

**PROCEEDINGS  
OF THE  
EIGHTH SYMPOSIUM  
ON THE  
NATURAL HISTORY OF THE BAHAMAS**

**Edited By:**

Carolyn A. Clark-Simpson

and

Garriet W. Smith

**Production Editor:**

Shawn W. Polson

Gerace Research Center  
San Salvador, Bahamas  
2001

**Cover Illustration:** *Passiflora cupraea* L. Smooth Passion Flower  
One of numerous new illustrations by Dan Flisser to be included in  
the 2<sup>nd</sup> Edition of **Common Plants of San Salvador** by Lee Kass.

**Cover Illustration By:** Daniel Flisser  
Biology Faculty  
Camden County College  
New Jersey

© Copyright 2001 by Gerace Research Center

All Rights Reserved

No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopy, recording, or any information storage and retrieval system, without permission in written form.

Printed in USA

ISBN 0-935909-70-2

## STUDIES ON THE BIOLOGY OF INLAND FISHES OF THE BAHAMAS: ADAPTATIONS OF CYPRINODONT FISHES

Michael Barton and Christopher Anderson  
Division of Science and Mathematics  
Centre College  
Danville, KY 40422

### ABSTRACT

Studies on the fish populations that occur in inland waters of the Bahamas present a unique opportunity to investigate fundamental questions concerning the adaptations of organisms to unusual environmental circumstances. Of particular interest is the potential for evolution involving variations in morphological and/or life history features arising from the isolation afforded by existence in discrete bodies of water. The potential for such variation exists both among bodies of water within a given island, as well as among the several islands that constitute the Bahamian archipelago. The focus of this series of studies has been the pupfishes of the genus *Cyprinodon* (family Cyprinodontidae). Two species of *Cyprinodon* are known to be present in the Bahamas, *C. variegatus* and *C. laciniatus*. While *C. variegatus* is broadly distributed throughout coastal eastern North America and the Caribbean, *C. laciniatus* is endemic to New Providence Island. This study documents the distribution and microhabitat preferences of *C. laciniatus* and assesses the potential for variation in life history parameters in several populations of pupfishes, both within New Providence Island and from other islands of the Bahamas as well. The distribution and adaptations of the fish species native to the inland waters of the Bahamas is discussed in the context of the potential impact of introduced species. Species flocks of cyprinodont fishes have been described from the American southwest as well as the Yucatan peninsula. Studies suggest that the Bahamas is also host to such species flocks, consisting of several yet to be described species.

### INTRODUCTION

The Bahamas is characterized by a landscape composed of limestone with varying degrees of consolidation. In this depositional substrate, numerous inland bodies of water have formed throughout the numerous islands that constitute the Bahamian archipelago. Sealey (1985) has characterized the lakes and ponds that form as either ridgeland or rockland, based on the shape and mode of origin. Blowing sand created ridges anywhere from 1000 to 5000 years ago and the depressions between them below the water table created somewhat crescent-shaped bodies of water such as Lake Cunningham on New Providence Island or the numerous inland lakes on San Salvador Island. Other bodies of water, such as Lake Killarney on New Providence Island, were created from shallow depressions in the coralline rock. For a given island, the result is a complex of inland bodies of water with a verifiable age that serves as a habitat for a diversity of biota including several species of fishes. The fish populations observed in these inland waters may be classified into two ecological groupings: species that visit inland waters that are confluent with coastal areas (this confluence may be of a seasonal nature), and species that are permanent residents of inland waters that are more or less completely isolated from the surrounding ocean. In either case, the fish fauna is coastal marine in its biogeographic and phylogenetic affinities. A total of 21 families of fishes have been identified as having species that inhabit inland waters of the Bahamas (Barton and Wilmhoff, 1996). From an evolutionary standpoint, these inland bodies of water present a unique opportunity to study speciation events as each island represents a discrete population with well-defined

boundaries. Islands such as New Providence or San Salvador, with a complex array of inland waters with varying degrees of connection, enable investigation of differentiation of populations that may occur within a single island. In this sense, the individual bodies of inland water on a given island can be viewed as islands themselves with the possibility of exemplifying both allopatric or sympatric speciation events.

One of the most widespread groups of fishes to be found in the inland waters of the islands of the Caribbean and the Bahamas, as well as in the coastal waters of the tropical and temperate western Atlantic, are the Cyprinodontiformes. This group includes the mosquitofishes, mollies, and pupfishes that are the most numerous fishes seen in the inland waters of the Bahamas. The pupfishes of the family Cyprinodontidae are well known for their propensity to develop genetically discrete populations in the numerous inland waters that they may inhabit (c.f. Turner and Liu, 1977; Humphries and Miller, 1981; Echelle and Echelle, 1992; Parker and Kornfield, 1995). Two species of pupfishes, *Cyprinodon variegatus baconi* and *C. laciniatus* are known to inhabit the inland waters of the Bahamas (Lee et al, 1983). The latter species, commonly called the Bahama pupfish (figure 1) is one of only a few endemic species known from the Bahamas (Barton, 1999; Smith-Vaniz and Bohlke, 1991). Although described over 50 years ago (Hubbs and Miller, 1942), virtually nothing is known of its life history. The purpose of this paper is to review some of the current studies underway on the biology of the

pupfishes, with emphasis on the populations that occur on New Providence Island.

