Cryptic Biodiversity

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Just how many aquatic animal species do we have in the Southeast? We don't have a final answer to this question yet, but through the collaborative efforts of agency biologists and scientists specializing in taxonomic classification, we are moving in the right direction. We do know that the southeastern United States harbors the greatest level of temperate zone aquatic biodiversity in the world. For creatures such as freshwater mussels, the most highly imperiled animal group in the U.S., the level of diversity exceeds that of any other region globally.

Researchers in systematic biology continue to learn about the biological diversity of this region, some of which is referred to as "cryptic," or unknown, biodiversity. The discovery of formerly unrecognized species has been made possible by the development of sophisticated analytical tools. Advances in both technology and theory in systematic and evolutionary biology have permitted scientists to detect additional species diversity around the world on the basic of divergences in genetic, morphological (body form), ecological, and behavioral traits that were previously unknown.

Most biologists with a knowledge of aquatic organisms are familiar with species "complexes." Generally, a species complex describes a relatively wide-ranging species that has an unusual distribution across its range in morphological characters, habitat preferences, or other aspects of its anatomy, life history, or ecology. This understanding is rapidly changing. Species are now considered evolutionary lineages, and these lineages are identified using a variety of heritable traits that can have differing degrees of differentiation within and between groups. Scientists are incorporating various types of data into their studies to reveal naturally occurring patterns of diversity. Accurate knowledge of diversity is not only critical to scientists seeking to understand processes responsible for biological diversification, but is equally critical to resource managers hoping to develop effective conservation programs.

Over the past decade or two, thorough studies of the morphological, behavioral, ecological, and genetic variation in species have resulted in the "splitting" of several fairly well-known polytypic (containing populations that have different morphological traits) species into numerous "new" species. Two recent changes that have been important in refining this science include the technological advances in molecular genetics and a more pronounced emphasis on field studies with the examination of live organisms.

Historically, morphological data obtained from preserved museum specimens was the primary source of characters used in differentiating new taxa. Museum materials are essential, but often they do not readily reveal important characteristics found in cryptic species complexes. These types of traits are best found by examining live specimens or by using other methods useful in identifying evolutionary lineages, such as genetic traits. Following the identification of new taxa, all of the evidence, whether it is genetic, morphological, behavioral, ecological, or combinations thereof, is compiled into a formal species description for publication in a peer-reviewed scientific journal.

Several recent examples among the fishes show how the use of genetic and morphological data, combined with phylogenetic (genetic relationships of related organisms) systematics and a revolutionized theory of how species are determined, has improved our understanding of diverse biological lineages. The greenbreast darter (*Etheostoma jordani*) was long thought to consist of a single species found in most of the major rivers of the highly rich Mobile Basin. A thorough evaluation of the

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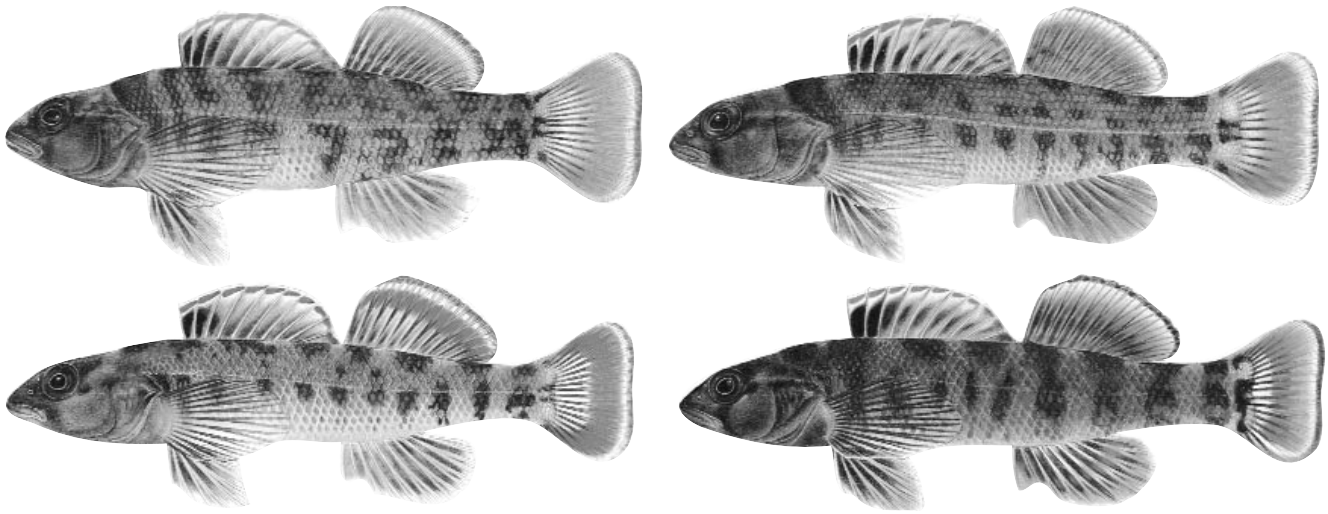

Fig. 1. Newly discovered and described species in the *Etheostoma jordani* complex. Clockwise from upper left: greenbreast darter (*E. jordani*), Tuskaloosa darter (*E. douglasi*), lipstick darter (*E. chuckwachattae*), and Etowah darter (*E. etowahae*). Illustrations © Joseph R. Tomelleri.

variation in the species based on live and museum specimens revealed four distinct species (Fig. 1), one of which, the Etowah darter (*E. etowahae*), is now listed as endangered. As its name indicates, this fish is endemic to the Etowah River in the upper Coosa River Basin. The speckled chub (*Macrhybopsis aestivalis*) complex was long considered a wide-ranging polytypic species with six subspecies. Now, this "species" is known to contain at least 10 genetically and morphologically distinct species (Fig. 2), some of which are likely imperiled. Numerous other fish species complexes are known. In fact, a recent compilation of the status of all native southeastern freshwater fishes led to an estimate that approximately 10% of the 662 known taxa are formally undescribed (Warren et al., 2000).

