamo proyectado para dicho propósito, y

RESUELTO, que copias de estas resoluciones sean enviadas inmediatamente al Presidente de México; al Secretario de Desarrollo Urbano y Ecología; al Director General de Conservación de Recursos Naturales; al Presidente del Banco Mundial; a los Directores de sus Divisiones de Ambiente y de Agricultura; así como a otros funcionarios involucrados que se considere pertinente.

APROBADO POR UNANAMIDAD

Edwin P. Pister
Secretario Ejecutivo

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Unusual (unexpected) Catostomid feeding morphologies: introgressive hybridization, previously unappreciated ontogenetic changes, or ecophenotypic adaptation. Allozymes to the rescue?

Within Chasmistes are four Recent species (one extinct) each restricted in geographic range and, based on oral morphology, implicated in intergeneric hybridization with sympatric Catostomus species. Two of these hybridization hypotheses were tested. Electrophoretic analyses were done at OSU, UNR, and UCD. Numerous fixed allele differences were observed between "pure form" cui-ui and Tahoe suckers. Every sucker of unusual morphology ("hybrid") possessed cui-ui genotypes. Probability of hybridization between cui-ui and Tahoe suckers is much lower than 1%. Fewer genetic differences were found between shortnose suckers and sympatric Catostomus spp. Nevertheless, the maximum level of hybridization was still estimated to be less than 5% (morphological analysis suggested up to 55% hybridization). Intergeneric hybridization is not the primary cause of Chasmistes morphologic diversity. Alternative hypotheses involve ontogenetic effects and ecophenotypic plasticity. An ontogenetic hypothesis suggests only older, 20-30 year old individuals exhibit characteristic "Chasmistes" oral morphology. "Hybrid" specimens may simply be younger fish. Ecophenotypic responses to environmental cues may result in observed morphologies. Specific cues may include food sources, limnological variables, and competition. These hypotheses are potentially falsifiable and should be tested. Understanding of Chasmistes morphologic diversity has application beyond questions of catostomid hybridization.

[Chasmistes spp., Catostomus spp., hybridization, genetics, ontogenetic, ecophenotype]

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Compiled by

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July 1992

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