### Identification and Characterization of New Providence Cyprinodonts

Two species of *Cyprinodon* have been identified from New Providence Island, *C. variegatus*, known from coastal lagoons such as Corry Sound, and *C. laciniatus*, originally described from collections from Lake Cunningham (figure 2). One of the characteristics that most readily distinguishes these two species are the deeply lacinate scales from which *C. laciniatus* derives its name (figure 3). Assessment of population density and microhabitat preferences of *C. laciniatus* were carried out in Lake Cunningham by sampling fish density along transects laid out along the southern shoreline. From these, it was determined that the populations are concentrated within a few meters of shore in water not much more than two meters in depth, typical microhabitat preferences for cyprinodontiform fishes (figure 4). Preference for such shallow, inshore environments probably minimizes contact with predatory fishes. In many of these inland waters, however, large predators may not be present and inhabitation of inshore waters by pupfishes makes them most vulnerable to predation by shorebirds.

### Variation in New Providence Populations

It is unclear whether the populations of pupfishes present in other inland bodies of water on New Providence Island are *C. variegatus*, *C. laciniatus*, or some hybrid form. Studies are underway to clarify the extent of variation among the numerous inland populations of pupfishes.

### Morphological variation

Because scale morphology is such a useful feature in distinguishing the two species of New Providence pupfishes, detailed studies of scale structure, using the scanning electron microscope (SEM) were undertaken to assess the species integrity of different populations.

Fig. 1. Bahama Pupfish (*Cyprinodon laciniatus*), family Cyprinodontidae

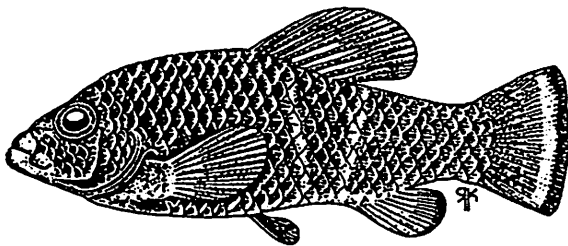


Fig. 2. Map of New Providence Island showing sample sites

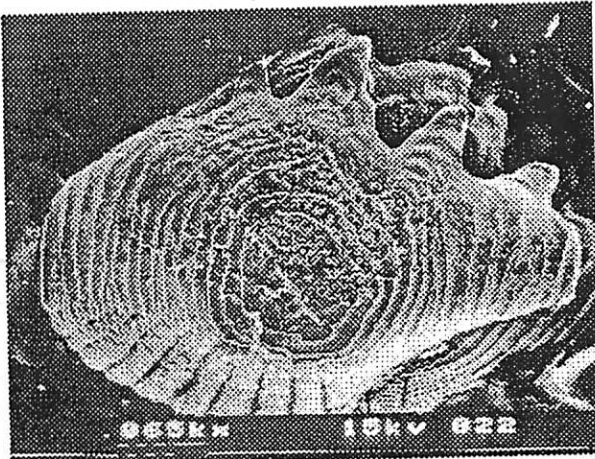
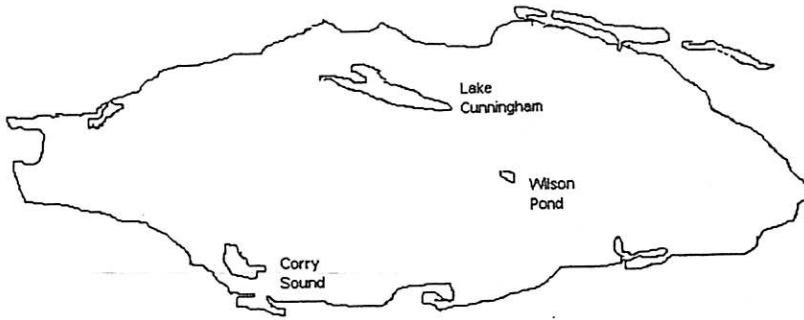