High levels of cryptic diversity probably also exist for certain other aquatic groups that warrant more thorough systematic evaluations. Few mollusk or crayfish biologists are systematists and taxonomists, making it difficult to know if our inventories of understudied groups reflect natural diversity. But the number of taxa described in these poorly known groups is considered artificially low by conservationists. Numerous additional taxa are presumed to occur in the Southeast.

The rich aquatic biodiversity in the southeastern U.S. is attributable to various geological and zoogeographic (geographic distribution of animals) factors. The Southeast is an ancient and highly diverse landscape over half a billion years in age and is composed of numerous physiographic provinces (major land area classifications based on geology and geographic features). Each province has a distinct lithography, or mineral composition, which influences the chemistry of surface and ground waters. Southeastern waters receive abundant rainfall and display a diverse array of habitat types. Differentiation of species also has been fostered by the Southeast's stable geologic history. None of the streams draining upland areas of the Southeast were glaciated during Pleistocene ice ages or inundated by Cretaceous seas during interglacial periods. These upland areas have served as the primary "spawning sites" for the evolution of various new aquatic species. Unlike birds and mammals, most freshwater organisms have physical barriers (e.g., waterfalls, relatively abrupt changes in water or substrate quality, marine waters) to their dispersal; therefore, they are often endemic to discrete watersheds or regions.

Plotting species distributions on drainage maps with GIS (geographic information systems) technology is aiding researchers in identifying species that may represent complexes of diversity. A characteristic distribution pattern for many aquatic species complexes has been physiographic integrity. Although many currently recognized complexes are found in several physiographic provinces, some forms are found to be endemic to a particular province, group of provinces, or possibly to the transition region between adjacent provinces. Others may be found in a single river system, or, in the extreme, from a single spring. For instance, the pygmy sculpin (*Cottus paulus*) is known only from Coldwater Spring, part of the Coosa River system of northeast Alabama. Species with normally disjunct distributions or widely separated populations may also indicate that more than one taxonomic entity is represented.

Another clue for potential cryptic biodiversity may be when populations in one portion of a species' range are doing

Fig. 2. Four undescribed species of the *Macrhybopsis aestivalis* species complex found in rivers of the southeastern United States. Illustrations © Joseph R. Tomelleri.

well while populations in another region are disappearing. The frecklebelly madtom (*Noturus munitus*) complex, until recently considered a single species, represents an excellent example. The undescribed madtom species in the upper Coosa River system is highly imperiled and is disappearing from one of the two major watersheds it occurs in, whereas the lowland form of frecklebelly madtom is relatively common in major river systems below the fall line where it is endemic. The best pyramid pigtoe (*Pleurobema rubrum*) populations remaining occur in Arkansas, while all populations east of the Mississippi River are highly imperiled. This mussel should be investigated to determine if it represents a species complex.

Some of the complexes of species being sorted out taxonomically are already relatively rare. In addition to the greenbreast darter example above, the vermilion darter (*Etheostoma chermocki*) group illustrates cryptic diversity and the disjunctions of imperiled taxa. When the vermilion darter, now a federally listed species, was discovered, a thorough analysis of presumed close relatives revealed three undescribed species and disjunct relatives. One of these species was later described as the Warrior darter (*E. bellator*). The other two, both considered imperiled by Warren et al. (2000), await formal taxonomic description.

The general lack of critically needed resources needed to delineate new taxa continues to hamper species assessment and listing activities. This has resulted in various elements of biodiversity becoming increasingly rare. Consequently, an increasing number of aquatic organisms that serve as natural resources for human populations and indicators of the state of our environment will be "circling the drain," inevitably spiraling toward extinction. In some cases, these organisms will not have been formally described or even recognized as distinct before they disappear. Only through increased awareness by the public and governmental agencies and a proportional increase in resources can we curb this loss of biodiversity.

Because of the forethought of concerned academicians, agency biologists, and others, there is a ray of hope. Recovery plans and recently penned strategies to protect imperiled faunas —specifically North American mussels and southeastern fishes—make the search for cryptic biodiversity a high priority task. Working groups, such as the Upper Coosa River Basin Aquatics Summit, meet regularly to discuss newly discovered taxa, their threats, and conservation strategies. Resource managers are tackling the imperiled cryptic biodiversity issue by allocating funding for molecular genetic and morphometric studies of presumed complexes.

By working together in innovative ways, elected officials, budgetary administrators, resource conservation managers, and researchers in academia can turn the tide of increasing imperilment and protect the vast richness of biodiversity hidden within our southeastern waters.

Reference

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