Figure 3. Scale from *C. laciniatus* from Lake Cunningham

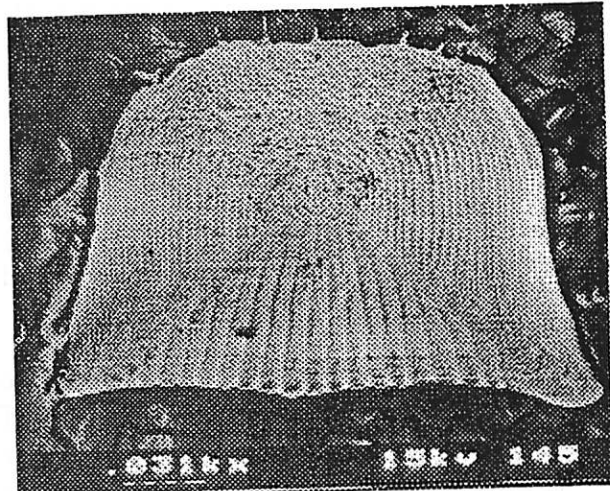


Figure 5. Scale from *C. variegatus* from Corry Sound

Fig 4. Proportion of Total Population at Each Transect Distance

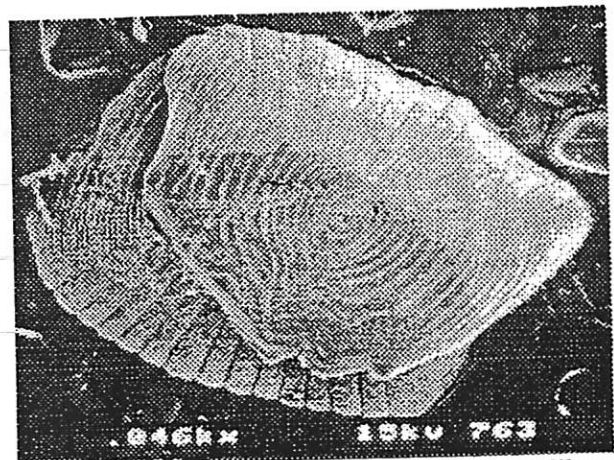
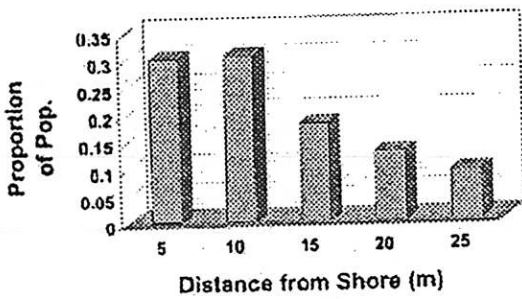
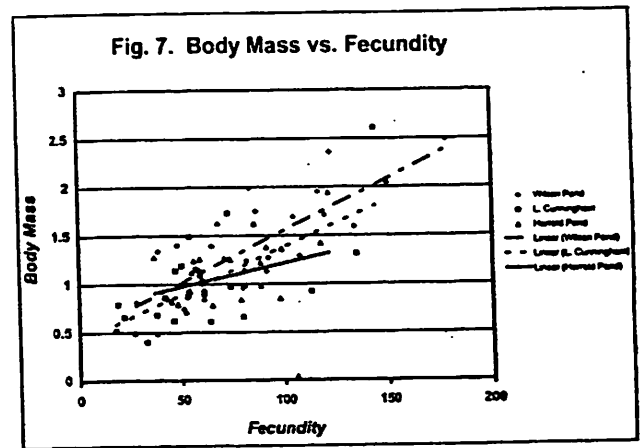


Figure 6. Scale from *Cyprinodon* from Wilson Pond

Individuals were sampled from Lake Cunningham, the type locality of *C. laciniatus*, Corry Sound, the location of readily identifiable populations of *C. variegatus*, and Wilson Pond, an inland body of water with dense populations of pupfishes of unknown identity. Scales were removed from five regions on the bodies of the individuals sampled to account for variation in scale structure. The scales were then cleaned of tissue, subjected to dehydration using a graded ethanol series and a final dehydration step with tetramethylsilane, sputter coated with gold, and viewed with the SEM. The scales of *C. variegatus* from Corry Sound exhibited a broadly truncate form on its embedded margin with well-defined ctenii on the exposed margin. The exposed part of the scale was also characterized by relatively smooth edges (fig. 5). Scales of *C. laciniatus* from Lake Cunningham were distinctive in their absence of ctenii, and in showing the well-developed laciniate condition with an exposed margin of deep invaginations (fig. 3). Pupfishes from Wilson Pond were somewhat intermediate lacking the broadly truncate embedded margin and with poorly defined ctenii and a weakly laciniate exposed margin (fig. 6).

Life history variation. A number of life history parameters can be assessed in order to determine the extent of population variation among New Providence cyprinodonts. We have measured fecundity in these three populations in order to determine if any variation exists in the correlation between fecundity and body mass. Fecundity was assessed by removal of the ovaries from female individuals and counting the total number of eggs, both developing and ripe. The variation in this correlation that was observed (fig. 7) may reflect genetic differences in the allocation of resources in different populations or it may reflect differences in the availability of nutrients in the different inland ecosystems.



## DISCUSSION

Cyprinodontiform fishes are broadly distributed and abundant in the myriad inland and coastal waters of the Bahamas. They are a relatively short-lived species with high population turnover. From these and other studies on the biology of cyprinodontiform fishes in the Bahamas, it is apparent that they present a most unusual opportunity to study speciation processes that have occurred over a relatively short period of time. Because we are able to date the formation of these inland bodies of water with a reasonable degree of accuracy, we can infer that the incipient speciation observed in the Bahamas populations of *Cyprinodon* must have taken place within the past couple of thousand years. We are currently utilizing other meristic and morphometric measurements to further define the extent of variation and apparent introgression among the New Providence populations. Even more dramatic variation has been observed among the inland waters of San Salvador Island. Morphologically distinct forms of *C. variegatus* have been discovered and studies are underway to assess the genetic integrity of these variants. One of these forms, the so-called "bulldog" variant, so-named because of its pronounced jaw structure, has been observed to appear in different species flocks elsewhere (Humphries and Miller, 1981). We have observed "bulldog" variants among populations of *C. laciniatus* in Lake Cunningham. That such a morphologically distinct form appears as convergent among different species of pupfishes in different

localities is an especially intriguing phenomenon.

It is especially urgent that we quickly achieve a thorough understanding of the extent of variation that exists among Bahamas pupfish species owing to the potential for loss of critical habitat and introduction of exotic species that may compete with these native forms. The building boom that is currently underway in the Bahamas, with its attendant degradation of coastal shallow water habitat, seriously jeopardizes the continued existence of these populations. Cichlid fishes have been widely introduced, especially in New Providence (Barton and Wilmhoff, 1996); these have been proven to have a detrimental effect on native cyprinodont fishes (Schoenerr, 1985; Tippie et al, 1991). It would be most unfortunate if the systematics and life history of this remarkable group of fishes, including one of the very few documented endemic Bahamian species, becomes known to us just as they are extirpated through our disregard for their habitat.

#### LITERATURE CITED

- Barton, M. 1999. Threatened fishes of the world: *Cyprinodon laciniatus* Hubbs & Miller, 1942 (Cyprinodontidae). *Env. Biol. Fishes* 55: 422.
- Barton, M. and C. Wilmhoff. 1996. Inland fishes of the Bahamas – new distribution records for exotic and native species from New Providence Island, Bahamas. *Bahamas J. Sci.* 3(2): 7-11.
- Echelle, A. A. and A. F. Echelle. 1992. Mode and pattern of speciation in the evolution of inland pupfishes in the *Cyprinodon variegatus* complex (Teleostei: Cyprinodontidae): An ancestor-descendant hypothesis. pp 691-709 in R.L. Mayden (ed.), *Systematics, Historical Ecology, and North American Freshwater Fishes*. Stanford Univ. Press.
- Hubbs, C. L. and R. R. Miller. 1942. Studies of the fishes of the order Cyprinodontes
- XVIII. *Cyprinodon laciniatus*, new species from the Bahamas. *Occ. Pap. Mus. Zool. U. Mich.* 458: 1-11.
- Humphries, J. M and R. R. Miller. 1981. A remarkable species flock of pupfishes, genus *Cyprinodon*, from Yucatan, Mexico. *Copeia* 1981(1): 52-63.
- Lee D. S., S. P. Platania, and G.S. Burgess. 1983. Atlas of North American freshwater fishes, 1983 supplement. N. C. State Mus. Nat. Hist. Biol. Surv. Cont. no. 1983-6.
- Parker, A. and I. Kornfield. 1995. Molecular perspective on evolution and zoogeography of cyprinodontoid killifishes (Teleostei: Atherinomorpha). *Copeia* 1995(1): 8-21.
- Schoenherr, A. A. 1985. Replacement of *Cyprinodon macularis* by *Tilapia zilli* in an irrigation drain near the Salton Sea. *Proc. Desert Fishes Council* 13: 65-66.
- Sealey, N. E. 1985. Bahamian Landscapes: an introduction to the geography of the Bahamas. Collins Caribbean.
- Smith-Vaniz, W. F. and E. B. Bohlke. 1991. Additions to the ichthyofauna of the Bahama Islands, with comments on endemic species. *Proc. Nat. Acad. Sci. Phil.* 143: 193-206.
- Tippie, D., J. E. Deacon, and C-H Ho. 1991. Effects of convict cichlids on growth and recruitment of White River springfish. *Great Basin Nat.* 51: 256-260.
- Turner, B. J. and R. K. Liu. 1977. Extensive interspecific genetic compatibility in the New World killifish genus *Cyprinodon*. *Copeia* 1977(2): 259-269.